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Students' attitudes towards learning chemistry using mobile phone simulations: a case of two secondary schools in Dar es salaam Region.

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STUDENTS' ATTITUDES TOWARDS LEARNING CHEMISTRY USING MOBILE PHONE SIMULATIONS: A CASE OF TWO SECONDARY SCHOOLS IN DAR ES SALAAM REGION.

BY

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APPROVAL PAGE

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I hereby give my permission for the research project of the above –named student, for whom I have been acting as a supervisor, to proceed to the examination

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The members of the Research Project Evaluation Committee appointed to examine the research project of the above named student find it satisfactory and recommended that it be accepted

(Internal Examiner)

DATE 31-05-2022

DEDICATION

To Allah Subhanahu wa ta’ala

To my lovely son, FAREED AHMED

For his Patience and Understanding at such a young age. May Allah S.W. grant him good health, continuity in excelling in his academic life and bless his growth physically and spiritually.

To my late mother, ANNIECYNTHIA MWAKATOBE

I believe you are in a dignified place; you always encourage us to work hard and live our dreams. This work is my dedication to you. Rest in peace my beloved MOTHER.

To my brother, ABUBAKAR NYENGA

For your Love and Support

To all those who have been praying for me

May God bless you all

ABSTRACT

Students' attitudes have significant influence on their academic achievement in life. While at a younger age, they show keen interest towards scientific concepts, they grew in teenage years with a declining curiosity and will to take up science subjects. This has been due to abstract content overload for which a student needs sequential understanding as new concepts are built on older ones. Although technology has presented us with simulation applications in mobile phones, which would bring back the exciting nature of learning that children experienced with toys and video games at a tender age, efforts in terms of studies to transform students' attitudes towards learning chemistry subject are not significant in Tanzanian context. This study aimed at investigating Students Attitudes towards learning Chemistry using Mobile Phone simulations. A total of 106 participants from two schools participated in Concurrent Mixed methods study, where by data was collected using a number of tools ranging from self-administered Pre and Post Questionnaire, Pre and Post focused Group (FGD)discussions conducted on a total of 104 students and Pre and Post Interview sessions with the two (2) teachers from respective schools. Quantitative Data was presented using Descriptive statistics while recorded qualitative data was transcribed and patterns identified. Statistical analysis was done using Statistical Package for Social Science(SPSS).

Findings from survey questionnaires showed that students' attitudes are significantly influenced or affected by the usage of mobile phone simulation in Teaching and learning chemistry. Moreover, students displayed lower level of interest and negative attitudes towards learning via the existing Traditional methods. Similarly, FGD results showed students' attitudes improve with usage of mobile simulation applications, and teachers too showed a significant interest towards moving to simulated learning and usage of mobile phone simulations in teaching. The study recommends school management team to develop an integrated ICT policy that demands full involvement of technological facilities in teaching and learning, and encouraging teachers to be innovative in coming up with tools that can improve learning experiences in students. Curriculum developers should consider embedding mobile-based simulation learning in chemistry subject as it helps improving students' attitudes.

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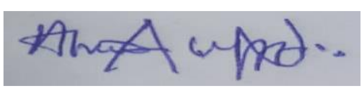
The proof reading of this work would not be possible without interminable effort of my fellow course mates Mr. Abdallah Magongo, Mabonga Geofrey, Tumweboneire Saulo and Edda Kamau all of whom I owe much appreciation.

Finally, I appreciate all those whose names have not been mentioned here, but have contributed to the success of this work. Thank you so much, may God bless you all.

DECLARATION OF ORIGINALITY

I, Ahmed Mbaruku Nyenga declare that this dissertation is my own work. It represents my own efforts and has not been taken in whole or in part, without reference to whom or from where the information was obtained.



Signature: ____________________________ Date: 7th January 2022

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ACRONYMS AND ABBREVIATIONS

BYOD =BRING YOUR OWN DEVICE

S = ST. ANNEMARIE SECONDARY SCHOOL

F = FEZA INTERNATIONAL SCHOOL

GSM = GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

GSMA = GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS ASSOCIATION

SPSS = STATISTICAL PACKAGE FOR SOCIAL SCIENCES

MHz = MEGA HERTZ

MoEVT = Ministry of Education and Vocational Training

SIDA = Swedish International Development Agency

CoICT = College of Information and Communication Technologies

FGD = FOCUSED GROUP DISCUSSION

CAS = Chemistry Attitudes Scale

TOSRA = Test of Science Related Attitude

PhET = PHYSICS EDUCATION TECHNOLOGY

Chem Lab = Chemistry Laboratory

N = total number of participants

AR = AUGMENTED REALITY

AMs =ALVEOLAR MACROPHAGES

$PM_{2.5}$ = SIZE OF DUST PARTICLES

PCK = PEDAGOGICAL CONTENT KNOWLEDGE

TPK= TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE

TCK= TECHNOLOGICAL CONTENT KNOWLEGDE

TK= TECHNOLOGICAL KNOWLEDGE

PK= PEDAGOGICAL KNOWLEDGE

CK= CONTENT KNOWLEDGE

TPACK=TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

ICT = INFORMATION COMMUNICATION TECHNOLOGY

AKU IED = AGA KHAN UNIVERSITY INSTITUTE OF EDUCATION

VSEPR = VALENCE SHELL ELECTRON PAIR REPULSION THEORY

CHAPTER ONE

1.1 Introduction

The present study examined students' attitudes towards learning chemistry using mobile phone simulations. The main intension was to find out how students feel or perceive the learning process when it is done using mobile phones simulations. This chapter presents background of the problem, statement of the problem, general objectives, specific objectives of the study, research questions, significance of the study, scope of the study, definitions of terms and abbreviations.

1.2 Background and Context of the Study

The natural sciences are present throughout the educational process of all students, who seem to show particular curiosity and positive attitudes for these disciplines during their early years of schooling. However, these favorable attitudes growing at an early age do not persist for long in a student's time at school (Montes et al., 2018). They in fact tend to decrease, and in the case of chemistry, there is a gradual loss of interest in the subject, accompanied by feelings of boredom, rejection, and experiences of failure of scoring good grades (Potvin & Hasni, 2014). Indeed, the learning of chemistry is becoming less attractive for children and young students, which has a direct influence on the understanding of key concepts associated with the discipline, and consequently their attitudinal changes (McClary & Bretz, 2019).

Students' negative attitudes toward learning chemistry subject was also stated as the cause of low enrolment in the subject which form central part of science combinations, and therefore contributing to lower number of students pursuing science based disciplines (Eusebius, 2016). Gradual loss of interest in chemistry as stated previously comes out of difficulties students face while learning the subject. However, Mango (2015) asserted that students' lack of interest diminishes when they are told to use digital devices such as computer, iPads and mobile phones to tackle similar difficulties. They in fact show high level of engagement while working with mobile phones in particular (Ahmad, 2020). In Sweden, the one mobile phone per one child project has led to high academic achievements and positive attitudes towards learning science subjects. Additionally, students express their mobile phone as a tool in their learning (Ott et al., 2018).

Moreover, handset prices have dropped meanwhile studies across a range of African countries indicate that even in remote rural areas, young people have access to mobile phones, even if they do not own for themselves. An increasing number of these phones are smart phones, particularly in urban centers (Porter et al., 2016; Swarts & Wachira, 2010). This creates obvious possibilities for their use in education. Lack of adequate traditional landline communication infrastructures is encouraging policy makers and educators to consider using mobile phones in learning. Charging mobile phones depends only on occasional electricity supply, something increasingly possible with solar power, rather than the large and constant power supply required by computers. More positively, learning by mobile phone can be personal, unobtrusive and spontaneous (Traxler & Kukulska-Hulme, 2012) in addition to their portability, affordability, accessibility, operability and applicability as stated by Kafyulilo (2014).

