UNIVERSITY OF EDUCATION, WINNEBA

EMPLOYING MOBILE PEDAGOGY AS A MODEL FOR INSTRUCTION AND ASSESSMENT: A CASE STUDY AT ST. FRANCIS COLLEGE OF EDUCATION, HOHOE, GHANA

AMBROSE KWAME AYIKUE

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

DECEMBER, 2022

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE……………………………

DATE ………………………………......

SUPERVISORS' DECLARATION

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

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DEDICATION

To Ayikue, Yekple and Attipoe families.

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TABLE OF CONTENTS

Contents **Pages**

LIST OF TABLES

Tables **Pages**

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The purpose of the study was to employ mobile pedagogy as a model for instruction and assessment in other to improve upon the learning outcomes of science students in the concepts of acids, bases and salts in chemistry at St. Francis College of Education (FRANCO), Hohoe. The study was an action research employing pretest-posttest design. The target population for the study comprised all the first year science students in four Colleges of Education in the Volta Region of Ghana. However, the accessible population was made up of two intact first year science classes of ninety-six students of FRANCO. Purposive sampling technique was employed to select the sample for the study. Test, questionnaire and opinionnaire were used to collect data. The data collected were analysed using IBM SPSS version 22. It was found out that all the science students have mobile devices and the most common types used were the Android Phones, Cellular Phones and Laptops. The devices were mostly used for non-academic purposes. In their opinion, the nature of the devices, internet availability and the rate of uplink and downlink influenced how they used their devices. However, large memory size had no influence on how they use their mobile devices in the school. Mobile pedagogy helped level 100 science students at St. Francis College of Education to understand the concepts of acids, bases and salts. It also increased their active participation in chemistry lesson, increased their motivation to learn chemistry and inevitably increased their test scores.

It was concluded that employing mobile pedagogy for instruction and assessment had significant effect on students' academic achievements. It was recommended that science teachers and students should employ mobile pedagogy as a tool for instruction, learning and assessment.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter deals with the background to the study, statement of the problem, purpose of the study, objectives, research questions, null hypothesis, significance of the study and delimitation.

1.2 Background to the Study

Information and Communication Technology (ICT) is a potent force in driving economic, social, political and educational reforms (Rodríguez-Arancón, Arús, & Calle, 2013). Educational institutions that fail to recognise and act according to the trends in new content and new methodologies in education may find it very difficult to compete in the global economy (Bright Hub Education, 2013; Miller, 2016). Delannoy (2000) stated that, the integration of technology in education could enhance learning environment for learners by providing opportunity to learners to be constructively engaged with instruction. Students appear to respond to information differently. Therefore, it is necessary for teachers to use many different methods and modes to teach the subject matter of a lesson. With the advent of technology and internet, information can be communicated over the World Wide Web, and therefore, there are new and exciting ways to present information to learners. One of them is the use of smartphones. Most smartphones allow the use of animation, moving pictures, and sounds and access to large domain of multimedia (Miller, 2016; Williams & Pence, 2011). Materials that encourage students‘ interaction with the subject matter can also be presented using smartphones. Pictures and animations help bring to life scientific principles, and multimedia allow students to take a more active role in learning. Students can watch experiments online; see microorganisms with large magnification; they can navigate images, simulate other interactive materials. One of the advantages of using multimedia is to convey information quickly and effectively to students and keep them interested in learning (Clark & Luckin, 2013). According to Karimi (2016), mobile pedagogy is synonymous to mobile learning (m-learning) which involves using mobile devices such as smartphones, personal digital assistants (PDAs), tablets and laptops to allow learners to learn anywhere and at any time. Mobile devices are technological devices that run an open operating system and are permanently connected to the internet if an active SIM card(s) is/are inserted (Louw, & von Solms, 2015).

Yu and Conway (2012) particularly noted that, the QWERTY keyboard design (a keyboard design for Latin-script alphabets and its name comes from the order of the first six keys/letters on the top left of the keyboard, QWERTY), either physically or virtually available on mobile devices, make typing as easy as on a personal computer whilst basic functions such as call, text messaging, and camera give an added bonus of mobility to the devices. Trinder (2005) stressed that, mobile devices can be used in presenting documents, writing notes, playing educational games, listening to audio recordings and other sound files, viewing pictures and watching video clips, plus taking photographs. Mobile devices have become technological tools for doing so many things. Teachers/Tutors/Lecturers, farmers, bankers, security forces, pastors, and students just to mention a few, use mobile devices in many ways. Students visit the internet: Facebook, WhatsApp, You-Tube, all e-mail search engines, and all search engines for different kinds of information for different reasons. It is possible for students to stay with their mobile devices for a very long time because there are so many places for them to visit for whatever kinds of information they wanted. Most of the places they visit too, do not have direct bearing on their academic works. In line with this, Wenderson, Fatimah, Ahmad & Nazleeni (2010) concluded from their study that mobile devices have become one of the technologically addicted tools to most students at the higher educational levels like the Colleges of Education, Technical Universities and other Universities. Colleges of education curriculum also emphasis the use of modern technology in for lesson delivery. The National Teachers Standard (NTS) also emphasised the use of technology to support teaching, learning and assessment by professional teachers.

The concepts of Acids-bases and salts have become objects of science education research for a long time (Lin & Chiu, 2010; Bayrak, 2013; Damanhuri, Treagust, Won & Chandrasegaran, 2016). There are two crucial problems related to students' understanding of Acids-bases and salts in Chemistry (Kind, 2004; Lin & Chiu, 2010; Artdej, Ratanaroutai, Coll & Thongpanchang, 2010; Kala, Yaman & Ayas, 2013; Bayrak, 2013) and students of St. Francis College of Education (CoE) are not exception. Misconception or alternative conception is the most common and the first problem of students' understanding of acid-base concepts. Several alternative conceptions on this topic have been uncovered by some researchers, e.g. Neutralisation is the division of an acid or something becoming different from an acid (Kind, 2004); there is neither H^+ nor OH^- ions in the resulting solutions at the end of all neutralisation reactions (Demircioglu, 2009); more bubbles produced by a strong acid upon reaction with metal than a weak acid (Artdej et al., 2010); pH represents the solution‘s acidity, while pOH is a measurement of the solution‘s basicity (Kala et al., 2013); and compounds containing OH^- group like CH_3COOH are bases (Bayrak, 2013).

The second crucial problems related to students' understanding of Acids-bases and salts in Chemistry is that, most students find it difficult to draw the differences between weak and strong acids, weak bases and strong bases (Kala et al., 2013). Students of St. Francis College of Education exhibited similar problems. The students face difficulties in understanding the concepts of acid-base chemistry. Meanwhile, acid–base chemistry form about 40% of the course outline for the second semester of year one programme (Appendix L).

Most instructional strategies have been developed to reduce the misconceptions and difficulties associated with acid-base chemistry (Rahayu, Chandrasegaran, Treagust, Kita & Ibnu, 2011; Kala et al., 2013; Georgiou & Sharma, 2015; Gordon, Sharma, Georgiou, & Hill, 2015; Naiker & Wakeling, 2015; Wegener, Doyle-Pegg & McIntyre, 2015; Williamson, Huang, Bell & Metha, 2015). However, none of such instructional strategies made use of modern technology especially the use of mobile devices at the College of Education levels. Also problems related to college students‘ concepts of acid-base chemistry have not been resolved completely.

Science educationists are already becoming more aware of the enormous prospects that smartphones can have in science education in the developing and developed countries. Zakaria, Fordjour and Afriyie (2015), Quist and Quashie (2016), Twum (2017), Sarfoah (2017) all did some works on the use of mobile devices in the teaching and learning processes.

Seven different works on teaching and learning of acids, bases and salts and the use of mobile devices in science education, both local and foreign contexts, were reviewed to establish the knowledge gap which this work sought to fill. Damanhuri, Treagust, Won and Chandrasegaran, (2016) investigated High School Students‘ Understanding of Acid-Base Concepts which is an ongoing Challenge for Teachers in

Malaysia. In their report, they developed Acids-Bases Chemistry Achievement Test (ABCAT) and used it to evaluate the extent to which students in Malaysian secondary schools achieved the intended curriculum objectives on acid-base concepts. Two-tier multiple choice items were created and administered to 304 students from seven secondary schools. The studies identified 12 alternate conceptions which were displayed by learners. The study concluded that the 12 alternative conceptions about acids and bases were endemic. The findings showed that there is still a need for these Malaysian science teachers to carefully review their classroom instructional methods to ensure that students are provided with opportunities to develop appropriate understandings of acid-base concepts.

Even though the study identified misconceptions related to acid-base chemistry, the study however, did not suggest or provide a modern and appropriate way of addressing the identified misconceptions.

Lin and Chiu (2010) also published a paper in the area of teaching the concept of acids and bases. The aim of the study was to compare the characteristics and sources of students' mental models of acids and bases with a teacher's anticipations and, based on this comparison, to explore some possible explanations why motivated students might fail to learn from a subject-knowledgeable chemistry teacher. The study involved a chemistry teacher and 38 ninth graders and focused on the mental models of three high achievers and three low achievers who were interviewed in depth. Four students' mental models of acid and base were identified. The mental models and sources of students' conceptions of acids and bases that influenced the high achievers were compared to those of the low achievers. It was found out that, the teacher in the study made accurate anticipations of students' mental models in the case of the high achievers but inaccurate anticipations of the low achievers' mental models. Also, it was discovered that, the diverse sources of learners' prior knowledge influenced their mental models. In addition, the teacher incorrectly attributed the poor achievement of the low- achieving students to their intuition and underestimated the effects of teaching on the achievement of these students. As a result, the teacher's instruction reinforced the low achievers' incorrect mental models. This research work also did not suggest ways of addressing the misconceptions or the incorrect mental models of the learners.

Williamson, Huang, Bell and Metha (2015) came out with a research work on how to assist students of no or little prior chemistry knowledge background to make them understand chemistry concepts in University of Adelaide. In the process, they introduced restructuring of courses. The restructure introduced Process-Oriented Guided Inquiry Learning (POGIL) style activities in lectures to deliver the majority of the course content and a new online learning platform for summative assessment. Three entirely new Foundation of Chemistry courses were developed, one in each semester. The study outlined the restructure process that led to the creation of three new courses and how these developments have impacted on student learning outcomes. Students have responded positively to the restructured courses, and end-of-semester results showed that there has been an increase in the proportion of Distinction and High Distinction grades. In this work, even though there was a use of technology, its purpose was for summative assessment, thus, assessment *of* learning and not *for* or *as* learning.

Twum (2017) also worked on utilisation of smartphones, an example of mobile device, in science teaching and learning in selected universities in Ghana. The study intended to examine the use of smartphones in science teaching and learning and propose a model in the use of smartphone for teaching and learning. The findings revealed that, the mobile phone had great potential as a learning tool and it could positively be used for teaching and learning purposes in science. One of the conclusions made from the study was that, though most lecturers use smartphones to access up-to-date information on science and reading materials online, only a few were aware of the instructional importance of the smartphones. It was suggested that, similar studies be done to cover specific elective science areas (chemistry, physics or biology). Following that, lecturers could design activities that would allow students to appropriately use their smartphones during lectures or at their convenience.

The study also failed to focus on the employment of mobile pedagogy in teaching chemistry at CoE level. In addition to that, the researcher did not design any interactive activities to be used by the students on their mobile devices.

Quist and Quashie (2016) also worked on the use of mobile devices among undergraduate students in Ghana. The objective of the study was to review the level of usage of the mobile device by college students in both the private and public institutions in Ghana. The study looked at what the average student's level of usage of the mobile phone on a daily basis and the frequency of usage for the following activities; education-related research, personal finance, religious activities, making and receiving calls, current events, work related research, playing games watching movies, listening to music and social networking. The research revealed that (20.0%) of the respondents always listened to music on their mobile devices, playing games (7.9%), watching movie (2.0%), social networking (46.5%), work-related research (12.9%), educational related research (17.8%), religious programmes (3.2%), personal finance (15.0%), current events (3.2%) and making and receiving calls (65.0%). The research also looked at the duration of usage by the students at school and home. When it came to using the mobile devices at home (42.0%) said they spent 7 hours or more on their mobile devices at home whiles the rest agreed that they spent less than 2 hours. Others (49.9%) also agreed that they spent 7 hours or more at school and few others also spent varied hours which were not up to 7 hours on the phone at school. The work also did not address the use of mobile devices as a model for instruction and assessment in a chemistry course at the CoE level in Ghana.

Sarfoah (2017) also presented a master‘s thesis on the use of Smart Phone for Learning. The study was designed to determine the use of smart phones for learning among students in the University of Ghana. The main objectives pursued by this study were to investigate the adoption factors most relevant in students‘ use of smartphone as a learning tool, and also to investigate the role of educators (lecturers) in students‘ resolution to learning via smartphones, as well as investigate factors that inhibit the use of smartphones as a learning tool. Recommendations for future study was that other researchers should attempt examining smartphone learning in other contexts, i.e. other Universities, as well as carry out a comparative study among the institutions so as to inform authorities on how smartphone learning can be integrated into the learning activities of Universities in Ghana. It was observed that the research work done could not address instructional and assessment strategies for chemistry concepts formation.

Zakaria, Fordjour and Afriyie (2015) published a paper on the use of mobile phones to support coursework in WA Polytechnic, Ghana. The study investigated how students of Wa Polytechnic use the mobile phone as an interactive medium to access educational content to support coursework and the challenges that confront them. It was discovered that, the major challenge the students faced as they used mobile phones to support coursework was poor network service. Other relatively moderate challenges were; inadequate knowledge in the use of mobile phones, faulty mobile phones, and lack of Microsoft Office applications on their mobile phones. The study recommended that mobile service providers should innovatively improve network stability during school sessions for students to effectively use mobile phones to support course work. This paper could not also address the use of the mobile phone as instructional tool for teaching and learning of chemistry concepts.

It can be seen from the previous works done on acid-base and salt chemistry and the use of mobile devices in education that:

1. Some forms of teaching strategies were designed to teach the concept of acids, bases and salts, but all of them could not make use of m-learning.
2. All the research works discussed above were done either in the Universities, Poly-Technics, or the Secondary Schools. None was done in the Colleges of Education in Ghana and also in the area of acids, bases and salts.
3. None of the works was done on the effect of using interactive activities on mobile devices on students' academic performance in chemistry at CoEs level in Ghana.

This implies that, there has not been much empirical study done in the Colleges of Education in Ghana about the uses and effects of mobile pedagogy and concept development in chemistry. Meanwhile, the CoE course outlines emphasised the use of technology during teaching and learning. The National Teachers' Standards also encouraged the use of modern technology for teaching, learning and assessment. Hence this work sought to fill this knowledge and methodological gap. It is therefore necessary that one looks at the potential of employing mobile pedagogy as a model for teaching, learning and assessment of the concept of acids, bases and salts in chemistry at St. Francis CoE, Hohoe, Ghana. To help in achieving that, there was the need to create interactive exercise using hot potatoes software in the form of *assessment as learning* and *for learning* on mobile devices to teach and assess the concept of acids, bases and salts in St. Francis College of Education (CoE) in the Volta Region of Ghana.

1.3 Statement of the Problem

Many educators, parents and students believe that, the reasons for using technology seem so obvious that everyone should recognise them. The rationale is based on two major views:

1. Technology is everywhere and therefore should be in education - what Miller, (2001), calls the ―societal inevitability" rationale, and
2. Research has shown how and where technology based pedagogy are effective (Cordes & Miller, 2001).

Both of these commonly held beliefs have some validity and both provide rationale for using mobile devices in teaching science. The gap in knowledge which this work sought to address is that, even though, much works had been done in the area of teaching and learning of the concept of acids, bases and salts (Lin & Chiu, 2010, Bayrak, 2013) and the use of mobile devices in education at different levels (Damanhuri, Treagust, Won & Chandrasegaran, 2016; Zakaria, Fordjour & Afriyie, 2015; Quist & Quashie, 2016; Twum, 2017; Sarfoah, 2017) , there is still much work to be done in making the concept of acids, bases and salts be understood by learners at St. Francis College of Education, Hohoe. Learners found the concepts difficult and confusing to them because, different perspectives of the concepts were proposed by different proponents, namely, Arrhenius, Bronsted-Lowry and Lewis and this makes learners become confused (Sarfoah, 2017). Also the concepts of acids and bases as explained by Arrhenius had limitation which Bronsted-Lowry sought to address. But he could not solve all the limitations and in his concepts too, there were limitations. University of Cape Coast chief examiner‘s report on first year second semester chemistry consistently for four years (2018, 2019, 2020 & 2021) also identified various challenges learners demonstrated in answering questions related to acids, bases and salts. The reports exposed the facts that some of the learners could not differentiate between strong acids and weak acids (45%), strong bases and weak bases (37%), acidic, basic and neutral salts (52%). The reports had also shown that 42% of learners could not demonstrate understanding of calculations involving pH and pOH. Most candidates (56%) could not write the correct IUPAC name of some of the acids and salts.

While mobile pedagogy has become increasingly popular and has received growing research interest, there appears to be insufficient empirical evidence from rigorous experimental research that supports its effectiveness on teaching, learning and assessment of the concept of acids, bases and salts at the CoE levels in Ghana. Hence this research sought to employ mobile pedagogy as a model for instruction and assessment to help level 100 science students at St. Francis College of Education to improve upon their performance in the concept of acids, bases and salts.

1.4 Purpose of the Study

The purpose of the study was to employ mobile pedagogy as a model for instruction and assessment to help level 100 science students at St. Francis College of Education, Hohoe, to improve upon their performance in the concept of acids, bases and salts.

1.5 Objectives of the Study

This study sought to determine the:

1. Types of mobile devices that level 100 science students use at St. Francis College of Education, Hohoe.
2. Purposes for which science students use mobile devices at St. Francis College of Education, Hohoe.
3. Factors that affect the use of mobile devices as learning tools at St. Francis College of Education, Hohoe.
4. Students‘ opinions of mobile pedagogy as an instructional model for learning the concept of acids, bases and salts at St. Francis CoE.
5. Effects of employing mobile pedagogy as an instructional model on students‘ cognitive achievement in the concept of acids, bases and salts at St. Francis CoE.

1.6 Research Questions

The research questions that guided the study were:

1. What types of mobile devices do level 100 science students use at St. Francis College of Education, Hohoe?
2. What are the purposes for which science students use mobile devices at St. Francis CoE?
3. What factors affect the use of mobile devices as learning tools at St. Francis College of Education, Hohoe?
4. What are the science students‘ opinions about the use of mobile pedagogy as an instructional model for learning the concepts of acids, bases and salts at St. Francis CoE?

5. What are the effects of employing mobile pedagogy as an instructional model on students' cognitive achievement in the concept of acids, bases and salts at St. Francis CoE?

1.7 Null Hypothesis

The null hypothesis was formulated to determine if there was any statistically significant difference associated with research question 5:

H_{01} There is no statistically significant difference between the performance of the science students before and after employing the mobile pedagogy for teaching, learning and assessment of the concepts of acids, bases and salts.

1.8 Significance of the Study

The study would bring to light the types of mobile devices use by level 100 science students and purposes of which they use the device at St. Francis College of Education. It would reveal the relevance of using mobile pedagogy as a model for instruction and assessment of the concepts of acids, bases and salts at St. Francis CoE. The study would have the added advantage of providing useful insights into vital information about how mobile devices are changing the way students learn and think about learning. It would also satisfy the demands of the CoE curriculum and the NTS. It would serve as a source of reference for science teachers at St. Francis CoE. Finally, it would add to the volume of knowledge and pedagogy in science education.

1.9 Delimitations of the Study

The study was conducted in St. Francis Collage of Education in the Volta Region of Ghana. First year science students of the colleges were the targeted group because the topic that posed challenge to the students is mounted in the first year. The study narrowed its focus on the use of mobile pedagogy as an instructional and assessment model of the concept of acids, bases and salts at St. Francis CoE.

1.10 Limitations of the Study

One of the limitations of the study was that, only one science college from the Volta Region was selected and this would affect the generalisation of the findings. In addition, there should be internet connectivity for all users of the hot potatoes software used to design the mobile pedagogy. This would allow for effective supervision of what learners are doing from the moment they login for learning until when they logout of the platform. It would also allow for prompt feedback. But it was used offline to reduce cost and avoid internet network challenges. However, students could send screenshot-feedbacks through WhatsApp and e-mails for appreciation and evaluation.

1.11 Operational Definitions

1. Mobile devices: these include any devices that can contain SIM card and can be connected to the internet.
2. Mobile Pedagogy: a created interactive teaching, learning and assessment activities using hot potatoes software in the form of *assessment as learning* and *for learning* on mobile devices of learners to assist them acquire concepts.
3. Smartphone: is a phone that runs an open operating system and is permanently connected to the Internet, if an active SIM card is inserted.
4. Mobile learning (m-learning): involves using mobile devices such as smartphones, personal digital assistants (PDAs) and tablets, to allow learners to learn anywhere and anytime. It is synonymous to mobile pedagogy.

5. Assessment *as* learning: It occurs when students are their own assessors, when they monitor their own learning, ask questions and use a range of strategies to decide what they know and can do, and how to use assessment for new learning.
6. Assessment *for* learning (AFL): is an approach to teaching and learning that provides feedback on students' learning which is then used to develop concepts and improve students' performance. It involves qualitative feedback rather than scores and this makes students become more active in their learning and starting to ‗think like a teacher'.
7. Hot Potatoes Software: It is a software that is compatible with Windows 98, ME, NT4, 2000, XP, Vista, Windows 7 and a modern Web browser (Firefox, Opera, Safari etc.) and enables the creation of interactive activities that will lead to concept development and assessment of concept (Assessment *as* learning, *for* learning and *of* learning).

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter reviewed literature related to the problem. The review focused on theoretical and empirical framework in connection with m-learning in the field of science education. The review covered theoretical and conceptual frameworks. The empirical framework also covered Mobile Pedagogy, Concept of Mobile Devices, M-Learning and D-Learning. It finally covered Assessment and Learning, Feedback System and Learning, Learners' Misconceptions of Acids, Bases and Salts.

2.2 Theoretical Framework

A teacher's role in the 21st century has critically changed from that of being a pedagogue to being a facilitator. Teaching in this century is an altogether new phenomenon, more so because the way students learn has been revolutionised. Today, learning happens everywhere, on the go, and can be customised according to one's style and preferences. As education changes to reflect new social and educational needs, teaching strategies also change; consequently, strategies change to allow the integration of technology into teaching and learning. Today, educators' definition of the appropriate role of technology depends on their perceptions of the goals of education itself and appropriate instructional methods to help students attain those goals. Henriksen, Mishra, and Fisser (2016) claimed that, new technologies have altered teaching and learning rapidly, with innovations for creating and sharing new ideas on content. Most educators seem to agree that changes are needed in education. But learning theorists disagree on which strategies would achieve the best educational goals today. This controversy has served as a catalyst for two different views on teaching and learning. One view, which is called directed instruction, is grounded primarily in behaviourist learning theory and the information-processing, a branch of the cognitive learning theory. The other view, which is referred to as constructivist evolved from other branches of thinking in cognitive learning theory. A few technology applications such as drill practice and tutorials are associated only with directed instruction; most others (problem solving, multimedia production, web-based learning) can enhance either directed instruction or constructivist learning, depending on how they are used. These beliefs guided the purposes of this study.

It is important to recognise that both directed instruction/objectivist and constructivist approaches attempt to identify what Gagné (1985) called the conditions of learning or the sets of circumstances that are obtained when learning occurs. Both approaches are based on the work of respected learning theorists and psychologists who have studied the behaviour of human beings as learning organisms. The two approaches diverge when they define learning and describe the conditions required to make learning happen and the kinds of problems that interfere most with learning. The two approaches disagree because they attend to different philosophies and learning theories, and they take different perspectives on improving current educational practice.

The differences begin with underlying epistemologies: beliefs about the origins, nature, and limits of human knowledge. Constructivists and objectivists (those who espouse directed methods) come from separate and different epistemological ―planets," although both nurture many different tribes or cultures (Garfield & Ben-Zvi, 2009). Philosophical differences between them can be summarised in the following way:

1. Objectivism: Knowledge has a separate, real existence of its own outside the human mind. Learning happens when this knowledge is transmitted to people and they store it in their minds.
2. Constructivism: Humans construct all knowledge in their minds by participating in certain experiences; learning happens when one constructs both mechanisms for learning and his or her own unique version of the knowledge, coloured by background, experiences, and aptitudes (Jenkins, 2010).

2.2.1 Differences in procedures and processes of objectivists and constructivists

Not surprisingly, differences in language and philosophies between constructivists and objectivists signal dramatic differences in the curriculum, teaching and learning methods that each considers appropriate and effective. Sometimes, these differences of opinion have generated strident debate (Baines & Stanley, 2000). Yet many believe that both kinds of strategies may be useful to teachers for addressing commonly recognised instructional and educational problems.

Some of the ways in which these differences are reflected in the classroom are summarised in Table 1.

Table1: Methodological Differences between Directed and Constructivist Theories

	Directed/Objectivist	Constructivist
Teacher roles	Transmitter of knowledge; expert source; director of skill/concept development through structured experiences	Guide and facilitator as students generate their own knowledge; collaborative resource and assistant as students explore topics
Students roles	Receive information; demonstrate competence; all students learn same material	Collaborate with others; develop competence; students may learn different material
Curriculum characteristics	Based on skill and knowledge hierarchies; skills taught one after the other in set sequence	Based on projects that foster both higher level and lower level skills concurrently
Learning goals	Stated in terms of mastery learning and behavioural competence in a scope and sequence	Stated in terms of growth from where student began and increased ability to work independently and with others
Types of activities	Lecture, demonstration, discussions, student practice, seatwork, testing	Group projects, hands-on exploration, product development
Assessment strategies	Written tests and development of products matched to objectives, all tests and products match set criteria; same measures for all students	Performance tests and products such as portfolios; quality measured by rubrics and checklists; measures may differ among students

Source: Baines & Stanley, (2000).

In the constructivist context, the instructor utilises active learning strategies to scaffold activities and tasks (so that students can progress from the simple to the complex), explore information, discover concepts, and construct knowledge and meaning. According to Wu (2014), in this context, instructors become ―facilitators, provocateurs and questioners." This allows for the development of deep conceptual understanding, that is, the ability to know ―what to do and why" rather than surface knowledge.

Constructivism has brought about a shift in education from what is called ―standard" or ―traditional" teaching practices (Serafín, Dostál, & Havelka, 2015). It is derived from the broader concept of social constructivism, and when applied to pedagogical theory, constructivism shifts the educator‘s role from lecturer to facilitator (Wu, 2014). Student roles change as well, with the focus shifting from getting the right answer to being able to apply learned strategies in various situations (Serafín et al., 2015). The expectation for students in early elementary classrooms is to apply problem-solving and reasoning skills to solve problems (Serafín et al., 2015; Wu, 2014). For students to be able to accomplish this task, Wu (2014) underlined the importance of teachers‘ planning and preparing for how they would get their students to acquire concepts individually and to collaborate with peers during learning. The mobile pedagogy, is a relatively intuitive method for teaching, learning and assessment which makes use of learner centered approaches such as self-regulated and peer learning, peer-assessment, self-assessment, feedback system and enquiry skills to acquire the concept of acids, bases and salts (Abdi, 2014; Ku, Ho, Hau, & Lai, 2014). The above elements of the mobile pedagogy are some of the characteristics of constructivists‘ learning theories while the try-and-error, instant feedbacks and the drill components also leaned the model towards directed learning theories.

2.2.2 Merging the two approaches

As Molenda (1991) observed, an either stance seems to gain us little. Rather, there is the need to find a way to merge the two approaches in a way that will benefit learners and teachers. A link between the two‛ planets must be forged so that students may travel freely from one to the other, depending on the characteristics of the topics at hand and the individual learning needs. Sfard (1998) agreed that one metaphor is not enough to explain how all learning takes place or to address all problems inherent in learning.

Bereiter (1990) initially supported directed instruction methods and later shifted toward constructivist principles. The study suggested that much of what educators want students to achieve is sufficiently complex that none of the existing learning theories can account for how it is actually learned, let alone the conditions that should be arranged to facilitate learning. The study points out the futility of theory and research that attempts to identify relevant social, environmental, or individual influences on learning such as prior experiences, types of reinforcement, and learning styles. The study also quantified their comparative contribution to what the study calls difficult learning, that is, higher order thinking and problem solving.

Bereiter (1990) also observed that each of these contributing factors tends to interact with others, thus changing their relative importance. The study quotes Cronbach‛s vivid metaphor: ―Once we attend to interactions [between these relevant factors], we enter a hall of mirrors that extends to infinity". Practicing teachers could encounter endless variations of explanations about how people learn or fail to learn. Escaping from this hall of mirrors will require a more all-inclusive learning theory than those currently available. In light of Bereiter (1990), the debate between directed and constructivist proponents seems likely to inspire different methods primarily because they focus on different kinds of problems (or different aspects of the same problems) confronting teachers and students in today's schools. Like the blind men trying to describe the elephant, each focuses on a different part of the problem, and each is limited in observations. It is the combination of the two proponents in teaching and learning that guided this research.

In summary, the Directed/Objectivist Instructional Models tend to focus on teaching sequences of skills that begin with lower level skills and build on to higher level skills. This clearly state skill objectives with test items matched to them, stress more individualised work than group work and emphasise traditional teaching and assessment methods (lectures, skill worksheets, activities, and tests with specific expected responses). On the other hand, Constructivist Learning Models tend to focus on learning through posing problems, exploring possible answers, and developing products and presentations. It also pursues global goals that specify general abilities such as problem-solving and research skills, stress more group work than individualized work. It finally emphasises alternative learning and assessment methods (exploration of open-ended questions, scenarios, doing research, developing products, assessment by student portfolios, performance checklists, and descriptive narratives written by teachers.

2.3 Conceptual Framework

The research work is also guided by conceptual framework which is diagrammatically represented in Fig. 1.

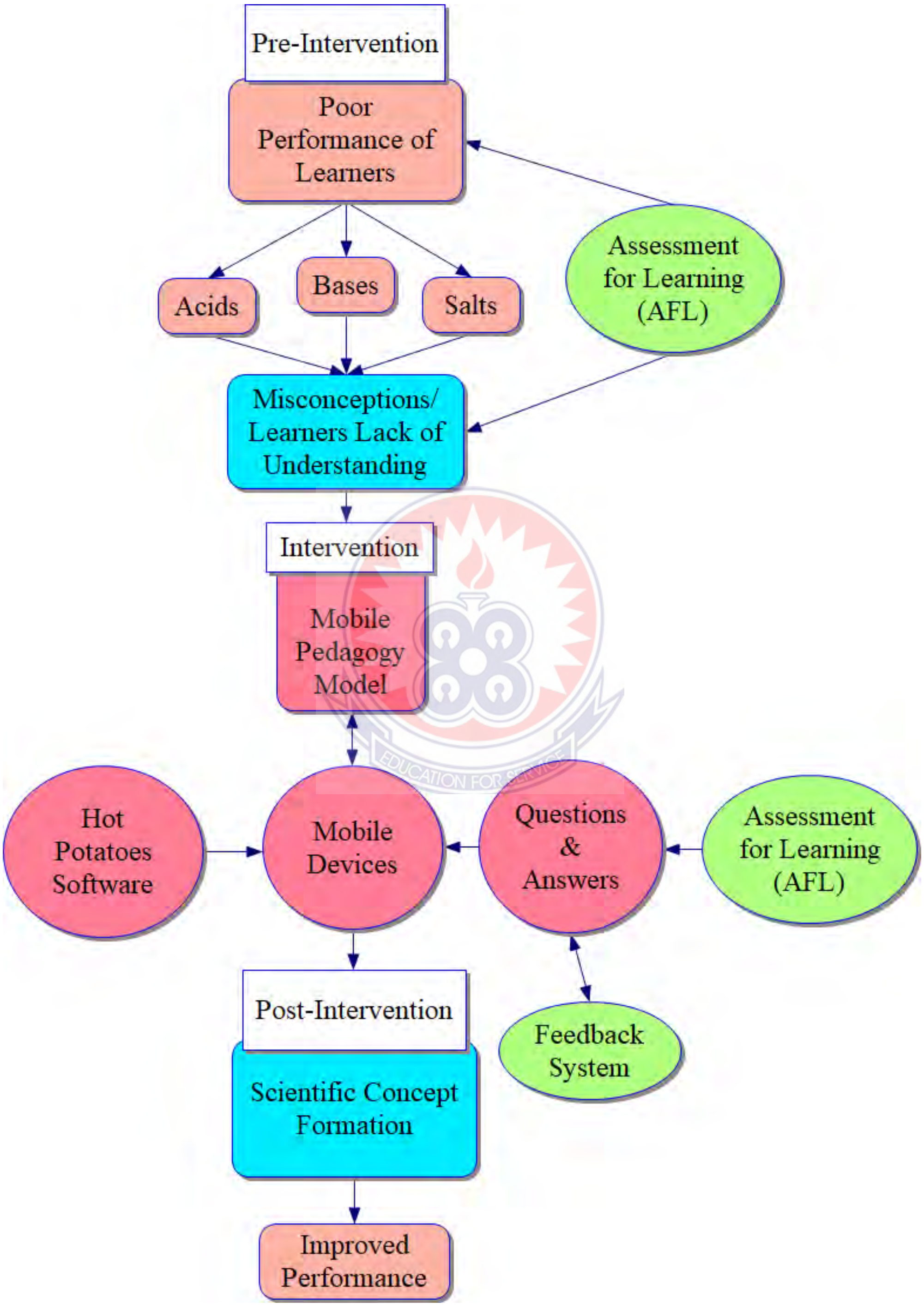

Fig. 1: Conceptual Framework
Source: Researcher Developed

In this framework, there are three phases by which data were collected and these are the pre-intervention, intervention and post-intervention stages. For the purpose of this study the pre-intervention stage was the stage where the poor performance and misconceptions of the learners about acids, bases and salts (Taber, 2017) were determined using assessment for learning principles (Swaffield, 2011). The intervention includes designing mobile pedagogy model as a tool for instruction and assessment (Chee et al., 2017) using hot potato software and uploading it on mobile devices for students (Jahnke & Liebscher, 2020). This mobile pedagogy model employed questions and answer technique (assessment for/as learning) for teaching the concepts of acids, bases and salts. Assessment as learning principles was employed, thus, where the learner is at the centre of the learning process. It involves self-assessment, peer assessment, feedback system, self-regulated learning and self-mastery of concepts (Harris, & Brown, 2013; Brown, 2019). The feedback system thus, feed-up, feedback and feed forward component of the mobile pedagogy model, which was embedded in the questions and answers method employed, makes it self-tutoring model which facilitate concept acquisition (Keengwe & Maxfield, 2014). The feedback system employed in developing the model has the ability to help the learners to move from misconception to acquisition of scientific concepts (Sri, Arif & Yuli (2019) and poor performance to improve performance (Rummel & Bitchener, 2015; Mamoon et al., 2016; Heitink et al, 2016).

In the designing stages, two learning theories were considered: constructivism and behaviourism. The model as a learning tool puts the learners at the centre of the learning process with little or no guidance from any teacher/tutor. The knowledge is generated by the learners. These components of the model leaned more towards constructivism (Wu, 2014). However, there are stages in the use of the model where a lot of try and error are used to make it flexible for learners to gain mastery. Repetition and instant feedbacks components of the model employed the behaviourist theory (Hariry, 2015). In brief, the two learning theories were considered during the designing of the mobile pedagogy model.

2.3.1. Mobile pedagogy

Development in information technology, according to Yang and Arjomand (1999), has generated more choices for today‘s education. One of the choices is to use mobile devices to teach, learn and assess learning (Rushby, 2012). This is described as mobile pedagogy.

From another perspective, pedagogy, the art and science of teaching, is combined with the term mobile, which denotes learners learning being mobile, moving between places, linking classroom learning with work, home, play and other spaces and embracing varied cultural contexts, communication goals and people (Kukulska-Hulme, Norris & Donohue, 2015). Similar to Twigg (2002) description of e-learning approach, mobile pedagogy also focused on the learners and its design involves a system that is interactive, repetitious, self-paced, and customizable. According to Abaidoo and Arkorful (2014), mobile pedagogy involves the use of digital tools for teaching and learning. It makes use of technological tools to enable learners study anytime and anywhere. This means that space and distance are not barriers to learning when mobile pedagogy is employed. It involves the training, delivery of knowledge and motivation of students to interact with contents as well as each other. It eases communication and improves the relationships that sustain learning. Mobile pedagogy is an effective method of teaching and learning using mobile technologies. It can also be described as using mobile technologies for teaching and learning (Ciampa, 2014). Mobile learning (m-learning) is a current development that supports pedagogy. It enables students to learn in environments that do not necessarily have formal structures. The emergence of m-learning has greatly enhanced the pedagogical process because learning is not restricted to the formal class set up (Laurillard, 2007). Mobile pedagogy has similar advantages as e-learning. Prominent among them are:

i. It helps recompense for insufficiencies of academic staff, including instructors or teachers as well as facilitators and laboratory technicians.

ii. According to Rabah (2005), objectives can be accomplished in the shortest time with least amount of effort.

iii. The environments for mobile pedagogy are tolerant to learners because it offers a good way of equal access to the information irrespective of the locations of the users, their ages, ethnic origins, and races.