In Tanzania, it has been found that students, pre-service teachers and college instructors are all in favor of mobile phone usage for learning in educational settings, although the majority of in-service teachers are opposing the use of mobile phones for learning in schools (Kafyulilo, 2014). Recommendations are therefore given for these in service teachers to be enrolled in professional development programs that would help them have a wide understanding on how manageable, how available and how accessible the mobile phones are to their learning community and how that can be turned to an opportunity to teach effectively. Moreover, in depth investigation is therefore recommended to find out why these in service teachers are seemingly reluctant on usage of mobile phones and ICT facilities as a whole. Exploring their willingness, confidence, motivation, feelings, beliefs and background can therefore lead to answers on why they do not support mobile phone usage in their classrooms (Ndibalema, 2014). A survey report based on ICT usage in education for 53 countries in Africa, including Tanzania indicated that for a developing nation like Tanzania where there is unreliable supply of electricity, lack of skilled ICT teachers (Hare, 2007) as well as lack of ICT tools in schools (Kafyulilo, 2010), mobile phones can be a better replacement in teaching and learning as they are more accessible to teachers and students, being owned by the majority of teachers and an average of 60 % of students.

1.3 Statement of the Problem

Research evidence shows that students' attitudes towards learning chemistry improve when they are allowed to use mobile phone simulations (Mango, 2015). Additionally, positive attitudes towards chemistry have been proved to lead to a better achievement in chemistry (Benny & Blonder, 2018; A. Kahveci, 2015; M. Kahveci, 2015; Xu et al., 2013). Studies have shown that students are highly interested in digital devices for playing or learning puzzles or simulations (Mango, 2015). In an experimental study on effectiveness of simulations for chemistry learning showed that a sequential application of mobile simulations on experimental group has led to more effective understanding to students as compared to a control group for which students were taught without mobile simulations (Plass et al., 2012). It was found that animated images in simulations transform abstract idea into concrete images, thus improving the understanding and their attitudes. This also enhances and stimulates the cognitive thinking of learners and at the same time relates the basic concept of science with their real life experiences (Staley, 2015). Kousa et al. (2018) assert that the most preferred teaching method to improve the low achieving students' attitudes towards learning chemistry is through the use of video games which students can learn from the comfort of the mobile phones. And since attitudes influence academic achievement of students (Ozel et al., 2013), it is imperative that teachers make their lessons more involving, enjoyable and exciting which can be achieved through letting students use their mobile phone simulations under guidance. This is important as attitudes tend to decline over time with continuous buildup of abstract ideas over each other (Metsämuuronen, 2012; Potvin & Hasni, 2014).

Negative attitudes towards chemistry subject still persist in students because they are facing challenges which have not yet been resolved. These difficulties are largely centered at the ability to interact with abstract nature of chemistry concepts at both micro and macroscopic levels of thoughts (Watts, 2018). It is now time, especially with COVID 19 situation, and with the introduction of Competency Based Curriculum that teachers can consider using mobile phone simulators which are learner centered, hence in line with the new curriculum, to improve their students' attitudes (Ali, 2020).

Although a large number of studies have been done around the area of education simulation, there are very few studies linking students attitudes with learning methodologies involved in chemistry (A. Kahveci, 2015; M. Kahveci, 2015). No focus has been paid on the significance or to what extent is the use of simulations via mobile phones help improving students' attitudes towards chemistry subject, owing to its vital role in science subjects combinations pursued by students. Having identified this gap in knowledge, the researcher looks forward to using his study in transforming the attitudes of students towards learning chemistry.

1.4 Significance of the study

Research in educational technology indicates that students learn efficiently when introduced to technology at the earliest stage of their educational life. Egyptian teachers have been using M S photo story telling applications as a way to help students learn through images which summarize contents studied but also in linking events or processes described while learning, this has started right from nursery school levels (Sadik, 2008). Cognitive development in children as stated by Piaget (1964), takes place through interaction of instinctive capacities and the environment or the exposure, and this is because simulated learning give students opportunities to discuss and debate with each other while teachers guide and facilitate their discussion. Therefore, earlier exposure to interactive learning with technology solidifies students' understanding and being able to fill up discrepancies between what they knew and what was being shared to them. Through this constant interaction with their surroundings in this case simulated learning, students can invent and re-invent knowledge. As student progress to higher classes, subject content builds up with an ever decreasing emphasis on students' abilities to transform their ideas into application. If mobile phones or rather other available portable ICT devices have been on the use from lower grades, these students are more likely to have a fighting chance to reason and understand their lessons without losing interests or developing bad attitudes, and therefore coping with an ever increasing abstract nature of chemistry subject. Given opportunities to pursue their learning via mobile phone simulations, these students are more likely to have their attitudes improved (Mango, 2015). Additionally, Wang (2017) asserted that using mobile phone applications in teaching and learning provides positive ideas and benefits that motivate students to learn and understand better.

Creating and using tools of interest to students such as simulations not only increase their understanding of scientific phenomena but also improve their interests in science (Damşa & de Lange, 2019).

As ideas or concepts are broken down into well revealed segments found in mobile game simulations, students would be in a position to understand them better and so does their general perception about the subject. Based on results obtained, this study is more likely to motivate students particularly females, who are usually deprived of confidence in undertaking on choosing science combinations in their future studies and endeavors.

This study may therefore provide the following benefits

Researchers in the area of educational technology. Educational technologists' thorough understanding of how people learn can be instrumental to creating user friendly software applications. Since educational technologists understand the need of the end users (students &teachers), they can work with software developers to ensure simulation applications reflect learners' levels of understanding by providing customized options.

This work may also inform decision makers in relevant ministries (education and science and technology) who are responsible for setting policies, guidelines for school management systems, including trustees, principals and school board officials.

Science teachers may also find this study beneficial as it informs them to revisit their Technological Pedagogical Content Knowledge, encouraging those in difficult work conditions to improvise, create supportive technologies in collaboration with their students, right from their surroundings in order to have a better learning experience.

Parents also are informed on why they should let their children have a controllable access to mobile phones which at times can replace the need to hire private tutors.

School administrators through this study can learn and arrange professional development sessions with teachers to help them acquire necessary ICT skills for efficient teaching.

Mobile network providers, recognizing the increased internet usage across educational platforms, can a strike a deal by providing affordable bundles exclusively to educational institutions.

This work also may inform software developers in coordination with educators to collaboratively come up with simulation applications which foster formative assessments in line with the curriculum. The fact that students may remotely access and do the exercises outside classroom settings not only encourage independent learning but also help students bridging the gaps in their background knowledge, helping to clear misconceptions.

The study may also benefit students who may be wondering on which particular simulation applications are essential to learning chemistry as this study have them described.

1.5 Rationale and justification

In a course of seven years working in the teaching field, that is before and after being employed at different occasions, in two private schools equipped with technology, I had solid reasons as to why this study should be conducted. As a part time tutor in a tuition centre, I relied on my own laptop and a smartphone to be able to teach students concepts that they previously only imagined of, and continued to encourage them to make good use of their phones. Students who had prior exposure to such mobile applications had more room when it comes to explaining concepts they learn as compared to those who have no access to the applications. Now as a researcher and a teacher, I had to fulfill that urge to see whether the intervention; simulation applications on mobile phones would have a widespread effect if conducted on large scale so that more students will be able to study using them and teachers too will be confident to rely mobile simulation usages.

This study highlights students' interests on using simulation application for non-educational and educational purposes. Interests which should be spearheading their will to take on challenges while pursuing science studies. Regardless of level or kind of subjects they take, students find simulations awakening and exciting (Aldrich, 2005; Liu, 2016; Petranek, 2000;

Verkuyl et al., 2017). This excitement is an opportunity presented to teachers to make use of captivating mobile simulations as tools to help students achieve highest level of understanding, leading to an improvement in their attitudes and academic performances in chemistry.

Through this study students will be able to use Mobile phone simulations as reference applications proven to facilitate deep learning of chemical formulae and observe the way chemical reactions take place (Twum, 2014; Williams & Pence, 2011). Moreover, the language aspect of scientific conceptions is also well considered in mobile simulations as students also learn new vocabularies (Rahmani, 2016).

The study also brings awareness to teachers especially in how they can overcome tight schedules, helping them stay connected to professional development opportunities which enable them to learn at convenient times and places, thereby enhancing their career performance and professional growth (Mfaume, 2019). Highly trained teachers are more likely to produce students with higher academic achievement (Kunter et al., 2013) and as previously stated by other researchers in this study, good achievement in students leads to good attitude (Joyce & Showers, 2002; Ozel et al., 2013). It is therefore expected that this study will provide alternative approaches towards teaching and learning, making students owners of what is learnt.

In this study, educational simulations are expected to provide students with chances to study concepts of their own liking, their own chosen environment, their own time or at their own pace. They do so by either minimizing disturbances and unwanted attention or controlling variables that may arise while conducting an actual experiment in the lab (Verkuyl et al., 2017). Doing it over time will consequently improve students' attitudes towards learning.

This study ensures efficient investment to get desirable feedback which will add room to the body of knowledge due to the fact mobile simulations exhaust students' need for learning by making sure they are engaged via audio, video animation or text based materials. This minimizes confound factors present in their learning environment. Additionally, using simulations from mobile phones provide a great chance for more students to access them due to the fact that mobiles phones are cheaper as compared to other forms of technology (laptops, desktops); can be repaired easily, are not as affected as computers or other electronic devices with our Tanzania's fluctuating electric power, and they are at a lower risk from damage by electric shock as compared to computers (Kafyulilo, 2014; Traxler & Kukulska-Hulme, 2012)

This study presents mobile phone simulations as an easier way to provide students and teachers with ability to view conceptions that cannot be displayed in our labs due to their complexity nature (Tüysüz, 2010). Computers with required specifications are overly expensive as compared to mobile phone of similar specifications, hence more families can afford having a phone as compared computers. This situation continues to extend scope of the study as it is more inclusive and can give a more realistic impression on how students in general setting will respond to it, before and after the intervention.

Last but not least, this study adds value to smartphone users particularly younger generation through informing how useful phones can be in terms of their day to day learning. Smartphones offer a rich set of mobile computing functions with connectivity. This combination frees the user from desk-based ICT associated with traditional computing in education. Smartphones are ubiquitous and accessible devices that travel with the user, so empowering them to respond to situations, ideas and needs as they emerge. The capacity of a smartphone to access, manipulate, produce, store or share content almost as soon as it is created, wherever it is created, provides the rationale for why education needs to explore the technology. This versatility promises to change the nature of educational content and communication and therefore the nature of learning itself.

1.6 Purpose of the study

The purpose of this research is to study the extent at which students' attitude towards learning of chemistry as a subject can be improved through the use of mobile phone simulations. The study therefore gathered students' attitudes via use of questionnaires and focus group discussions, in learning the subject when taught via traditional way/lecturing and when they were taught using mobile simulation in same group of students. Moreover, information was also obtained from the teachers through pre and post interviews, so as to have a better understanding what leads to a declining attitude towards learning chemistry?

1.7 Research Objectives

1.7.1 General Objective

To investigate students' attitudes towards learning chemistry.

1.7.2 Specific Objectives

1. To explore students' attitudes towards learning chemistry subject via use of mobile phone simulations.
2. To find out challenges encountered by teachers and students in using mobile phones (simulation) as a tool for learning chemistry.

1.8 Research questions

1.8.1 Main Question

How do learning through mobile simulations affect students' attitudes towards chemistry?

1.8.2 Subsidiary questions

1. How do the use of mobile simulation influence students' attitudes towards learning chemistry?
2. What challenges do students and teachers encounter in using mobile phones (simulation) as tools for learning chemistry?

1.9 Definition of key terms

A mobile phone simulation – It is a technique used to replace and amplify real experiences with guided ones, often "immersive" in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion, through the use of software application found in a mobile phone (Lateef, 2010).

Design Thinking - Design thinking is an iterative process in which we seek to understand the user, challenge, assumptions and redefine problems in an attempt to identify alternative strategies and solutions that might not be instantly apparent with our initial level of understanding, meanwhile providing a solution-based approach to solving problems (Deepa, 2022).

Bring your own device [U] or BYOD- the practice of schools allowing students to come with their own electronic devices such as computers, phones to school for the purpose of doing their work (Cambridge university dictionary).

Mobile learning – Mobile learning is defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices" (Crompton, 2013).

Multiplier effect – is a factor that if applied or executed causes a positive change in other factors. Originally used in economics or business to mean a factor that if applied will increase the base value of another factor. In this context technology has a multiplier effect as its presence may improve students understanding, perceptions towards scientific concepts they learnt (Charness, 2008)

m-learning – mobile learning. Refers to the use of mobile or wireless devices for the purpose of learning while on the move (Park, 2011).

Global System for Mobiles (GSM) - cellular network standard in use established in 1982, it transmits data on different frequencies 900MHz, 1800Mhz, or 1900Mhz (Scourias, 1995).
Carrying capacity – the ability of an environment to support a specific number of individuals (Eric J. Chapman, 2018).
Hawthorne effect - tendency of some people to work harder and perform better when they are participants in an experiment. In such situation, individuals change the way they behave due to the presence of a researcher rather than the manipulation of independent variables (Sedgwick & Greenwood, 2015).

Blended Learning - A process through which a variety of tools used in teaching and teaching methodologies are combined or mixed up to generate a teaching experience which is balanced (Marwa, 2022)

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

In this chapter, review of literature relevant to research questions is presented, through the following subheadings: usage and practices of mobile phones in secondary schools, current situation of mobile usage in secondary schools in Tanzania, and bring your own device theme (BYOD). Conceptual framework for the study showing usage of mobile phones in teaching and learning is presented and perception of students in mobile learning discussed.

2.2 Usage and practices of mobile phones in secondary schools

It is reported that 67.03 % of the world's population is on mobile phone usage, equivalent to 6.112 billion people, as compared to 62.9% in 2019. Mobile connections are over 8.8 billion in total worldwide according to GSMA real time intelligence data (2021). The teenage usage of mobile phone applications surpasses all other age groups, with their interest on non-educational simulations (gaming) as compared to a small fraction of them using simulations for educational purposes (Cha & Seo, 2018). These teenagers have access to 3.48 million applications and 2.22 million applications in Google and Apple stores respectively, for downloading their favorite programs. 57% of all the downloaded apps are for gaming, 24.86% are business oriented, and 9.77% are educational applications (GSM Association, 2019).

Recognizing the immense importance of a mobile phone, most countries have integrated it into their mainstream education systems (Isaacs, 2012; Wang, 2017). For instance, in the United States of America (USA) the device has been used as a pedagogical tool in more than 85% of education institutions. In the United Kingdom (UK) 90% of secondary school teachers use the device as an instructional tool (Isaacs, 2012). In Africa, mobile phones popularity grows exponentially due to their portability, user flexibility, and with a sheer availability of educational applications ranging from virtual labs such as Chemi Lab, offered by Aama foundation and Monster brain and Chemistry Pro by Gigantic Apps, Chemistry X10 by AppCrab LLC to collaborative tools such as Skype, Duo, Zoom to mention a few, contributing to effective learning experiences in the teenage group, which includes students in their junior and senior secondary education (Carvalho & Ferreira, 2015)

Usage of mobile phones for classroom instructions in Tanzania secondary schools is still low as compared to the extent with which computers (laptops and desktops) have been on use (Kenyatta, 2017). A significant proportion of secondary teachers disapprove the usage of mobile phone for teaching and learning with their views grounded on beliefs that mobile phones encourage irresponsible behaviors such as watching pornography, sexting, violence and intrusion of funny dressing and shaving styles in students; tying them to pregnancies and increased school drop outs (Joyce-Gibbons et al., 2018). However, if proper parental guidance is given and teachers awareness on educational use of mobile devices is increased through seminars, workshops then it is very likely that students' attitudes towards learning chemistry will improve (O'Bannon et al., 2017). It is now evident that usage of mobile phone simulation will offer higher chances for teacher colleges for example in the developing world in taking an upper hand in teaching and learning in both aspects of content and pedagogy as smartphones are owned by the larger proportion of the teachers. Ministry of Education and Vocational Training (MoEVT) partnered with the Swedish International Development Agency (SIDA) have spearheaded the ICT development and its deployment in teacher education colleges (TCs), and therefore efforts are underway to move into using mobile phone for mainstream education (Chirwa, 2018).