Despite the above advantages of mobile pedagogy, it has its own inherent demerits. Some of which are:

i. Since tests for assessments in e-learning are possibly done with the use of proxy, it would be difficult, if not impossible to control or regulate bad activities like cheating (Abaidoo & Arkorful, 2014).

ii. It is difficult and sometime complex to develop it to meet the standards of teaching, learning and assessments.

Pedagogy

Pedagogy, or ―leading the young," refers mainly to developing habits of thinking and acting. Within pedagogy, a teacher's main role is to provide opportunities for students to learn through experiences (Colleen, 2015).

Types of pedagogy

According to Kukulska-Hulme, Norris and Donohue (2015), there are four main forms of pedagogy. These are:

i. Behaviourism**:** The belief that a learner‘s behaviour is affected and reinforced by external conditions rather than internal ones. Positive reinforcement and conditioning are the most well-known form of behaviourism and are used often in teaching children through reinforcing desired behaviour, values and attitude with a reward.

ii. Constructivism**:** The idea that learners create their own learning based on previous knowledge and experience. Teachers act more as guides and facilitators to help learners understand concepts and ―construct" their processes and applications to further their learning.

iii. Social Constructivism: Incorporates teacher-guided and student-centered instruction. This concept believes that ―the group is greater than the individual" and allows the students to influence and form outcomes.

iv. Liberationism**:** The practice of placing the students‘ opinions at the center of developing the learning environment, wherein the classroom is often managed democratically.

Andragogy

Knowles (1970) introduced the idea of andragogy into the learning community in the 1970s when he proposed that there are differences in the way adults learn. Knowles (1970) developed five assumptions that underlie his theory of andragogy:

i. Adults are self-directed learners.

ii. Adults bring a great deal of experience into the classroom.

iii. Adults who seek education are ready to learn.

iv. Adults are internally motivated.

v. Adults want problem-based learning.

Knowles (1970) did not view andragogy as a true epistemology. Instead he viewed it as a concept rather than a theory. He based his work on that of constructivists, in particularly Carl Rogers (1969). Knowles also based it on the hierarchy of needs developed by Abraham Maslow (1954). As learners continue to mature, they become more self-directed (Blondy, 2007). Knowles (1980) outlined a seven-step process for faculty to promote andragogy:

i. Develop cooperative learning environment

ii. Involve learner in the setting of goals

iii. Diagnose learner needs and interests

iv. Help learner formulate objectives based on his/her interests and needs

v. Design sequential learning experiences to meet these objectives

vi. Meet objectives with materials and resources

vii. Evaluate the quality of learning and impact on future learning

Differences between andragogy and pedagogy

Though there are many differences in methods and motivations between andragogy and pedagogy, the audience (adults vs. children) is most important. Kukulska-Hulme, Norris and Donohue (2015) highlighted some marked differences between andragogy and pedagogy. These are:

i. ***Dependence***

Andragogy: Adults are independent and desire to be self-directed and empowered in their learning.

Pedagogy: Children are dependent on the teacher to facilitate and structure their learning.

ii. Learning reasons

Andragogy: Teaching adults centers learning on the necessary skills or knowledge to further personal and professional development.

Pedagogy: Teaching children centers learning on the essential stages that a child must accomplish before being able to move on to the next stage.

iii. Learning resources

Andragogy: Adults use their own experiences and the experiences of others to gain a better understanding of the curriculum at hand.

Pedagogy: Children are dependent on the teacher for all learning resources. The teacher‘s role is to create and incorporate engaging methods for knowledge retention.

iv. Learning focus

Andragogy: Adult learning is often problem-centered, making the impact more focused on current events or real life.

Pedagogy: Child learning is a subject-focused model with prescriptive curriculum.

v. *Motivation*

Andragogy: Adults gain motivation from internal, self-motivated sources (self-esteem, confidence, recognition, etc.)

Pedagogy: Children gain motivation from external sources (parents, teachers, tangible rewards, etc.).

*vi. **Teacher's role***

Andragogy: The teacher acts more as a facilitator, encouraging collaboration, mutual respect, and openness with learners.

Pedagogy: The teacher acts more as an expert, bestowing knowledge, skill, and structure to learners.

Colleen (2015) also opined some differences between pedagogy and andragogy in Table 2.

Table 2: Comparison of Pedagogy and Andragogy

Concept	Pedagogy	Andragogy
Role of learners	Dependent	Self-directed
Role of Faculty	Member Delivers knowledge	Facilitates Knowledge
Experiential	No	Yes
Primary Activities	Lecture-Based; Objective Testing	Experiential Strategies: group work, case studies, simulations, field experience; varied types of testing
Readiness	Are told when they are ready	Decide what additional knowledge is needed
Sequencing	Step-by-step uniform progression	Based on learner skills and readiness
Learning	Facts which will only be useful later on	Process-oriented for future potential
Curriculum	Simple to Complex	Competency-based or categorical
Age Group	All age groups	Higher education
Motivation	External	Internal
Knowledge	Done without question	Must understand why it is important
Readiness to Learn	What is required	When content is relevant
Focus	Subject-centered	Life-centered

Source: Colleen (2015)

2.3.2 Mobile devices

Since the 1980s, mobile devices have become increasingly popular (Padiapu, 2008). The objective of the first portable computer, the Dynabook, was to help learners with their studies and to improve communication. Using technology for learning in educational institutions could achieve this objective (Alexander et al., 2019). The first attempt to include mobile devices in learning did not achieve wide acceptance from educational institutions because of usability limitations (Maxwell, 2012). In using mobile devices, according to Song (2007), allow the course content can be divided into six categories such as pushing, messaging, response and feedback, file exchange, posting, and the classroom communication.

In the 1970s, Motorola invented the mobile cell phone and introduced it to the commercial market (Eddy, 2011). These cell phones, later known as the first generation of cell phones, could communicate only between each other (Brookes, 2012). Nonetheless, people accepted these basic devices, which inspired other companies, such as Apple and Nokia, to develop cell phones in the 1990s. Technological improvements in microchips and battery storage led to the development of a second generation of cell phones (Brookes, 2012). Due to the use of new technology in the manufacturing of second-generation cell phones, these devices were significantly smaller than the previous ones. In addition, this technology sparked enhancements, advancements and possibilities, such as text messaging and payments for other services via cell phone (Brookes, 2012).

With the emergence of second-generation phones, rival manufacturers developed devices with innovative features and designs. These apparatuses, called Palm or Personal Digital Assistance (PDA) devices, are distinct in terms of new features, such as larger sizes than that of existing cell phones; improved battery life, storage and memory; email access; and QWERTY keyboards (Viken, 2009). These features of PDA and Palm devices led to the development of a third generation of cell phones.

Third-generation cell phones emerged from a combination of second-generation cell phones and other mobile devices (Viken, 2009). With third-generation phones, mobility innovations moved from those found in a typical laptop to those found in smart mobile devices and tablets. These cell phones are not typical phones that allow users to only make and receive calls and send and receive text messages. They also allow users to browse the internet, support Hyper Text Markup Language (HTML), facilitate email, capture video, record sound and store data. Reductions in size and weight turned mobile devices into handheld devices that are easy to carry. It typically features high-resolution cameras, microphone recorders, touchscreens and Wi-Fi connectivity. These improvements have led to a dramatic increase in the public‘s acceptance of mobile technology. A survey by The International Telecommunication Union estimated that there were 6 billion mobile subscriptions worldwide at the end of 2011 (MobiThinking, 2012). The widespread use of mobile devices by the youth has led researchers to consider the inclusion of mobile devices in educational delivery as a new approach to learning, referred to as mobile learning (m-learning) (Chen, 2020; Benedek, 2004).

According to Goundar (2011), mobile devices are ICT devices that contain fragile electronic components, need power to operate and connectivity for access. Mobile devices can be explained as hand held electronic devices that can be comfortably carried around in a pocket or bag, including MP3 players, digital recorders, e-readers, tablets, and smartphones. They have the ability to connect to Wi-

Fi and download or upload and ‗share' images, sound files and notes. Laptops are ―now considered transportable rather than mobile" (Rushby, 2012).

Kopackova and Bilkova (2014) carried out a research with the purpose of finding out if students at University of Pardubice, Faculty of Economics and Administration were equipped with mobile devices and if they were able to use them effectively. Quantitative approach, in the form of questionnaire, was selected to gather primary data. The study focused only on three basic and most common types of mobile devices; smartphone, tablet PC and notebook. The encouraging result, obtained through this study, was the fact that, in the entire survey samples there was not a single student who would not have any mobile device. If the student did not have a smartphone, then he/she had the notebook and vice versa. The study concluded that, technological readiness is sufficient; each student had at least one of these mobile devices smartphone, tablet PC and notebook. It was also concluded that most of the students use their mobile devices for academic works.

Sand and Madhusudhan (2017) published a paper which provided an insight of actual use of mobile devices by LIS students' in everyday life and their perceptions regarding the usefulness and effectiveness of mobile phones for academic purpose in Central Universities in Uttar Pradesh State, India. A structured questionnaire was designed, comprising of 20 different type of questions, such as dichotomous (yes/ no), multiple choice, and opinion questions, to elicit experiences from the users. The findings of the study reveal that most of the respondents used mobile devices daily for more than 3 hours. Smartphone was the most used mobile device. Respondents use productivity tools on their mobile device for creating documents. Gmail app, Whatsapp, google app, adobe reader and PDF viewer are the most frequently used mobile apps. Most of the respondents access Library Website through their mobile device and only 1.96% are accessing e-books from their mobile device. The study also discovered that, the following factors influenced the use of the devices for learning: poor network coverage, high charging data plans, slow load time, small screen size and lack of Internet speed. It was suggested that an in-depth study should be conducted to understand the impact of the use of mobile devices on students‘ learning. A detailed study should be done on smartphone addiction and benefits to students.

Korucu and Usta (2016) published a paper with the aim of determining the usages of smartphones of prospective instructors who receive education in different branches of faculty of education in terms of various variables. ―Personal information form" and "Smart Phone Dependency Scale" were used to collect data for the study. Descriptive statistics, t-test for independent samples were employed in the study. It was found out that there was no reasonable difference among the grades of participants in terms of their departments, classes, gender and ages. Based on the findings, it was concluded that, the smartphone dependencies of the participants don‘t differ in terms of their genders, classes and departments, socio-economic levels, weekly internet usage durations and internet possession situations. Hence the study defined today‘s students as youngsters of digital generation who are more eager to digital learning.

Goundar (2011) provided an overview of what was out there and explores the opportunities and issues with regards to using mobile devices in education. The research mainly focused on document analysis and was based on the case study research strategy. It was found out that mobile devices have been introduced in education and having tremendous impact on teaching, learning and assessment. It was concluded that mobile devices are more needed in the developing countries than the developed ones since books and teaching and learning resources are limited in the developing countries. It was also concluded that fully realised potential of any mobile device and its use in education is entirely dependent upon electrical power, network connectivity and user competency.

2.4 E-learning

The e-learning (electronic learning) term originated in the mid-1990s when the Internet began to gather momentum (Garrison, 2011). The application of e-learning includes a computer-based learning as well as web-based learning. Finally, these learning contents can be transferred via Internet, intranet, video/audio tapes, CD-ROM, DVD, and TV channels (Mohanna, 2015). Papanis (2003) as cited in Tittasiri (2005) stated that ―e-learning provides faster learning at reduced cost, increased access to learning, and clear accountability for all participants in the learning process".

A study conducted by Harriman (2010) indicated different types of e-learning, namely, online learning, distance learning, blended learning and m-learning. In the case of online learning, it was done through the Web and it might add graphics, animation, text, audio, video, email, discussion boards, and testing. In addition, it is self-directed and ―on demand" but it can incorporate the web-based teleconference such as audio, graphics, synchronous chat, or technology that were similar (Harriman, 2010). In the case of distance learning, it takes place when learners and instructors are not in the same place or when learners and instructors are at the same place but work through a medium at different times. In recent days, the distance learning takes place using a number of media and these media are from the postal mail to the teleconferencing or the Internet. In addition, these two terms, distance learning (learner focus) and distance education (instructor focus) are used interchangeably since learning is the result of education.

In the case of blended learning, it is nothing but the combination of two learning steps that are face-to-face learning and online learning. The main purpose of blended learning is to combine delivery modalities of the efficient and effective instruction experience. Furthermore, it is used to describe a solution that includes different delivery methods, namely, collaboration software, Web-based courses, and the electronic performance support systems.

According to Rosenberg (2001), e-learning is the use of Internet technologies that can provide a wide range of solutions to enhance knowledge and performance. It facilitates and enhances the learning through and based on the computer and communication technology. In addition, it can also support learning through a Wide Area Network (WAN) and it can be considered as a flexible learning (Wentling, Waight, Gallaher, La Fleur, Wang & Kanfer, 2000). Papanis (2005) stated that e-learning components include the content delivery in different formats, to manage the learning experience, learners' network community, and content developers and experts.

E-learning is a personalised approach that focuses on the individual learner and it includes self-paced training, many of the virtual events, mentoring, simulation, collaboration, assessment, competency road map, authoring tools, e-store, and the learning management system. It also includes many of the different components that are very familiar with the traditional learning, namely, learner's presentation ideas, group discussions, arguments and other different forms that convey the information, and accumulating knowledge (Bencheva, 2010).

A number of studies found that the following factors affect e-learning : bandwidth (Homan & Macpherson, 2005), lack of formal implementation process (Masoumi & Lindstreom, 2012), lack of interest of faculty in the e-learning activities (Forman, Nyatanga & Rich, 2002; Qureshi, Ilyas, & Yasmin, 2012), lack of ICT-enabled teachers (Iqbal & Ahmad, 2010; Nawaz & Khan, 2012), lack of ICT-enabled students (Qureshi, Ilyas, & Yasmin, 2012), power failure, socio-cultural norms and lack of resources (Iqbal & Ahmad, 2010), accessibility of Internet broadband (Farid, Ahmad & Niaz, 2014), cost of mobile Internet, practical arrangements for practical oriented courses, and literacy rate (Farid, Ahmad & Niaz, 2015).

2.5 M-learning

Mobile learning expands the digital learning channel. It increases educational information, and provides educational resources and services anytime and anywhere (Hoi, 2020). Mobile learning has the following features: learning convenience, teaching personalisation, abundant alternatives and context association. Furthermore, the technological advances in mobile devices have established new possibilities for diffusion of learning among learners and provided an opportunity for the realisation of mobile learning in an educational environment. Providing equal access to learning materials, resources and information to all learners regardless of their background, culture, disability and where they live is a significant human rights issue (Fox, 2019). Mobile learning offers an excellent opportunity to achieve this objective by making education more accessible.

M-Learning, which means learning through mobile devices such as smart mobile phones and tablet PCs, is changing the educational environment by offering learners the opportunity to engage in asynchronous and ubiquitous instruction (Díez et al., 2017; Hyman, Moser, & Segala, 2014). M-learning is a teaching method that has the intersection between mobile computing and e-learning (Fagan, 2019; Keengwe & Maxfield, 2014). It integrates several software and firmware technology in multimedia applications (Lavín-Mera, Moreno-Ger & Fernández-Manjón, 2008) which facilitates learning through a variety of wireless mobile devices (Fox, 2019; Stevens & Kitchenham, 2011). It uses wireless networks (WiFi) or broadband services (Caudill, 2007) without limit in terms of location or time (Hussin, Manap, Amir & Krish, 2012). Furthermore, Keegan (2002) contemplates the possibility of M-Learning as a harbinger of the future for learning and this is real in today‘s classrooms.

M-learning is a form of e-learning that employs mobile devices to extend, provide and deliver educational content to learners using mobile networks and tools (Díez et al., 2017). Mobile devices are portable electronic devices such as PDAs, tablet personal computers, laptop personal computers and mobile phones that are used in higher education to access and share information (Hoi, 2020; Geist, 2011; Miller, 2012). Kothamasu (2010) argued that, five basic parameters are used in m-learning, namely, portable, social interaction, sensitive to the context, connectivity, and customised. In the case of portable, it is easy to carry a PDA along with users everywhere, including a wash room and this can help learners to get information very quick and rapid. In the case of social interaction, it helps to interact with friends to send messages. In addition, it also helps to exchange data with other people and gain some extra knowledge. In the case of sensitive to the context, it helps to gather data (real data and simulated data) unique to the current location, time, and the environment. In the case of connectivity, it helps to get a strong network where a learner can connect to mobile phones, data collection devices, and to a common network. Finally, in the case of customised, it is very unique because it can help learners to customise learning information.

A study conducted by Sobri and Fatimah (2012) on Malaysian students on the awareness and requirements of mobile learning services in higher education, the results of the study revealed that students have enough knowledge and awareness to incorporate m-learning in their education environment. Another study conducted by Mao (2014) at the Southwest University on 300 undergraduate learners revealed that, 76% of the learners were satisfied with the use of m-learning. In addition, 84% of the respondents also indicated that they would use m-learning as a future learning tool. Furthermore, the study also revealed that majority of the learners immensely benefited from the m-learning because it helped them to quickly solve problems they encountered in their learning.

According to Chen and Kotz (2000), there are four categories of mobile context, namely, computing context, user context, physical context, and the time context. Computing context is all about a network connection, communication bandwidth, and the use of internet resources. The user context is about the learner profile and location. The physical context is all about noise, lighting, traffic conditions, and the temperature of the learner‘s physical location. Finally, in the case of time context, it is about the specific time of learning. Similarly, Zhao and Zhu (2010) and Li and Qiu (2011) stated three important factors that are needed to be considered when dealing with the m-learning systems and having considered, these three pillars can provide the desired level of quality. These three pillars are namely, learner‘s style, mobile device or applications and the learning content. Furthermore, the advanced hardware of mobile devices such as camera, accelerometer, and different software such as Apps provide more capabilities to manipulate, organise, and to generate information for teaching and learning (Keskin & Metcalf, 2011).

Mohanna (2015), and Vasilevski and Birt (2020) agreed that m-learning can be integrated into the classroom with the help of various software and hardware technologies into the multimedia applications that can facilitate teaching and learning in different formats such as games, short messages, quizzes, and multimedia contents. Similarly, m-learning can also be applied to many subjects in different level of education such as primary, secondary, higher, community, and the professional education. Different devices of m-learning applications include mobile phone, PDA, smartphone, portable media player (Apple's iPod), or event in the tablet computer and all these applications are incorporated with the WiFi, 4G, and 4G Long Term Evaluation (LTE) telecommunication networks.

Pollara (2011) stated that, m-learning: enables knowledge building to take place in different contexts, provides the ability to gather data, unique to the current location, environment, and time (real and situated). The study further stated that, it enables learners construct their own understanding (customised to the individual's path of investigation) and changes the pattern of learning or the work activity (supports interactivity). Finally, it supports the use of mobile learning applications which are mediating tools and can be used in conjunction with other learning tools which goes beyond time and space in which learning becomes part of a greater whole.

A study conducted by Adeyeye, Musa and Botha (2013) revealed that several factors are linked to the success or failure of m-learning projects and these factors are: technology availability, support of the concerned institution, network connectivity, assimilation with study curriculum, student experience, or real life and the technology ownership by the learners. According to UNESCO (2011), m-learning considers several factors for the successful adoption and these factors are affordability, leadership, content, support from educators and parents, well-defined m-learning goals, recognition of informal learning, and the defined target learner groups for m-learning.

Huang, Hwang, and Chang, (2010) revealed that m-learning applications does not only facilitates learning but also interacts with others for collaborations anytime and anywhere. Hereafter, m-learning for education has significant implications in the way learners and instructors interact in educational institutions. Romero-Rodríguez et al., (2020) evaluated mobile learning (m-learning) practices implemented by university teachers and to compile experiences on good teaching practices of m-learning developed in the classroom. A mixed method was used in which the responses of 1125 professors from 59 different universities located throughout Spain were analysed. The study developed Average Margin Per User (APMU) scale and applied it for the detection of good teaching practices of m-learning. Structured interview was used for collection of concrete experiences of good teaching practices. The results showed that, the largest proportion of good teaching practices were concentrated at the University of La Laguna, University of Almeria, University of La Rioja, Camilo José Cela University and University of Seville. Furthermore, three experiences carried out by teachers who were agents of good practice were collected. Based on this, three models of good teaching practices were generated and exemplified through the concept mapping technique.

It was evident in the study that, m-learning was applied in teaching and learning in some universities in Spain and it yielded good results. This current study also uses m-learning to develop the concepts of acids, bases and salts in Colleges of education, Ghana. This would make the students develop better understanding of the concepts involved.

Kearney, Schuck, Burden and Aubusson (2012) presented a study on ‗Viewing mobile learning from a pedagogical perspective'. A pedagogical framework was developed and tested through activities in two mobile learning projects located in teacher education communities: *Mobagogy*, a project in which faculty members in an Australian university developed understanding of mobile learning; and *The Bird in the Hand Project*, which explored the use of smartphones by student teachers and their mentors in the United Kingdom. The framework was used to critique the pedagogy in selected mobile learning scenarios. It enabled an assessment of mobile activities and pedagogical approaches and considered their contributions to learning from a socio-cultural perspective. A succinct framework highlighting distinctive, current socio-cultural features of mobile pedagogy emerged from their design and development procedures, leveraged by their project activities. Three constructs characterising the pedagogy of m-learning emerged: authenticity, collaboration and personalization. It was found out that the authenticity feature highlights opportunities for contextualised, participatory, situated learning; the collaboration feature captures the often-reported conversational and connected aspects of m-learning while the personalisation feature has strong implications for ownership, agency and autonomous learning. The study concluded that, how learners ultimately experienced these distinctive characteristics was strongly influenced by the organisation of spatial and temporal aspects of the m-learning environment, including face-to-face and virtual teaching strategies.

The data was collected from student teachers on their use of smartphone. The study focused on mobile pedagogy, thus, m-learning. The current study also sought to employ mobile pedagogy as a model for instruction and assessment. It involves the use of assessment *for* and *as* learning with a feedback system incorporated and uploaded unto mobile devices as teaching, learning and assessment strategies.

Chee, Yahaya, Ibrahim and Hasan (2017) carried out a study which examined the longitudinal trends of M-Learning research using text mining techniques in a more comprehensive manner. One hundred and forty-four refereed journal studies were retrieved and analysed from the Social Science Citation Index database selected from top six major educational technology-based learning journals based on Google Scholar metrics in the period from January, 2010 to December, 2015. Content analysis was implemented for further analysis based on (a) category of research purpose, (b) learning domain, (c) sample group, (d) device used, (e) research design, (f) educational contexts (i.e., formal learning and informal learning), (g) learning outcome (i.e., positive, negative and neutral), (h) periodic journal, (i) country, and (j) publisher. The study presents ten new findings: (1) Taiwan was the most dominance country contributing to M-Learning research. (2) British Journal of Educational Technology (BJET) and Journal of Emergencies, Trauma and Shock (JETS) were the most periodic journal while ProQuest is the most publisher, contributing to the M-Learning field. (3) Most studies of M-Learning focused on effectiveness, followed by M-Learning review. (4) Most M-Learning studies took sample from higher education institution, followed by elementary or primary school. (5) Most M-Learning studies took higher education students as sample, followed by elementary or primary school students. (6) Most M-Learning studies feature positive outcomes. (7) M-Learning most frequently supports learning in the Language and Art, followed by Science. (8) Smartphone currently is the most widely used devices for M-Learning. (9) Informal learning is the most preferred approach carried out with M-Learning. (10) Most M-Learning studies adopted quantitative method as the primary research design. The study presented findings, which could become a layover platform and guidance for researchers, educators, policy makers or even journal publishers for future research or reference in the realm of M-Learning.

The current study used mobile pedagogy for teaching, learning and assessment. It was aimed at presenting contents in science for conceptual understanding in order to improve performance in acids, bases and salts chemistry. The study was also carried out in a tertiary institution. These are all in consonance with some of the findings of the study under review. However, the current study is providing pedagogical intervention and strategy which the study under review did not address.

Hariry (2015) investigated how to change the mobile phone device from a communication device to an educational tool. It demonstrated that a mobile phone could be a useful tool in learning and teaching the English Language. The researcher emphasized the potential of mobile phones as a learning tool for students and has incorporated them into the learning environment. Many theories (e.g. Behaviourist learning, Constructivist learning, Situated learning, Sociocultural theory of learning and Informal learning) relevant to the use of mobile phones in education were presented. The salient features of mobile phones (Facebook, SMS, MMS, Twitter, internet access, mp3/mp4 player, digital camera, video recorder and multimedia contents including audio and video, inbuilt learning software such as e-dictionary, flash card software, quiz software, voice recording and listening tools) which make them useful for classroom learning were also discussed. Activities were classified in terms of the main theories and areas of learning relevant to learning with mobile technologies. This study concluded with a discussion of how moderate use of mobile devices could bring interest among the learners and transform the learning process as it helps learners to raise their self-esteem and self-confidence. The researcher tried to foresee the future of mobile learning in general and mobile phones in particular in learning English since the English language has become the most requested and widespread means of communication all over the world. It was also discovered from the study that most students used their mobile phones for science related learning like calculations, taking pictures and magnifying lenses than learning English language. Others also used their smartphones for listening to music and touch lights for reading when there is light out.

The above study was done on the use of mobile pedagogy which depended on learning theories including constructivism and behavourism. The current study is also on mobile pedagogy and grounded in constructivist and behavourist theories.

Cook (2010) argued for the need to re-examine approaches to the design of, and research into, learning experiences that incorporate mobile devices in the learning context. Following an overview of ‗mobile learning' the author's argument describes two initiatives: Firstly, Design Research was presented as an approach that tends to have interventionist characteristics, and is process-oriented and contributed to theory building. Secondly, describing Augmented Contexts for Development; these place context as a core construct that enables collaborative, location-based, mobile device-mediated problem-solving where learners generate their own ‗temporal context for development. One of the questions raised from the study with respect to mobile learning is worth noting and that is ‗What is there to commend mobile phone usage as a mediating tool for learning inside and outside the formal learning context? The answer to this question drawn on literature to delineate three phases of mobile learning (Pachler, Bachmair, & Cook, 2009; Cook, 2010) b): (i) a focus on mobile devices, thus, making productive use of the affordances of mobile technologies such as e-books, classroom response systems, handheld computers in classrooms, data logging devices and reusable learning objects; (ii) a focus on learning outside the classroom, this can include field trips, museum visits, professional updating, bite-sized learning and personal learning organisers ; and (iii) a focus on the mobility of the learners, thus, the design or the appropriation of learning spaces and on informal learning and lifelong learning.

From the review, it was evident that, mobile learning is relevant to academic pursuit and it should be appropriately designed, developed and used in education. Some merits of mobile learning were outlined in the review. Notable among them were: the mobile phone itself has a lot of materials for the purpose of learning and sites for academic tours. It also made the learner learn anywhere, at any time either alone or in collaboration with peers or instructor. The current study is about designing m-learning to help chemistry students to learn anywhere and at any time the concept of acid, base and salt. Whiles the above study was done in general context of education, this current study is being done in the context of a specific course area and level, thus, chemistry in CoE.

Akaglo and Nimako-Kodu (2019) investigated the effects of the use of mobile devices on second cycle students in Ghana. It was found out that the use of smartphone enhanced learning outcomes. It helped students to carry out research at their own pace, retrieved relevant and up to date information for their learning and projects without necessarily visiting the library physically. Additionally, it enabled students to do advance preparation for a lesson. This helped them to have a fair idea of lessons yet to be taught. It helped them to participate in class activities more. Finally, the learners said that, the mobile helped them to accomplish learning tasks more quickly and made it easier for them to communicate with their course mates and lecturers. The current study was carried out at the college of education level in the Volta Region of Ghana. The study of Akaglo and Nimako-Kodu and the current study were related in that, both studies used m-learning and mobile devices.

Darko-Adjei (2019) examined the use and effects of mobile device as learning tools in distance education. The study was rooted in the Technology Acceptance Model (TAM). The findings revealed that the distance learning students find it easier to use a smartphone in their learning activities. It was also clear from the findings that, the use of smartphones performed remarkable roles among the distance learning students of the University of Ghana in their academic activities. However, the findings disclosed some demerits of using the smartphones on the distance learning programme which included smartphones freezing during important learning moments, unstable internet connectivity, intruding calls and messages during class hours, create an isolation, makes one to spend more time on an activity at the expense of others and the screen and keyboard sizes are small, which made the smartphone an uncomfortable device for learning, as compared to laptops. The study also collected and analysed data on the purpose of students using smartphones in the university. It was revealed that majority of the respondents 126(42.9%) indicated agree to the statement ―I always use my smartphones more for playing games and accessing social media platforms instead of using it for learning, while 100(34.0%) strongly agreed, 27(9.2%) indicated neutral and a few of them 30(10.2%) indicated disagree. Also, a considerable number of the respondents 119(40.5%) were undecided on the statement ―smartphone can potentially increase multitasking and task switching during academic activities leading to decrease in academic performance", 84(28.6%) concurred whiles 52(17.7%) disagreed. Further, it was noticed that smartphone took more of respondents' attention from their studies as the majority of the respondents

151(51.4%) agreed whiles 44(15.0%) and 21(7.1%) indicated neutral and disagree respectively.

This comprehensive study by Darko-Adjei (2019) was done using questionnaire as one of the instruments for collecting data. The review was also related to the use of smartphones in an educational institution. It was also to determine the perception of learners about the use of smartphones for academic purpose. The current study also used questionnaire as one of its instruments for collecting data and was to find out the effect of employing mobile pedagogy as a tool for teaching and assessment on students' academic performance. Finally, the two studies were to find out the purpose of students using phones in the school environment. However, whiles the current work is rooted in constructivism and behaviourism, Darko-Adjei's (2019) work was rooted in TAM.

Ifeanyi and Chukwuere (2018) published the findings on the impact of using smartphones on the academic performance of undergraduate students in South Africa. The study employed quantitative methodology and used questionnaire to collect data from 375 participants. The study discovered that there were negative and good sides of the use of smartphone as a tool for teaching and learning. The study emphasised that, it could become a big distraction to learning. For instance, there was a high propensity that students who were glued to their mobile devices check updates or notification almost every minute if not strictly controlled. Consequently, this diverts their focus from their studies and even at a lecture time when a lecturer is at the peak of teaching. The study also revealed that, the respondents' used of mobile devices for academic purpose with numerous merits. Prominent among them were: downloading of study materials, recording of live lectures, accessing lecture slides at a convenient time, aiding in research work and doing assignments. The study concluded that the effect of mobile devices on academic performance were mixed with challenges.

Kibona and Mgaya (2015) opined that despite the outstanding benefits of mobile phone in learning it was considered as double-edge sword where most of the applications such as WhatsApp, Facebook, and games, affect students in Tanzania negatively at all levels because of its addictive nature. It unconsciously steals away learners‘ productive time which affects their academic performance undesirably. Similarly, Lee et al., (2015) investigated mobile devices‘ addiction among university students and its implication for learning among 210 Korean female university students (mean age=22 years). The study concluded that students were now becoming addicted to using smartphones. Correspondingly, this study agrees with Ifeanyi and Chukwuere (2018) who discovered that the use of smartphones consume most of the users‘ time and in addition does not enhance their academic performance (72.0%). This was also affirmed in the works of Lin et al., (2014), Sarfoah (2017) and Darko-Adjei (2019). In the study of Lin et al., (2014) it was revealed that excessive use of smartphones leads to health complications known as repetitive strain injuries (RSI) which include vascular permeability, neck pain, and musculoskeletal disorders.

2.6 Digital Learning (D-learning)

D-learning (digital learning) is perceived to be an educational tool that is capable of changing the way higher education is delivered and it continues to get wide spread and gain popularity day by day in the digital world (Chitkushev, Vodenska & Zlateva, 2014). It is an instructional practice that is effectively engaged by technology in order to strengthen students‘ learning experiences. It encompasses a wide spectrum of tools and practices which includes online and formative assessment; an increase in the focus and quality of teaching resources and time; online content and courses; applications of technology in the classroom and school building; adaptive software for students with special needs; learning platforms; participation in professional communities of practice; and access to high-level and challenging content and instruction (Alliance for Excellent Education, 2012).

D-learning can also facilitate new strategies and formats, namely, online and blending learning and the competency-based learning that has a potential in terms of contributing to the deeper learning (VanderArk & Schneider, 2012). According to Suhonen (2005), D-learning environments can provide solutions to support teaching and learning activities. Anohina (2005) stated that d-learning environment includes educational software, digital learning tool, and online study programme or the learning resource. D-learning has the following components: organization of learning, testing, submission and assessment of assignments, management and use of student information, timetabling, internships and final projects, developing, managing and sharing of learning materials, learning analytics, communication, collaboration, multimedia, and freely available applications (Anohina, 2005).

In the case of organizational learning, it makes assurance to learners that clear and easy accessibility for the right content. In addition, this also includes the functionalities namely, learners assigning into groups, learners assigning to courses and finally arranging their access management. In the case of testing, it can improve the learning quality and testing in the education. For the submission and assessment of assignment, it is a key element of the learning environment that is provided by an uploaded tool. Moreover, this component also incorporates the functionalities to manage the submission and evaluation process, namely, setting and communication deadlines (deadline alerts and the inclusion of deadlines for learner‘s calendars), to allocate the first and second assessors, to coordinate between assessors, to provide feedback to learners, awarding marks for learners, notifications of assessment, and the option for learners in terms of appeal decisions. In the case of management and use of student information, it involves with the student administrative data management (such as personal details) and the registration of marks, progress, and the attendance. For the timetabling, it is all about time and resource distribution across learners and teachers. In the case of internships and final projects, it provides the opportunity to evaluate the match between internship assignment or final assignment and the host organization and learners. For the developing, managing, and sharing learning materials, it deals with the functionalities in terms of developing, managing, and sharing learning materials. For the learning analytics, it deals with the collection and analysis of information of the learners' learning process to improve their knowledge and skills for the teaching and learning process (Chitkushev, Vodenska & Zlateva, 2014). With regards to communication, it is an essential part of the sort of education that involves sending message and information and staring dialogues. For the collaboration, it enables and enriches the depth of learning. In the case of multimedia, it plays an important role in the education sector and this multimedia are video, virtual reality, 3D-printing, etc. and finally, for the freely available applications, institutions provides learners and teachers to use social media, software and many other applications for their learning process.

Some factors that affect d-learning includes, instructor overall rating, facilitator rating, and the overall course satisfaction (Chitkushev, Vodenska & Zlateva, 2014); system characteristics and their perceived functionality (Hayashi, Chen, & Ryan, 2004); academic success, funding and technology access (Copley & Ziviani, 2004); lack of ICT knowledge and teachers providing little support (Drent &

Meelissen, 2008); teachers' attitudes and teaching styles, learner motivation, technical competency of learners, learner–learner interaction, easy access to technology, infrastructure reliability, lack of support at the postsecondary level (Selim, 2007); teachers are prone to teach using the traditional methods, novice teachers with less training are less likely to use the technology, a lack of commitment for the constructivist pedagogy, lack of availability for the professional development, and a low level of contact between teachers who have little experience using technology (Becker, 2000).

2.7 Similarities among E-learning, M-learning, and D-learning

There are similarities among e-learning, m-learning, and d-learning; each of the tools needs infrastructure and with or without WiFi (Cisco, 2013). All the three tools are digitised and used in educational environment and learners and instructors can have access to them. The learning materials delivered in e-learning, m-learning, and d-learning are texts, images and video clips. For all the three models, learners and teachers are the main users. All the three models provide learning opportunities for learners and teachers and finally, the learning materials can also be updated and modified (Edudip, 2016).

All the three technology tools (e-learning, m-learning, and d-learning) are very important and play a crucial role in the modern education society. These tools help teachers as well as learners to take responsibility of their personal growth. E-learning, m-learning, and d-learning require innovative approach that are interrelated. Therefore, we can conclude that learners and teachers need to acquire technological skills to succeed in the e-learning, m-learning, and d-learning environments.

2.8 Assessment, Feedback System and Learning

Formal and informal assessment of learning has always been part of educational institutions. With the advent of universal schooling at the turn of the 20th century, children were expected to attend school to learn basic skills. Assessment was the mechanism for making decisions about future progress, and for providing information to parents about their children‘s learning. At the middle of the 20th century, it became clear that schooling was an important key to social mobility, and that achievement in school was the basis for entry into the workplace. Tests and examinations took on major importance in deciding which students would have access to higher education. Many jurisdictions instituted standardised testing programme alongside classroom assessment to ensure fair, accurate, and consistent opportunities for students. Also, throughout most of the 20th century, classroom assessment was considered a mechanism for providing an index of learning, and it followed a predictable pattern: teachers taught, tested the students‘ knowledge of the material, made judgments about students‘ achievement based on the testing, and then moved on to the next unit of work. More recently, however, this approach to assessment was questioned as societal expectations for schooling have changed, cognitive science has provided new insights into the nature of learning, and the traditional role of assessment in motivating student learning has been challenged.