Ministry of Education in collaboration with the College of Information and Communication Technologies (CoICT) of the University of Dar es Salaam, carried out a pilot study on the use of short message services (SMS) to upgrade subject content knowledge of secondary school science and mathematics teachers (Mtebe et al., 2015). The results of the pilot projects and other empirical studies conducted in the country on mobile phone usage (Joyce-Gibbons et al., 2018; Kafyulilo, 2014; Kibona & Rugina, 2015; Kihwele & Bali, 2013; Msuya, 2015; Mtebe et al., 2015; Mtega et al., 2012; Urassa, 2012), have supported the enormous educational benefits of using the device. Given the inspiring results, teachers were expected to take full advantage of the opportunity offered by the device towards improving their career performance and delivery of a higher quality teaching and learning in schools.

Surprisingly, despite the apparent benefits attached to usage of the device and several initiatives undertaken to integrate its use in education, extant studies (Joyce-Gibbons et al., 2018; Kafyulilo, 2014; Msuya, 2015; Swarts & Wachira, 2010) indicate that many teachers in Tanzania hardly utilize mobile phones for academic purposes. This situation creates uncertainties about their awareness of the device as a potential pedagogical tool. It also hinders the government's efforts to integrate modern technologies in education as a strategy to provide a higher quality education.

2.3 Bring Your Own Device Policy (BYOD)

2.3.1 What is BYOD and where does it come from?

Bring Your Own Device alternatively known as Bring Your Own Technology (BYOT), or Bring Your Own Phone(BYOP) or your personal computer (BYOPC) is a policy initially developed to allow workers to bring their own devices to work rather than relying on employers' devices which would limit their work outside offices. Initially used by a VoIP service provider Broad Voice in 2004, then entered a common use in 2009, courtesy of an American Multinational corporation and Technology company headquartered in Santa Clara, California in the United States known as INTEL (Handfield, 2014).

In terms of teaching and learning in a school, BYOD means that instead of school providing technology for students to use, such as class sets of laptops or tablets or short range radio call devices, students bring to class technology they already own and use it in and out of school. BYOD encourage students to become independent learners and researchers by letting them find information on their own devices.

The BYOD policy has increased employee productivity by 16% over a 40 hours' period per every week of working (Pillay et al., 2013). Additionally, it has cut shot the costs of maintenance at workplace on ICT facilities, software licensing and device maintenance, as these are all managed at personal or owner level. Moreover, A Cisco 2011 Annual Security Report stated that 81% of students believe they should be able to choose the devices they need to do their activities. 72% of survey respondents are formally supporting BYOD programs to be used in working environment.

2.3.2 BYOD adoption to teaching and learning and its challenges

In Tanzania context, BYOD policy is not supported in most schools, while there's a little hope in the international schools for which students are allowed to take on projects which put use of their mobile phones and therefore allowed to operate with them during school hours. Other challenges include teachers' adequate awareness on the essential applications which serve students' needs, network restrictions at school or workplaces, and behavioral control on the usage of the devices which give students uncontrolled freedom especially if the devices are not configured. And last but not least is the higher internet costs since students are accessing the school network without control. It is therefore recommended that BYOD should be approached as a pilot study, following stages for which learners will be taken through to be able to adapt to the differences that may be experienced. Devices are all supposed to be configured to allow access to prioritized educational contents during learning hours. Advantages coming with controlled execution of BYOD far outweighs the challenges mentioned previously and these in a nutshell are cost effectiveness, learning anywhere, familiarity with current technology, personal respect for the devices, organized learning in groups without necessarily interacting physically, flexibility and mobility, satisfaction, freedom of learning and choice.

While fundamental academic practices have remained the same in BYOD approach, reduction cost, increased productivity, innovation and less stress on IT are some of the benefits coming with the BYOD approach. Moreover, BYOD holds several attractions for learning. It allows learners to retrieve online learning resources which would be unavailable without significant infrastructural and capital investment by the institution. Secondly it allows learning which is more closely aligned with learner interests, expectations and lifestyle in the rest of their society (Cheng et al., 2016). Precisely looking at sub-Saharan Africa, the ability to use mobile technology to compensate for a lack of existing infrastructure, erratic internet connection and unreliable power supply are all strong 'push' factors towards the adoption of a BYOD model. BYOD also make lesson less teacher-centered and learners empowered to determine how and to what extent they should be engaged in the learning process (Cheng et al., 2016).

Looking at the situation in Tanzania and other developing nations, we still have very limited ICT facilities in schools, coupled with reasons mentioned previously (power shortage, low budget on ICT sector and inadequate availability of teachers with ICT skills), adopting BYOD to educational settings will enable teachers and students to possess their mobile phones while learning and therefore compensating for reasons explained. Since Employees in this case teachers are more likely to organize their personal lives using a smart telephone, they bring this expectation to the workplace and want to use their telephones to organize their work life too (Caldwell et al., 2012).

2.4 Students' attitudes towards mobile phones

Based on the surveyed literature, the researcher noticed that there is a lack of studies on students' attitudes towards the utilization of mobile technologies in the East African Region where mobile phone usage is rapidly increasing (Kaliisa & Picard, 2017). Studies worldwide have indicated that students are massively interested in mobile phone usage for education regardless of inadequate guidance given by their elders who are for the larger proportion, digital immigrants. Reports in the middle east, through a study about students perceptions on use of mobile phone simulations for learning, have shown 99% of students have agreed to a movement towards mobile learning (m-learning), with a higher proportion of male students into mobile phone usage than girls (Al-Emran & Salloum, 2017).

A good number of studies published have discussed issues pertaining to usefulness of mobile phone simulations at a higher education institution (colleges and universities) where there are no restrictions on mobile phone usage and therefore even challenges and suggested solutions are seemingly inconvenient when applied to lower education. Students who are in tertiary education are already matured with clear intent on their studies and future aspirations, while at a young age students need motivation to study efficiently.

There are no studies in the Tanzanian context which focus on how students' attitudes towards learning chemistry can be rectified given mobile phone as a motive. Additionally, looking at how mobile phone simulations can be combined with other tools in blended learning, a more effective approach in reaching students as it incorporates both online and offline ways to teaching and learning, supported in mobile learning. Observing this gap, the researcher is therefore interested in exploiting students' immense interests in mobile phone to incorporate educational simulations that will make their learning user friendly, keeping them in charge of what is learnt and how is learnt.

2.5 Conceptual Framework

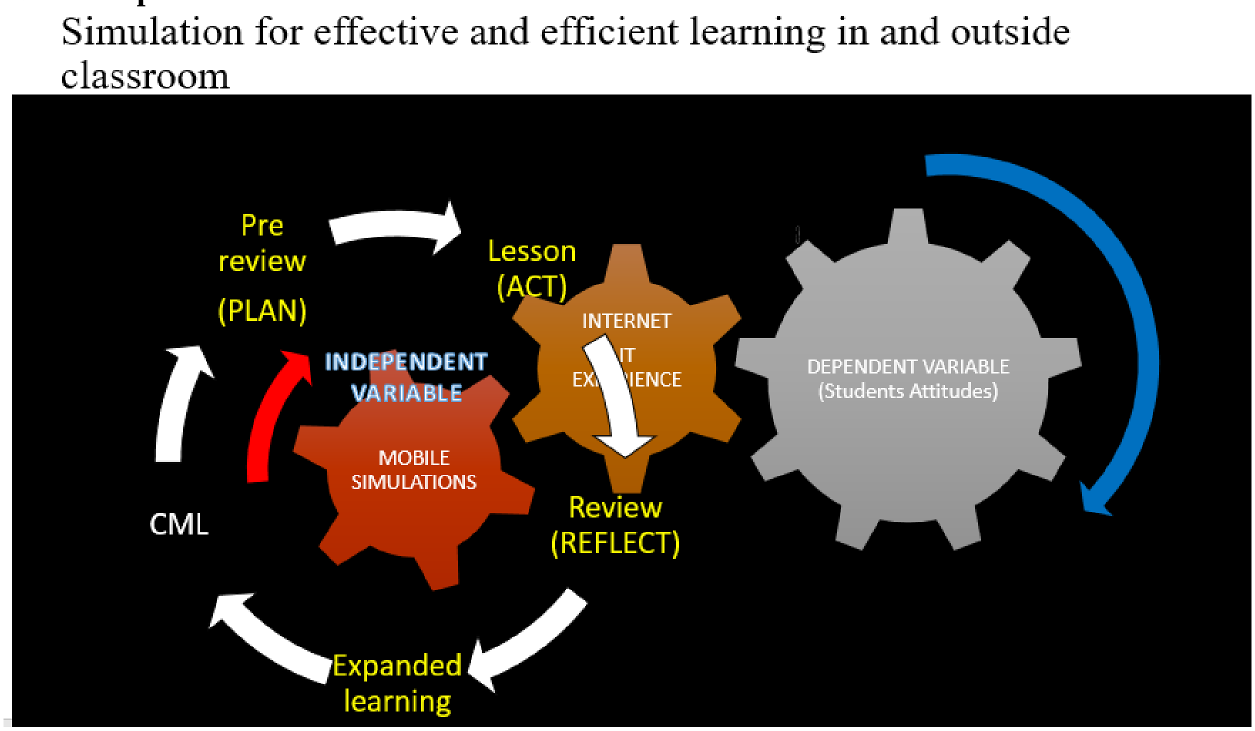


Figure 1: Conceptual framework

2.5.1 Conceptual framework adoption and modification

This conceptual framework was adopted and modified from cyclic model of learning (CML) as put forth by Takeuchi (2007), as a teaching design, and its most distinctive characteristic is that it integrates in-class teaching practice with-out of the class or students' self-learning with the aid of technology (O.Takeuchi, 2010). In this model online resources and software applications are put into use to enable learning of students both in and out of classroom, which is strongly supported by the use mobile phone as a device for learning which can be relocated easily compared to other forms of technological devices. Four elements of CML model in ascending order are preview, lesson, review and expanded self-learning. These elements are putting a mobile phone simulation usage at the fore front as it allows students to have remote reviewing, accessing lessons in private, do review in terms of sharing screens and engage in activities for example lab simulated titration procedures, or analysis of chemicals (without need to come and access actual laboratories or even school) and thereafter proceed with their own personal pace in learning. Not only students, the CML elements also puts the teacher as an action researcher, getting engaged in a planning, acting or executing plans, reflecting and adjusting his or her efforts based from previous action plans in a timely basis to generate more desirable results.

Having that in mind, the observed conceptual frame work has borrowed the cyclic nature from CML model giving it a direct linkage between the intervention or the independent variable (mobile simulation) and dependent variable (students' attitudes towards learning chemistry) through the horizontal arrows (one pointing left and the other right). To be able to perform cyclic movement which has a multiplier effect between different moving parts, gear model has been developed.

Clockwise movement of the gear (labelled dependent variable) indicates a positive move or an improvement in students' attitudes towards learning chemistry. This is indicated by the arrow pointing right. This is caused by a clockwise movement of another gear to the left, labelled independent variable (simulations). A clockwise movement in the independent variable causes a clockwise movement in the dependent variable or an improvement in attitudes. CML model is crucial as it eliminates the negative effects which might be caused by confounding factors as indicated above, as it relies on offline applications which can be accessed without internet at any point in time while a student is studying. Nor does the simulations require prior experience in order to use them effectively.

The cyclic nature refers to a fact that learning is an ongoing process coupled with series of activities which regularly re appears at intervals while students are progressing from one level to another in their learning process.

CHAPTER THREE

DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents research design, location, sampling procedures, tools used in collecting data, as well as participants involved. Issues of trustworthiness in qualitative phase, rigor in quantitative phase, assumptions and limitations of the study, ethical issues are also discussed.

3.2 Research design

The researcher employed concurrent mixed methods or concurrent triangulation (single phase) method in this study, in which data was collected and analyzed individually but at the same time. Collection and analysis of two separate quantitative and qualitative data was done, followed with merging them for the purpose pf comparing or combining the results (Creswell & Clark, 2017).

The rationale for choosing concurrent triangulation methods design was because it provided broader and more complete vision of the problem asked in the research questions. Not only the method answers comprehensively the comparative analysis existing in the study for which pre and post studies are undertaken but also getting an in depth understanding of the findings that are obtained in the study (Almeida, 2018). While dealing with numerical findings, the researcher would be able to probe questions to the participants to get in depth information which would verify patterns or tendencies discovered in both strands which are qualitative and quantitative part of the study.

The researcher finds concurrent mixed methods design suitable with nature of his research as it ensures corroboration and validation of the study meanwhile observing limitation of time that researcher faces in his study. The design also confirms findings found in one approach by using another approach (Creswell & Clark, 2017; Rossman & Wilson, 1985; Tashakkori et al., 1998).

The researcher used Questionnaire survey in the quantitative phase of the study in order to obtain the numerical data on participants' perceptions, learning experiences and confidence levels in learning chemistry using mobile phone simulations. Questionnaire surveys are swift in the sense that they can reach a large number of participants or population while providing standardized and quantifiable data which would also offer a near perfect reflection of how an entire population would have responded to the same study (Cohen et al., 2018). In order to gain in depth information, the researcher conducted focus group discussions (FGD) with students and interviews with their teachers in which text based data was gathered in the qualitative phase. FGDs maximize interaction between participants and between participants and the researcher, thereby minimizing Hawthorne effect which lead participants to be behave artificially by providing more expected feedback rather than the reality. The relaxing nature of the focus group discussions which is set to begin with minimal intervention from the researcher, and as it proceeds enabling him to set arena for asking for more details, allowing participants to keep up with the pace without feeling overburdened. Discussions of this nature not only allow passive –active role played by the researcher but also do not interfere with the flow of conversation given by the participants, meanwhile encouraging debate to continue beyond point it would have ended (Kitzinger, 1994).

3.3 Setting and Researcher location

This study was conducted in two private secondary school located in Kinondoni district, Dar es salaam. These schools are presented by short forms S and F respectively, throughout in this study. All students' participants are described using numbers and letters. Students from S school are numbered 1A, or 1B in ascending order to 80A or 80B. A stands for male students and B for female students. Students from F school are numbered 1X, or 1Y in ascending order to 24X or 24Y. Similarly, Y stands for male students and X for female students. No any misrepresentation or disregard in using a particular letter to represent either of the participants' sex. Teachers are represented by the First Name Initials, namely J and A for teachers in S and F school.