Since the 1960s and 1970s, the purpose for classroom assessment have expanded. The terms formative assessment and summative assessment entered the language of educators-formative assessment being assessment that takes place during teaching to make adjustments to the teaching process, and summative assessment being assessment at the end of a unit or term to convey student progress. In order to fulfil these two objectives, educators extended their assessment practices and began assessing a wider range of student work, such as practical tasks, coursework, projects, and presentations. For the most part, however, assessment was still a matter of making statements about students' weaknesses and strengths. More recently, the focus in educational policy has been on preparing all students for tomorrow's world. At the same time, the expectations for students have increased in breadth and depth, dramatically affecting teachers' instructional and assessment roles, and students' roles as learners.

Amua-Sekyi (2016) opined that assessment in its various forms has always been a central part of educational practice and that evidence gleaned from the empirical literature suggests that assessment, especially high stakes external assessment has effect on how teachers teach and consequently, how students learn (Amua-Sekyi, 2016). The study used focus group discussions to draw upon the experiences of 12 tutors and 18 student-teachers in 3 colleges of education in Ghana. The findings showed that although teachers were expected to nurture evaluative thinking skills in their students, it was not reflected in the assessment and teaching and learning practices of student-teachers. The study argues that for teachers to be effective in supporting the desired goals of the basic school curriculum, greater acknowledgement must be accorded to the power of assessment on teaching and learning, the understanding of which could arguably play an important role in introducing changes that would promote the cognitive processes and thinking skills desired in our schools and classrooms. In conclusion the study suggested that the transition in the goal of the basic school curriculum from a mainly lower level recall cognitive domain to a much higher thinking and reasoning level is not reflected in the teaching, learning and assessment of student- teachers. If formative assessment practices fail to elicit the _multi-party' dialogue that would encourage evaluative feedback on student-teachers‘ work and summative assessment does not demand evaluation of issues, student- teachers would not be equipped with the knowledge and skills they require to foster evaluative thinking in their schools and classrooms. The gap between teacher education and curriculum expectation in basic schools is a barrier to understanding and facilitating the sort of engagement that would nurture the evaluative thinking required. Consequently, the practice of teaching would not change and the cognitive processes that develop thinking and problem solving are unlikely to be practiced, or are little understood. The gap can however be controlled if assessment, teaching and learning are brought into better alignment with the requirement of the basic school curriculum. Other studies also supported the findings of this study (Lipnevich et al., 2016; Voelkel, 2013).

In the study above, it was evidenced that assessment, when done well and brought into better alignment with the prerequisite of the curriculum, it would tremendously improve performance of learners. This is in line with the current study which believes that assessment, as a component of M-learning model, can help in improving the performance of CoE students in the concepts of acids, bases and salts.

2.9 Objectives of Classroom Assessments

Earl and Katz (2006) published a book on *Rethinking Classroom Assessment with Purpose in Mind: Assessment for Learning, Assessment as Learning, Assessment of Learning* and the focus of the book was on three distinct but inter-related objectives for classroom assessment: assessment *for* learning, assessment *as* learning, and assessment *of* learning. The book explained that, assessment *for* learning (AfL) is a formative assessment that is designed to give teachers information to modify and differentiate teaching and learning activities. It pointed out that individual students learn in idiosyncratic ways and that many students follow predictable patterns and pathways. There is therefore the need for teachers to use the resulting information to determine not only what students know, but also to gain insights into how, when, and whether students apply what they know in real life situations. The information can be used by instructor to streamline and target instruction and resources, and to provide feedback to learners to help them progress in their learning. It was explained in the book that assessment *as* learning (AaL) is also a formative assessment which is a process of developing and supporting metacognition of students. It focuses on the role of the student as the critical connector between assessment and learning. When students are actively engaged, self and peer assessors, they make sense of information, relate it to prior knowledge, and use it for new learning. This was the regulatory process in metacognition.

The above positions of the book have two implications for this current work and the classroom: (1) learners should monitor their own learning and use the feedback to make adjustments, adaptations and even major changes in what they understand. (2) Instructors should help learners to develop, practice, reflect and do critical analysis of their own learning. The designed M-learning model has self-assessment and feedback system embedded in it which made it leaned towards AaL.

Finally, the book explains the third objective of assessment, Assessment *of* learning (AoL), as summative in nature and that it is used to confirm what students know and can do, to demonstrate whether they have achieved the curriculum objectives, and, occasionally, to show how they are placed in relation to others. This has a major implication for teachers, that is, the teachers should concentrate on ensuring that they have used AoL to provide accurate and sound statements of students' proficiency, so that the recipients of the information can use the information to make reasonable and defensible decisions.

Fisseha (2010) reviewed studies on the roles of assessment in operating and experiencing the curriculum, importance of continuous assessment for enhancement of student learning, and the roles of feedback and comments for curriculum practice and learning enhancement. In this review, the author explained that assessment is an obligatory factor of curriculum practice. In educational systems, one of the major concerns of administrators, teachers, and students alike are the outcomes of learning: what ability students can demonstrate because of increase in their knowledge and changes in understanding because of experiences in school or college. The review laid emphasis on the fact that most of the time, instructors emphasise on factual knowledge, bind students too firmly within currently acceptable theoretical framework, and do the same while assessing learning. This approach was frowned on by the review and transferable skills valued by employers such as problem solving, communication skills, and working effectively with others were promoted in the review. It was put forward in this study that, teaching and learning would be more effective if assessment is integrated into them and if learning tasks are also carefully structured. Also performance assessment, portfolios, authentic assessment and student self and peer assessment together with feedback and comments have been advocated as procedures that align assessment with current constructivist theories of learning and teaching. It was proposed in the study that teachers were responsible for providing feedback that students need in order to re-learn and refine learning goals. It was concluded that teachers should devise assessment tasks that practically challenge students, provide feedback and comments as they assess, and engage students in the assessment process. This conclusion was made because as discussed in the study, the current state of assessment, particularly formative/continuous assessment in higher learning programme is not in line with best practices to enhance student learning and actualise curriculum intentions.

In the above review, the author proposed that, assessment should form integral part of teaching and learning process. Also effective feedback is necessary for effective learning to take place. This current work also suggests assessment *as* learning and feedback systems to be used as learning tools and based on that they were employed in the designing of the M-learning model for teaching the concept of acids, bases and salts at the College of Education level.

2.10 Assessment *as* Learning as a Learning Strategy

Dann (2014b) promoted, in her study, *Assessment as learning: blurring the boundaries of assessment and learning for theory, policy and practice,* the concept of assessment *as* learning (AaL) stated that assessment is not merely an adjunct to teaching and learning but offers a process through which pupil involvement in assessment can feature as part of learning – that is assessment *as* learning. A substantial part of Dann‗s (2014b) argument relates to developing pupils‘ engagement in and response to pupil self-assessment with a focus on exploring processes such as self-regulation, self-efficacy, metacognition and feedback as dimensions of both assessment and learning. The essence of what is taken forward in the study was the view that ‗AaL' is the complex interplay of assessment, teaching and learning which holds at its core the notion that, pupils must understand their own learning progress and goals through a range of processes which are in themselves cognitive events (Dann, 2002a). The implication is that, there is the need for pupils to be actively involved in both learning and assessment processes. This has particular connotations for how pupils are involved in assessment because learners' self-assessment lies at the heart of ‗AaL. The study further assertion was on how learning was co-constructed in the classrooms so that it was not so much a matter of instruction and transmission by the teacher but an interactive interplay of minds in real contexts. The study argued that one of the key features in AaL is feedback. This supported Black and Wiliam (2010) who claimed that feedback is as fundamental in the learning process as having a teacher. Part of the argument related to the concept of AaL is that, the learner could use assessment as part of the learning process. Feedback could be one source of information that could help in the processes. Assessment as learning is used by pupils as part of the process of learning. Such assessment information is therefore part of formative assessment, yet it is controlled by the pupils own dominant discourse in the process of learning. The study concluded that, in ‗AaL', assessment and learning become inextricably interlinked, so that their processes serve each other, thus, bring assessment and learning together, blurring their boundaries and supporting the argument for assessment *as* learning to be seen as an aspect of learning. Other studies also supported the findings of this study (Gibbs, 2010; Sadler, 2010). The feedback system embedded in the M-learning model and for the fact that, students would use it with little or no external support makes it more of a learning tool than an assessment tool.

2.11 Assessment and Feedback

Voelkel (2013) carried out a study to develop and evaluate the feasibility and effectiveness of weekly online tests. This was done in a Year 2 theory module in biological sciences. The tests were anticipated to encourage student engagement with the lecture material, and to support their learning through formative assessment and feedback. It was an action research project in which three cycles were completed. Four stages of action research were followed which include the identification of a problem or question (How can I improve engagement and learning?), the process of tackling the problem (interventions: introduction of online tests), evaluation and reflection, followed by further modification of practice. The general hypothesis for the project was that students would enhance their learning following the introduction of online tests. The course was on animal physiology module, which is offered to second year students from various programmes within biological sciences at the University of Liverpool. This theory module is taught through 18 lectures in six weeks (three lectures per week).

Statistical analysis of performance data was done using Sigma Plot (version 11.1). Statistical differences between examination average marks were assessed using one-way ANOVA and Student‘s independent sample t-test as appropriate. Significance was assessed at 95% confidence level with $p < 0.05$.

The results suggested that, increasing the time on task alone (by forcing them to spend time on online tests) did not improve student learning. Only when students were guided towards a meaningful interaction with the material, learning (as measured by examination performance) improved. The prompt, specific feedback after the formative part of the online tests enabled the students to see exactly what they needed to do in order to improve their performance. Students need to make sense of what they have learnt before they are ready to move on. Giving feedback to incorrect answers and confirming correct answers contributed towards empowering students to take responsibility for their own learning. Other studies also supported the findings of this study (Mamoon et al., 2016; Sadler, 2010; Price & Donovan, 2010;).

Learning was long thought to be an accumulation of atomised bits of knowledge that are sequenced, hierarchical, and need to be explicitly taught and reinforced. Learning is now viewed as a process of constructing understanding, during which individuals attempt to connect new information to what they already know, so that ideas have some personal coherence. Individuals construct this understanding in many different ways, depending on their interests, experience, and learning styles (Brown, 2015).

2.12 The Effects of Classroom Assessment on Learning

Black and Wiliam (2010) synthesised over 250 studies linking assessment and learning, and found that the intentional use of assessment in the classroom to promote learning improved student achievement. When learning is the goal, teachers and students collaborate and use ongoing assessment and pertinent feedback to move learning forward. When classroom assessment is frequent and varied, teachers can learn a great deal about their students. They can gain an understanding of students' existing beliefs and knowledge, and can identify incomplete understandings, false beliefs, and naive interpretations of concepts that may influence or distort learning. Teachers can observe and probe students' thinking over time, and can identify links between prior knowledge and new learning. Learning is also enhanced when students are encouraged to think about their own learning, to review their experiences of learning (What made sense and what didn't? How does this fit with what I already know, or think I know?), and to apply what they have learned to their future learning. Assessment provides the feedback loop for this process. When students (and teachers) become comfortable with a continuous cycle of feedback and adjustment, learning becomes more efficient and students begin to internalise the process of standing outside their own learning and considering it against a range of criteria, not just the teacher‘s judgment about quality or accuracy. When students engage in this ongoing metacognitive experience, they are able to monitor their learning along the way, make corrections, and develop a habit of mind for continually reviewing and challenging what they know. When they are learning in any area, students make connections and move along a continuum from emergent to proficient. Learners at the emergent stage are generally uncertain, and rely heavily on direct instruction, modelling, and whatever ―rules" may exist to give them direction about how to proceed, with little sense of underlying patterns. As learners become more competent, they develop more complex schemata of understanding, gain in confidence and independence, and become efficient in problem-solving within new contexts. They are able to apply the new learning independently and direct their own learning. They concluded that when teachers understand this emergent-to-proficient process as it relates to curriculum outcomes, they can use assessment as the mechanism for helping students understand and value their own learning and predict what comes next. The findings are in line with Western and Northern Canadian Protocol (WNCP) (2006) which believed that the ongoing cycle of assessment and feedback can guide students and scaffold their learning as they move along the learning continuum. This is presented in Table 3 below.

Table 3: Stages in Growth from Emergent to Proficient

Emergent				Proficient
Little or no practical experience. Dependent on ―rules" and emulating those thought to be proficient.	Expects definitive answers. Some recognition of patterns. Limited experience. Still relies on rules.	Locates and considers possible patterns. Has internalized the key dimensions so that they are automatic.	Uses analysis and synthesis. Sees the whole rather than aspects. Looks for links and patterns. Adjusts to adapt to the context.	Understands the context. Has a holistic grasp of relationships. Considers alternatives and independently integrates ideas into efficient solutions. Makes ongoing adaptations automatically.

Source: Adapted from WNCP (2006, p.6)

2.13 Feedback System and Learning

Klimova, (2015) presented a study at an International Conference on Teaching and Learning English as an Additional Language in Antalya-Turkey on the topic: The role of feedback in English as a Foreign Language (EFL) class. The aim of the study was to emphasize the importance of feedback and focus on its different forms, such as formal and informal; or continuous and end of semester feedback.

The study defined feed forward as the information about current performance that can be used to improve future performance. It was further explained that, Feedback plays a crucial role in any educational process since it can significantly improve both learner‗s and teacher‗s performance and indicate some key aspects of their performance which can be improved. The study went on further to quote Dignen (2014) to support the argument that ‗feedback is the most important communication skill, both outside and inside the classroom because it is around all the time; it is just another word for effective listening; it is an opportunity to motivate; it is essential to develop performance; and it is a way to keep learning‘ (Dignen, 2014). Analysis of self-reflection essays, diary writing, focus interviews and constructive were forms of feedback mentioned in the study. The study concluded that any form of feedback which could encourage personal and professional development of learners and help them recognise their strength and weakness could result in understanding and development of their skills in the future. Besides, giving constructive feedback could support students‘ motivation to work on the development of their language skills regularly. Other studies were also in line with this conclusion (Van Der Kleij & Adie, 2020; Zahida, Zaru & Farrah 2014; Fisher & Frey, 2009).

The study is in line with the current study in that, this definition and explanation are related to feed forward, a component of feedback system used in the current study. Additionally, the current study purported that feedback system (feed-up: clarifies the learning outcomes and motivates learners before teaching and learning occur; feedback: provides personalised responses to learners‘ work; and feed forward: aids in the assessment of challenges students encounter during learning in order to modify future learning), when employed very well would result into effective learning. It was based on the same understanding that the current study employed feedback system to design the mobile pedagogical model to drive home the concept of acids, bases and salts.

2.14 Misconceptions of Acids, Bases and Salts

Science educators have focused their attention on how students learn and the factors which influence their learning. The purpose of teaching and learning of chemistry is beyond passing examination but equipping students with problem solving skills. If the misconceptions of the learners are not diagnosed and addressed, the learners could have good grades without being able to solve problems in an unfamiliar context.

Learning is the interaction between what the student is taught and his/her current ideas or concepts. Concepts can be categorised in two ways as abstract and concrete ones. While concrete concepts are improved as a result of students' experiences, it is considerably challenging for students to perceive abstract concepts (Uce & Ceyhan, 2019). Chemistry concepts, largely, are abstract concepts, but applicable in real life situations, and are considered to be difficult to comprehend by students (Erdemir, Geban & Uzuntiryaki, 2000). Students have some sort of thoughts and ideas which are scientifically incorrect. The concepts constructed by students can only explain scientific phenomena if the concepts did not deviate from the scientific concepts being explained (Kay & Yiin, 2010). The unscientific or incorrect information or ideas are called misconceptions (Taber, 2017). Misconceptions can also be explained as differences between the scientifically accepted views and students' views (Aufschnaiter & Rogge, 2010) and also as alternative conceptions (Adu-Gyamfi, Ampiah, & Agyei, 2015).

Many factors can be considered as the sources of students' misconceptions. Few among them are: previous experiences of the student, common use of some terms in scientific and non-scientific languages, not paying attention to the terms used in the class, contexts and images in the textbooks, teaching method, internet, traditional beliefs and the misconceptions of the teacher (Muchtar & Harizal, 2012). If the misconceptions are not corrected, new concepts would be difficult to be learnt (Gonen & Kocakaya, 2010).

The main objective of teaching and learning chemistry concept is to attain a meaningful learning. In order to achieve this, it is required that students are assisted through the use of effective teaching strategies to filter the ideas obtained from the external world within their own cognition. Students who correctly understand the concept give clear explanations about solutions to problems they encounter and may be able to tackle most puzzles properly whereas students with incomplete understanding of the concept may likely resort to rote learning (Omwirhiren & Ubanwa, 2016). Below are some reviews done in the areas of misconceptions in chemistry involving acids, bases and salts.

Omilani and Elebute (2020) carried out a study on analysis of misconceptions in chemical equilibrium among senior secondary school students in Ilesa Metropolis in Osun State, Nigeria. The results revealed widespread misconceptions among students in the areas related to (1) equilibrium constant, (2) heterogeneous Equilibrium, (3) Approach to chemical equilibrium, (4) Application of Le-Chatelier Principle and (5) adding a catalyst.

Even though, the study revealed the misconceptions in chemical equilibrium, however, it did not suggest ways by which such misconceptions could be addressed. But in this study, the perceived misconceptions in acids, bases and salts would be addressed using mobile pedagogical model. The sampling technique used in the study is in consonance with this current study.

Sri, Arif and Yuli (2019) published a study on students‘ misconceptions of acid-base titration assessments using a two-tier multiple-choice diagnostic test. It was seen that 11.25% of the students were having a good understanding of the endpoint of the titration although some students still had difficulty in distinguishing between the endpoints of a titration and the equivalent point. The results showed that the students should have deep understanding of acid-base reactions before learning acid-base titrations. However, this study also failed to propose solutions to the identified misconceptions.

2.15 Summary of Literature Review

In brief, the literature review covered the following areas:

a) Theoretical Framework
b) Differences in procedures and processes of objectivists and constructivists
c) Conceptual Framework
d) Mobile pedagogy
e) Mobile devices
f) E-learning
g) M-learning
h) Digital Learning (D-learning)
i) Similarities among E-learning, M-learning, and D-learning
j) Assessment, Feedback System and Learning
k) Objectives of Classroom Assessments
l) Assessment as Learning as a Leaning Strategy
m) Assessment and Feedback
n) The Effects of Classroom Assessment on Learning
o) Feedback System and Learning
p) Misconceptions of Acids, Bases and Salts

CHAPTER THREE

METHODOLOGY

3.1 Overview

The chapter covered the research paradigm, research approach, Research Design Population, Data Collection Procedures and the Conceptual Model for the Research Procedure. It finally dealt with the Data Analysis and Ethical Considerations.

3.2 Research Paradigm

Research paradigms inherently reflect our beliefs about the world we live in and want to live in (De Vos, Strydom, Fouche, & Deport, 2013). Based on this belief, De Vos, et al. (2013) distinguish between positivist, post-positivist and postmodernist enquiry, grouping postmodernism and post-structuralism within ‗critical theory'. The nature of reality assumed by positivism is realism, whereby a reality is assumed to exist; in contrast, post-positivism assumes that this ‗reality' is only ‗imperfectly and probabilistically understandable' (Guba & Lincoln, 1994). Post-positivism is viewed as a variant of the former positivism, but they are both objectivist. This study is guided by post positivism assumptions.

The post-positivist paradigm recognises that all observations are fallible and have error and that all theories are reversible (Creswell, 2013). Since the post-positivism paradigm recognises that observations and measurements are fallible the paradigm also emphasises the importance of multiple measures and observations (Creswell, 2013). Plano Clark and Creswell (2011) argued that, according to the post-positivism paradigm each measurement or observation might possess different types of errors therefore the need to use triangulation across these multiple error sources to try to get a bead on what is happening in reality. It is therefore needful to adopt the post-positivism approach in the proposed study since the mixed research approach was adopted to promote the use of different data collection sources.

3.3 Research Design

The study was an action research employing pre-test-post-test design. In a pre-test-post-test design, the dependent variable is measured once before the treatment is implemented and once after it is implemented. It offers the benefit of comparing outcomes before intervention and after the intervention. This comparison after data is collected helped to determine if there would be a difference in performance after the treatment. This would assist in making inferences about the possible existence of a cause and effect relationship of the treatment and this is one of the major reasons why the design is chosen for this study. If the average post-test score is better than the average pre-test score, then it makes sense to conclude that the treatment might be responsible for the improvement. Also, it does not deny others the opportunity to interact with the intervention activities.

3.4 Population

The study was conducted in Hohoe of the Volta Region, Ghana. There are five public Colleges of Education in the Region, namely: St. Francis College of Education (FRANCO), Hohoe, St. Teresa‘s College of Education (TERESCO), Hohoe, Peki Government College of Education (GOVCO), Akatsi College of Education, (AKATSICO), and Amedzorfe College of Education (AMECO), Amedzofe. The target population for the study comprised all the first year science students in the five Colleges of Education in the Volta Region of Ghana. However, the accessible population was made up of 96 students of two first year science classes of FRANCO.

The college is a science collages but also offers general programmes. The number of students offering general causes are more than the science students.

3.5 Sample and Sampling Procedures

Purposive sampling technique was employed to select the sample for the study. Makhado (2002) agrees with the use of purposive sampling technique by stressing on the fact that it is important to select information rich cases as this would help to address the purpose of the research. McMillan and Schumacher (2001) further recommended purposeful sampling because, the samples that are chosen are likely to be knowledgeable and informative about the phenomenon the researcher is investigating. Also, it is best used when one wants to focus in depth on relatively small sample. It is against this background that purposive sampling was used to select the sample for the study. The sample selected for this study was made up two intact classes of 96 first year students at St. Francis CoE, Hohoe. Since the students learn together most of the time, there could be chances of interferences of the results if a controlled group was created.

3.6 Instrumentation

Teacher made test, questionnaire and opinionnaire were used as the main instruments for collecting data from the students before and after the intervention. Qualitative data were collected using opinionnaire from the science students to address research question 4. Quantitative data were gathered from students using questionnaire to answer research questions 1, 2 and 3 and teacher made tests used to collect data to address research question 5. Table 4 describes the distribution of the research questions and the instruments used to collect data for the study.

Table 4: Distribution of Research Questions, Type of Data and Instruments

Types of Data	Instruments	Research Questions
Qualitative Data	1. Opinionnaire	Q4
Quantitative Data	1. Questionnaire	Q1,Q2 & Q3
	2. Teacher made Test	Q5

3.6.1 Teacher made test

Forty objective items (questions) were constructed from year one course, Chemistry 1, FDC115C/CP, (for the interactive activities on learners‛ mobile devices). It comprised 30 multiple choice items, (A-D), five true or false (A= true or B=false) items and five filled in items. The items were used as pre-test and post-test (Appendix A and B). The questions covered acids (15 items), bases (15 items) and salts (10 items). The questions were distributed based on specification table as shown in Appendix E. The rubric for scoring the questions was developed alongside the instructions. Both the pre-test and the post-test rubrics were discussed with colleague tutors. Each correct answer was awarded one (1) mark. Data collected for the pre-test and post-test were used to address research question 5 and to test the null hypothesis.

3.6.2 The questionnaire

Two sets of questionnaires employed to collect data to address research question 1, 2 and 3. A 14- and 20- item questionnaire were constructed to find out the type of mobile devices used and the purpose of using the mobile devices respectively among the sample (Appendix F-H. Learners were expected to respond ‗USE‛ or ‗NOT USE‛ for the first questionnaire and ‗Yes‛ or ‗No‛ for the second questionnaire. Research question 3 sought to determine the Factors that affect the use of mobile devices as learning tools and to address this research question, 23 items were formulated to seek information on the factors that affected the use of mobile devices from the first year science students.

3.6.3 The Opinionnaire

A 16-statement of opinionnaire was also designed and administered after the intervention to address research question 4. The main purpose of the opinionnaire was to find out about the learners' opinion about employing the mobile pedagogy as instructional model for teaching, learning and assessment of the concept of acids, bases and salts. Learners were expected to demonstrate the extent they agree or disagree with the statements. The levels of agreement were from Strongly Agree (SA-5), Agree (A-4) Undecided (U-3), Disagree (DA-2) and Strongly Disagree (SD-1) Appendice F and G.

3.6.4 Validation of instruments and the interactive activities

Validity of a research instrument is concerned with how well it measures the concept(s) it is intended to measure (Alhassan, 2006; Awanta & Asiedu-Addo, 2008). The instruments and the interactive activities of the mobile pedagogy underwent content validity. Pilot testing were also done. These resulted in the modification of some components, deletion of some items and the inclusion of new ones. Views were sought for validity analysis of the teacher made test, questionnaire and opinionaire. Finally, face validity of the instruments were done.

3.7 Trial Testing of Instruments

It is essential to thoroughly trial-test instruments before they are used in a study. Trial testing should include a sample of individuals from the population from which you would draw your respondents. It helps researchers to obtain feedback on the research instrument, administration procedure and analysis that could be used to improve the outcome of the main study (Kuranchie, 2014). It is because of this assertion that the data collection instruments were trial-tested at Jasikan College of Education to find out how the respondents would react to the items in the instruments. It was also done to identify and correct some lapses in the instruments before the real intervention was done. Trial testing of the instrument enhanced the content and construct validities and quality of the instruments since ambiguities would be corrected before the actual administration of the final ones. After the instruments were trial tested, ambiguous and weak items were restructured and some were eliminated to ensure clarity, suitability and validity of the instruments. The data from the trial tests were used to determine the reliability of the instruments.

3.8 Reliability

The reliability of the main instruments was determined based on Cronbach‘s alpha values between 0.70 and 0.95. Gall, Borg and Gall (2007) posited that, the coefficient of reliability values above 0.75 is considered reliable. The magnitude of the Cronbach‘s alpha value depends on the number of test items used. Based on this, as many as 40 test items were constructed from the topics of interest so as to maximize the value of Chronbach alpha. The Crombach alpha value was calculated using IBM SPSS version 22. For reliability analysis, the trial test was implemented at Jasikan College of Education, Jasikan, Oti Region with 89 students in level 100 who had taken the course previously. The college was chosen because it runs elective science courses. Items analyses were done following the trial testing to identify wrong test items for elimination or modification. The Cronbach alpha values of the test items were found to be 0.891. This value was within the recommended level of 0.70-0.95

and therefore met the minimum acceptable standard. The Cronbach alpha values calculated for the three questionnaires and the opinionnaire were found to be 0.85, 0.900 and 0.956 respectively. These values obtained indicates that the instruments were reliable since they fell within the recommended levels of 0.70 to 0.95. The results of the reliability analysis were in Appendix D.

3.9 Data Collection Procedure

Data were collected in three stages and these were the pre-intervention, intervention and post-intervention using the instruments. The detailed processes are described under each of the stages in Table 5.

Table 5: Order and Duration of Activities for Data Collection and Reporting

Activities	**Duration**
Designing of the Model	8 weeks
Trial testing of the Mobile Pedagogical Model	1 week
Designing and piloting of the instruments	3 weeks
Training of students on the use of the Model	1 week
Using the validated instruments to collect data from students	1 week
Using the designed Model for teaching and learning	4 weeks
Coding and analysing of data and reporting	2 weeks
Total	**20 Weeks**

3.10 Pre-Intervention

The pre-intervention involved the administration of pre-test, questionnaire, designing, trial testing and validation of the mobile instructional model. The students were also trained on how to use the mobile pedagogical model on their mobile devices.

3.10.1 Administration of the pre-test and the questionnaire

The test was administered to the whole first year science students in the College for 40 minutes and under strict supervision. The test was conducted in line with the laid down regulations of the Institute of Education, University of Cape Coast (UCC) in use at all their affiliate CoEs for conducting examinations. All the answered scripts were marked, recorded and the scores were collated for further processing. Questionnaire was also administered, analysed and the results were presented in tabular form for discussion.

3.10.2 Designing the mobile pedagogical model

The mobile pedagogical model is an independent system on its own and was designed by using laptop, mobile devices, hot potatoes software and interactive activities (Questions and Answers technique). Overhead projector was used to project processed data from word processor. The finished work was uploaded onto the mobile devices for learners and made operational by any browser on the devices. Navigation through the interactive activities was done by using touch screen/ navigation control keys and keypads of the mobile devices.

3.10.3 System architecture for the mobile pedagogical model

The mobile instructional model system was made up of thre main components, i.e., the user (human), the hardware (mobile devices/laptop) and the software (hot potatoes). The hardware enabled the user to access the software. The users were the tutors and the students.

3.10.4 System specific relationship

Tutor: (i) communicates directly to the system (sets questions, provide answers and design appropriate feedback).

(ii) communicates directly to students (gives feedback).

Student: (i) communicates directly with system (accesses questions and feedback).

(ii) communicates directly to the tutor (gives and receives feedback).

Software: Communicates directly only to the student (receives and gives feedback)

The system specific relation is represented in Fig. 3.

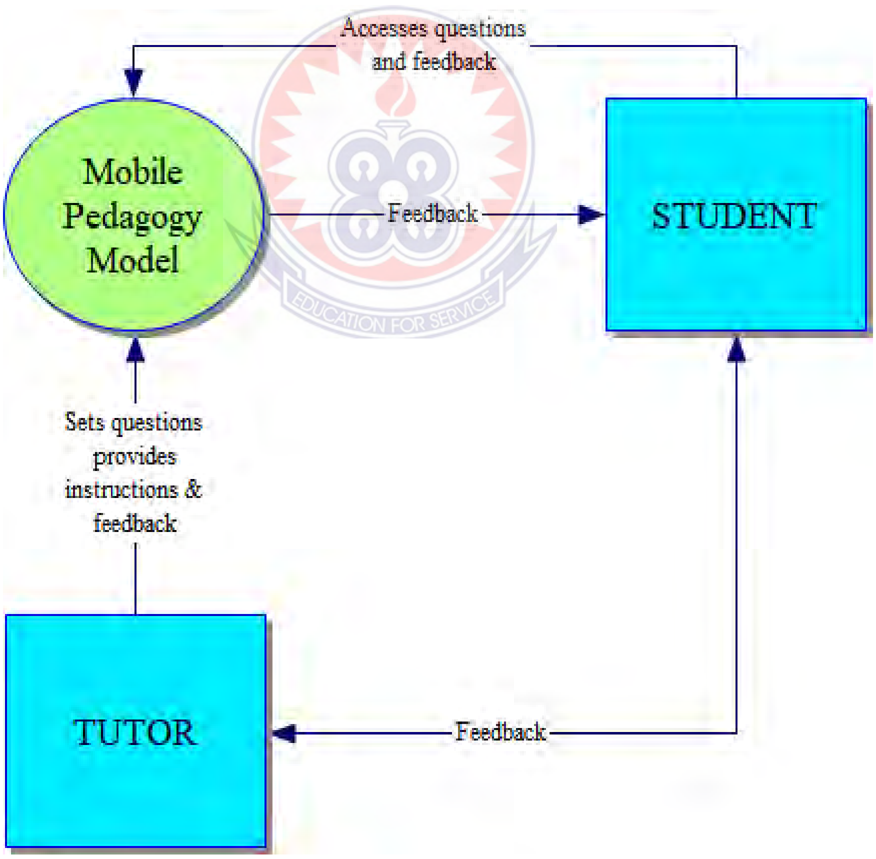

Fig. 2: System Specific Relationship
Source: Researcher Developed

3.10.5 Trial-testing of the mobile pedagogical model

Trial-testing of the interactive exercises on the devices was done at Jasikan College of Education, to identify and correct probable lapses in it before use. It was also shared with the supervisors of this study and colleague chemistry and ICT tutors to make their input in order to perfect it. It eliminated ambiguity and errors in the interactive exercises.

3.10.6 Validation of the mobile pedagogical model

The interactive exercises on devices were subjected to content validation analysis by the supervisors of the study. This resulted in the modification and the cancellation of some aspects and the inclusion of new ideas. For instance, some repeated items were deleted and those that may be confusing were modified.

3.11 Intervention

The intervention process involved the use of the mobile pedagogical model to teach the concepts of acids, bases and salts at St. Francis College of Education, Hohoe. The interactive activities covered the following areas in the second semester of first year science manual for UCC Colleges of Education: Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases, relative strength of acids and bases, pH of acids, bases and solutions, the concept of salts and types of salts. All the areas were treated within 4 weeks which was the duration to complete the topics as specified in the course outline. The following stages were followed during teaching:

Stage 1: The pre-test was administered to all participants and their scripts were marked and the scores recorded for further analysis. Following that, the model developed to teach Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases was sent to the participants to interact with. This stage lasted for 1 week and learners shared their experiences and challenges with peers and the researcher. This allowed room to address challenges learners encountered.

Stage 2: The model that was developed to teach relative strength of acids and bases was sent to learners. This model was made up of both the previous contents of the previous stage (stage 1) and the current contents to be studied. This stage also lasted for ones week and learners shared their experiences and challenges with peers and the researcher on a forum platform. This allowed for challenges learners encountered during its use to be addressed.

Stage 3: The model that was developed to teach pH of acids, bases and salt solutions were sent to the learners. This model was made up of both the previous contents of the previous stage (stages 1&2) and the current contents to be studied. This stage lasted for three days and learners shared their experiences and challenges with peers and the researcher. This allowed for challenges learners encountered during its use to be addressed.

Stage 4: The model that was developed to teach the concept of salts and types of salts were sent to learners. This model was made up of both the previous contents of the previous stages (stages 1, 2 & 3) and the current contents to be studied. This stage lasted for 3 days and learners share their experiences and challenges with peers and the researcher in order to address the challenges they encountered during its use.

Stage 5: The first day of this stage was used to address, the concerns of students about the previous stages. The general quiz involving all the 4 stages was carried out on the second day which represented the post-test. The scripts were collected, marked and recorded for analysis. On the same day, just after the quiz, the opinionnaire were given to all who used the mobile pedagogical model for learning the concepts of acids, bases and salts.

3.12 Post-Intervention

The procedure for the pre-test was repeated using the second set of the test items. Opinionnaire was also administered to learners to find out their opinion about the use of the model for learning of the concept of acids, bases and salts.

All the data collected were analysed, studied, compared and conclusions were drawn based on the outcomes. Detail description of the intervention activities on how to use the mobile pedagogy was presented at Appendix K.

3.13 Schematic Representation of the Research Procedure

The conceptual model for the research procedure is in Fig. 4.

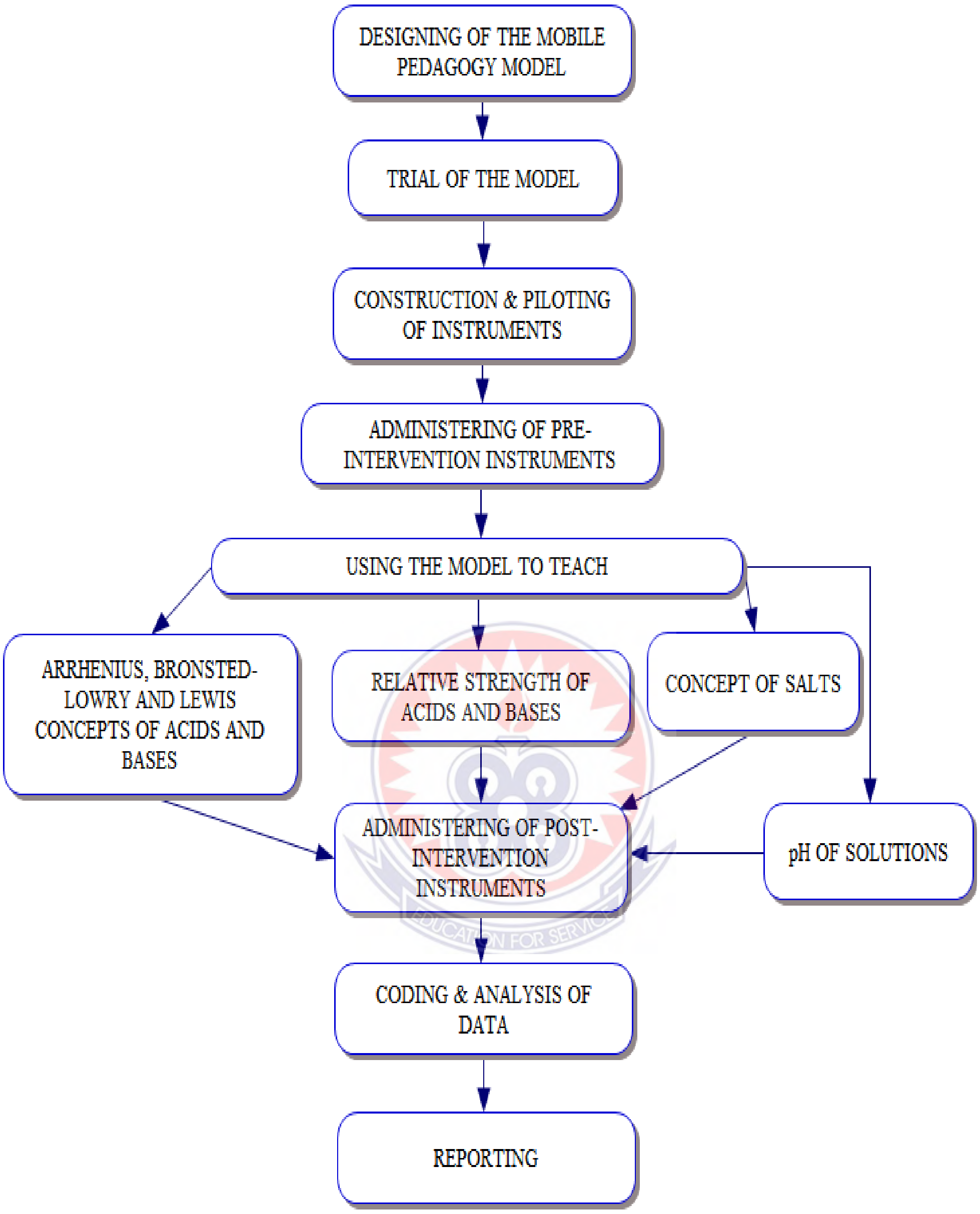

Fig. 3: Conceptual Model of the Research Procedure
Source: Researcher Developed

3.14 Data Analysis

This study employed both the descriptive and inferential statistics. The descriptive statistics (measure of central tendencies, frequencies & percentages) and inferential statistics (hypotheses testing: paired samples t-test) were used respectively to process and describe the data collected for this study. The methods of data processing for the study are illustrated in Fig. 5. Data collected were analysed using IBM SPSS version 22. The pre-test and post-test scores of students were analysed statistically using paired samples t-test to discover if any significant difference existed between them. Inferences were drawn from the statistical analysis results to address the research questions. Fig. 5 is the schematic representation of methods of data processing for the study.