Consideration to choose the schools is based on the availability of resources needed in the study, the area being reachable from where the researcher resides and the fact that while in one school teachers are obliged by the school regulation to incorporate ICT in their teaching and learning, in the other school the ICT usage is not mandatory in teaching and learning. Studies are carried in science lab and computer room as they are installed with needed equipment for the study.

3.4 Sample and Sampling procedure

3.4.1 Sample

Sample consisted of 104 students and two teachers from the two schools; 80 students and 1 teacher from school S and 24 students and 1 teacher from School F. A larger sample ensured generalizability of the study but also minimizing possibilities of having random errors (Marshall, 1996; Mullinix et al., 2015).

3.4.2 Sampling procedure

The researcher purposely sampled one science class in each school which is actively involved in ICT subject, but also not facing the external exams in the same year. For this reason, form three and Year 11-12 students from school S and F respectively participated in the study. In school S, 80 students were purposefully selected to participate in the pre and post questionnaire survey in the quantitative phase and 6 students were selected purposefully from them to proceed participating in pre and post focus group discussion(FGD) in the qualitative phase. One teacher was purposefully selected to participate in pre and post interview. In school F, 2 groups each having 6 students were selected purposefully for a pre and post FGD, and one teacher chosen purposefully to participate in pre and post interview.

3.5 Data collection procedures and tools

Following approval from the Aga Khan University-Tanzania Institute of Education Ethical Review Commission (AKU-TIHE-ERC), the researcher's process of gathering data commenced for which he received research permits from the Regional Administrative Secretary (RAS) Dar es salaam Region and Kinondoni District Administrative Secretary(DAS) which allowed him to collect data in two selected schools. From there on the researcher followed protocol starting with visiting schools for the purpose of introducing himself and his intent to collect information which is used for studying purposes only and it was aided with consent forms and information sheets for which the school administrations and participants had ample time to understand the study and their roles in it.

Information in this study was obtained through the use of self-administered close ended questionnaires that are presented with a 5 points rated Likert scale in the quantitative phase. In the qualitative phase information was tape recorded in the focus group discussions with students and also during interviews with teachers. Data was collected in two rounds for which pre questionnaires, pre focus group discussions and pre interview were concurrently conducted in the first round (pre intervention) and the same was repeated in the second round (post intervention). Qualitative data was recorded and later on transcribed with an audio to text transcriber mobile application in the researcher's phone and finally saved in a locker and the Bitdefender Vault System.

3.5.1 Pre and Post Survey Questionnaire

Researcher adopted and modified a questionnaire having 25 items (See Appendix G) for which 10 items focused on students' perceptions towards learning chemistry, 8 focused on challenges towards learning chemistry, 5 looked at learning experiences and benefits of studying chemistry, and 2 looked at confidence levels of students who are learning chemistry. These items are presented in the 5 points attitudinal scale also called Likert or Ordinal scale, known as Chemistry Attitudinal Scale (CAS). This scale is an adaptation of two scales namely Test of Science Related Attitude (TOSRA) developed by Fraser (1998) and Likert Attitudes Scale by Ozden (2008).

3.5.1.1 Likert scale

The researcher used a 5 point Likert scale to measure attitudes of participants in the study. The scale named after its inventor, Rensis Likert in 1932.It gives participants an opportunity to rate their opinions to a degree they find suitable. In an ordinal scale, responses can be rated or ranked, but the distance between responses is not measurable. (Sullivan & Artino Jr, 2013). Example of Labels in 5 point Likert scale used in this study are as shown in Table 1 below.

Description	Scale
Strongly Agree	5
Agree	4
Neither Agree or Disagree	3
Disagree	2
Strongly Disagree	1

Table 1: Likert Scale

3.6 Pre and post interview questions

Enlisted in Appendix I section of this study are interview questions that a researcher asked the teachers before and after the Intervention. Researcher main focus during pre-Interview session was to let teachers reveal their experiences with ICT integrated teaching for which simulations come into play. Moreover, teachers had to mention challenges they face with traditional teaching methodologies or if they have been using mobile simulations for teaching or learning. Following the intervention through which teachers were exposed to using different simulation applications to uncover abstract concepts or problems they face while teaching, teachers from school S and F had an opportunity to reveal their experience with simulations but also difficulties they encountered. The interview questions not only prepared teachers to accepting changes in their teaching but also looking at ways to shifting their responsibilities as being masters of knowledge in class to being facilitators, giving students chance to own the learning process.

3.7 Data analysis procedures

Data from pre and post questionnaires (ordinal scale data) was analyzed using dependent t test, for which results from pre and post intervention were compared to see whether there is a significant difference between them, a sign that the intervention has negatively or positively influenced learning experiences of students (Meek et al., 2007). Additionally, charts and histograms were presented to inform research questions on what was obtained in the data collected. Interviews and discussions were recorded and transcribed verbatim using an audio-text software. Coding was conducted where by the patterns and eventually themes were identified and noted. To have a complete picture, the researcher merged results and presented them concurrently while answering the problems found in the study.

3.8 Assumptions and limitations of the study

3.8.1 Assumptions

While self-administered questionnaires were used to collect quantitative data, the researcher assumed that students provided honest information regarding their attitudes towards learning chemistry. In qualitative data collection through focus group discussions and interviews, the assumption was that the participants are answering to the best of their knowledge and that what they said reflect the reality on ground. Moreover, the study assumed that the presence of a researcher does not influence participants' behaviors which can lead to Hawthorne effect for which participants behave artificially due to the presence of a research and not because of the effect on an independent variable on them.

3.8.2 Limitations

In this study, it was noted that participants were sometimes unwilling to answer the questions while others had misunderstood why were they selected while others were left in the study. Additionally, due to limited time some participants had hard time filling up the questionnaire. Some participants lack authenticity as they tried to ask their colleagues about their responses. Gillham (2008) asserted that participants behave naturally when they have plentiful time and would resort to going back referring to some details while trying to answer a questionnaire. Participants delay to appear on time was also limiting the study progress, this led to researcher demanding more time for completion of data collection.

3.9 Research Rigour and Trustworthiness

Being a mixed methods research study, issues about rigour in quantitative phase of the study as well as trustworthiness in the qualitative phase present throughout the study from when data was collected to when results were made and thereafter shared. By definition, research rigour is the degree to which researchers have worked so that the quality of study is enhanced (Heale & Twycross, 2015). The researcher ensured research rigour through evaluation of the tools reliability and validity.

Validity refers to what degree is a concept has been accurately measured. The instrument (questionnaire) used in this study was modified to gather data accurately using a scale that give participant wide chance of precisely pin pointing at which level is their level or degree of attitudes falling as per every item provided in the questionnaire. For example, not all participants had a clear yes or no response to a statement “Learning chemistry is boring” (see Appendix G), some were not able to decide so they maintained undecided option as their choice, while others had extreme experiences whether good or bad with learning chemistry and hence their opinions would have been less represented if the statement had binary options for an answer.

To ensure validity, the researcher made sure the instrument (questionnaire) clearly measures one attribute which is attitudes of students by including items which specifically look at how students perceive learning of chemistry before and after the intervention.

Secondly, minimizing confounding factors such as the internet availability and ability to use the simulation by making sure that all the participants had access to it at the time of conducting an intervention but also all participants were taught and had proven ability to open, run or customize their simulation applications. Moreover, he made sure consistency is also attained by having all the mobile simulation versions similar to all participants’ phones and computers having mobile versions. Trials were also taken to ensure reliability especially for those participants who were found asking for what was filled by their colleagues.

Thirdly, through triangulation all other instruments used in the research, such as interview and focused group discussions measured similar concepts or had alternative explanations which correspond to the findings in the questionnaires.

Trustworthiness in qualitative phase refers to the extent or degree of confidence in data, interpretation and methods applied to warrant the quality of a study (Polit & Beck, 2014). To ensure high degree of confidence in data collected, procedures and protocols were established which also allow consideration from other researchers and readers (Amankwaa, 2016). To ensure trustworthiness, researcher study entailed the following elements in his work and these are credibility, transferability, dependability and confirmability.