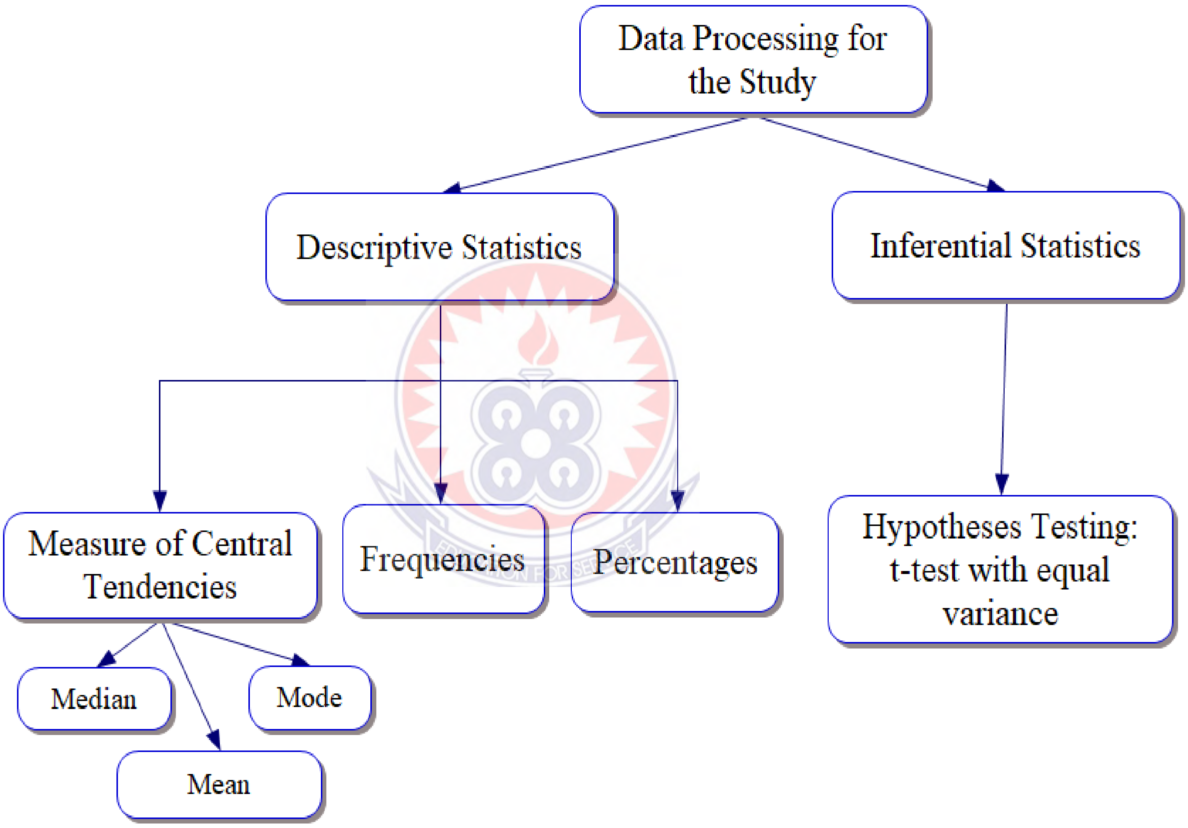

Fig. 4: Methods of Data Processing for the Study
Source: Researcher Developed

3.15 Ethical Considerations

An introductory letter was obtained from the Science Education Department of the University of Education, Winneba which was sent to the two colleges concerned to enable the researcher undertake the study. Teachers‘ and students‘ consent were sought to participate in the study. Anonymity and confidentiality of the respondents' identity were considered in all stages of the study. The participants were informed of the code of ethics of the study before the study commenced allowing them to participate fully, being aware of their rights.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

The purpose of this chapter was to present findings on the effect of employing mobile pedagogy as a model for instruction and assessment at St. Francis College of Education, Hohoe. It also focused on discussion of the data analysis findings. The presentation of results followed the order in which the research questions were posed in chapter one. Questionnaires were employed to collect data for research question 1, 2 and 3. Opinionnaire were used to collect data for research

question 4 and teacher made tests were used to collect data to address research question 5. A null hypothesis was also tested to determine if there was any statistically significant difference associated with research question 5.

Each data collected was presented in a tabular form and immediately after each table, the analysis and discussion followed.

4.2 Types of Mobile Devices Used by Level 100 Science Students

Research question 1: What types of mobile devices do level 100 science students use at St. Francis College of Education, Hohoe?

Responses to the questionnaire items were presented in Table 6 and expressed in terms of percentage for discussion.

Table 6: The Type of Mobile Device Used by Students in School

S/N	Type of Mobile Device	Use		Don't Use	
		No.	%	No.	%
1.	Android phone	90	93.8	6	6.3
2.	iPhone	26	27.1	70	72.9
3.	Cellular Phone	76	82.3	20	17.7
4.	Tablet	23	24	73	76.0
5.	Phablet	0	0	96	100.0
6.	Laptop	69	71.9	27	28.1
7.	iPad	8	8.3	88	91.7
8.	Chromebook	0	0	96	100.0
9.	MacBook	0	0	96	100.0
10.	Notebook	37	38.5	59	61.5
11.	Netbook	0	0	96	100.0
12.	Workstation	0	0	96	100.0
13.	Smartwatch	16	16.7	80	83.3
14.	Pocket PC	0	0	96	100.0

N=96; Source: Computed from Field Data, 2022

From Table 6, the most obvious findings that emerged from the analysis was that, Android phones (93.8%), Cellular phones (82.3%), and Laptop (71.9%) were the most popularly used mobile devices among first year science students in St. Francis College of Education, Hohoe. Few first year science students used Notebook (38.5%) iPhones (27.1%), Tablets (24%), Smartwatches (16.7%) and iPads (8.3%) in the school. However, none of the first year science students used Phablet, Chromebook, MacBook, Netbook, Workstation and Pocket PC in the school.

These results corroborate the findings of Eddy (2011) and Brookes (2012) who suggested that cellular phones were very popularly used due to their simple and ease of use and how affordable it is on the market. The results also support the findings of Vicken (2009) who asserted that the most popular phone among the youth was the Android phone due to its improved features. For example, broad screen size, large memory and storage sizes and the QWERTY keyboard. The findings were inconsistent with Bencheva (2010) who was of the view that Laptops were most popular among learners because of their ease of connectivity to overhead projectors for presentations. The results finally agreed with Fox (2019) that most learners do not use some types of mobile devices because of high cost involved in purchasing and maintaining them. Fox (2019) concluded that in some instances, unavailability of the devices and environmental conditions do not permit some learners to use some of the devices in school. The findings also reflected the study of Chan et al. (2015) who opined that, mobile devices such as laptop computers, smart phones and tablets have increasingly been used by students during Problem Base Learning (PBL) tutorials in recent years, probably due to their decreasing cost and the ease of connectivity to Wi-Fi anytime and anywhere on campuses. This was also the case for Hong Kong, in a recent study by Ang et al. (2012) indicating that students in Hong Kong were mobile enabled and interested in learning opportunities provided by mobile devices hence they have more smartphones and laptops for their learning. The results indicated that almost every student had at least a mobile device in one way or the other. This finding confirmed the findings of Zhao and Zhu (2010) and Li and Qiu (2011) who stated that mobile devices are important factors that were needed to be considered when dealing with m-learning systems. The findings offer an insight into the types of mobile devices that students have and what they can do with them. This means that activities can be designed so that a larger number of students can support their learning through these devices. This also means that the availability of mobile devices is very important for mobile learning to take place at St. Francis College of Education.

Research question 2: What are the purposes for which science students use mobile devices at St. Francis CoE?

This research question sought to unveil the purposes for which first year science students use their mobile devices in the college. There were 20 items related to academic and non-academic purposes. Some items fell under both purposes. Table 7 presents the results of the responses from learners.

Table 7: Purposes Use Mobile Devices in School

SN	Purpose of Mobile Device Use	Yes		No	
		No.	%	No.	%
	I use my mobile device for playing games.	93	96.9	3	3.1

Table 6: The Type of Mobile Device Used by Students in School

S/N	Type of Mobile Device	Use		Don't Use	
		No.	%	No.	%
1.	Android phone	90	93.8	6	6.3
2.	iPhone	26	27.1	70	72.9
3.	Cellular Phone	76	82.3	20	17.7
4.	Tablet	23	24	73	76.0
5.	Phablet	0	0	96	100.0
6.	Laptop	69	71.9	27	28.1
7.	iPad	8	8.3	88	91.7
8.	Chromebook	0	0	96	100.0
9.	MacBook	0	0	96	100.0
10.	Notebook	37	38.5	59	61.5
11.	Netbook	0	0	96	100.0
12.	Workstation	0	0	96	100.0
13.	Smartwatch	16	16.7	80	83.3
14.	Pocket PC	0	0	96	100.0

I use my mobile device for listening to music.	95	99.0	1	1.0
I use my mobile device for watching movies.	30	31.3	66	68.8

I use my mobile device for taking pictures.	96	100	0	0.0
I use my mobile device for Global Positioning System (GPS) for directions.	25	26.0	71	74.0
I use my mobile device for religious activities.	94	97.9	2	2.1
I use my mobile device for personal financial transactions.	94	97.9	2	2.1
I use my mobile device for reading current news.	93	96.9	3	3.1
I use my mobile device for making and receiving calls.	96	100	0	0.0
I use my mobile device for whatsApp charts.	96	100	0	0.00
I use my mobile device for Telegram charts.	23	24.0	73	76.0
I use my mobile device as magnifying lens.	25	26.0	71	74.0
13. I use my mobile device as Calculator	42	43.8	54	56.3
I use my mobile device for recording lectures/ tutorials.	29	30.2	67	69.8
I use my mobile device for educationally related research.	23	24.0	73	76.0
I use my mobile device for storing academic data/material.	30	31.3	66	68.8
I use my mobile device for tracking weekly lecture time table.	22	22.9	74	77.1
I use my mobile device for watching tutorial videos.	32	33.3	64	66.7
I use my mobile device for scanning lecture notes.	31	32.3	65	67.7
I use my mobile device to download academic materials.	40	41.7	56	58.3

N=96; Source: Computed from Field Data, 2022

It is evident from Table 7 that the highest percentages (96.0%-100%) of how first year science students at St. Francis College of Education used their mobile devices were related to reading latest news, playing games, religious activities, making phone calls and for WhatsApp charts. The above purposes are not directly related to academic work.

Unfortunately, very lower percentages (22.9%-43.8%) of the students use their mobile devices for academic purposes. These include keeping and planning weekly timetable for studies (24.0%), doing educational research (24%), recording and scanning of lecture notes (30.2% & 32.3%), downloading academic materials and watching tutorial videos (41.7% & 33.3%). The highest percentage (43.8%) for academic use was the use of the mobile device for calculation purposes.

The findings are in consonance with Taner, (2013) who stated that most learner use their mobile devices for social purposes. Only few of them use the mobile devices for academic purposes. Wilson and McCarthy (2010) also agreed that most learners use their mobile devices for simplification of life which they explained further as anything entertainment and also amusement.

The results are not in congruence with the recommendations of Chan et al. (2015) who stated that learners should use mobile devices for only learning purposes but not for social networking such as listening to music, texting and chatting. The findings are also in line with Trinder (2005) who stressed that, mobile devices could be used in presenting documents, writing notes, playing educational games, listening to audio recordings and other sound files, viewing pictures and watching video clips, plus taking photographs. Also, the use of mobile devices for educational purposes supported the findings of Zakaria, Fordjour and Afriyie (2015), Darko-Adjei (2019) and Akaglo and Nimako-Kodu (2019) that mobile devices can be used to improve teaching and learning in the tertiary institutions of Ghana if they are well directed.

On the issue of using the mobile devices for academic purposes, the findings were inconsistent with the findings of Twum (2017) that most University students in Ghana used their mobile devices for academic purposes. Twum (2017) suggested that lecturers should positively engage learners towards the use of mobile devices for learning by giving them assignments that involved the use of the devices. These results corroborate the findings of Goundar (2011), Korucu and Usta (2016) and Quist and Quashie (2016) that few students use their mobile devices for academic purpose despite the immense potentials they bring to the academic environment.

Research question 3: What factors affect the use of mobile devices as learning tools at St. Francis College of Education, Hohoe?

Research question 3 sought to determine the Factors that affect the use of mobile devices as learning tools at St. Francis College of Education, Hohoe. A questionnaire of 23 items were formulated and used to collect information on the factors that affected the use of mobile devices by the first year science students at St. Francis College of Education, Hohoe. The factors were classified into 3 themes: factors related to (a) the nature of device (b) internet (c) personal and (d) the institution. The keys used were, SA=Strongly Agree, A=Agee, U=Undecided, DA=Disagree, SD=Strongly Disagree. The responses of the students are presented in Table 8. The analysis and the discussions of the finding were done immediately after the table.

Table 8: Factors that Affect Students' use of Mobile Devices for Learning

Statements: Which of the following factors affect how you use mobile devices for learning at St. Francis College of Education, Hohoe?	SA		A		U		DA		SD	
	No.	%	No.	%	No.	%	No.	%	No.	%
Factors Related to the Nature of Device										
1. Type of device	35	36.5	35	36.5	20	20.8	6	6.3	0	0
2. Screen size	40	41.7	20	20.8	10	10.4	24	25.0	2	2.1
3. Battery strength	60	62.5	21	21.9	1	1.0	10	10.4	4	4.2
4. Ability of the device to support applications/features e.g. 3G/4G	50	52.1	39	40.6	3	3.1	4	4.2	0	0
5. Ability to expand features/ softwares/hardwares e.g. increase memory size and install new drivers	5	5.2	2	2.1	1	1.0	77	80.2	11	11.5
6. Ability to connect to other devices	48	50.0	39	40.6	5	5.2	4	4.2	0	0
7. Ability to connect to the internet.	70	72.9	23	24.0	3	3.1	0	0	0	0
8. User friendly nature of the device	93	96.9	3	3.1	0	0	0	0	0	0
9. Ability to be updated/ upgraded the device	30	31.3	9	9.4	10	10.4	32	33.3	15	15.6
10. Storage space of the device	70	72.9	10	10.4	6	6.3	10	10.4	0	0
Factors Related to the Internet										
11. Internet availability	23	24.0	53	55.2	20	20.8	0	0	0	0
12. Availability of good broad band width e.g. 3G/4G	91	94.8	5	5.2	0	0	0	0	0	0
13. The rate of uplink and downlink e.g. internet speed.	87	90.6	3	3.1	2	2.1	3	3.1	1	1.0
14. Availability of internet data	92	95.8	1	1.0	1	1.0	1	1.0	1	1.0

	SA		A		U		DA		SD	
	No.	%	No.	%	No.	%	No.	%	No.	%
Personal Factors										
15. Personal Interest	70	72.9	10	10.4	6	6.3	10	10.4	0	0
16. Knowledge about how the device can help me learn with ease.	80	83.3	10	10.4	1`	1.0	3	3.1	2	2.1
17. Knowledge about search engines/learning sites	89	92.7	5	5.2	1	1.0	1	1.0	0	0
18. Avoidance of addition to the device	9	9.4	4	4.2	2	2.1	62	64.6	19	19.8
19. Resistance to change from learning using hard copy materials to soft copy and internet materials.	33	34.4	29	30.2	3	3.1	19	19.8	12	12.5
Factors Related to the Institution										
20. Availability of internet facility	90	93.8	1	1.0			3	3.1	2	2.1
21. Availability of free software	83	86.5	7	7.3			3	3.1	3	3.1
22. Encouragement/motivation/ support from tutors.	38	39.6	41	42.7			10	10.4	7	7.3
23. Over restrictions of use of devices in the school	60	62.5	20	20.8			10	10.4	6	6.3

N=96; Source: Computed from Field Data, 2022

NB: For easy interpretation of the results of the questionnaire, Strongly Agree (SA) and Agree (A) were interpreted as agree (A) and disagree (DA) and strongly disagree (SD) as disagree (DA).

4.3 Nature of Device

It can be seen from Table 8 that 73% of the students agreed that the type of mobile devices they have affected how they used them whiles 6.3% disagreed with the assertion. On the issues of screen size and battery strength, 62.5% and 84.4% of the students respectively confirmed that they influence how they use their devices. In relation to ability of the device to support applications/features e.g. 3G/4G, 92.7% of the students agreed that they affect the way they use the devices in the school. Only 7.2% disagreed with the statement. It could also be seen from Table 8 that large number of the students (90.6% & 83.3%) agreed to the fact that ability to connect to other devices and storage space of the devices affected how the devices were being used by the students in the school. Ninety-six percent of the students confirmed that the user friendly nature of the device surely affected how the devices were being used in the school. However, none of them disagreed to the assertion. Only 3.1% were not sure if the user friendly nature of the device affects how the devices are being used in the school. Interestingly, 91.7% disagreed that ability to expand features/softwares/ hardwares e.g. increase memory size and install new drivers affect how the devices were being used in the school.

4.4 Internet Connectivity

It can be seen from Table 8 that 79.3% of the students agreed that internet availability influences the use of mobile devices in the school. However, none of them disagreed with the statement. Also, majority of the students (93.7% & 96.8%) confirmed respectively that, the rate of uplink and downlink e.g. internet speed and availability of internet data contributed to the factors that affected how they use mobile devices in the school. It was revealed from the results that all the students believed that availability of good broad band width e.g. 3G/4G affects the use of mobile devices in the school.

4.5 Personal Factors

With the issues of Personal Interest (83.3%), had Knowledge about how the device could help the students learn with ease (93.7%) and Knowledge about search engines/learning sites (97.9%). Large number of students also agreed to the statements that they influenced how they used the mobile devices in school. On the contrary, 84.4% of the students disagreed that avoidance of addiction to the mobile devices influenced how they used the devices in the school.

4.6 Factors Related to the Institution

It is clearly seen in Table 8 that 94.8%, 93.8%, 82.3% and 83.3% agreed respectively to the statements that availability of internet facility, free software, tutor support and over restrictions of the use of devices in the school to a large extent influences how mobile devices were used in the school.

The findings of this study support the proposition of other studies Viken, (2009) and Chen (2020) that, the nature and type of devices affect how they were employed for their services. They believed that some of the devices cannot have networks easily and others do not have broader screen sizes and would not be preferred to those with broader screens when being used to watch educational videos. From the finding, large number of the students disagreed to the fact that, memory sizes and installation of new features affected how their devices were used in school. This was in consonance with the discovery of Fox (2019) who stated from a study conducted that, because of cloud spaces individuals do not need big physical memory space for storage and installations. All could be done using cloud space so long as you were able to afford. It was not suppressing that none of them disagreed with the fact that user friendliness of the devices affected how they were being used. Nowadays, the preference of a device depends largely on how user friendly the devices are and also, how affordable they are (Farid, Ahmad & Niaz, 2014). The findings of this study supported a study conducted by Adeyeye, Botha and Musa (2013) which revealed that several factors were linked to the success or failure of m-learning projects and these factors were from the existing literature, namely, device availability, support of the concerned institution, network connectivity, assimilation with study curriculum, student experience, or real life and the technology ownership by the learners. According to UNESCO (2011), mobile pedagogy considers several factors for the successful adoption and these factors are affordability, leadership, content, support from educators and parents, well-defined m-learning goals, recognition of informal learning, and the defined target learner groups on which the pedagogy would be implemented. The findings also confirmed those of Chitkushev, Vodenska and Zlateva (2014) that the availability of the internet and speed affected how quick information was downloaded and uploaded, most especially videos and pictures. They study concluded that despite the fact that Bluetooth, zender and other software and applications are available for transmitting data, they had limited ranges at which they could operate. Hence internet availability was of great importance. In general the findings supported quit a number of other findings including too much of institutional restrictions, lack of knowledge about search engines and the overall course satisfaction (Chitkushev, Vodenska & Zlateva, 2014); system characteristics and their perceived functionality (Hayashi, Chen, & Ryan, 2004); academic success, funding and technology access (Copley & Ziviani, 2004); lack of ICT knowledge and teachers providing little support (Drent & Meelissen, 2008); teachers' attitudes and teaching styles, learner motivation, technical competency of learners, learner–learner interaction, easy access to technology, infrastructure reliability, lack of support at the postsecondary level (Selim, 2007); teachers were prone to teach using the traditional methods, novice teachers with less training were less likely to use the technology and also prevention of other to use them, a lack of commitment for the constructivist pedagogy, lack of availability for the professional development, and low level of contact between teachers who have little experience using technology (Becker, 2000).

Research question 4: What are the participants' opinions after employing the mobile pedagogy as an instructional model for teaching, learning and assessing the concepts of acids, bases and salts at St. Francis CoE?

Opinionnaire were used to collect data from students to address research question 4. The purpose was to find out the opinion of level 100 science students at St. Francis College after the use of the mobile devices (MD) for learning the concepts of acids, bases and salts. The keys used were, SA=Strongly Agree, A=Agee, U=Undecided, DA=Disagree, SD=Strongly Disagree. The responses are presented in Table 9.

Table 9: Opinion of Students after the Use of Mobile Device for Learning

		SA		A		U		DA		SD	
	Statements	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
1	The MD helped me with my class assignments for my chemistry courses.	92	95.8	1	1.0	1	1.0	1	1.0	1	1.0
2	The MD helped me prepare for my chemistry quizzes.	84	87.5	7	7.3	0	0	2	2.1	3	3.1
3	MD fostered interaction and teamwork between me and my course mates.	86	89.6	2	2.1	8	8.3	0	0	0	0
4	MD increased my interaction with the chemistry content.	96	100.0	0	0	0	0	0	0	0	0
5	MD made it easier for me to communicate with my chemistry lecturers.	90	93.8	6	6.3	0	0	0	0	0	0
6	MD with scientific, educational software have increased my test scores in chemistry.	96	100.0	0	0	0	0	0	0	0	0
7	MD increased my motivation to learn Chemistry.	70	72.9	10	10.4	5	5.2	10	10.4	1	1.0
8	MD helped me increase access to learning materials and educational resources.	70	72.9	10	10.4	5	5.2	10	10.4	1	1.0
9	MD use has been beneficial in studying chemistry.	80	83.3	10	10.4	6	6.3	0	0	0	0
10	MD provided enhancement materials to supplement the textbook.	95	99.0	1	1.0	0	0	0	0	0	0
11	MD enable me to accomplish chemistry learning tasks quickly.	40	41.7	50	52.1	1	1.0	0	0	5	5.2
12	MD increased my creativity in chemistry class.	60	62.5	10	10.4	6	6.3	10	10.4	10	10.4
13	MD helped me participated more in chemistry lessons.	65	67.7	20	20.8	6	6.3	5	5.2	0	0
14	MD helped me to be more prepared for chemistry lessons.	95	99.0	1	1.0	0	0	0	0	0	0
15	MD provided me with the opportunity to work at my own pace.	73	76.0	19	19.8	0	0	4	4.2	0	0
16	MD was useful as a supplementary to the chemistry teacher teaching me the concepts.	96	100.0	0	0	0	0	0	0	0	0

N=96; Source: Computed from Field Data, 2022

It can be seen from Table 9 that a large number of students were of the opinion that, the use of mobile device helped them to do class assignments (96.8%), prepared for quizzes (94.8%), personal learning (97.8%), have access to learning resources (83.3%) and accomplished learning tasks quickly (93.8%). A significant number of them also were of the view that, the mobile devices helped them increase their presentation creativity during chemistry lessons (72.9%), increased their active participation in chemistry lesson (88.5%) and increased their motivation to learn chemistry (83.3%). All the students (100%) agreed that, the use of the devices improved communication between them and their chemistry tutors, increased their test scores and had effective interaction between them and the chemistry content. All of them (100%) also had the opinion that the use of mobile devices served as supplement to a chemistry teacher in the classroom and prepared them for chemistry lesson by reading and getting information about what was to be learnt before the start of lesson. From the result, 93‘7% of the students expressed their opinion that the use of mobile devices benefited them in the learning process.

The findings of this study in relation to learners‘ opinion after using mobile devices in learning the concepts of acids, bases and salts were in consonance with the findings of various studies. Prominent among them are the study of Clark and Luckin (2013) who pointed out that the use of mobile devices through the multimedia convey information quickly and effectively to students and keep them interested in learning. Clark and Luckin (2013) concluded in their study that, if mobile devices were effectively employed in lessons, they would help learners to do independent learning, increase their test scores and participation in lessons. Twum (2017) also worked on utilisation of mobile devices specifically the use of smartphones. The findings in Twum‘s study revealed that, the mobile devices had great potential of increasing learners' participation in lessons, preparation for quizzes and helped in class assignments hence they could be employed in teaching and learning science. Quist and Quashie (2016) also believed that mobile devices could help learners to be actively engaged during learning and inevitably improve performances in science lessons. It can be deduced from the study of Zakaria, Fordjour and Afriyie (2015) that, the use of mobile devices, smartphones, can improve good communication between teacher-teacher, teacher-learner and learner-learner. Damanhuri, Treagust, Won and Chandrasegaran (2016) agreed that, the use of mobile device pedagogy provided a platform for teachers and learners to interact with content and motivate learners to keep learning even outside the classroom. Darko-Adjei (2019), examined the use and effects of smartphones as learning tool in distance education in Ghana. One major conclusion drawn from the study was that, mobile phones as mobile devices for teaching and learning, have the potential of improving performance of learners.

Research question 5: What are the effects of employing mobile pedagogy as an instructional model on students' cognitive achievement in the concept of acids, bases and salts at St. Francis CoE?

To address this research question, a null hypothesis was also formulated to find out if there is significant difference between the performance of students before and after employing the mobile pedagogy in the teaching concepts.

H_{01} There is no statistically significant difference between the performance of the science students before and after employing the mobile pedagogy for teaching, learning and assessment of the concepts of acids, bases and salts.

To find out if there was a significant difference between the performance in the pre-test and the post-test results, they were analysed using paired sample t-test. If there is any difference in favour of the post-test, then one could conclude that the use of the mobile pedagogy as an intervention for teaching the concepts of acids, bases and salts yielded positive results. However, the contrary would also be true if the output shown otherwise.

Output from the paired sample t-test result showed that the post-test mean score of (M=33.23, SD=2.755) was higher than the pre-test mean (M=8.98, SD=1.563) with a mean difference of 24. This suggested that the intervention had positive effect on the students' achievements.

To test for the hypothesis that the performance of the science students before (M=33.23, SD=2.755) and after (M=8.98, SD=1.563) employing the mobile pedagogy for teaching, learning and assessment of the concepts of acids, bases and salts were not statistically significantly different, a paired samples t-test was performed.

Table 10: Summary Statistics and Paired Samples t-test Results of Students' Pretest and Post-test Scores

Groups	N	Mean	Mean Dif.	STD	N	t	*df*	Sig(2-tailed)
Pre-Test	96	8.98		1.563	96	-82.290	95	
			-24.250					.000*
Post-Test	96	33.23		2.755				

*= Significant; $p<.05$

Prior to conducting the analysis, the assumption of normality of difference scores was examined (Refer to Appendix J). This was done to find out if the differences between the observations are normally distributed. The assumption was considered satisfied, as the skew and kurtosis level were estimated at -.152 and .138, respectively (Refer to Appendix J) which is less than the maximum allowable values for a t-test (ie, skew <2.0 and kurtosis < 9. 0 (Posten, 1984)). The null hypothesis was rejected $t(95) = -82.290, p < .000$. This meant that there was significant difference between the pre-test and the post-test results. It also implied that the intervention worked and the difference in the two performances was not by chance.

This finding supported the findings of Mohanna (2015) and Vasilevski and Birt, (2020) who agreed that mobile pedagogy can be employed to facilitate teaching and learning in different formats such as games, short messages, quizzes, and multimedia contents. It was also in line with findings of the study of Akaglo and Nimako-Kodu (2019) who investigated the effects of the use of mobile devices on second cycle students in Ghana. It was found out that, the use of mobile devices for delivery of contents and carrying out assessments enhanced learning outcomes of the students. Finally, the findings confirmed the assertion of Kalpana (2020) who proposed that, the used of mobile pedagogy had the potential of improving educational outcomes. It was however concluded in the same study that if not well directed, it would cause more harm than the intended good. This may happen because mobile devices were employed in the creations and used for the mobile pedagogy and they could be abused by students.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter highlights the summary of major findings, conclusions and implications for science teaching and learning. It also provides the recommendations.

5.2 Summary of Major Findings

There were 5 objectives that guided the study and the major findings are presented in line with the objectives.

1. To determine the types of mobile devices that level 100 science students use at St. Francis College of Education, Hohoe, it was found out that all the science students' use one mobile device or the other. It was also discovered that the most common types of mobile devices used by level 100 science students at St. Francis College of Education were the Android Phones, Cellular Phones and Laptops. The least used were the Notebook, iPhones, Tablets, Smartwatches and iPads. However, none of the first year science students used Phablet, Chromebook, MacBook, Netbook, Workstation and Pocket PC in the school.
2. To determine the purposes for which science students use mobile devices at St. Francis College of Education, Hohoe, it was found out that most level 100 science students at St. Francis College of education used their mobile devices for non-academic purposes such as playing games and making and receiving personal calls. Only few of them used their mobile devices for academic works such as recording and scanning of lecture notes, downloading academic materials and watching tutorial videos.

3. To determine the Factors that affect the use of mobile devices as learning tools at St. Francis College of Education, Hohoe, most of the level 100 science students were of the view that the nature of the devices such as type of mobile devices they have, screen size and battery strength influenced how they used their devices. Also, all of them agreed that the user friendly nature of the devices affect them as well. However, large number were of the view that large memory size and installation of new driver do not influence how they use their mobile devices in the school. Most of them agreed that the issues related to internet connection such as internet availability, the rate of uplink and downlink and availability of good broad band width affected how they use their devices in the school. It was also found out that personal issues such as knowledge about how the mobile devices can help them learn with ease and knowledge about search engines/learning sites influenced how mobile devices are used in the school. However, large number of the students were of the view that being afraid of addition to the mobile devices had no influence on how they use the devices in the school. Finally, factors relating to how the institution influence how the devices are used in the school such as availability of internet facility, free software and over restrictions of the use of devices in the school, a lot of the students confirmed that they influenced how the devices are used in the school.
4. To find out about Students' opinion after employing the mobile pedagogy as an instructional model for teaching, learning and assessing the concept of acids, bases and salts at St. Francis CoE. Most students accepted the fact that the mobile pedagogy helped them to understand the concepts of acids, bases and salts. Specifically, they were of the view that the devices increased their active participation in chemistry lesson, increased their motivation to learn chemistry

and inevitably increased their test scores. Finally, the students were of the opinion that the use of mobile devices benefited them during and after learning of the concepts of acids, bases and salts.

5. To determine the effects of employing mobile pedagogy as an instructional model on students‘ cognitive achievement in the concept of acids, bases and salts at St. Francis CoE. It was found out that employing mobile pedagogy, that is, using mobile devices for teaching, learning and assessment, had positive effect on students‘ academic achievements.

5.3 Conclusion

Based on the major findings of the study, the following conclusions were made:

1. The popular mobile devices used by Level 100 science students at St. Francis College of Education were the Android Phones, Cellular Phones and Laptops due to affordability. None of the students used Phablet, Chromebook, MacBook, Netbook, Workstation and Pocket PC in the school due to high cost.
2. Most level 100 science students at St. Francis College of Education used their mobile devices for non-academic purposes. Only few of them used their mobile devices for academic works.
3. The following factors affect how level 100 science students at St. Francis College of education used the mobile devices in the college: type of mobile devices they have, screen size, battery strength, internet availability, the rate of uplink and downlink, availability of good broad band width, availability of internet facility, free software and over restrictions of the use of the devices.

4. Mobile pedagogy helped level 100 science students at St. Francis College of Education to understand the concepts of acids, bases and salts. It also increased their active participation in chemistry lesson, increased their motivation to learn chemistry and inevitably increased their test scores.
5. Employing mobile pedagogy, that is, using mobile devices for teaching, learning and assessment, had positive effect on students‘ academic achievements $t(95)=2.887, p<.000$ at St. Francis College of Education, Honoe.

5.3.1 Implications for science teaching and learning

The following implications were deduced from the results and findings of the study:

1. Some mobile devices are common among science students, hence employing them for effective delivery of scientific concepts would help the students make purposeful use of such devices.
2. In designing interactive activities for science students to be used on their mobile devices, one needs to consider the nature of the device the students have, institutional support and as to whether internet is available or not, since these among others affect how mobile devices are employed for teaching and learning.
3. It is possible that students can use their mobile devices for activities that do not relate to learning hence science teachers can redirect the students to mostly use the devices for academic works.
4. Mobile pedagogy involves the use of mobile devices in different forms to teach, learn and assess students‘ learning. Science educators should update

themselves about how to employ mobile pedagogy in the science classrooms at the College of Education levels since it produces good results.

5.4 Recommendations

The following recommendations were made based on the findings of the study:

1. St. Francis College of Educations should encourage the use of mobile devices by making available internet facilities, reduce restrictions of use and provide policy guidelines on how mobile devices should be used in the college to support learning by all.
2. Science teachers should positively engage science students by designing activities that would involve mobile learning online or off-line or both.
3. Based on the findings, the use of mobile pedagogy enhanced teaching, learning and assessment of level 100 science students at St. Francis College of Education, Hohoe.
4. The College should collaborate with other stakeholders, companies and NGOs to provide mobile devices with educational software to support all science students and teachers.

5.5 Suggestions for Further Studies

1. It is suggested that similar studies should be done to cover other concepts in chemistry and also cover other levels at St. Francis College of Education, Hohoe.
2. A study should be done on the effects of mobile learning on students‘ academic performance in organic chemistry at the College of Education level in Ghana.

3. It is suggested that a study be done to find out about science tutors‘ competences in digital literacy at St. Francis College of Education, Hohoe.

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APPENDICES

APPENDIX A

SAMPLE PRE-TEST QUESTIONS

Extracted from:

MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)

Sample Interactive Exercise on Acids, Bases and Salts

For any question that has options A-D, select the best option that answers the question. For any question that needs supply, do so accordingly.

1. Which of the following statements does not explain the concept of Lewis acids?

A. ? Acids may be an ion or neutral molecule.
B. ? An acid accepts lone pair of electrons
C. ? An acid donates proton in acid-base reactions
D. ? An acid should have at least an empty atomic orbital in its central atom.

2. Proton transfer reaction as an acid – base reaction can be attributed to ....

A. ? Lewis
B. ? Arrhenius
C. ? Bromsteel – Lowry
D. ? Gay – Lussac

3. Which of the following gases could produce hydroxonium ions in water?

A. ? Butane gas
B. ? Ammonia gas
C. ? Hydrogen Chloride gas

D. ? Methane

4. According to Bronsted – Lowry, a base is..................

A. ? a compound which produce hydrogen ions in aqueous solution.
B. ? a compound that donates eletrons in acid – base reactions.
C. ? a compound with pH less than 7.
D. ? a compound that accepts proton in acid-base reaction.

5. Which of the following scientist suggested that acids and bases neutralize each other, and that the two classes of substances should be defined in terms of their reaction with each other.

A. ? Bronsted – Lowry
B. ? Gay – Lussac
C. ? Arrhenius
D. ? Lewis

6. Which of the following pairs are acid-base conjugate pairs?
$HSO^{4-}(aq) + H_2O \rightleftharpoons H_3O^{+}(aq) + SO4^{2-}$

A. ? $HSO4^{2-}$ (aq) and $SO4^{2-}$ (aq)
B. ? Gay – Lussac
C. ? Bronsted – Lowry
D. ? Lewis

7. Identify the conjugate acids of the following conjugate pairs: $NH4^{+}/NH_3$; CO_3^{2-} /HCO_3^{2-} and O^{2-} /OH^{-}.