Credibility, defined as the confidence given in the truth of research findings was ensured through prolonged engagement with participants, peer debriefing, triangulation, reflective journaling and member checks (Connelly, 2016). Prolonged engagement with participants made sure all participants have sufficient ability to use mobile simulations during the intervention phase, before they can give their opinions or attitudes as to whether it facilitated their learning or it did not live to their expectations. Prolonged engagement also ensured effective interventional effect to the participants.

Defined by Lincoln and Guba (1985) as a deliberate act for which a researcher exposes himself to a disinterested peer with intent to explore aspects of inquiry that may otherwise remain implicit or seem essential to the inquirer himself, Peer debriefing ensures trustworthiness as it encourage the researcher through de briefers, to probe for deeper understanding and biasness. De briefers offer a researcher an opportunity to develop and test upcoming steps in his research.

In effort to help exploring and explaining participants' attitudes and perceptions towards learning science subjects, a researcher used a variety of methods so that a more balanced explanation could be offered. A combination of different methods which are all geared at measuring and thereafter giving concise and complete information about participants is known as triangulation. Triangulation offers database diversity which enable different aspects found in the study to be explained (Noble & Heale, 2019). It also counterbalances a supposition made by one dataset which may invalidate another supposition by creating alternative explanations based on other possibilities coming with multiple methods used.

Finally, a researcher conforms with other research studies by embedding his findings in this study and providing link to the rest of the details which were gathered. This is also shown by relating findings of this study with numerous other studies done in the area of educational technology, teaching and learning and simulations.

3.10 Ethical issues

All necessary permissions were adhered by the researcher and this include ethical clearance approval from the Aga Khan University Ethical Clearance Committee and the permission to conduct research from the Ministry of Education and Vocational Training (MoEVT) in Tanzania.

Additionally, participants were assigned with pseudonyms as way to make sure their names are not revealed during and after the study had been done. They were also informed on the purpose of the study for which information sheets were provided. Participants were finally requested to fill consent forms. The researcher Participants informed participants that the entire process is under their free will and that none among them will be held accountable at any point during the process.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents the findings emerging from a study which aimed at using mobile phone simulation as an interventional tool to improve students' attitudes towards learning chemistry. Participants were taken through pre intervention, intervention and post intervention stages in order to effectively realize the impact brought by usage of mobile phone simulations on their attitudes. The study specifically intended to answer two questions; How do the use of mobile simulation influence students' attitudes towards learning chemistry? What challenges do students and teachers encounter in using mobile phone simulations as tools for learning chemistry?

To answer the questions as mentioned, the researcher gathered data from two schools in Kinondoni district, namely school S and F. In one school (S) he prepared and semi- adopted a self-administered fully structured pre and post questionnaire to a sample of 80 students. The researcher furthermore purposefully selected a total of 12 students who participated in pre and post focused group discussions (FGD). Additionally, he had face to face pre and post interviews with one (1) purposefully chosen chemistry teacher in the school who shared out his experience with mobile phone simulations in teaching as he has been moving with students from previous years to present. In another school (F), the researcher conducted pre and post FGDs with purposefully selected 12 students and pre and post interview with 1 chemistry teacher.

The findings are presented and analyzed through descriptive statistics from the quantitative phase which include findings from pre and post intervention, followed by explanations of the results. Then follows the presentation of the qualitative data gathered through interviews and focus group discussions. The researcher then linked the findings with what is in the literature in order to appreciate the similarities and differences and what would be the reason for the current observations made by the present study. Finally, the researcher draws out implications of the findings.

4.2 How do the use of mobile simulation influence students' attitudes towards learning chemistry?

Based on the study findings, it was clear that mobile phone simulations positively influenced students' attitudes towards learning chemistry. The findings presented below from the pre and post intervention phases indicate.

4.2.1 Perceptional change due to usage of mobile phone simulation

Students had negative perceptions towards learning chemistry for which they described it as boring, monotonous, makes hard to manage time, limited in scope of coverage and understanding, miscommunicated or one-way communication, abstract, theoretical and shallow.

However, having been exposed to mobile simulations it was observed that their perceptions towards learning chemistry changed from regarding it as a boring and monotonous learning experience to being a fun and engaging experience, among other perceptional changes as indicated below.

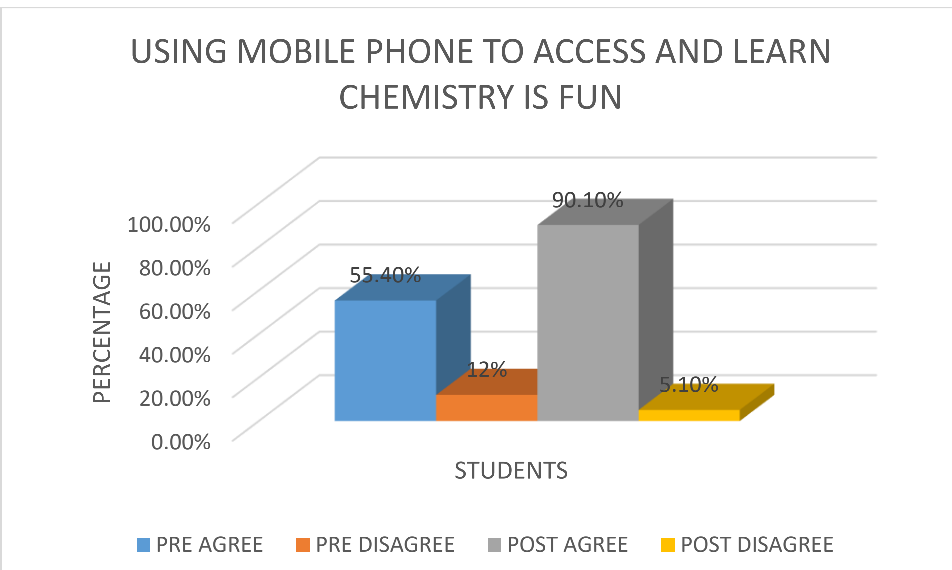


Figure 3: Mobile simulation brings fun in learning

Results show that 55.4% or 44 (N=80) of students perceived learning chemistry via mobile phones as being a fun experience, however when exposed to mobile phone simulations 90.1% or 72

(N=80) students perceived learning chemistry via usage of mobile phone simulation applications gives fun and enjoyable experience. A perceptual improvement in terms of percentages is also observed from 32.4% (N=80) of students who were uncertain whether mobile simulations would encourage their learning, to only 4.8% being unsure, Following the exposure to mobile phone simulations.

Similarly, findings show that 67.37% (N=80) of students either disagreed or were uncertain whether mobile phone simulations enhance their problem solving skills. However, following an intervention, no student was uncertain and only 6.25%(N=80) of all students still maintained a disagreement with the fact that mobile simulation enhanced the problem solving skills. Alternatively, it can be asserted that 93.75% (see figure 3) of all students agreed to a fact that their problem skills had been enhanced following the exposure with mobile simulation, while before the exposure 39.75% (N=80) of students agreed.