A. ? HCO_3^{-}, NH_4^{+} and OH^{-}

B. ? NH_4^+, O^{2-} and HCO_3^-

C. ? NH_4^+, OH^-, and CO_3^{2-}

D. ? NH_4^+, CO_3^{2-} and O^{2-}

8. In the reaction: $NH_3(g) + NaOH(aq) \rightarrow NaNH_2 + H_2O$, ammonia acts as…..

A. ? Bronsted – Lowry base

B. ? Lewis Base

C. ? Neutral species

D. ? Bronsted – Lowry acid

9. Electrical conductivity of electron transfer in aqueous solutions of acids and bases can be explained in terms of…….

A. ? Bronsted-Lowry concept of acid

B. ? liquid-liquid mixture

C. ? Lewis concept of acid and base

D. ? Bronsted – Lowry concept of base

10. Which of the following is not a limitation of Arrhenius definition of acids and bases?

A. ? Acid – base reactions can occur in non-aqueous solutions.

B. ? Hydroxide oxide ion is the only source of all basic character

C. ? Acid base reaction occurs in aqueous solutions only.

D. ? An acid must contain at least one replaceable hydrogen ions

11. Why is hydrogen ion considered as a proton in the Bronsted – Lowry concept?
(I) Hydrogen ion has one proton

(II) Hydrogen ion has no neutron

(III) Hydrogen ion has lost one electron

A. ? II and III only

B. ? I, II and III

C. ? I and II only

D. ? I and II only

12. Pure solid sodium hydroxide does not conduct electricity because…….

A. ? It is a strong base.

B. ? It is a non-electrolyte.

C. ? It is not a liquid.

D. ? It does not contain free mobile ions.

13. Which of the following pairs of substances are electrolytes?

A. ? NH_3(aq) and HCl(g)

B. ? NH_3(aq) and HCl(aq)

C. ? NH_3(l) and HCl(aq)

D. ? NH_3(g) and HCl(l)

14. BCl_3 and PCl_3 are both covalent compounds. Which of the following statements about both compounds is true?

A. ? Both BCl_3 and PCl_3 are Lewis bases

B. ? Both BCl_3 and PCl_3 are Lewis acids

C. ? BCl_3 is a Lewis base whiles PCl_3 is a Lewis acid.

D. ? BCl_3 is a Lewis acid whiles PCl_3 is a Lewis base

15. Aluminium hydroxide is amphoteric because it reacts with......

I.acids

II.water

III.alkalis

IV.salts

A. ? I, III, and IV only

B. ? I and III only

C. ? II, III and IV only

D. ? II and III only

16. $Al(OH)_3(aq) + NaOH\ (aq) \rightarrow NaAlO_2(aq) + 2H_2O(l)$. What is the function of $Al(OH)_3$ in the above reaction?

A. ? It acts as a base

B. ? It acts as a reducing agent

C. ? It acts as an oxidizing agent

D. ? It acts as an acid.

17. Which of the following bases is insoluble in water?

A. ? Potassium oxide

B. ? Ziric oxide

C. ? sodium oxide

D. ? Barium hydroxide

18. Which of the following statement is not correct? Dilute hydrochloric acid.....

A. ? can be neutralized by calcium oxide.

B. ? produces effervescence with potassium trioxocarbonate (IV).

C. ? produces hydrogen gas with copper.

D. ? produces hydrogen gas with zinc.

19. Which of the following statement is true about a solution whose pH is 12?

A. ? It is acidic

B. ? It can react with a base to produce salt and water.

C. ? It is neutral

D. ? It will liberate NH_3 with NH_4Cl

20. A student who was sting by an insect (wasp) felt better on putting vinegar on the sting area. The conclusion that could be drawn about the insect sting is that it is a/an…..

A. ? alkaline

B. ? neutral

C. ? acidic

D. ? amphoteric

21. Which of the following acids is an organic acid?

A. ? HNO_3

B. ? HCOOH

C. ? H_2SO_4

D. ? H_2CO_3

22. Which of the following substances is not a source of acid.

A. ? Milk from cow

B. ? Grapes fruit

C. ? Ash from plantain peel

D. ? Oil from palm fruit

23. Sodium hydroxide is an example of a………
A. ? Oil from palm fruit B. ? Milk from cow C. ? weak base D. ? Grapes fruit
24. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solution would reverse the change?
A. ? Hydrochloric acid B. ? Ammonium hydroxide solution C. ? Baking powder D. ? Lime water
25. Which of the following is not an acidic salt?
A. ? $CuSO_4$ B. ? $FeCl_3$ C. ? NH_4Cl D. ? CH_3COONa
26. Methyl orange indicator gives red colour in acidic solution and yellow colour in basic solution.
A. ? False B. ? True

27. The dilution of a concentrated acid should always be done by adding the concentrated acid to water gradually with stirring

Check Hint Show answer

28. If an acid is strong it means it is concentrated.

A. ? True

B. ? False

29. The cation of the salt, NaCl, comes from the base.

A. ? True

B. ? False

30. All the organic acids are strong acids.

A. ? True

B. ? False

31. The more alkaline a solution is, the higher its pH value.

A. ? True

B. ? False

C.

32. A base which is soluble in water is known as an ______________ .
Check Hint Show answer
33. Acid reacts with metal to form salt and ______________ gas.
Check Hint Show answer
34. Salts are generally produced from neutralisation reaction.The anion of salts general comes from the ....
Check Hint Show answer
35. The process by which bases react with acids is known as ....
Check Hint Show answer
36. A solution with pH of 14 is said to be ....

Check Hint Show answer

37. Bases taste ....

Check Hint Show answer

38. Acetic acid can dissociate in water, but only to a small extent. Hence we would describe acetic acid as ....acid.

Check Hint Show answer

39. A product form when an acid donates a proton is called? ....

Check Hint Show answer

40. The salts of carbonic acids are called ______________ .

APPENDIX B

SAMPLE POST-TEST

MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)

Sample Interactive Exercise on Acids, Bases and Salts

For any question that has options A-D, select the best option that answers the question. For any question that needs supply, do so accordingly.

Show questions one by one

1. The salts of carbonic acids are called _____________ .

Check Hint Show answer

2. Identify the conjugate acids of the following conjugate pairs: NH_4^+/NH_3; CO_3^{2-}/HCO_3^{2-}, and O^{2-}/OH^-.

A. ? NH_4^+, O^{2-} and HCO_3^-

B. ? NH_4^+, CO_3^{2-} and O^{2-}

C. ? NH_4^+, OH^-, and CO_3^{2-}

D. ? HCO_3^-, NH_4^+ and OH^-

3. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solution would reverse the change?

A. ? Hydrochloric acid

B. ? Baking powder

C. ? Ammonium hydroxide solution

D. ? Lime water

4. The dilution of a concentrated acid should always be done by adding the concentrated acid to water gradually with stirring

Check Hint Show answer

5. Aluminium hydroxide is amphoteric because it reacts with......

I.acids

II.water

III.alkalis

IV.salts

A. ? II, III and IV only

B. ? I and III only

C. ? II and III only

D. ? I, III, and IV only

6. Methyl orange indicator gives red colour in acidic solution and yellow colour in basic solution.

A. ? False

B. ? True

7. All the organic acids are strong acids.

A. ? True

B. ? False

8. A student who was sting by an insect (wasp) felt better on putting vinegar on the sting area. The conclusion that could be drawn about the insect sting is that it is a/an…..

A. ? acidic
B. ? neutral
C. ? alkaline
D. ? amphoteric

9. $Al(OH)_3(aq) + NaOH\ (aq) \rightarrow NaAlO_2(aq) + 2H_2O(l)$. What is the function of Al(OH)3 in the above reaction?

A. ? It acts as a reducing agent
B. ? It acts as an acid.
C. ? It acts as a base
D. ? It acts as an oxidizing agent

10. A solution with pH of 14 is said to be ....

Check Hint Show answer

11. Salts are generally produced from neutralisation reaction. The anion of salts general comes from the ....

Check Hint Show answer

12. Which of the following substances is not a source of acid.

A. ? Oil from palm fruit

B. ? Milk from cow

C. ? Ash from plantain peel

D. ? Grapes fruit

13. Which of the following statement is true about a solution whose pH is 12?

A. ? It is neutral

B. ? It can react with a base to produce salt and

C. water.

D. ? It will liberate NH_3 with NH_4Cl

E. ? It is acidic

14. Why is hydrogen ion considered as a proton in the Bronsted – Lowry concept?

(I) Hydrogen ion has one proton

(II) Hydrogen ion has no neutron

(III) Hydrogen ion has lost one electron

A. ? II and III only

B. ? I and II only

C. ? I, II and III

D. ? I and II only

15. Acid reacts with metal to form salt and ____________ gas.

Check Hint Show answer

16. Which of the following is not an acidic salt?

A. ? CH_3COONa

B. ? $FeCl_3$

C. ? NH_4Cl

D. ? $CuSO_4$

17. Bases taste ....

Check Hint Show answer

18. Which of the following statements does not explain the concept of Lewis acids?

A. ? An acid donates proton in acid-base reactions

B. ? An acid accepts lone pair of electrons

C. ? Acids may be an ion or neutral molecule.

D. ? An acid should have at least an empty atomic orbital in its central atom.

19. A product form when an acid donates a proton is called? ....

Check Hint Show answer

20. The process by which bases react with acids is known as

....

Check Hint Show answer

21. The cation of the salt, NaCl, comes from the base.

A. ? True

B. ? False

22. Which of the following pairs of substances are electrolytes?

A. ? $NH_3(l)$ and $HCl(aq)$

B. ? $NH_3(aq)$ and $HCl(g)$

C. ? $NH_3(g)$ and $HCl(l)$

D. ? $NH_3(aq)$ and $HCl(aq)$

23. Which of the following gases could produce hydroxonium ions in water?

A. ? Methane

B. ? Ammonia gas

C. ? Butane gas

D. ? Hydrogen Chloride gas

24. The more alkaline a solution is, the higher its pH value.

A. ? True

B. ? False
25. According to Bronsted – Lowry, a base is..................
A. ? a compound which produce hydrogen ions in aqueous solution. B. ? a compound that donates electrons in acid – base reactions. C. ? a compound with pH less than 7. D. ? a compound that accepts proton in acid-base reaction.
26. Sodium hydroxide is an example of a………
A. ? Milk from cow B. ? Grapes fruit C. ? weak base D. ? Oil from palm fruit
27. Which of the following bases is insoluble in water?
A. ? Potassium oxide B. ? Barium hydroxide C. ? Ziric oxide D. ? sodium oxide
28. Proton transfer reaction as an acid – base reaction can be attributed to ....
A. ? Gay – Lussac B. ? Lewis C. ? Arrhenius D. ? Bromsteel – Lowry

29. Which of the following scientist suggested that acids and bases neutralize each other, and that the two classes of substances should be defined in terms of their reaction with each other.

A. ? Bronsted – Lowry
B. ? Lewis
C. ? Gay – Lussac
D. ? Arrhenius

30. In the reaction: $NH_3(g) + NaOH(aq) \rightarrow NaNH_2 + H_2O$, ammonia acts as…..

A. ? Bronsted – Lowry acid
B. ? Bronsted – Lowry base
C. ? Lewis Base
D. ? Neutral species

31. Which of the following acids is an organic acid?

A. ? HNO_3
B. ? H_2SO_4
C. ? H_2CO_3
D. ? HCOOH

32. BCl_3 and PCl_3 are both covalent compounds. Which of the following statements about both compounds is true?

A. ? BCl_3 is a Lewis base whiles PCl_3 is a Lewis acid.

B. ? Both BCl_3 and PCl_3 are Lewis acids
C. ? BCl_3 is a Lewis acid whiles PCl_3 is a Lewis base

D. ? Both BCl_3 and PCl_3 are Lewis bases

33. Which of the following statement is not correct? Dilute hydrochloric acid…..

A. ? can be neutralized by calcium oxide.
B. ? produces hydrogen gas with zinc.
C. ? produces effervescence with potassium trioxocarbonate (IV).
D. ? produces hydrogen gas with copper.

34. Electrical conductivity of electron transfer in aqueous solutions of acids and bases can be explained in terms of…….

A. ? Bronsted – Lowry concept of base
B. ? Bronsted-Lowry concept of acid
C. ? liquid-liquid mixture
D. ? Lewis concept of acid and base

35. If an acid is strong it means it is concentrated.

A. ? True
B. ? False

36. Pure solid sodium hydroxide does not conduct electricity because…….

A. ? It is a strong base.
B. ? It does not contain free mobile ions.
C. ? It is a non-electrolyte.
D. ? It is not a liquid.

37. Which of the following pairs are acid-base conjugate pairs?

$HSO_4^-(aq) + H_2O \rightleftharpoons H_3O^+(aq) + SO_4^{2-}$

A. ? Bronsted – Lowry

B. ? Lewis

C. ? Gay – Lussac

D. ? HSO_4^{2-} (aq) and SO_4^{2-} (aq)

38. A base which is soluble in water is known as an _____________ .

Check Hint Show answer

39. Acetic acid can dissociate in water, but only to a small extent. Hence we would describe acetic acid as ....acid.

Check Hint Show answer

40. Which of the following is not a limitation of Arrhenius definition of acids and bases?

A. ? An acid must contain at least one replaceable hydrogen ions

B. ? Hydroxide oxide ion is the only source of all basic character

C. ? Acid – base reactions can occur in non-aqueous solutions.

D. ? Acid base reaction occurs in aqueous solutions only.

APPENDIX C

PRE-TEST AND POST-TEST RAW/ANALYSED RESULTS

PRE-TEST	POST-TEST
4	29
6	27
7	33
5	23
9	33
8	37
9	33
10	36
6	33
5	29
6	34
11	30
5	28
7	28
7	29
6	34
6	33
5	36
6	30
6	37
6	26
5	40
6	28
14	39
13	29
12	32
12	40
11	36

10	40
7	40
7	32
8	40
7	27
8	33
7	36
9	30
8	29
7	32
5	31
6	29
7	30
2	29
9	28
3	27
4	30
5	29
5	27
7	30
4	30
5	31
6	31
6	33
7	34
8	30
9	39
7	37
5	33
5	32
4	33

5	36
6	30
7	27
8	39
5	33
6	30
7	28
8	28
7	30
7	31
16	39
7	29
6	33
8	29
7	29
6	30
7	33
8	30
7	33
6	34
7	36
8	32
3	38
4	33
4	33
5	30
4	31
5	32
4	27
6	27
7	29

6	28
6	30
6	29
4	25
7	29
6	29

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETEST RESULTS	8.98	96	1.563	.159
	POSTTEST RESULTS	33.23	96	2.755	.281

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PRETEST RESULTS & POSTTEST RESULTS	96	.197	.055

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	PRETEST RESULTS - POSTTEST RESULTS	-24.250	2.887	.295	-24.835	-23.665	-82.290	95	.000

APPENDIX D

RESULTS OF RELIABILITY ANALYSIS

Reliability Statistics for the Questionnaire

Cronbach's Alpha	N of Items
.900	20

Reliability Statistics for the Opinionnaire

Cronbach's Alpha	N of Items
.956	16

Item-Total Statistics for the Questionnaire

	Scale Mean	Scale Variance	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha
playing games	27.62	13.916	.221	.	.901
listening to music	27.61	13.860	.240	.	.901
watching movies	27.62	14.317	-.150	.	.905
taking pictures	27.62	14.318	-.136	.	.905
GPS	26.65	14.092	.155	.	.902
religious activities	27.07	11.375	.766	.	.887
financial transactions	26.98	11.120	.894	.	.882
reading current news	27.59	13.725	.268	.	.901
making and receiving calls	27.62	14.317	-.150	.	.905
for whatsApp charts	27.62	14.328	-.162	.	.905
Telegram charts	27.57	13.591	.284	.	.901
magnifying lens	26.65	14.010	.206	.	.901
Calculator	27.63	14.233	-.093	.	.903
recording lectures/ tutorial	26.87	11.540	.863	.	.884
educationally related research	26.98	11.126	.896	.	.882
storing academic data	26.98	11.120	.894	.	.882
tracking lecture time table	26.90	11.357	.892	.	.882
watching tutorial videos	26.81	12.154	.717	.	.889
scanning lecture notes	26.87	11.490	.874	.	.883
download academic materials	26.89	11.412	.887	.	.882

Item-Total Statistics for the Opinionnaire

	Scale Mean	Scale Variance	Corrected Item-Total Correlation	Cronbach's Alpha
The smartphone helped me with my class assignments for my science courses.	69.78	29.531	.865	.847
helped me prepare for my science quizzes	69.66	28.903	.932	.843
fostered interaction and teamwork between me and my course mates	69.65	30.780	.826	.851
increased my interaction with the science content	69.26	31.873	.752	.856
made it easier for me to communicate with my science lecturers	69.89	26.856	.841	.845
Smartphones with scientific, educational software have increased my test scores in chemistry	69.21	34.153	.778	.863
increased my motivation to learn Chemistry	69.21	33.972	.584	.865
helped me increase access to learning materials and educational resources	69.38	32.731	.534	.864
beneficial to my study process	69.26	32.712	.569	.862
enhancement materials to supplement the textbook	69.69	31.502	.513	.865
accomplish learning tasks more quickly	69.72	37.709	-.159	.899
increased my creativity presentation	69.75	30.267	.686	.856
participated in class more	69.26	37.356	-.130	.887
prepared for class by accessing information before class	69.66	30.443	.718	.854
opportunity to work at my own pace	69.26	37.342	-.131	.886
supplementary to a teacher teaching me	69.15	35.564	.598	.870

APPENDIX E

SPECIFICATION TABLE

Content	Kn	Comp	App	Ana	Syn	Eval	Total
Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases	**3**	**2**	**3**	**1**	**1**	**-**	**10**
Relative Strength of acids and bases	**3**	**3**	**2**	**-**	**1**	**1**	**10**
pH of acids, bases and salt solutions	**4**	**2**	**1**	**1**	**1**	**1**	**10**
The concept of salts	**1**	**1**	**1**	**1**	**-**	**-**	**5**
Types of salts	**1**	**1**	**3**	**-**	**-**		**5**
Total	**12**	**9**	**10**	**3**	**3**	**2**	**40**

APPENDIX F

QUESTIONNAIRE FOR RESEARCH QUESTION 1

The Type of Mobile Device Used by Students in School

S/N	Type of Mobile Device	Use	Don't Use
1.	Android phone		
2.	iPhone		
3.	Cellular Phone		
4.	Tablet		
5.	Phablet		
6.	Laptop		
7.	iPad		
8.	Chromebook		
9.	MacBook		
10.	Notebook		
11.	Netbook		
12.	Workstation		
13.	Smartwatch		
14.	Pocket PC		

APPENDIX G

QUESTIONNAIRE FOR RESEARCH QUESTION 2

Purposes of Using Mobile Devices in School

SN	Purpose of Mobile Device Use	Yes	No
1.	I use my mobile device for playing games.		
2.	I use my mobile device for listening to music.		
3.	I use my mobile device for watching movies.		
4.	I use my mobile device for taking pictures.		
5.	I use my mobile device for Global Positioning System (GPS) for directions.		
6.	I use my mobile device for religious activities.		
7.	I use my mobile device for personal financial transactions.		
8.	I use my mobile device for reading current news.		
9.	I use my mobile device for making and receiving calls.		
10.	I use my mobile device for whatsApp charts.		
11.	I use my mobile device for Telegram charts.		
12.	I use my mobile device as magnifying lens.		
13.	13. I use my mobile device as Calculator		
14.	I use my mobile device for recording lectures/		

	tutorial.		
15.	I use my mobile device for educationally related research.		
16.	I use my mobile device for storing academic data/material.		
17.	I use my mobile device for tracking weekly lecture time table.		
18.	I use my mobile device for watching tutorial videos.		
19.	I use my mobile device for scanning lecture notes.		
20.	I use my mobile device to download academic materials.		

APPENDIX H

QUESTIONNAIRE FOR RESEARCH QUESTION 3

Factors that Affect the use of Mobile Devices for Learning

	SA	A	U	DA	SD
Statements: Which of the following factors affect how you use mobile devices for learning at St. Francis College of Education, Hohoe?					
Factors related to the Nature of Device					
1. Type of device					
2. Screen size					
3. Battery strength					
4. Ability of the device to support applications/ features e.g. 3G/4G					
5. Ability to expand features/ softwares/ hardwares e.g. increase memory size and install new drivers					
6. Ability to connect to other devices					
7. Ability to connect to the internet.					
8. User friendly nature of the device					
9. Ability to be updated/ upgraded the device					
10. Storage space of the device					

Factors related to the Internet					
11. Internet availability					
12. Availability of good broad band width e.g. 3G/4G					
13. The rate of uplink and downlink e.g. internet speed.					
14. Availability of internet data					
Personal Factors					
15. Personal Interest					
16. Knowledge about how the device can help me learn with ease.					
17. Knowledge about search engines/learning sites					
18. Avoidance of addition to the device					
19. Resistance to change from learning using hard copy materials to soft copy and internet materials.					
Factors Related to the Institution					
20. Availability of internet facility					
21. Availability of free software					
22. Encouragement/motivation/ support from tutors.					
23. Over restrictions of use of devices in the school					

APPENDIX I

OPINIONNAIRE FOR RESEARCH QUESTION 4

Opinion of Students after the use of Mobile Devices for Learning

Statements	SA	A	U	DA	SD
1. The MD helped me with my class assignments for my chemistry courses.					
2. The MD helped me prepare for my chemistry quizzes.					
3. MD fostered interaction and teamwork between me and my course mates.					
4. MD increased my interaction with the chemistry content.					
5. MD made it easier for me to communicate with my chemistry lecturers.					
6. MD with scientific, educational software have increased my test scores in chemistry.					
7. MD increased my motivation to learn Chemistry.					
8. MD helped me increase access to learning materials and educational resources.					
9. MD use has been beneficial in studying chemistry.					
10. MD provided enhancement materials to supplement the textbook.					
11. MD enable me to accomplish chemistry learning tasks quickly.					
12. MD increased my creativity in chemistry class.					
13. MD helped me participated more in chemistry lessons.					
14. MD helped me to be more prepared for chemistry lessons.					
15. MD provided me with the opportunity to work at my own pace.					
16. MD was useful as a supplementary to the chemistry teacher teaching me the concepts.					

APPENDIX J

RESULTS OF SKEWNESS LEVEL, KURTOSIS LEVEL AND TEST OF NORMALITY

```
COMPUTE DIFFERENCE=PRETEST - POSTTEST.
EXECUTE.
EXAMINE VARIABLES=DIFFERENCE
  /PLOT BOXPLOT HISTOGRAM NPPLOT
  /COMPARE GROUPS
  /STATISTICS DESCRIPTIVES EXTREME
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.
```

Explore

Notes

Output Created		25-OCT-2022 15:02:52
Comments		
Input	Data	C:\Users\AMBROSE AHOYA\Desktop\DESK TOP\PH.D VIP\AHOYA PH.D PROPOSAL PRESENTED\1,2,3 & 4\CHAPTER 3 ANALYSIS\Q5 - TTEST NEW - Copy.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	96
Missing Value Handling	Definition of Missing	User-defined missing values for dependent variables are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any dependent variable or factor used.
Syntax		EXAMINE VARIABLES=DIFFERENCE /PLOT BOXPLOT HISTOGRAM NPPLOT /COMPARE GROUPS /STATISTICS DESCRIPTIVES EXTREME /CINTERVAL 95 /MISSING LISTWISE /NOTOTAL.
Resources	Processor Time	00:00:01.36
	Elapsed Time	00:00:01.48

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
DIFFERENCE	96	100.0%	0	0.0%	96	100.0%

Descriptives

			Statistic	Std. Error
DIFFERENCE	Mean		-24.2500	.29469
	95% Confidence Interval for Mean	Lower Bound	-24.8350	
		Upper Bound	-23.6650	
	5% Trimmed Mean		-24.2106	
	Median		-24.0000	
	Variance		8.337	
	Std. Deviation		2.88736	
	Minimum		-31.00	
	Maximum		-17.00	
	Range		14.00	
	Interquartile Range		4.00	
	Skewness		-.152	.246
	Kurtosis		.138	.488

Extreme Values

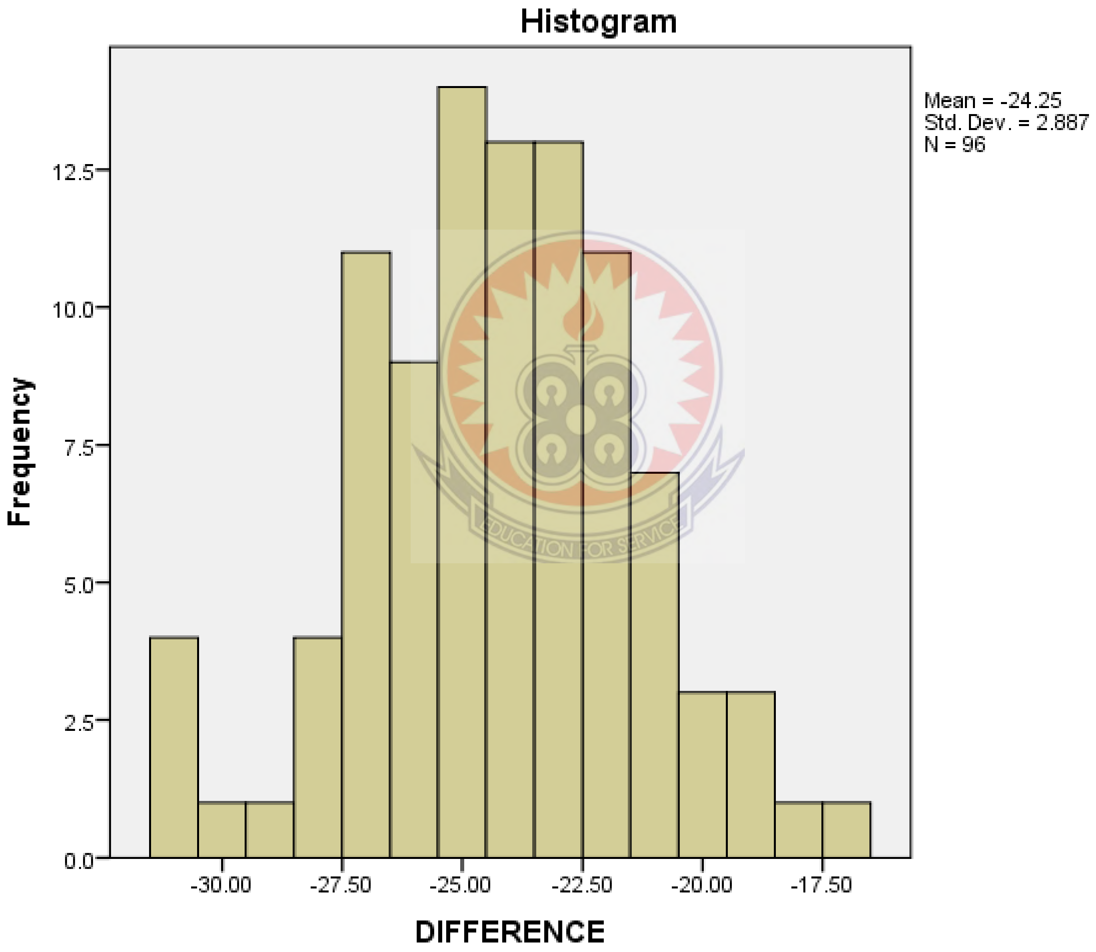
			Case Number	Value
DIFFERENCE	Highest	1	21	-17.00
		2	36	-18.00
		3	12	-19.00
		4	19	-19.00
		5	23	-19.00
	Lowest	1	88	-31.00
		2	82	-31.00
		3	70	-31.00
		4	63	-31.00
		5	55	-30.00

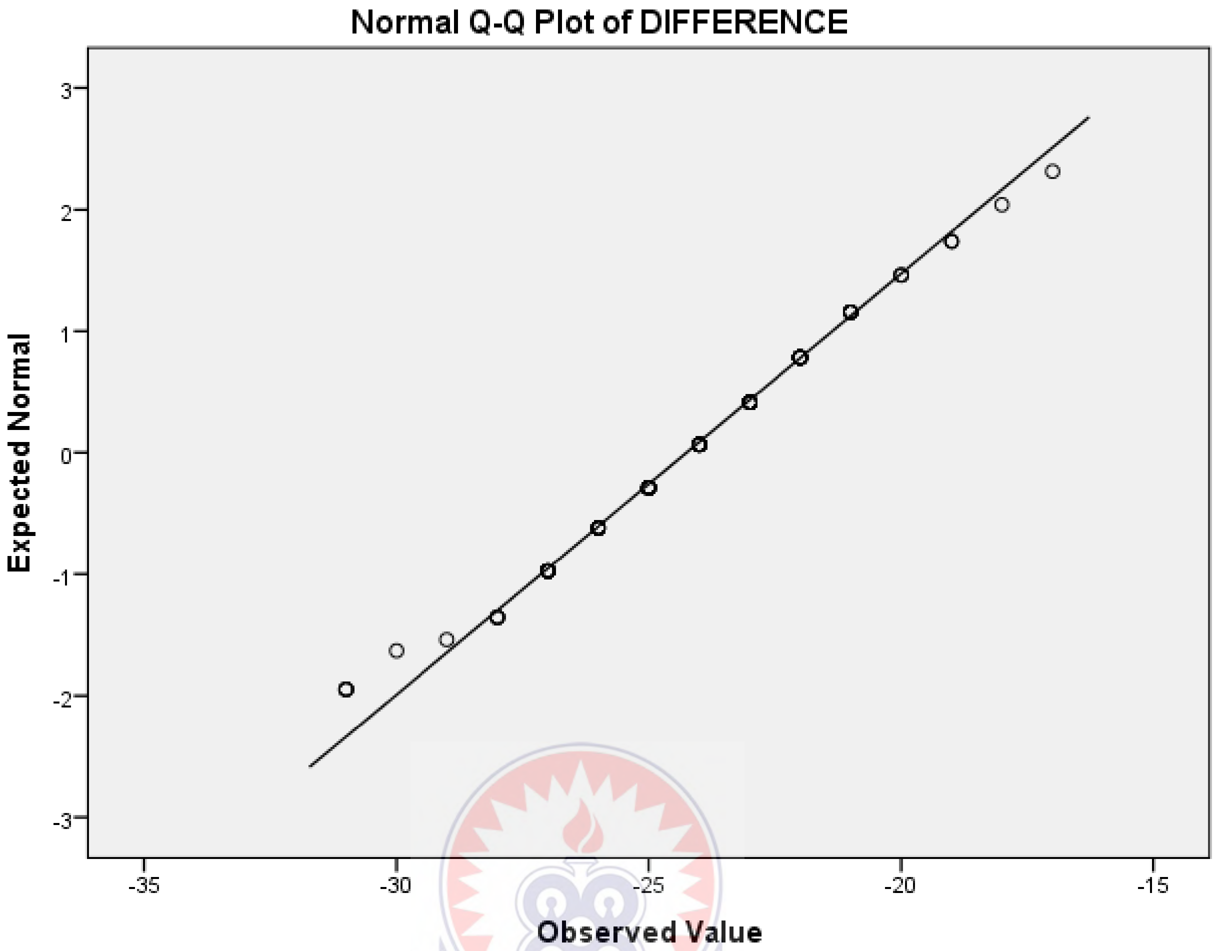
Tests of Normality

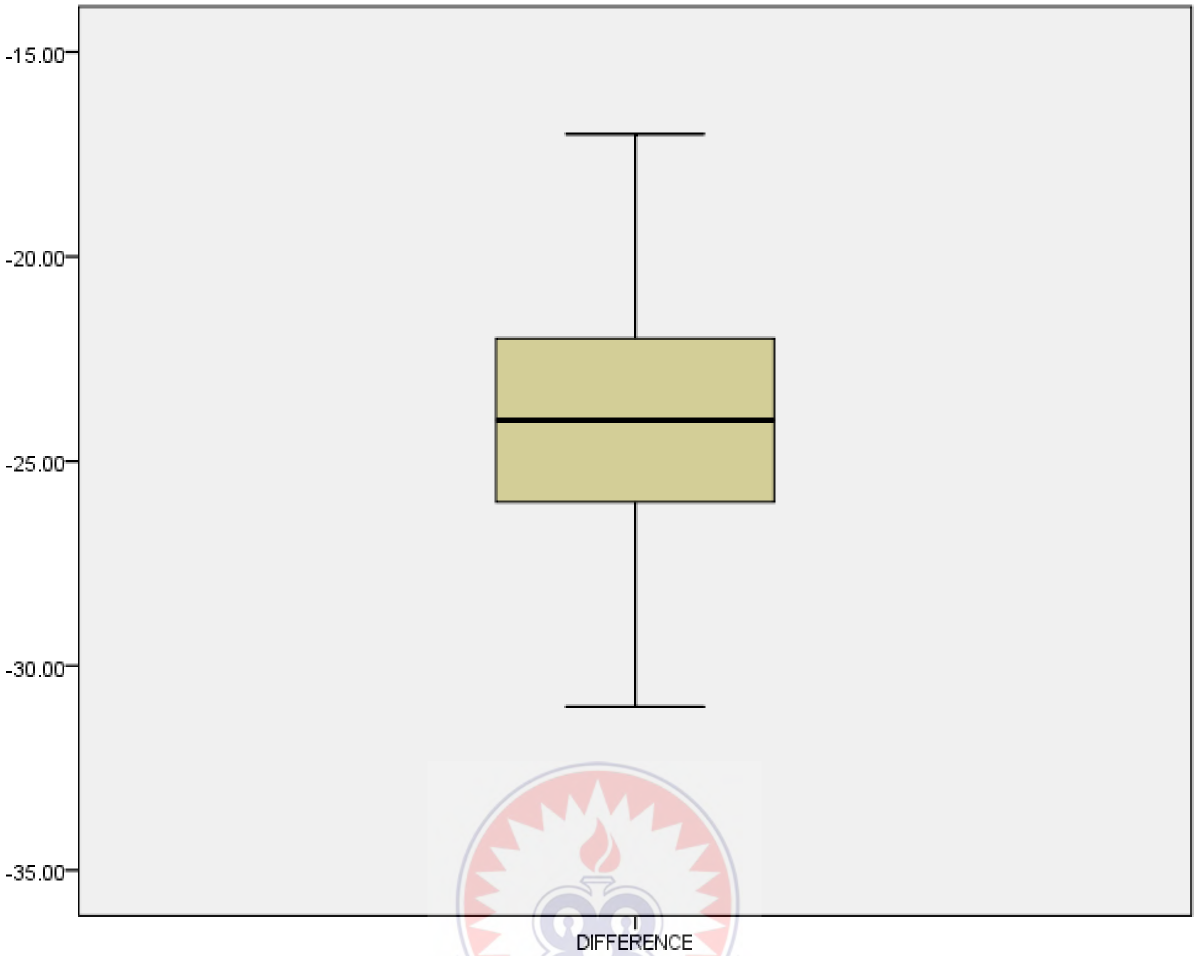
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
DIFFERENCE	.085	96	.084	.980	96	.154

a. Lilliefors Significance Correction

DIFFERENCE




Normal Q-Q Plot of DIFFERENCE
Expected Normal
3
2
1
0
-1
-2
-3
-35
-30
-25
-20
-15
Observed Value


-15.00
-20.00
-25.00
-30.00
-35.00
DIFFERENCE

APPENDIX K

SAMPLE UCC COURSE OUTLINE FOR LEVEL 100

COURSE TITLE: GENERAL CHEMISTRY THEORY I

COURSE CODE: EBS 115

COURSE OUTLINE

SPECIFIC CONTEXT ISSUES:

This course is mounted to equip year 1 student-teacher with basic concepts in in chemistry. The concepts are: the structure of the atom, arrangement of electron in an atom, amount of substances and the mole, acids, bases and salt; chemical bonding and the chemistry of carbon 1.

Course Title	General Chemistry Theory 1						
Course Code	EBS 115		Course Level: 100		Semester 2		Credit value: 2
Pre-requisite	**Student teachers have knowledge in** elective chemistry at the senior high school level.						
Course Delivery Modes	Face-to-face: [X]	Practical activity: [ ]	Work-Based Learning:[ ]	Seminars: [ ]	Independent Study: [X]	e-learning opportunities: [X]	Practicum: [ ]

Course Description for significant learning (indicate NTS, NTECF, BSC GLE to be addressed)	The general chemistry course covers some topics in physical chemistry. The course is for students who have studied elective chemistry at the senior high school level. The course is therefore intended to consolidate and expand on the content students have learnt. Topics studied in this course include the structure of the atom, arrangement of electron in an atom, amount of substances and the mole, acids, bases and salt; chemical bonding and the chemistry of carbon 1. NTECF, NTS 2c, pg.14, 3d,3f, 3i, 3j, 3k pgs.15, and 22	
Course Learning Outcomes	On successful completion of the course, student teachers will be able to:	Indicators
	CLO 1. Demonstrate knowledge and understanding of the concepts of the structure of the atom. **(NTECF, NTS 2c, pg14, 3d, pg15).**	Describe the structure of the atom in terms of : 1.1 proton, 1.2 neutron and 1.3 electron
	CLO 2. Demonstrate knowledge and understanding of the arrangement of electron in an atom. NTECF, NTS 2c, pg14, 3j, pg15).	2.1 Explain the principle that govern how electrons fill their orbitals. 2.2.Write electronic configuration of each of the first twenty elements of the periodic table using the guiding principles.
	CLO 3. Demonstrate knowledge and understanding of amount of substances and the mole concept. **NTECF, NTS 14c, 15i).**	3.1. Determine the amount of substances in aqueous solutions. 3.2 Calculate the number of moles of substances present in a solution of known concentration.

	CLO 4. Demonstrate understanding and knowledge in the concepts of acids, bases and salt. **NTECF, NTS, 3d, pg15 & 3j, pg15).**	4.1. Identify sources of acids, bases, salts 4.2. Use the pH scale to identify acids bases and neutral solutions. 4.3. Give practical example of what acids, bases and salts are used for in their daily life.
	CLO 5. Demonstrate knowledge and understanding of the concept of chemical bonding 1. **(NTECF, NTS 2c pg14, 3i, pg15 &3k, pg 15).**	5.1.Describe how covalent bond and an ionic bond are formed. 5.2. State the main difference between a covalent bond and an ionic bond. 5.3. Identify practical examples and uses of covalent and an ionic compounds in their daily lives.
	CLO 6: Demonstrate knowledge and understanding of the concepts of chemistry of carbon1. **NTECF, NTS 2c, pg14, 3d, pg15 & 22).**	6.1. State the types of hybridisation carbon atom can undergo. 6.2. Determine the empirical and molecular formulae of organic compounds.

	Units	Topics:	Sub-topics (if any):	Teaching and learning activities to achieve learning outcomes:
Course Content: General Chemistry Theory	1	The structure of the atom and the arrangement of electrons in the atom	- Dalton‘s Atomic theory and its limitations - The contributions of J.J. Thompson, Rutherford and Bohr"s towards the development of atomic structure - Definition of the following terms: electron, protons, neutron number,	Think-pair-share and running dictation to discuss and explain the basic rules and principle. Animation and simulations of structure of the atom and how electrons are arranged in the main orbitals from YouTube and other online resources. Use game and songs/acronyms to learn about

			atomic number, mass number and isotope - Arrangement of electrons in the main and sub-energy levels of an atom - Orbitals (shapes of *s, p* and d orbitals). - Rules and principles for filling in electron (Aufbau Principle, Hund's Rule of Maximum Multiplicity and Pauli Exclusion Principle). electronic configuration in terms of s, p, and d orbitals from hydrogen to zinc.	the 1st 20 elements and ‗Find someone who can' for the definitions.
	2	CHEMICAL BONDING 1.INTERATOMIC BONDING a. Ionic bond formation • Covalent character in ionic bond. • Name and chemical formulae for simple	a) Bond formation - Formation of Ionic Bonds, ionic compounds and properties - Lewis dot structures for simple ionic compounds - Factors that influence the formation of ionic bond.(ionization energy, electronegativity, lattice energy) - Covalent character in ionic bond.	Using concept mapping to present the concepts (being mindful of equity and inclusivity) Using individual and group presentations (being mindful of gender roles). Videos and animations from known science education sites online. Questions and answers technique can also be employed where appropriate.

		ionic compounds b. COVALENT BOND FORMATION • Lewis dot structures for some covalent compounds. • Polar covalent bonds • Properties of covalent compounds	-Name some binary and ternary ionic compounds from their formulae - Names and chemical formulae for simple ionic compounds including those that contain the polyatomic ions, ammonium, hydroxide, trioxocarbonate(IV), trioxonitrate(V), tetraoxophosphate(V), tetraoxosulphate(VI) and trioxochlorate(V). - Covalent Bonding and properties - Formation of covalent bonds involving same and different atoms. - Polar and non-polar covalent bonds - Dipole moments - Lewis formulas for molecules and polyatomic ions. - Ionic character (polarity) in covalent bonds based on electronegativity difference between the species involved. - .Discuss properties of covalent compounds under	

		c. METALLIC BOND FORMATION. • The properties of metals 2. INTER-MOLECULAR BONDING Types of intermolecular forces in covalent	➢ solubility in polar and non-polar solvents ➢ melting point ➢ boiling point ➢ electrical conductivity - Characteristics of the atoms and groups involved in the formation of metallic bond. - the formation of metallic bond. - Factors influencing the formation of metallic bond and how the factors relate to the hardness and softness of metals - Properties of metals. e.g □ heat and electrical conductivity □ hardness □ ductility □ malleability □ lustre □ sonority The different types of intermolecular forces in covalent compounds. Include: □ Hydrogen bond □ Van der Waal"s forces	

		compounds. Hydrogen bond Van de Waals • Hybridization and Shapes of Molecules Formation of sigma and pi-bonds. Shapes of molecular compounds	The structures of the following molecules ; H_2O, H_2S, NH_3 ,CH_4 - Formation of hydrogen bond. - The effect of hydrogen bonding on the properties of compounds (e.g. H_2O and H_2S) Van de Waals forces between and within covalent molecules. ➢ Dipole-dipole ➢ dipole-induced dipole forces ➢ ion-dipole forces Meaning of the term Hybridization. Hybridization of atomic orbitals. sp, sp^2, sp^3, sp^3d^2 orbitals The procedures for hybridizing atomic orbitals. - Formation of sp, sp^2, sp^3, sp^3d^2 hybrid atomic orbitals using carbon atom as an example. - Sketch the shapes of sp, sp^2 and sp^3 and sp^3d^2 hybrid orbitals using the following molecules:	

			CH_4, NH_3, H_2O, , $CH \equiv CH$ BCl_3 , $H_2C = CH_2$	
	3	AMOUNT OF SUBSTANCE AND THE MOLE Chemical formulae and chemical equations	a) Relative atomic mass , A_r b) Relative molecular mass, M_r c) The mole and molar quantities d) Quantity of solute in solution and preparation of solutions e) Chemical formulae of molecules and ionic compounds f) Naming of inorganic compounds (binary compounds, ions, base and salts) Chemical equations and mole ratios (writing and balancing chemical equations)	Using individual and group presentations Videos and animations from known science education sites online. Questions and answers technique can also be employed where appropriate (being mindful of equity and inclusivity).
	4	ACIDS BASES AND SALTS	Sources and classification of acids, bases and salts Arrhenius, Bronsted- Lowry and Lewis acids and bases Physical and chemical properties of acids and bases: Provide examples of processes and products that use knowledge of acid and base chemistry, e.g. (1) air pollution analysis (2) food and beverage analysis (3) water quality and environmental	Using concept mapping and cartooning for illustrating and discussing the concepts of acids, bases and salts. Using individual and group presentations Using ‗spider web' as a strategy to present the classification of acids and bases. Videos and whole class discussion can be

			analysis (4) in the soap industry (5) acidity of edible oils (6) analysis of antacids Classification of acids and bases: Strength of acids and bases (strong acids and weak aids and alkalis) pH scale and Universal indicator. pH as a measure of acidity and alkalinity. Buffer Solutions Acid-Base indicators Correct use of relevant apparatus. Knowledge of how acid-base indicators work in titrations. Acid-base titration: Calculations involving Molarity	used for presenting the concept on pH scale and titration.

			i. Tests for Acids and Bases using indicators. ii. Preparation of indicators from flowers. iii. Practical knowledge of how various acid-base indicators work in titration.	
		Preparation of standard solutions	iv. Preparation of acid solutions (e.g. HCI, H2SO4) of known concentration. v. Preparation of alkalis (e.g. NaOH) vi. Preparation of salts solutions (e.g. Na2CO3) NaHCO3 etc.)	
		Determination of concentrations of solution	vii. Known concentrations must be expressed in various units. e.g. 0.2M NaOH Solution: 2% NaCl (w/w and w/v solution) etc. viii. Dilution of solutions of known concentration to obtain other concentrations.	
		Volumetric analysis	ix. Titration involving weak acids and strong bases and strong acids versus strong bases using appropriate indicators and their applications in quantitative determination of concentration. x. Definitions and calculations xi. Double indicator and back titrations	

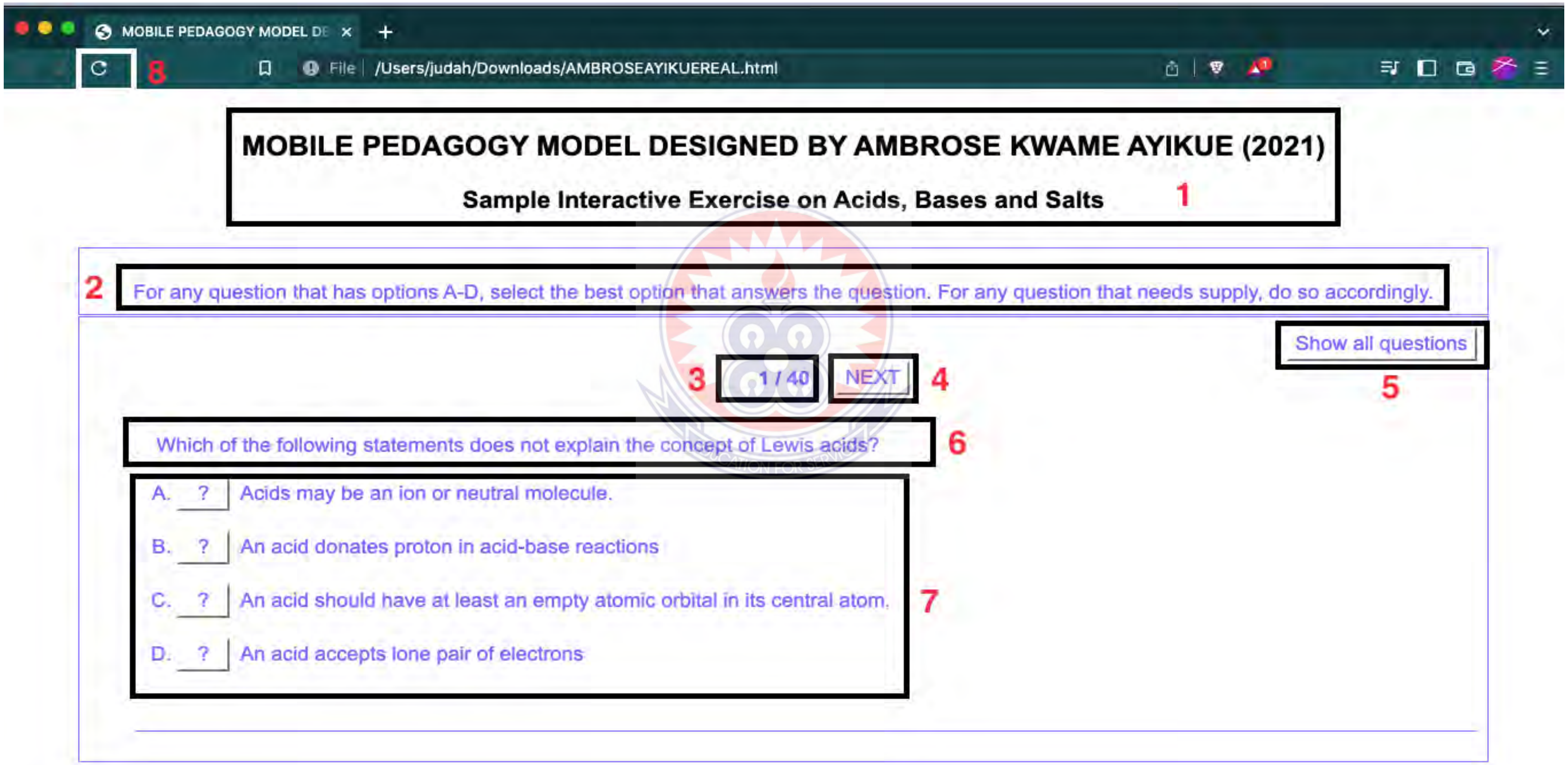
			Calculations	
	5	THE CHEMISTRY OF CARBON 1 • Tetravalent nature of carbon. • Definition and classification of organic compounds. • Components of organic compounds	Bonding and type of hybridization in Carbon (hybrid orbital e.g. sp, sp^2 and sp^3 and discuss sigma and pi-bond formation) Define organic compounds Classification of the following Organic Compounds: i. hydrocarbons (aliphatic and aromatic hydrocarbons) ii. functional group compounds (alcohols, carbonyls, carboxylic acids, ester and amines) Discuss and demonstrate the experimental Identification determination of the elements: C, H, O, N, S and halogens in a given organic compound. Use of a given data to determine the empirical and molecular formulae of organic compounds.	Videos and animations from known science education sites online. Running dictation can be used to present the tetravalent nature of carbon and classification of organic compounds. Group work, discussions and presentations as teaching strategies will be used for Components of organic compounds (being mindful of equity and inclusivity) •
Course Assessment (Educative	**Component 1**: Formative assessment (individual and group presentation) Summary of Assessment Method: Individual and group presentations on i) Intermolecular bonding, ii) Ar, Mr, iii) classification of acids, iv) bases and v) components of organic compounds (core skills to be developed: , digital literacy,			

assessment: of, for and as learning)	respect for diversity, critical thinking, collaboration and communicative skills,) Weighting: 20% Assesses Learning Outcomes: CLO 1 and 2 (units 1 & 2)
Component 2: Formative assessment (Quizzes and Exercises) Summary of Assessment Method: Quiz on atomic structure and periodicity (core skills to be developed: critical thinking and personal development) Weighting: 20% Assesses Learning Outcomes: CLO 3 and 4 (unit 3 and 4)	
Component 3: Summative assessment Summary of Assessment Method: End of semester examination on units 1 to 6 (core skills to be developed: critical thinking, personal development) Weighting: 60% Assesses Learning Outcomes: CLO 1-6	
1. Periodic Tables 2. Projectors and computers **3.** Audio-visuals and animations from YouTube	
Required references	Abbey, T.K., Ameyibor, K., Essiah, J.W., Nyavor, C.B., Seddoh, S. & Wiredu M.B. (1995).*GAST Science for senior secondary school*. London: Unimax Publishers Limited Ameyibor, K., &Wiredu M. B. (1991).*GAST chemistry for senior secondary school*. London: Macmillan Education Limited. Chang, R. (2003). *General chemistry: The essential concepts*. (3rded.). Boston: McGraw Hill.
Additional Reading List	Gallagher, R. & Ingram, P. (1987).*Chemistry made clear*. Oxford: Oxford University Press. Ohia, G.N.C., Amasiatu, G.I., &Ajagbe, J.O. (2005).*Comprehensive certificate chemistry*. Ibadan: University Press PLC. Whitten, K.W., Davis, R.E., & Peack M.L. (2000) *General Chemistry*. (6thed.). Fort Worth: Saunders College Publishing.

APPENDIX L

DESCRIPTION OF THE MOBILE PEDAGOGY IMPLEMENTATION

First Interface



Description of Items on the Interface

i. Item1 describes the name of the module.

ii. Item 2 gives instructions needed to complete the test in the module.

iii. Item 3 indicates the question you are currently answering, which is question 1 out of the total number of questions which in this case is 40.

iv. Item 4 is the “next” button and it takes you to the next question item and on the next page. There is a “back” button that takes you to the previous page.

v. Item 5 displays all questions in the module which does not need one to use the “next” button to navigate through the questions.

vi. Item 6 is the question to be answered.

vii. Item 7 presents the optional answers to be selected for the question and in other questions, like, fill-in questions, textbox is provided to input your answer.

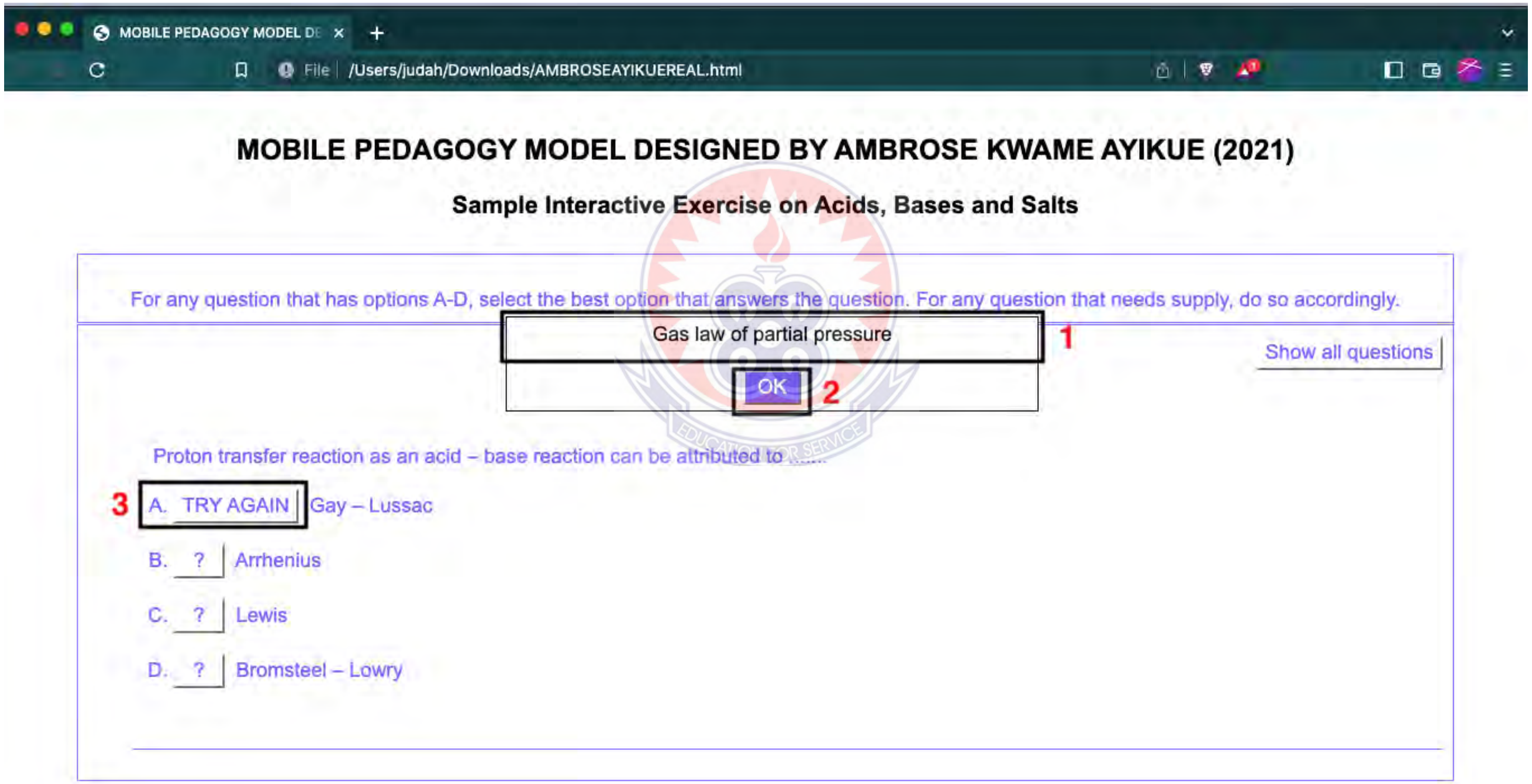
viii. Item 8 is the “Refresh” icon that when clicked, refreshes the page, reshuffles the questions and makes user start anew.

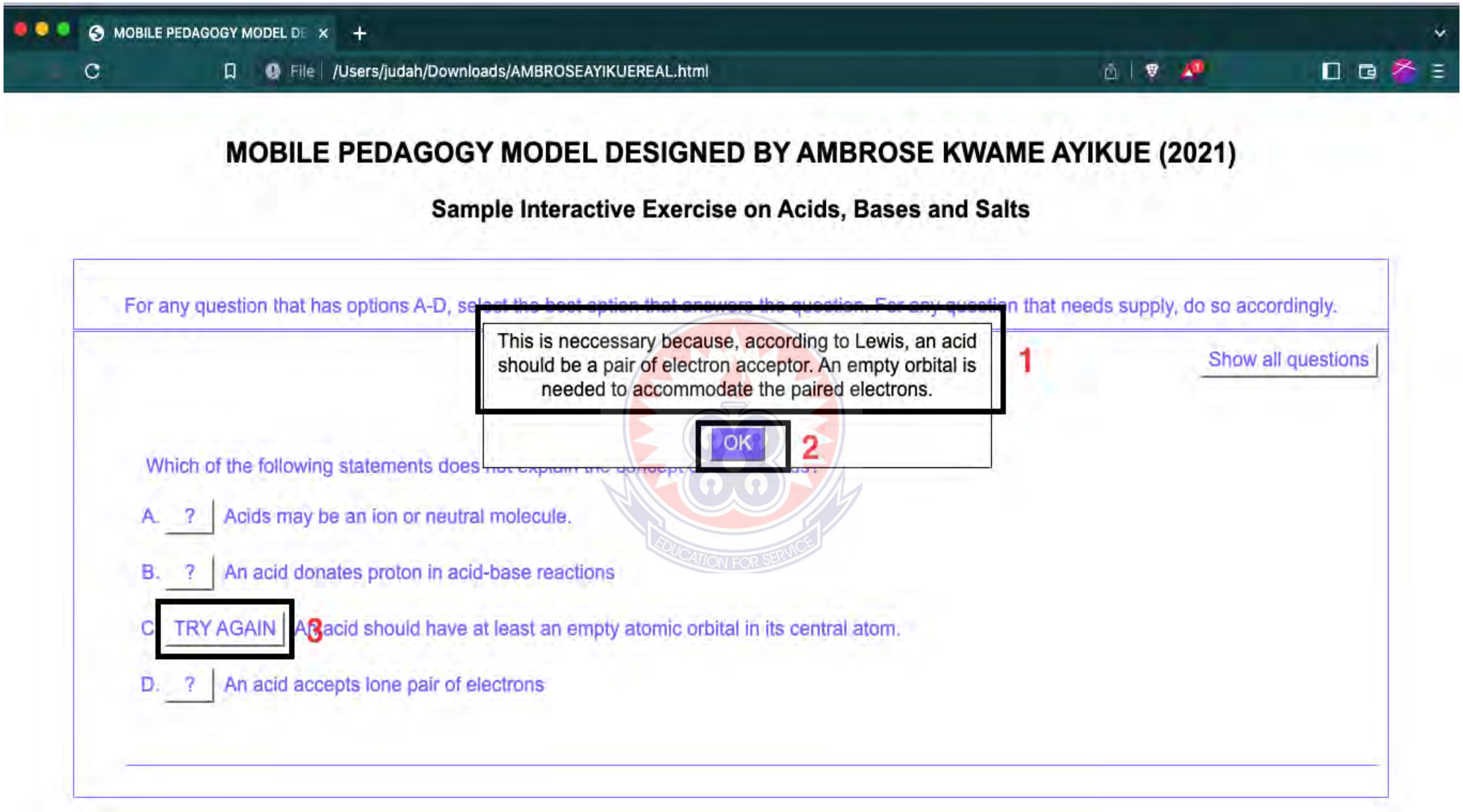
What Happens If:

a. **If Wrong Answers are Selected?**

b. **If Right Answers are Selected?**

When Wrong Answers Selected




MOBILE PEDAGOGY MODEL DE
File /Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
For any question that has options A-D, select the best option that answers the question. For any question that needs supply, do so accordingly.
This is neccessary because, according to Lewis, an acid should be a pair of electron acceptor. An empty orbital is needed to accommodate the paired electrons.
1
Show all questions
OK
2
Which of the following statements does
A. ? Acids may be an ion or neutral molecule.
B. ? An acid donates proton in acid-base reactions
C. TRY AGAIN acid should have at least an empty atomic orbital in its central atom.
3
D. ? An acid accepts lone pair of electrons

Description of Items on the Interface

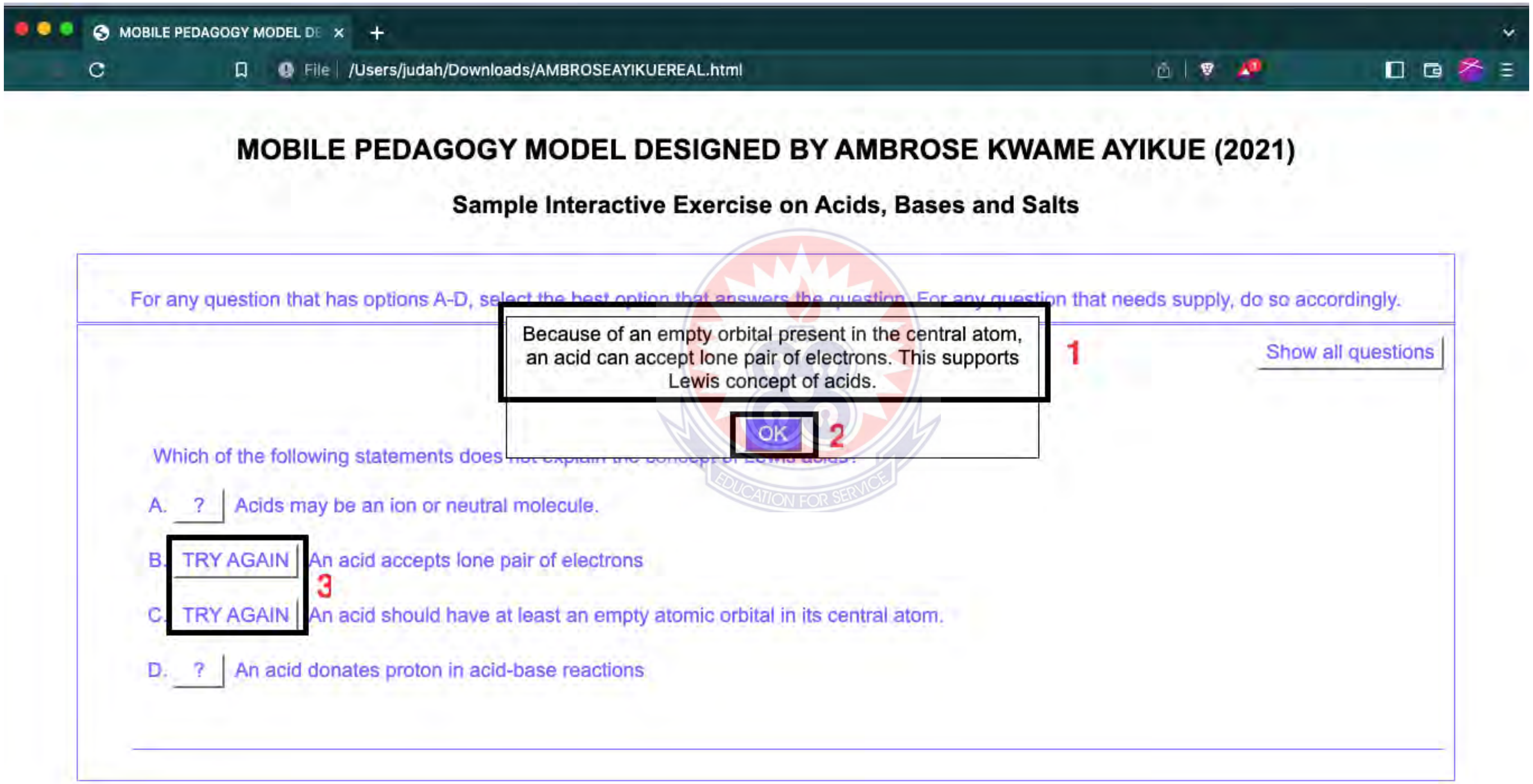
i. Item 1 popup when an answer is click/selected and it gives an explanation to why your selected answer is right/wrong, since the feedback serves as a teaching strategy and its self-teaching.

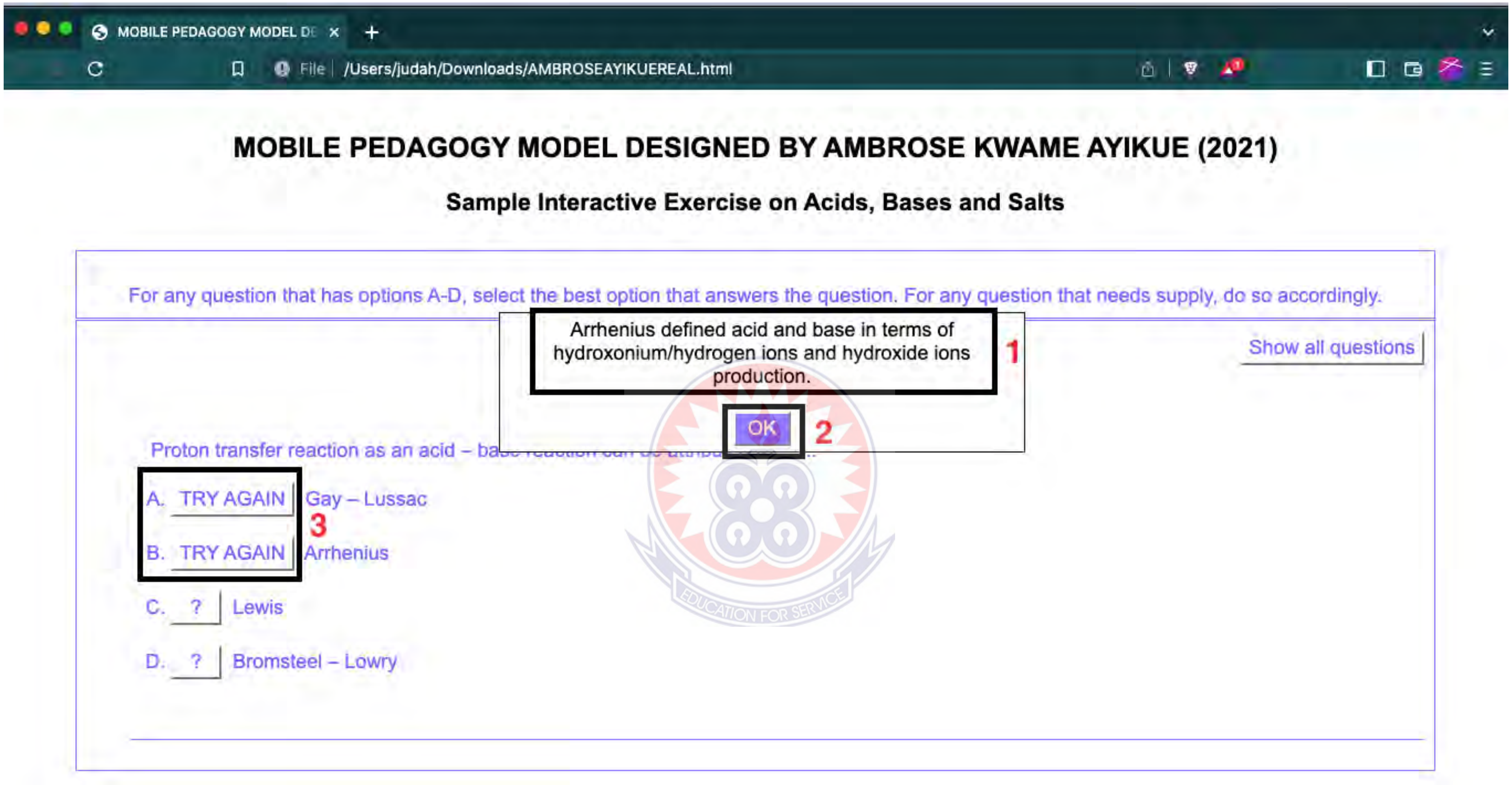
ii. Item 2 which is the "OK" button closes the dialog box when clicked.

iii. Item 3 displayed "try again" since a wrong answer is selected.

Another Wrong Answer Selected

You have three attempts to every multiple-choice question and when you click on another wrong answer you are asked to ―TRY AGAIN"




MOBILE PEDAGOGY MODEL DE
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
For any question that has options A-D, select the best option that answers the question. For any question that needs supply, do so accordingly.
Arrhenius defined acid and base in terms of hydroxonium/hydrogen ions and hydroxide ions production.
1
OK
2
Show all questions
Proton transfer reaction as an acid – ba
A. TRY AGAIN Gay – Lussac
3
B. TRY AGAIN Arrhenius
C. ? Lewis
D. ? Bromsteel – Lowry

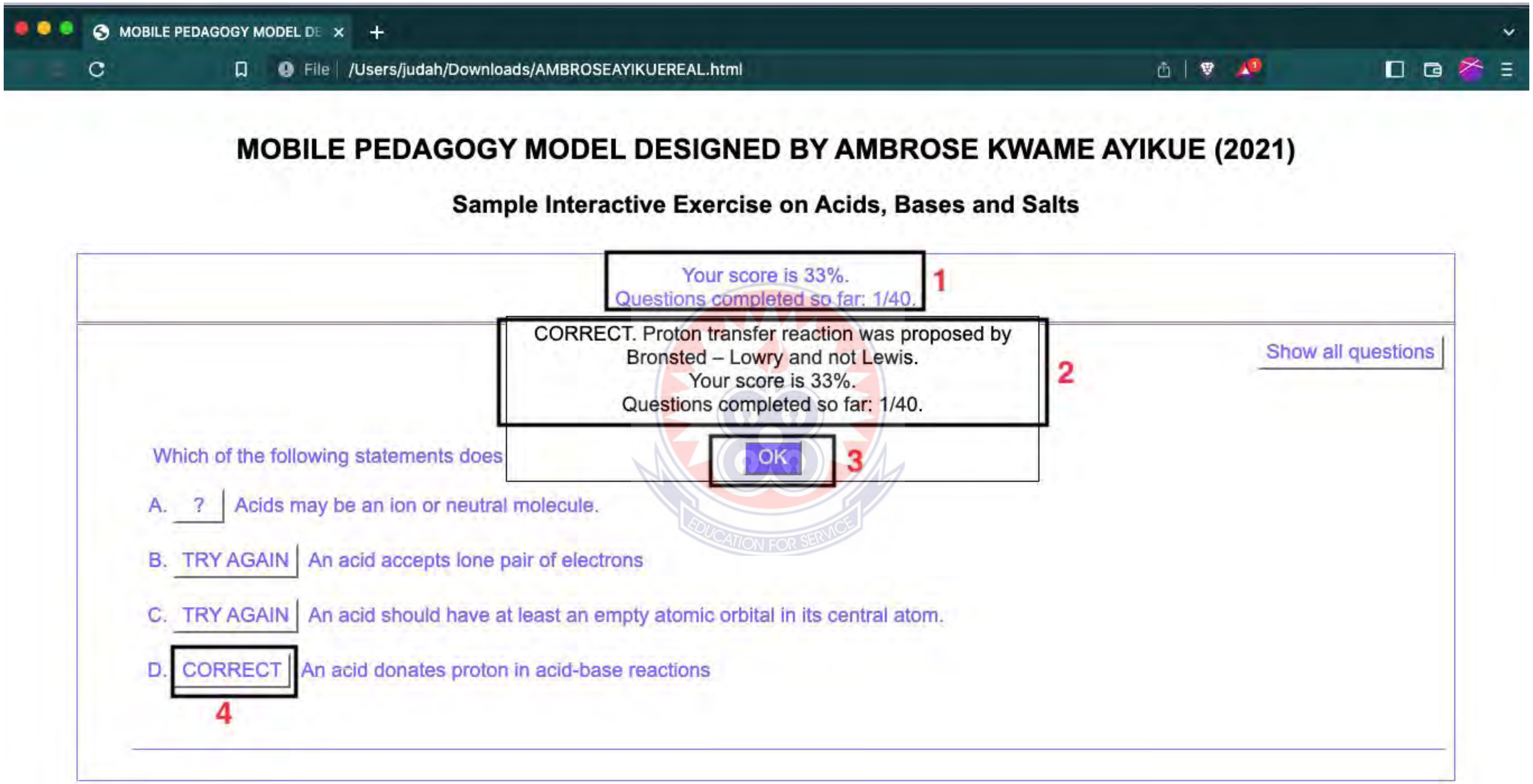
Description of Items on the Interface

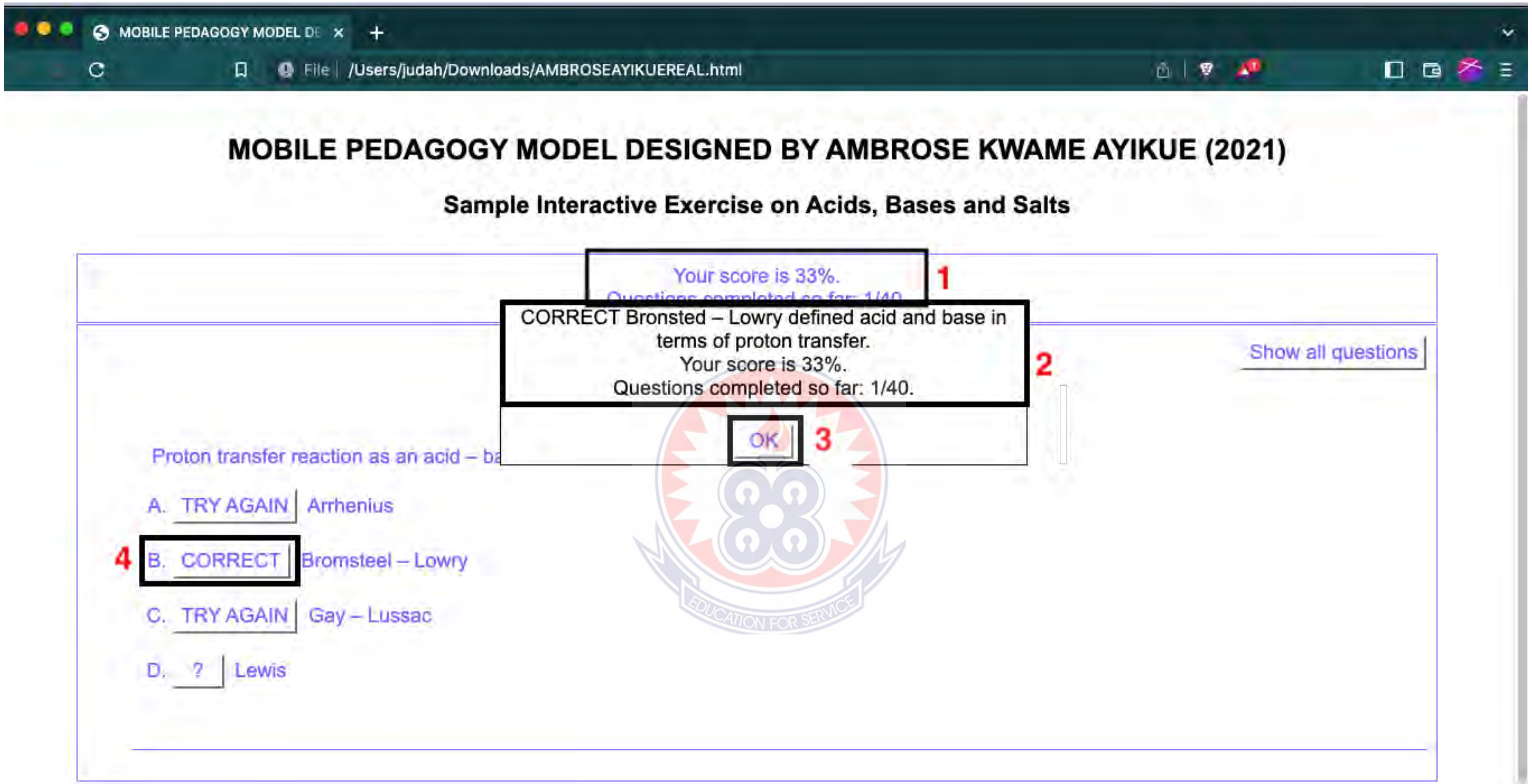
i. Item 1 popup when an answer is click/selected and it gives an explanation to why your selected answer is right/wrong, since this aid in teaching and learning.

ii. Item 2 which is the –OK” button closes the dialog box when clicked.

iii. Item 3 displayed –try again” since a wrong answer is selected.

Selection A Right Answer




MOBILE PEDAGOGY MODEL DE
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 33%.
1
CORRECT Bronsted – Lowry defined acid and base in terms of proton transfer.
Your score is 33%.
Questions completed so far: 1/40.
2
Show all questions
OK
3
Proton transfer reaction as an acid – ba
A. TRY AGAIN Arrhenius
4
B. CORRECT Bromsteel – Lowry
C. TRY AGAIN Gay – Lussac
D. ? Lewis

Description of Items on the Interface

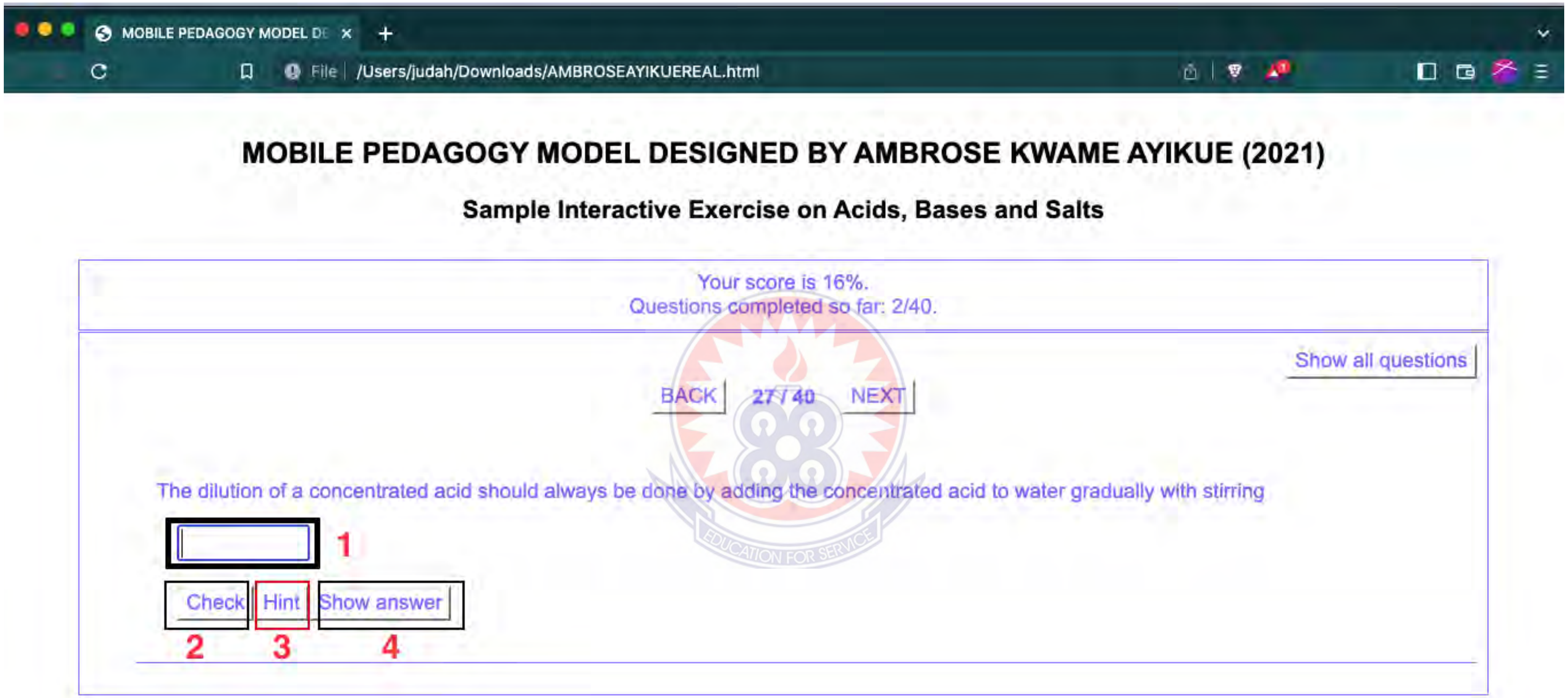
i. Item 1 shows your progress as in the number of questions answered and scored.

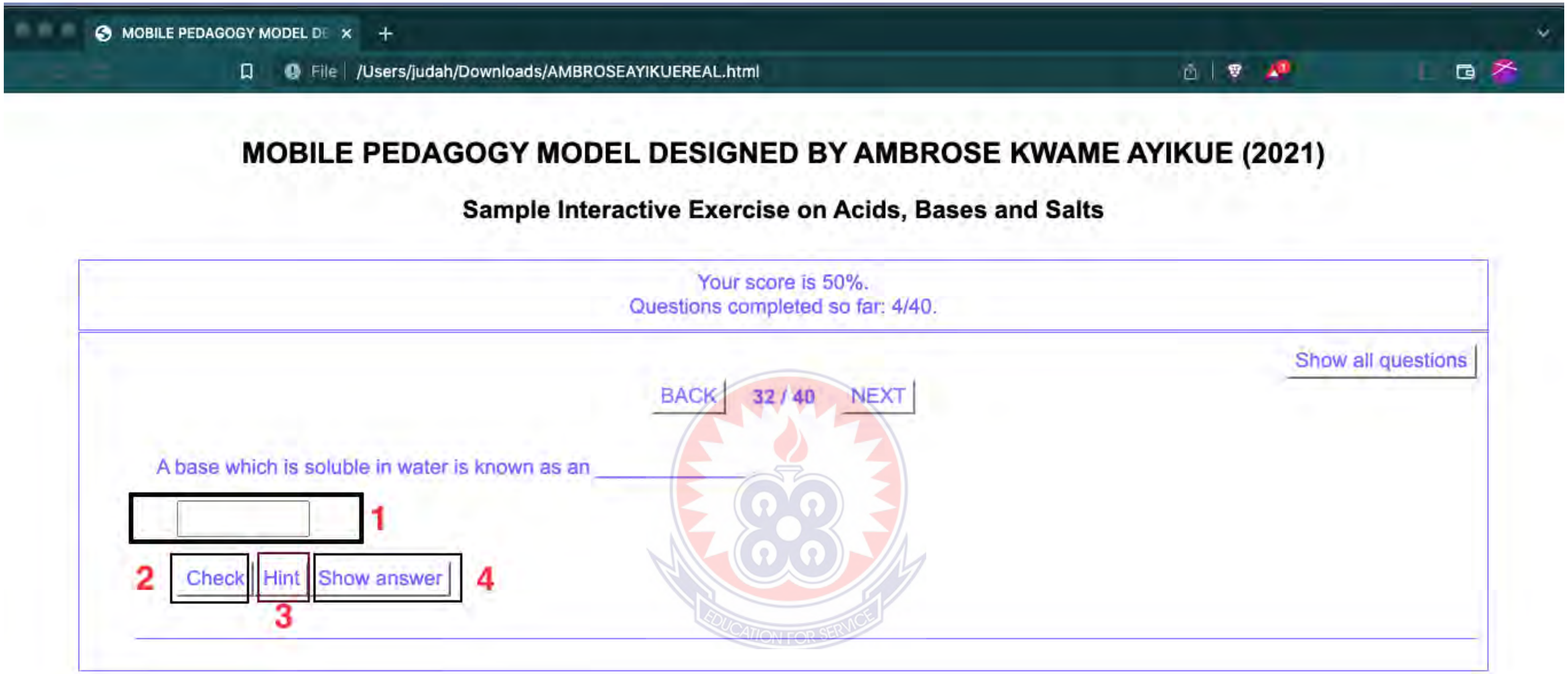
ii. Item 2 is a dialog box and it pops-up when an answer is click/selected and it gives an explanation to why your selected answer is right/wrong.

iii. Item 3 closes the dialog box when clicked.

iv. Item 4 indicates –CORRECT” on the button since the selected answer is right.

Fill in The Blank Question




MOBILE PEDAGOGY MODEL DE
File /Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 50%.
Questions completed so far: 4/40.
Show all questions
BACK
32 / 40
NEXT
A base which is soluble in water is known as an
1
2
Check
Hint
Show answer
4
3

Description of Items on the Interface

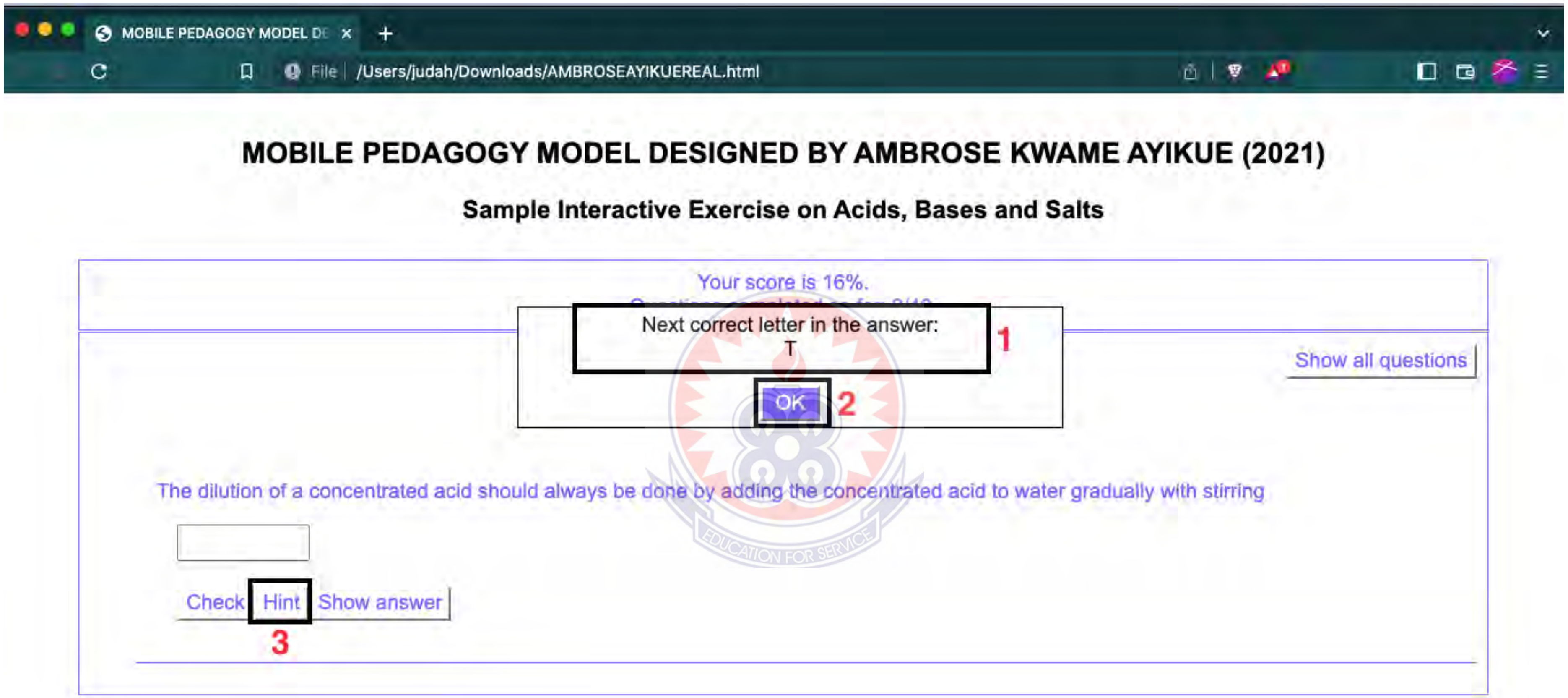
i. Item 1is the text box that learners are required to input their answer to the question.

ii. Click on Item 2 when you provided an answer to Item 1. It helps learners identify if they're on the right path of providing a correct answer.

iii. Item 3 is the Hint button; it gives the user a clue of the answer by providing a letter in the answer in a dialog box.

iv. Item 4 provides the learner with the right answer in a dialog box.

Hint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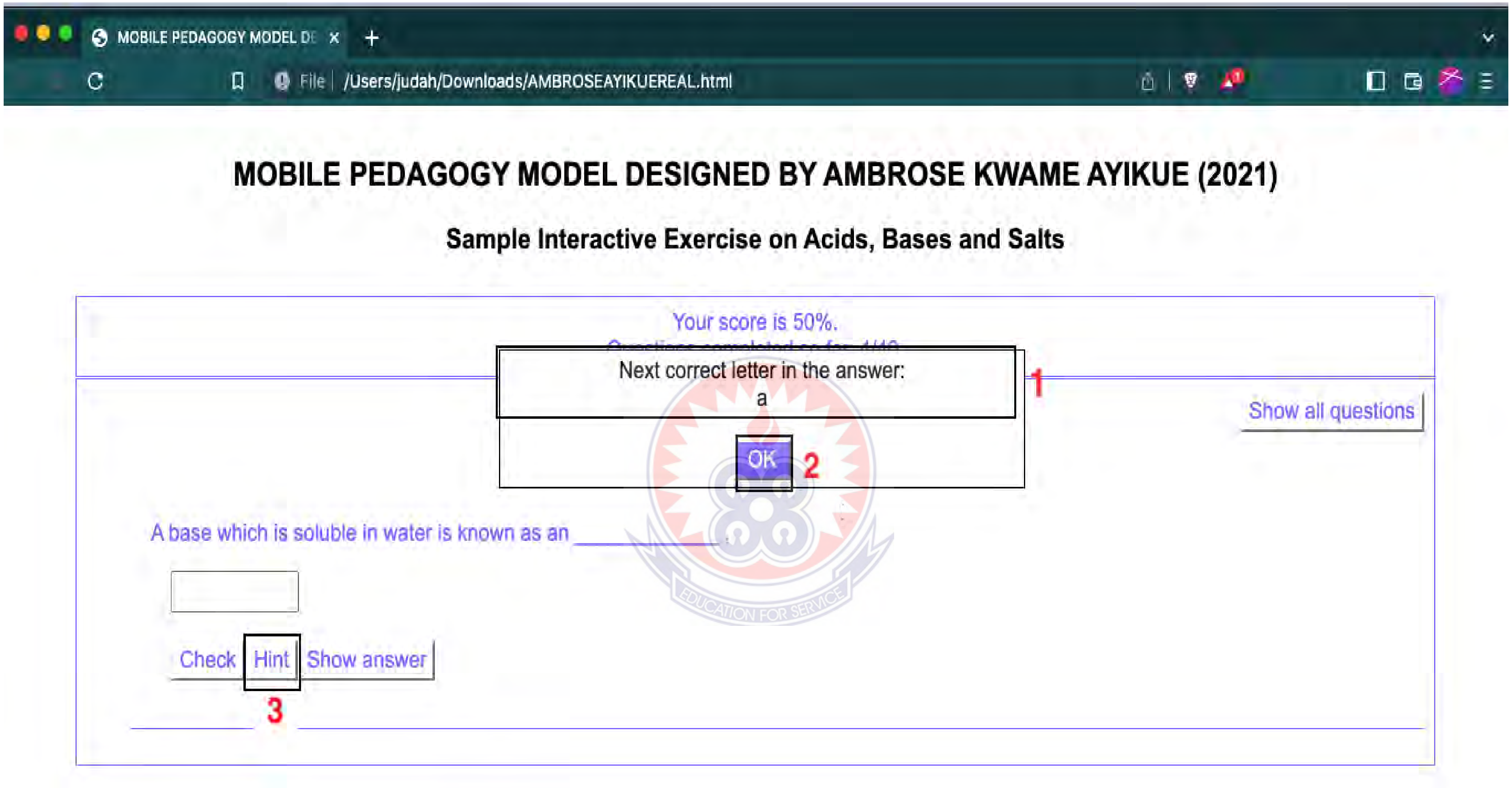
File /Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 16%.
Next correct letter in the answer:
T
1
OK
2
Show all questions
The dilution of a concentrated acid should always be done by adding the concentrated acid to water gradually with stirring
Check
Hint
Show answer
3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File
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 50%.
Next correct letter in the answer:
a
1
OK
2
Show all questions
A base which is soluble in water is known as an
Check
Hint
Show answer
3

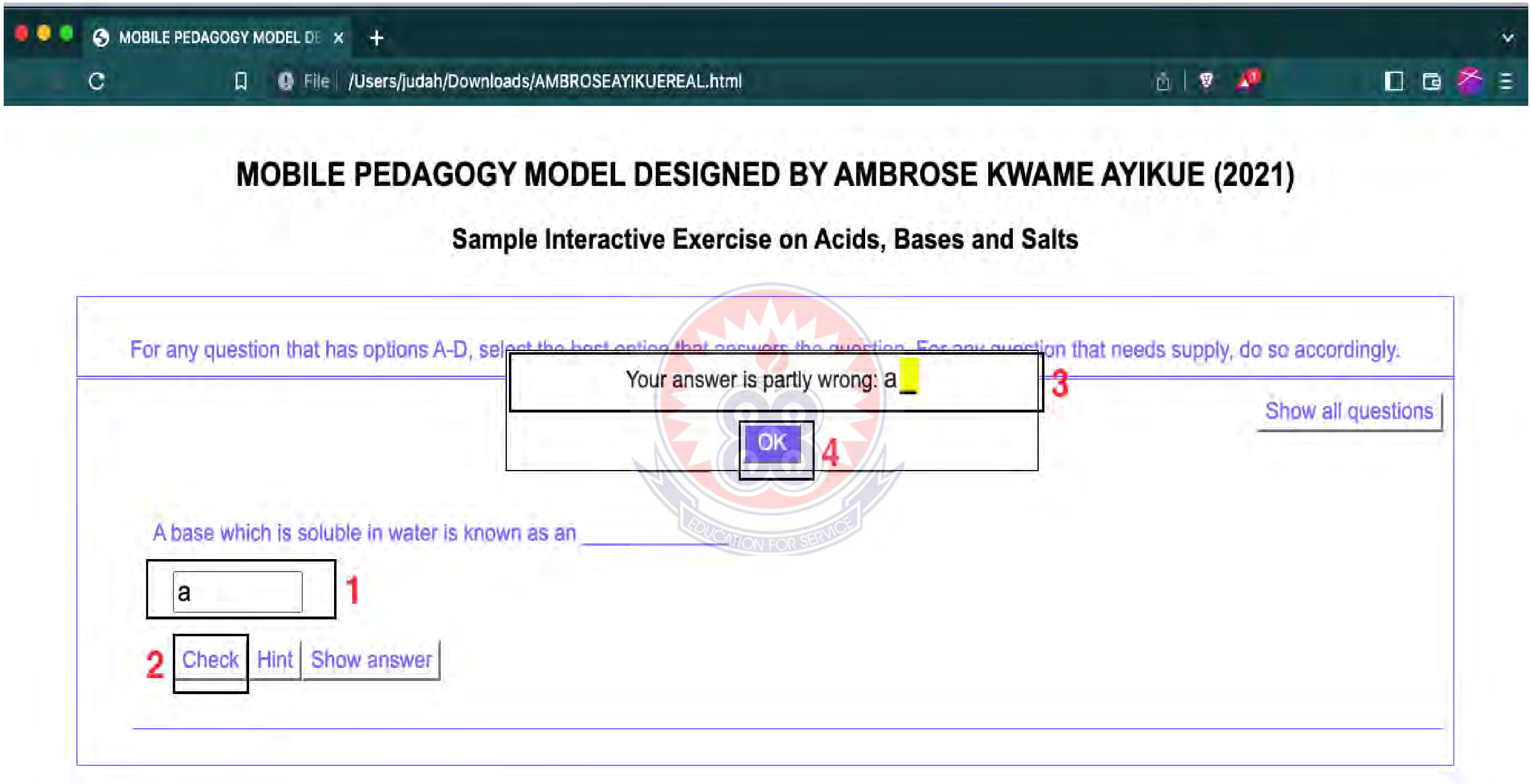
Description of Items on the Interface

i. Item 1 displays the next correct letter in the answer when the Hint button ―Item 3" is clicked.

ii. Item 2 closes the dialog box when clicked.

iii. Item 3 when clicked opens the dialog box ―Item 1" which suggests the next correct letter in the answer.

Check


MOBILE PEDAGOGY MODEL DE
File
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
For any question that has options A-D, select the best option that answers the question. For any question that needs supply, do so accordingly.
Your answer is partly wrong: a _
3
OK
4
Show all questions
A base which is soluble in water is known as an ______
a
1
2
Check
Hint
Show answer

Description of Items on the Interface

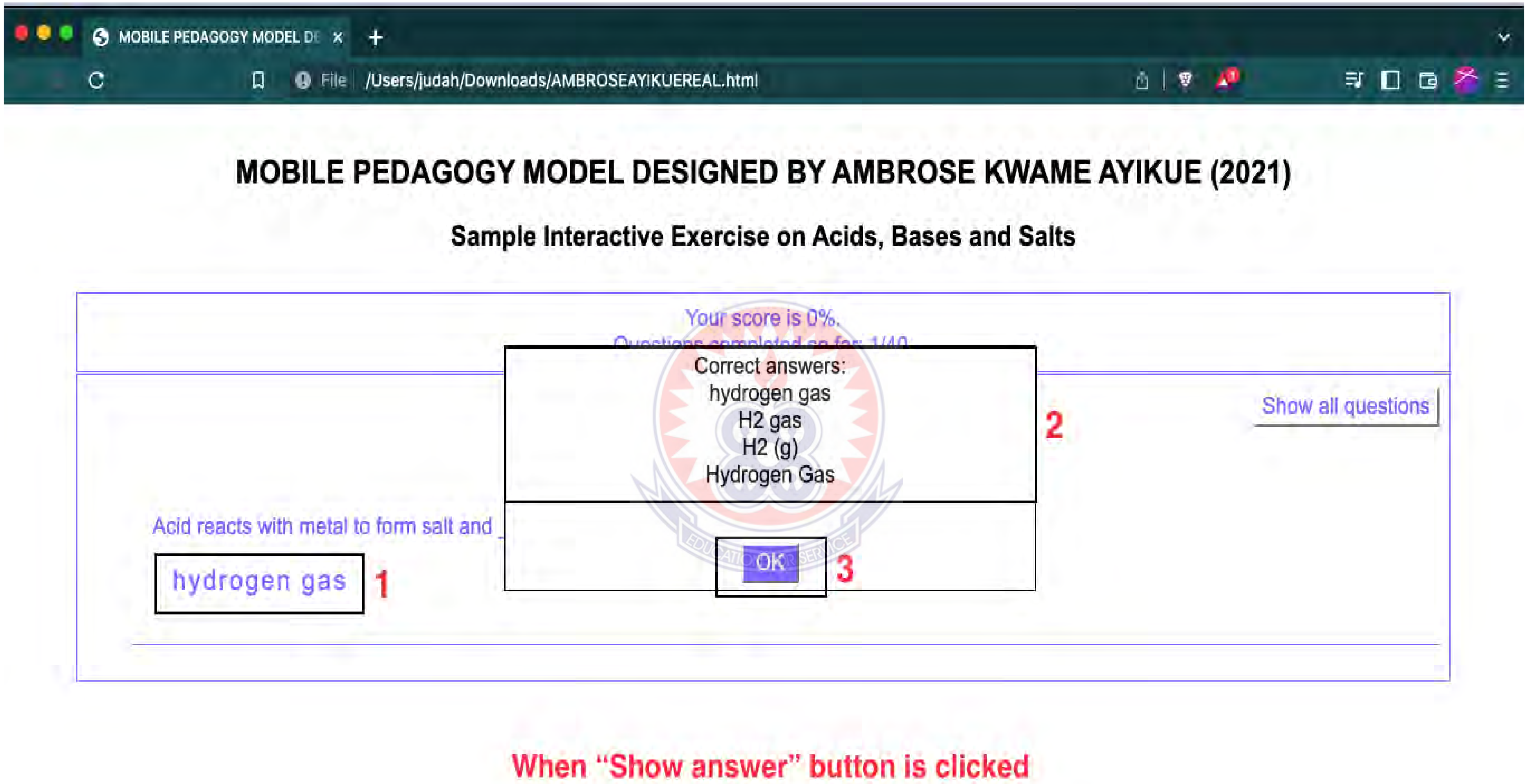
i. Input your answer the Item 1.

ii. Click on the Item 2 and it opens a dialog box that indicates whether you are right, partly wrong or wrong.

iii. Item 3 is the dialog box that indicates whether what was entered is right, partly wrong or wrong.

iv. Item 4 closes the dialog box when clicked.

Show Answer Button



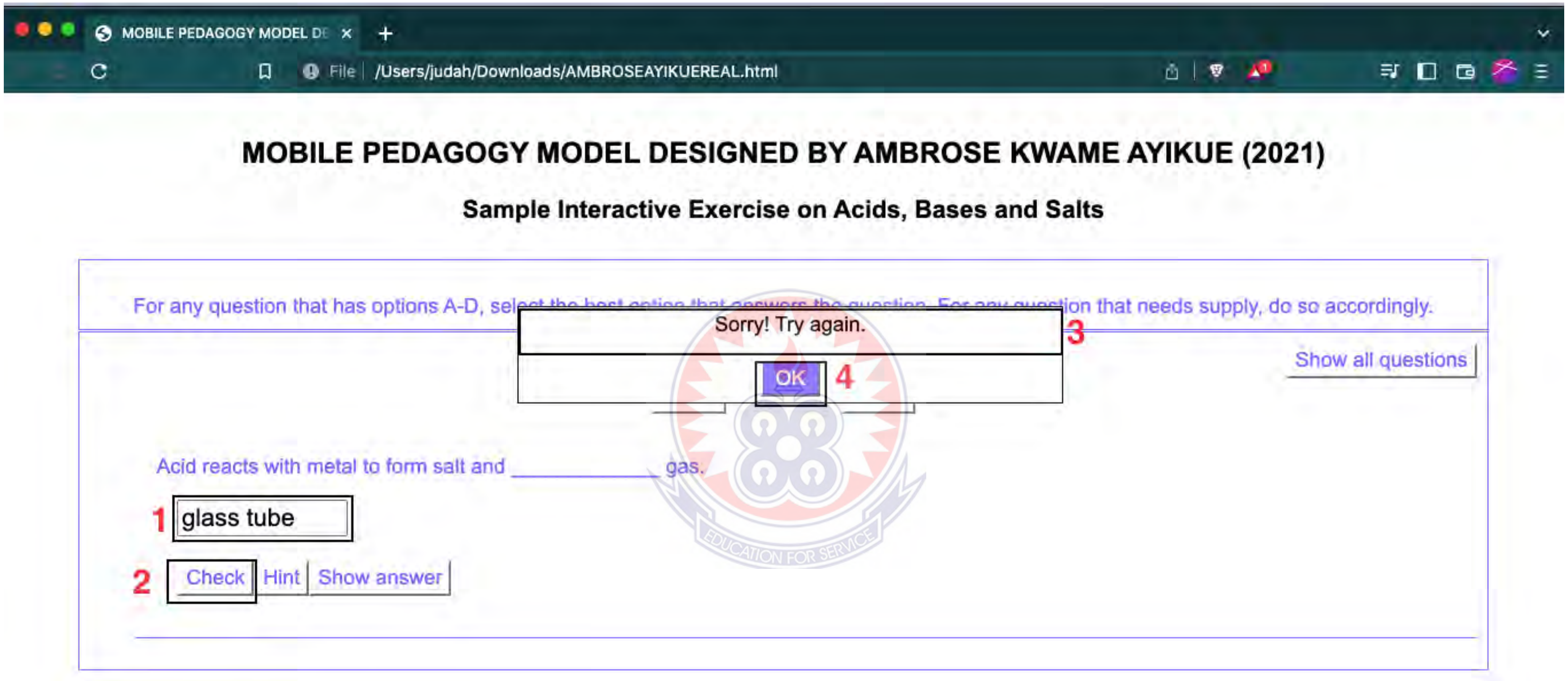
When the Show answer button is clicked:

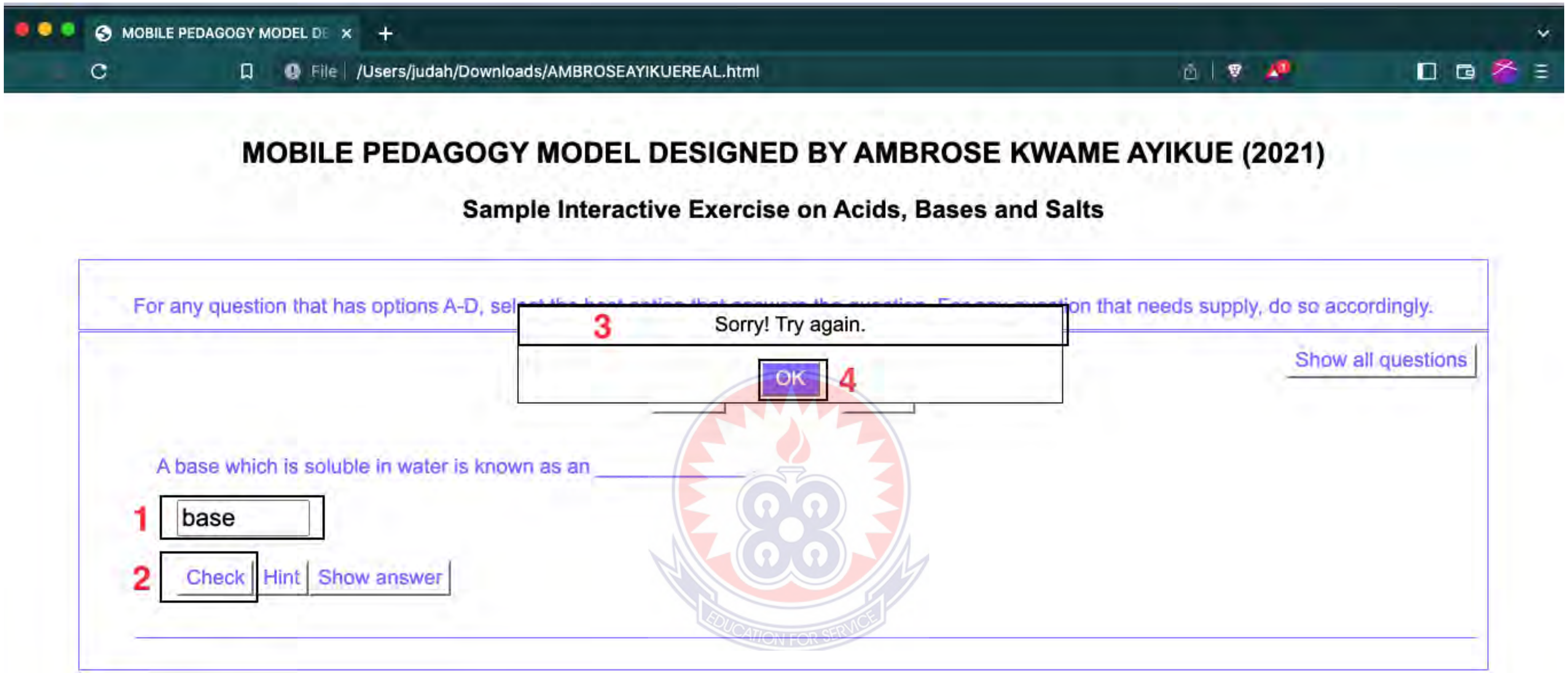
i. Item 1 displays the first answer in the right answer list.

ii. Item 2 displays a list of right answers the learner could have possibly provided.

iii. Item 3 closes the dialog box when clicked.

Wrong Answer

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File
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
For any question that has options A-D, sel
on that needs supply, do so accordingly.
3
Sorry! Try again.
OK
4
Show all questions
A base which is soluble in water is known as an
1
base
2
Check
Hint
Show answer

Description of Items on the Interface

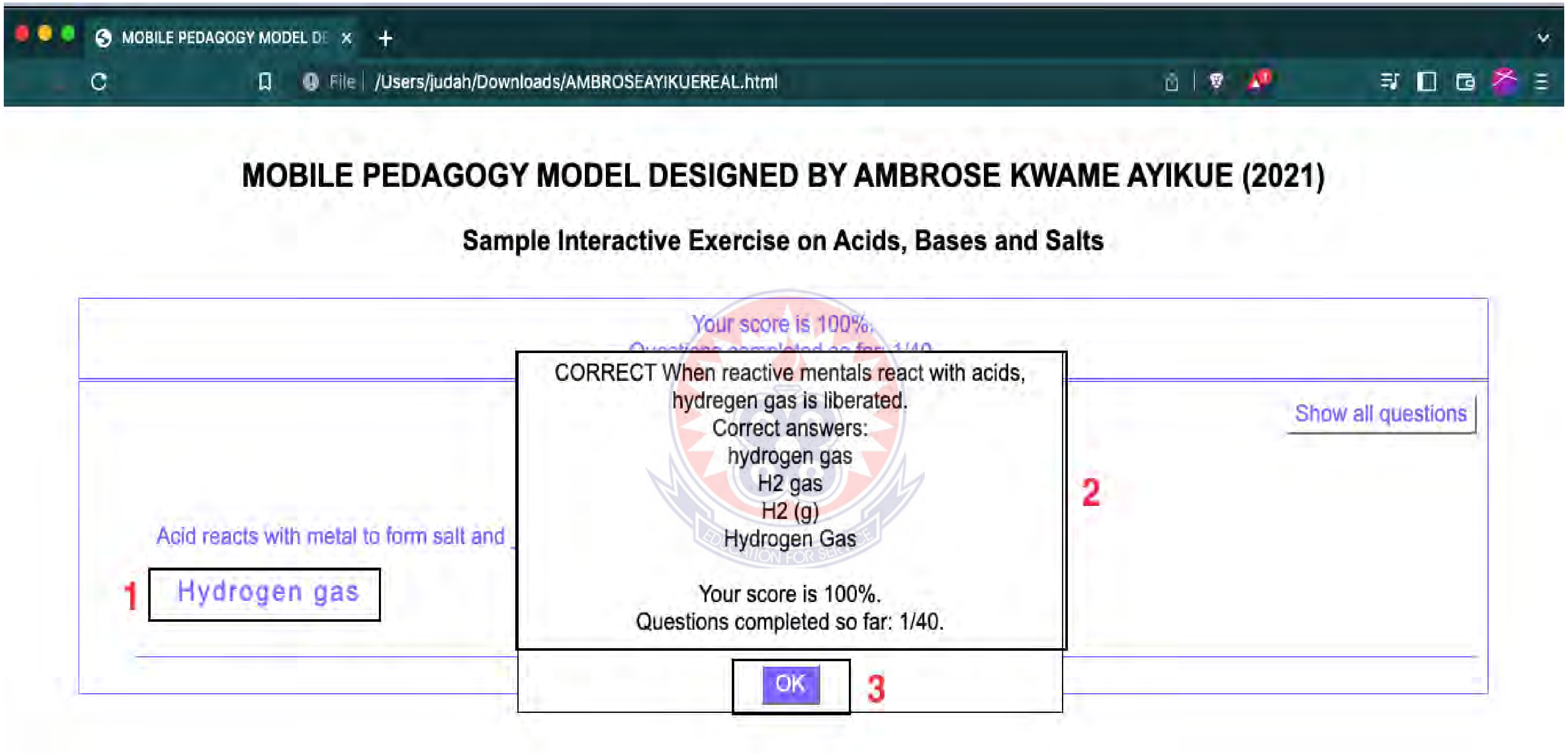
i. Item 1 receives the learner‘s input.

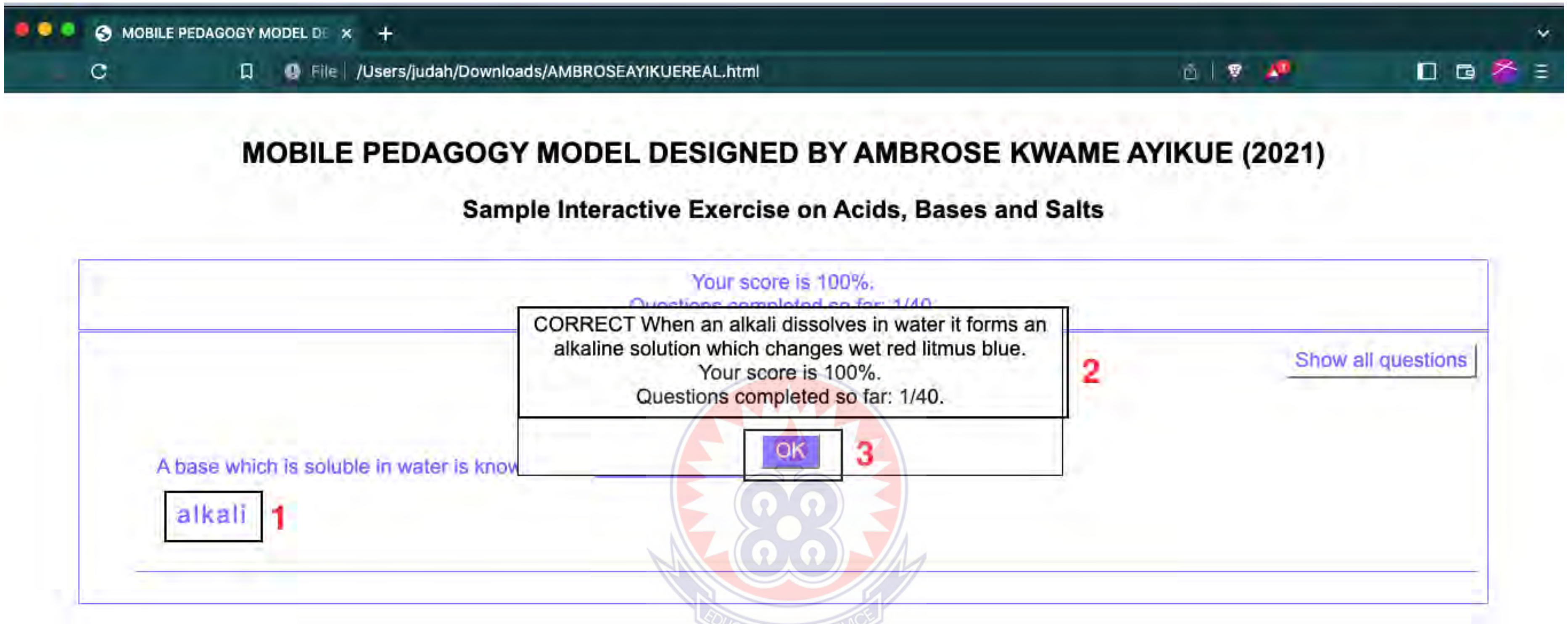
ii. Click Item 2 to check if the answer provided is right or wrong.

iii. Item 3 opens when Item 2 is click and if the answer is wrong it displays ―sorry! Try again".

iv. Item 3 closes the dialog box when clicked.

Right Answer




MOBILE PEDAGOGY MODEL DE
File | /Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 100%.
CORRECT When an alkali dissolves in water it forms an alkaline solution which changes wet red litmus blue.
Your score is 100%.
Questions completed so far: 1/40.
2
Show all questions
OK
3
A base which is soluble in water is know
alkali
1

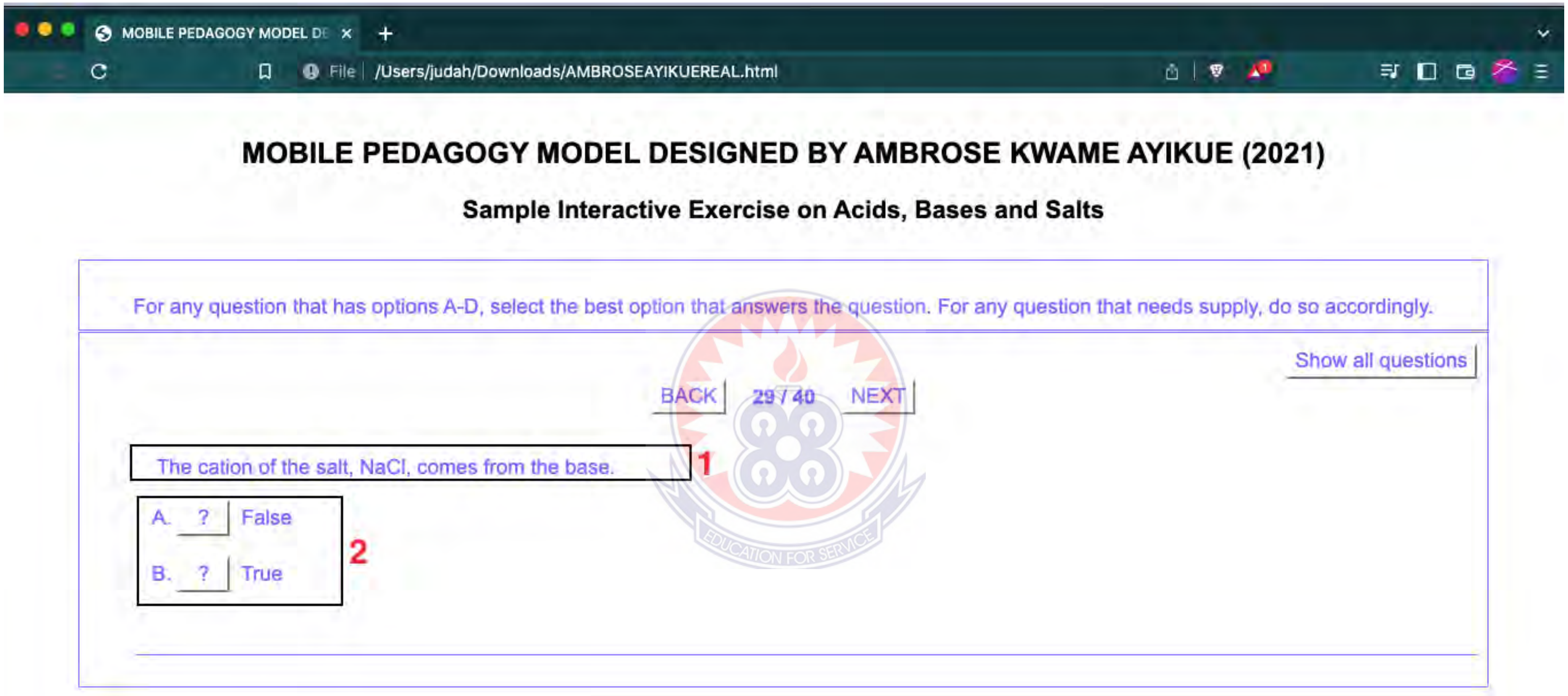
Description of Items on the Interface

i. Item 1 is the answer you entered in the text box.

ii. Item 2 pops-up and since the answer you entered is correct the dialog box displays ―Correct" and explains why it is so.

iii. Click Item 3 to close the dialog box.

TRUE OR FALSE QUESTIONS

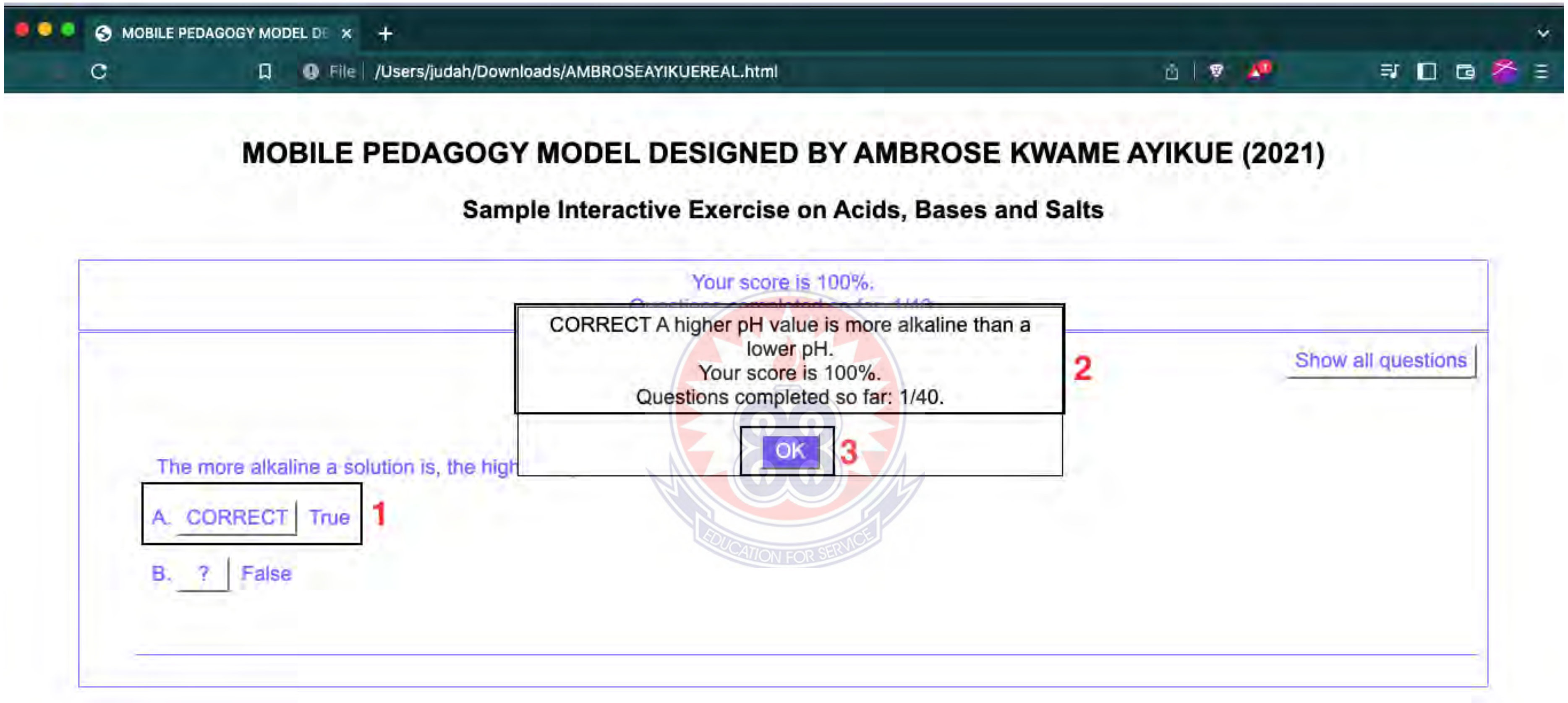


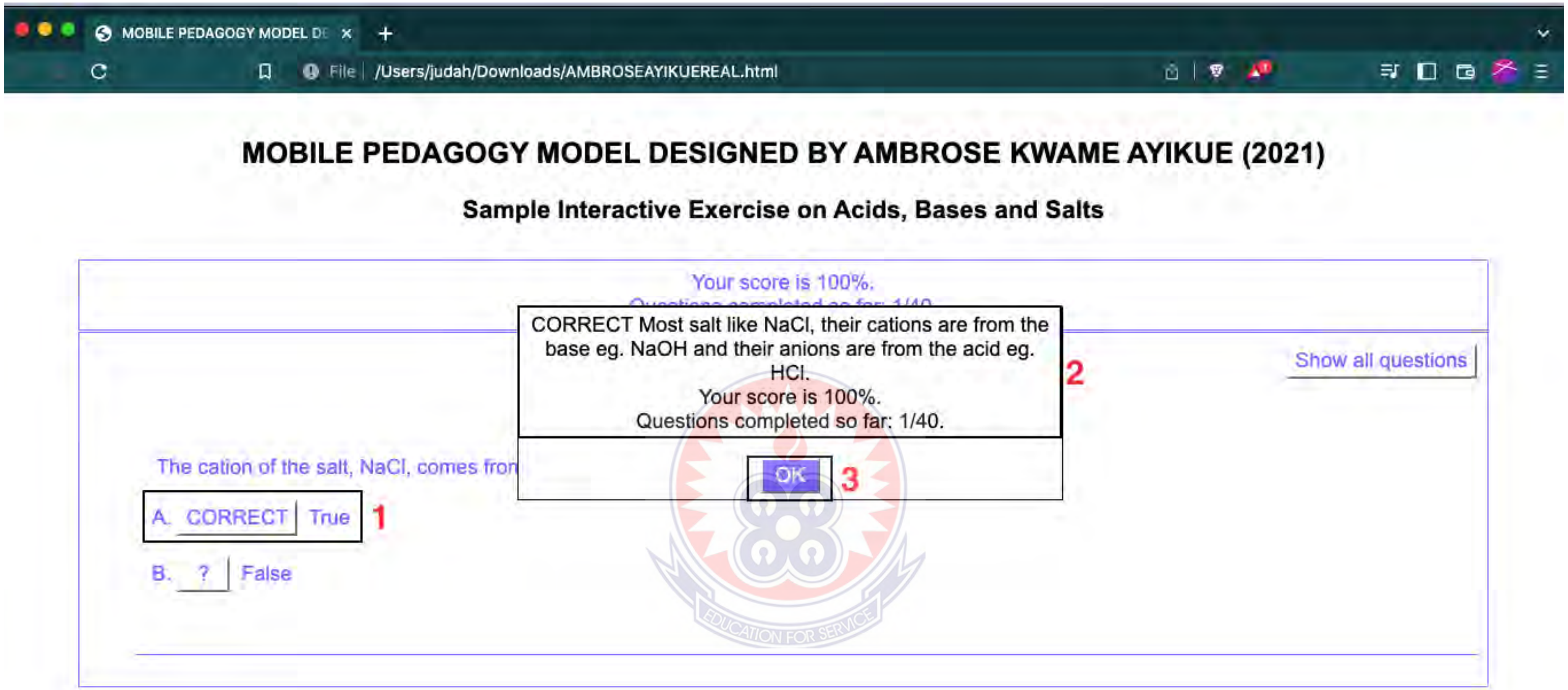
Description of Items on the Interface

i. Item 1 is the question presented to the learner.

ii. Item 2 are the options to select from.

Correct Answer

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File /Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 100%.
CORRECT Most salt like NaCl, their cations are from the base eg. NaOH and their anions are from the acid eg. HCl.
Your score is 100%.
Questions completed so far: 1/40.
2
OK
3
Show all questions
The cation of the salt, NaCl, comes fron
A. CORRECT True
1
B. ? False
EDUCATION FOR SERVICE

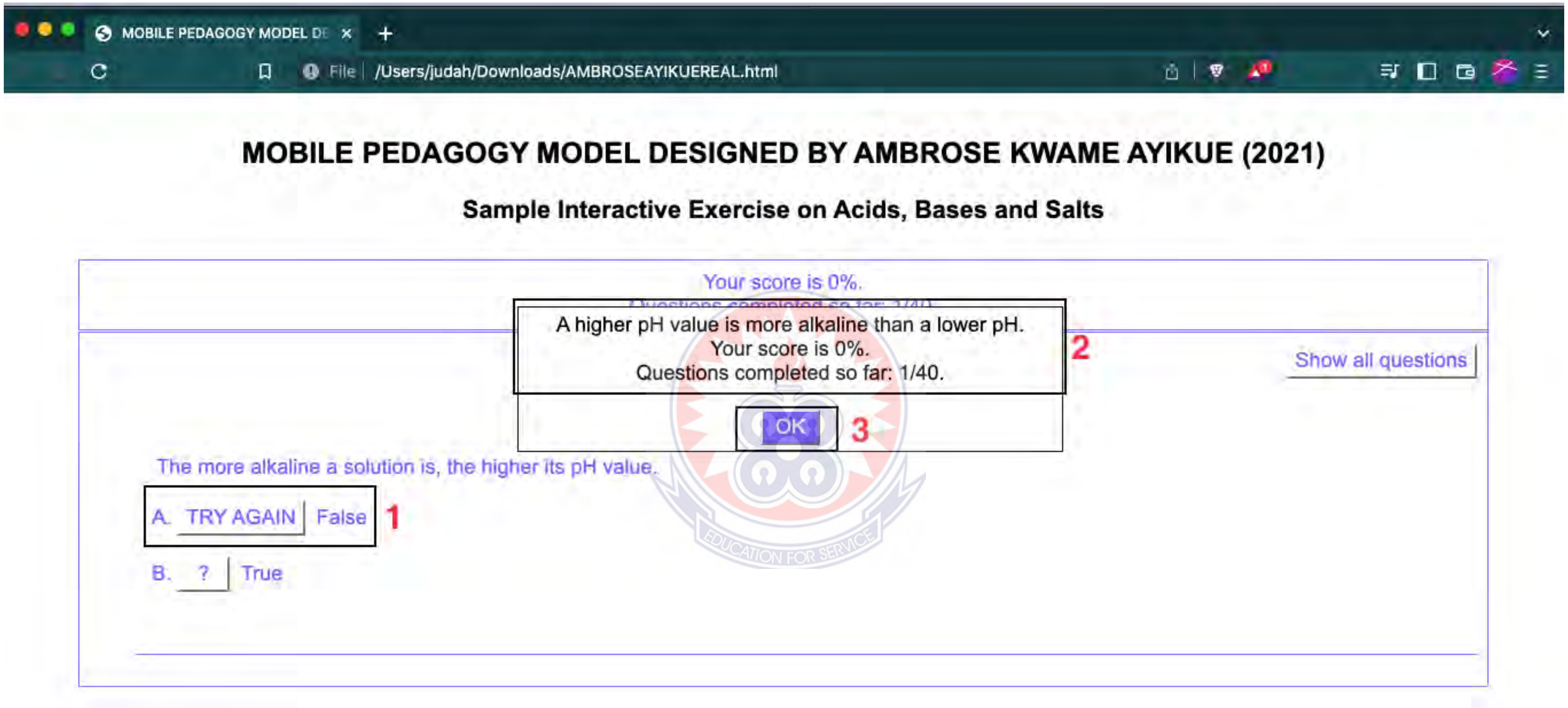
Description of Items on the Interface

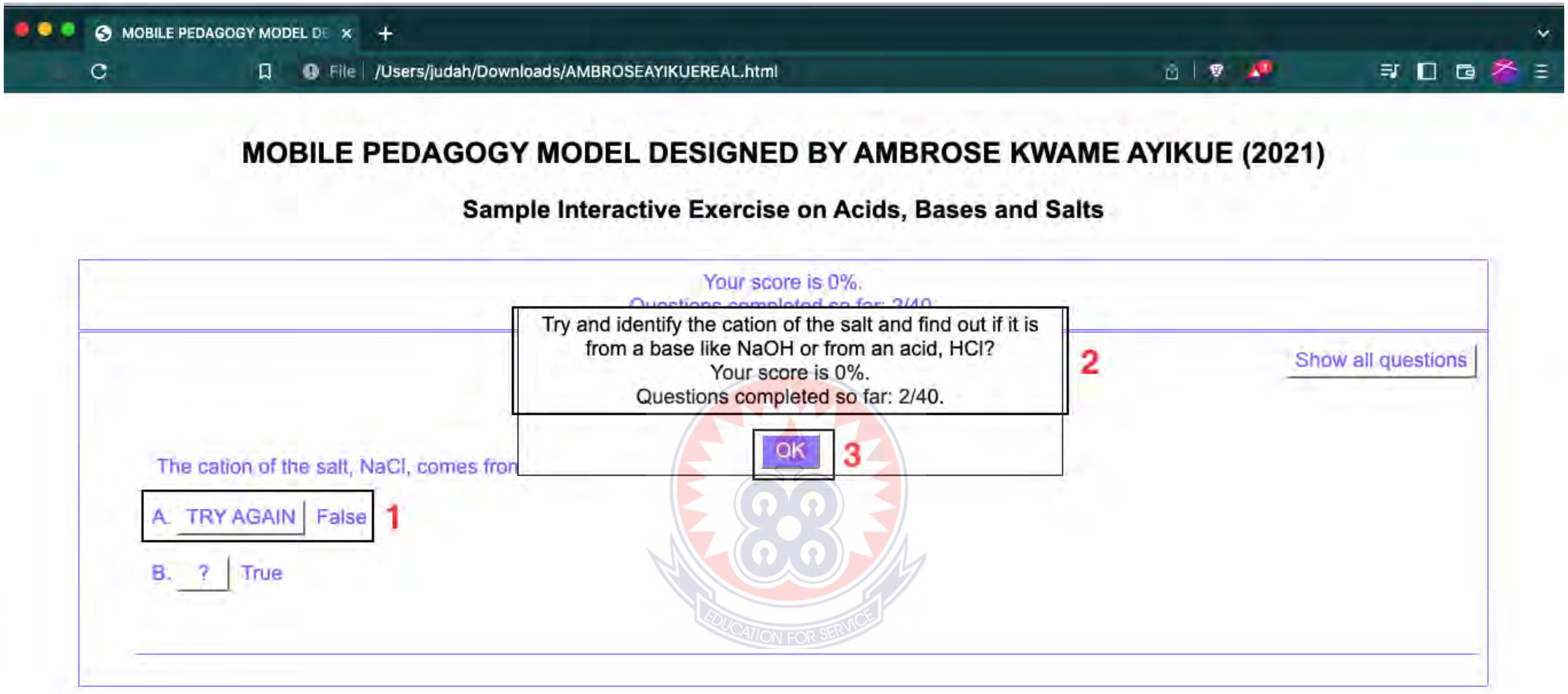
i. Item 1 is the selected answer from options provided and, in this case, ―True" was selected which is the correct answer hence, it is indicated by it.

ii. Item 2 pops-up when Item 1 is clicked and since the answer you selected is correct the dialog box displays ―Correct" and explains why it is so, with your score and the number of questions you have completed.

iii. Click on Item 3 to close the dialog box.

Wrong Answer




MOBILE PEDAGOGY MODEL DE
/Users/judah/Downloads/AMBROSEAYIKUEREAL.html
MOBILE PEDAGOGY MODEL DESIGNED BY AMBROSE KWAME AYIKUE (2021)
Sample Interactive Exercise on Acids, Bases and Salts
Your score is 0%.
Try and identify the cation of the salt and find out if it is from a base like NaOH or from an acid, HCl?
Your score is 0%.
Questions completed so far: 2/40.
2
OK
3
Show all questions
The cation of the salt, NaCl, comes fron
A. TRY AGAIN False
1
B. ? True

Description of Items on the Interface

i. Item 1 is the selected answer from options provided and in this case, the user selected False which is the wrong answer hence, it is indicated by it as ―try again".

ii. Item 2 pops-up when an answer is selected and, in this case, a wrong answer is selected hence the dialog box displays why it is incorrect, with your score and the number of questions you have completed.

iii. Click on Item 3 to close the dialog box.

APPENDIX M

SAMPLE UCC COURSE OUTLINE FOR LEVEL 100

COURSE TITLE: GENERAL CHEMISTRY THEORY I

COURSE CODE: EBS 115

COURSE OUTLINE

SPECIFIC CONTEXT ISSUES:

This course is mounted to equip year 1 student-teacher with basic concepts in in chemistry. The concepts are: the structure of the atom, arrangement of electron in an atom, amount of substances and the mole, acids, bases and salt; chemical bonding and the chemistry of carbon 1.

Course Title	General Chemistry Theory 1						
Course Code	EBS 115		Course Level: 100		Semester 2		Credit value: 2
Pre-requisite	**Student teachers have knowledge in** elective chemistry at the senior high school level.						
Course Delivery Modes	Face-to-face: [X]	Practical activity: [ ]	Work-Based Learning:[ ]	Seminars: [ ]	Independent Study: [X]	e-learning opportunities: [X]	Practicum: [ ]

Course Description for significant learning (indicate NTS, NTECF, BSC GLE to be addressed)	The general chemistry course covers some topics in physical chemistry. The course is for students who have studied elective chemistry at the senior high school level. The course is therefore intended to consolidate and expand on the content students have learnt. Topics studied in this course include the structure of the atom, arrangement of electron in an atom, amount of substances and the mole, acids, bases and salt; chemical bonding and the chemistry of carbon 1. NTECF, NTS 2c, pg.14, 3d,3f, 3i, 3j, 3k pgs.15, and 22	
Course Learning Outcomes	On successful completion of the course, student teachers will be able to:	Indicators
	CLO 1. Demonstrate knowledge and understanding of the concepts of the structure of the atom. **(NTECF, NTS 2c, pg14, 3d, pg15).**	Describe the structure of the atom in terms of : 1.1 proton, 1.2 neutron and 1.3 electron
	CLO 2. Demonstrate knowledge and understanding of the arrangement of electron in an atom. NTECF, NTS 2c, pg14, 3j, pg15).	2.1 Explain the principle that govern how electrons fill their orbitals. 2.2.Write electronic configuration of each of the first twenty elements of the periodic table using the guiding principles.
	CLO 3. Demonstrate knowledge and understanding of amount of substances and the mole concept. **NTECF, NTS 14c, 15i).**	3.1. Determine the amount of substances in aqueous solutions. 3.2 Calculate the number of moles of substances present in a solution of known concentration.

<table>
<tr><td rowspan="3"></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="3">CLO 4. Demonstrate understanding and knowledge in the concepts of acids, bases and salt. NTECF, NTS, 3d, pg15 & 3j, pg15).</td><td>4.1. Identify sources of acids, bases, salts
4.2. Use the pH scale to identify acids bases and neutral solutions.
4.3. Give practical example of what acids, bases and salts are used for in their daily life.</td></tr>
<tr><td colspan="3">CLO 5. Demonstrate knowledge and understanding of the concept of chemical bonding 1. (NTECF, NTS 2c pg14, 3i, pg15 &3k, pg 15).</td><td>5.1.Describe how covalent bond and an ionic bond are formed.
5.2. State the main difference between a covalent bond and an ionic bond.
5.3. Identify practical examples and uses of covalent and an ionic compounds in their daily lives.</td></tr>
<tr><td></td><td colspan="3">CLO 6: Demonstrate knowledge and understanding of the concepts of chemistry of carbon1. NTECF, NTS 2c, pg14, 3d, pg15 & 22).</td><td>6.1. State the types of hybridisation carbon atom can undergo.
6.2. Determine the empirical and molecular formulae of organic compounds.</td></tr>
<tr><td></td><td>Units</td><td>Topics:</td><td>Sub-topics (if any):</td><td>Teaching and learning activities to achieve learning outcomes:</td></tr>
<tr><td>Course Content: General Chemistry</td><td>1</td><td>The structure of the atom and the arrangement of electrons in the atom</td><td>- Dalton‘s Atomic theory and its limitations

- The contributions of J.J. Thompson, Rutherford and Bohr‟s towards the</td><td>Think-pair-share and running dictation to discuss and explain the basic rules and principle.
Animation and simulations of structure of the</td></tr>
</table>

Theory			development of atomic structure - Definition of the following terms: electron, protons, neutron number, atomic number, mass number and isotope - Arrangement of electrons in the main and sub-energy levels of an atom - Orbitals (shapes of *s, p* and d orbitals). - Rules and principles for filling in electron (Aufbau Principle, Hund‘s Rule of Maximum Multiplicity and Pauli Exclusion Principle). electronic configuration in terms of s, p, and d orbitals from hydrogen to zinc.	atom and how electrons are arranged in the main orbitals from YouTube and other online resources. Use game and songs/acronyms to learn about the 1st 20 elements and ‗Find someone who can‘ for the definitions.
	2	CHEMICAL BONDING 1.INTERATOMIC BONDING c. Ionic bond formation	b) Bond formation - Formation of Ionic Bonds, ionic compounds and properties - Lewis dot structures for simple ionic compounds	Using concept mapping to present the concepts (being mindful of equity and inclusivity) Using individual and group presentations (being mindful of gender roles). Videos and animations from known science education sites online.

		• Covalent character in ionic bond. • Name and chemical formulae for simple ionic compounds d. COVALENT BOND FORMATION • Lewis dot structures for some covalent	- Factors that influence the formation of ionic bond.(ionization energy, electronegativity, lattice energy) - Covalent character in ionic bond. -Name some binary and ternary ionic compounds from their formulae - Names and chemical formulae for simple ionic compounds including those that contain the polyatomic ions, ammonium, hydroxide, trioxocarbonate(IV), trioxonitrate(V), tetraoxophosphate(V), tetraoxosulphate(VI) and trioxochlorate(V). - Covalent Bonding and properties - Formation of covalent bonds involving same and different atoms. - Polar and non-polar covalent bonds - Dipole moments - Lewis formulas for molecules and polyatomic ions.	Questions and answers technique can also be employed where appropriate.

		compounds. • Polar covalent bonds • Properties of covalent compounds c. METALLIC BOND FORMATION. • The properties of metals	- Ionic character (polarity) in covalent bonds based on electronegativity difference between the species involved. - .Discuss properties of covalent compounds under ➢ solubility in polar and non-polar solvents ➢ melting point ➢ boiling point ➢ electrical conductivity - Characteristics of the atoms and groups involved in the formation of metallic bond. - the formation of metallic bond. - Factors influencing the formation of metallic bond and how the factors relate to the hardness and softness of metals	

		2. INTER-MOLECULAR BONDING Types of intermolecular forces in covalent compounds. Hydrogen bond Van de Waals • Hybridization and Shapes of Molecules	- Properties of metals. e.g □ heat and electrical conductivity □ hardness □ ductility □ malleability □ lustre □ sonority The different types of intermolecular forces in covalent compounds. Include: □ Hydrogen bond □ Van der Waal"s forces The structures of the following molecules ; H_2O, H_2S, NH_3 ,CH_4 - Formation of hydrogen bond. - The effect of hydrogen bonding on the properties of compounds (e.g. H_2O and H_2S) Van de Waals forces between and within covalent molecules. ➢ Dipole-dipole ➢ dipole-induced dipole forces	

		Formation of sigma and pi-bonds. Shapes of molecular compounds	➢ ion-dipole forces Meaning of the term Hybridization. Hybridization of atomic orbitals. sp, sp^2, sp^3, sp^3d^2 orbitals The procedures for hybridizing atomic orbitals. - Formation of sp, sp^2, sp^3, sp^3d^2 hybrid atomic orbitals using carbon atom as an example. - Sketch the shapes of sp, sp^2 and sp^3 and sp^3d^2 hybrid orbitals using the following molecules: □ CH_4, NH_3, H_2O, , $CH \equiv CH$ □ BCl_3 , $H_2C = CH_2$	
	3	AMOUNT OF SUBSTANCE AND THE MOLE Chemical formulae and chemical equations	g) Relative atomic mass , A_r h) Relative molecular mass, M_r i) The mole and molar quantities j) Quantity of solute in solution and preparation of solutions k) Chemical formulae of molecules and ionic compounds l) Naming of inorganic compounds	Using individual and group presentations Videos and animations from known science education sites online. Questions and answers technique can also be employed where appropriate (being mindful of equity and inclusivity).

			(binary compounds, ions, base and salts) Chemical equations and mole ratios (writing and balancing chemical equations)	
	4	ACIDS BASES AND SALTS	Sources and classification of acids, bases and salts Arrhenius, Bronsted- Lowry and Lewis acids and bases Physical and chemical properties of acids and bases: Provide examples of processes and products that use knowledge of acid and base chemistry, e.g. (1) air pollution analysis (2) food and beverage analysis (3) water quality and environmental analysis (4) in the soap industry (5) acidity of edible oils (6) analysis of antacids Classification of acids and bases: Strength of acids and bases (strong acids and weak aids and alkalis) pH scale and Universal indicator.	Using concept mapping and cartooning for illustrating and discussing the concepts of acids, bases and salts. Using individual and group presentations Using ‗spider web' as a strategy to present the classification of acids and bases. Videos and whole class discussion can be used for presenting the concept on pH scale and titration.

		Preparation of standard	pH as a measure of acidity and alkalinity. Buffer Solutions Acid-Base indicators Correct use of relevant apparatus. Knowledge of how acid-base indicators work in titrations. Acid-base titration: Calculations involving Molarity i. Tests for Acids and Bases using indicators. ii. Preparation of indicators from flowers. iii. Practical knowledge of how various acid-base indicators work in titration. iv. Preparation of acid solutions (e.g. HCI, H2SO4) of known concentration.	

		solutions Determination of concentrations of solution Volumetric analysis	v. Preparation of alkalis (e.g. NaOH) vi. Preparation of salts solutions (e.g. Na2CO3) NaHCO3 etc.) vii. Known concentrations must be expressed in various units. e.g. 0.2M NaOH Solution: 2% NaCl (w/w and w/v solution) etc. viii. Dilution of solutions of known concentration to obtain other concentrations. ix. Titration involving weak acids and strong bases and strong acids versus strong bases using appropriate indicators and their applications in quantitative determination of concentration. x. Definitions and calculations xi. Double indicator and back titrations Calculations	
	5	THE CHEMISTRY OF CARBON 1 • Tetravalent nature of carbon.	Bonding and type of hybridization in Carbon (hybrid orbital e.g. sp, sp^2 and sp^3 and discuss sigma and pi-bond formation)	Videos and animations from known science education sites online. Running dictation can be used to present the tetravalent nature of carbon and classification

		• Definition and classification of organic compounds. • Components of organic compounds	Define organic compounds Classification of the following Organic Compounds: iii. hydrocarbons (aliphatic and aromatic hydrocarbons) iv. functional group compounds (alcohols, carbonyls, carboxylic acids, ester and amines) Discuss and demonstrate the experimental Identification determination of the elements: C, H, O, N, S and halogens in a given organic compound. Use of a given data to determine the empirical and molecular formulae of organic compounds.	of organic compounds. Group work, discussions and presentations as teaching strategies will be used for Components of organic compounds (being mindful of equity and inclusivity) •
Course Assessment (Educative assessment: of, for and as learning)	**Component 1**: Formative assessment (individual and group presentation) Summary of Assessment Method: Individual and group presentations on i) Intermolecular bonding, ii) Ar, Mr, iii) classification of acids, iv) bases and v) components of organic compounds (core skills to be developed: , digital literacy, respect for diversity, critical thinking, collaboration and communicative skills,) Weighting: 20% Assesses Learning Outcomes: CLO 1 and 2 (units 1 & 2)			
Component 2: Formative assessment (Quizzes and Exercises) Summary of Assessment Method: Quiz on atomic structure and periodicity (core skills to be developed: critical thinking and personal				

<table>
<tr><td colspan="2">development)
Weighting: 20%
Assesses Learning Outcomes: CLO 3 and 4 (unit 3 and 4)</td></tr>
<tr><td colspan="2">Component 3: Summative assessment
Summary of Assessment Method: End of semester examination on units 1 to 6 (core skills to be developed: critical thinking, personal development)
Weighting: 60%
Assesses Learning Outcomes: CLO 1-6</td></tr>
<tr><td colspan="2">4. Periodic Tables
5. Projectors and computers
6. Audio-visuals and animations from YouTube</td></tr>
<tr><td>Required references</td><td>Abbey, T.K., Ameyibor, K., Essiah, J.W., Nyavor, C.B., Seddoh, S. & Wiredu M.B. (1995).GAST Science for senior secondary school. London: Unimax Publishers Limited

Ameyibor, K., &Wiredu M. B. (1991).GAST chemistry for senior secondary school. London: Macmillan Education Limited.

Chang, R. (2003). General chemistry: The essential concepts. (3rd ed.). Boston: McGraw Hill.</td></tr>
<tr><td>Additional Reading List</td><td>Gallagher, R. & Ingram, P. (1987).Chemistry made clear. Oxford: Oxford University Press.

Ohia, G.N.C., Amasiatu, G.I., &Ajagbe, J.O. (2005).Comprehensive certificate chemistry. Ibadan: University Press PLC.

Whitten, K.W., Davis, R.E., & Peack M.L. (2000) General Chemistry. (6th ed.). Fort Worth: Saunders College Publishing.</td></tr>
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