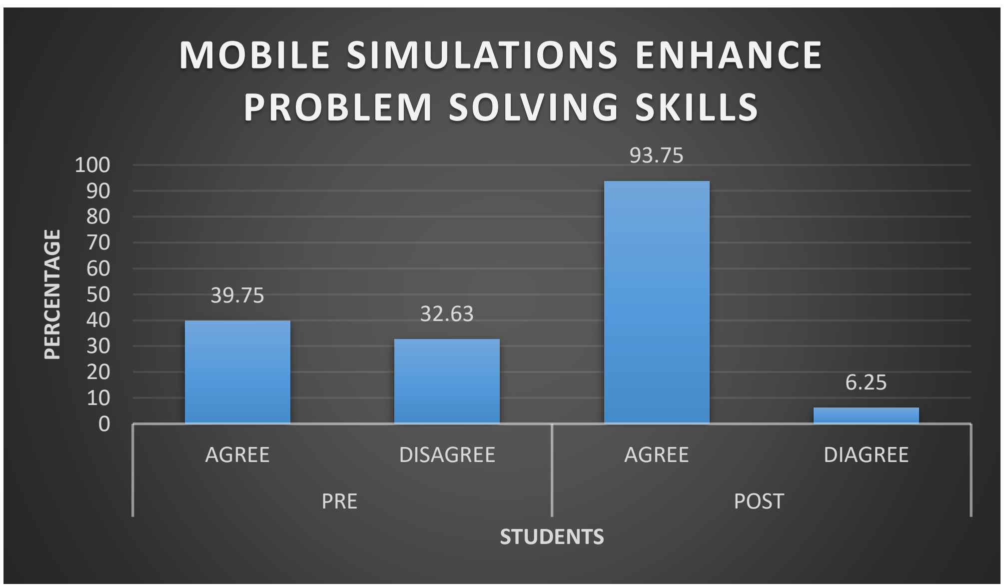


Figure 4: Mobile simulation and Problem solving skills

Similarly, in an interview with teacher J from school S following his teaching experience with simulation applications, had this to say:

> *"Not all students are better at understanding abstract concepts and be able to apply them in solving questions. Visual presentations in simulation applications help them realize and understand such concepts and therefore be able to link it while solving questions''* (Interview with Teacher J on 21/10/2022)

Additionally, teacher A from F school in a post interview on 22/10/2022 described his teaching' experience and students' perceptual changes while learning molecular structures.

> *" students perceived learning molecular structures and bonding formation being a boring and hard lesson even when video presentation was involved. However, when they played molecular maker game on Monster Lab Simulation, they were excited and able to attempt questions given"*

While textbooks and syllabus may be guiding us to use certain examples or follow a certain way to reach learning objectives, it is not always us who are supposed to know what to do, it is learners who need to know what is the essence of knowing and how will they apply the knowledge in solving problems which demand an in depth theoretical information which cannot be acquired through going given examples and scenarios. It is therefore evident that students' perceptual transformation towards learning chemistry can be improved given that mobile simulation applications are used in teaching and learning. This is also revealed in another instance, following exposure to simulations Student 15Y (student from F school) during Focus Group Discussion mentioned that:

> *"I think mobile learning encourages fair learning because then you're allowed to look for your things you can actually identify where you're getting stuck, you can try to look for that specific topic and practice just that instead of in class with a vast majority of things you have to do you could just focus on that and it also helps you work more effectively and test yourself more".* (Student number 15Y, FGD on October 25^{th}, 2021)

Both teachers perceived a move towards mobile learning as an efficient way towards improving students' attitudes as well as their performances, as revealed:

> *"It is time now the government and related ministry to allow usage of mobile phones to learners as it will help them access a wide variety of materials from different sources, adding to their in depth exposure and understanding"* (teacher J from school S on 28/10/2021).

> *"A movement towards simulated learning will help students understand more"* (teacher A from F school on 3/11/2021).

Similarly, students shared why they had positive perception towards moving to learning using simulation:

> *"We have different learning styles and these are well accommodated in simulation applications as there is Audio, Visual 3D Animations. I can do the activities on my own as a game platform"* (Student 3X, F 3/11/2021)

Additionally, participant 7 regarded Movement to simulated learning as

> *" Adequate way to move forward, with changing to technology, making students self-sufficient and independent researchers, all in all it's a good way towards effective learning".* (Participant 7Y, on 3/11/2021)

Describing inconveniences which would be avoided if mobile simulations are used in learning, student from school S had the following to share:

> *"Simulations allow us to re do activities and explanations in case we misunderstood, but this is not possible in a classroom with 60 students all listening to one teacher. So a teacher cannot attend everyone in class"* (Student 3B, on 22nd October 2021)

From the results above, it is evident that mobile simulations bring perceptual change through motivating learners to indulge in activities/games, which foster deeper learning. By doing so, mobile simulation facilitate transfer of knowledge ownership enabling students creativity and curiosity (Breckwoldt et al., 2014). Mobile simulation/games such as Chemi Lab provides right away feedback once a student has clicked for an answer. Findings from this study corroborates with research findings by Cai et al. (2014) who studied students attitudes in learning chemistry in which molecular studies were done using Mobile Phone Augmented Reality (AR) systems applications. His findings showed that the AR tool had a strong learning effect to students and it is more effective for low-achieving students than high-achieving ones. Additionally, students had positive attitudes towards learning chemistry using the AR mobile application.

It should however be noted that not all kinds of mobile simulations would bring positive perceptual changes to students towards learning as Tavares et al. (2021) has indicated. Tavares' research found that a larger proportion of simulation applications available for free in mobile store are not suitable for learners who are at their initial stages of learning. Significant amount of such applications offer visual images or animations without considering complexities with which a learner needs to overcome to have an understanding. Any high quality educational simulation should be relevant, consistent, practical and effective to its intended audience (Nieveen & Folmer, 2013). Relevance of a simulation application refers to how valid are its content, or has it been validated or proven by regulatory scientific boards. Consistency implies that there is logic with the floor and materials are synchronized with the current syllabus. Being practical means a simulation is usable and has customized settings reflecting levels of learning of the user, and being effective means the expected or desired outcomes which is to simplify learning and encourage practice, are met.

4.2.2. Mobile simulations improve confidence levels in learning chemistry

Results from pre focus group discussions with students from F school indicated that students are generally least confident towards learning chemistry as revealed:

> *"Am not very confident learning chemistry because there's a lot of information given at a go I won't have enough time to sit down or we won't have enough time to note it down or you won't have enough time to practice. Chemistry has a lot to do with practicing and be able to know the material and learning it as it comes, the current learning style makes it harder to do that.* (Student number 6X, F on 3rd October 2021).

Another student shared the following concerning her confidence in learning chemistry:

> *"I am not very confident with the limited nature of our current learning style in terms of information availability. It prohibits us from accessing most of the things that are part of the internet, and for example mocks (past papers) can only give some and you cannot learn so much from only one source, because there's a lot of different opinions and different ways of learning out there. So it's very important to have a balance of both"* (Student no. 1X, school F on 3/11/2021)

However, when students had an opportunity to learn via mobile simulation applications they had the following to share:

> *"I have learnt it is possible to slow down chemical processes which occurred in fraction of seconds as animations showed so that details can separated from each other, and can confidently be studied individually."* (Student no. 25Y, school F, on 23rd October 2021)

Participant no. 3 shared his experience by saying:

> *"I am very confident with using simulation applications, as I am not worried about causing errors with the simulations as we usually do when going to the lab". Teacher would constantly remind us of safety rules which instills fear in some students.* (Student no.3B, school S on 19th October, 2021)

He also added that:

> *"Simulations makes me confident as I could do task without fear of spilling acid solutions or other reactants. You know with chemistry experiments there is always a danger factor."* (Student no.3B, school S on 19th October, 2021)

In another instance student suggested that while mobile phones are not encouraged in classroom settings, school should make a special arrangement so that students are being given a certain length of time under teachers' supervision to use them for learning. Owing to their portability, students find it easier carrying phones compared to their personal computers.

Usage of simulation in learning makes student self-sufficient because they can manipulate or control conditions for which learning has to occur, they can control pace, time and levels at which their learning should occur, as shared by one student:

> *"I can decide to share what I learn with my colleague and share the exact spot which I find hard or interesting without need of relocating, physically"* (student 22B on 3rd November 2021)

Moreover, students indicated that using the simulations is more convenient for supporting their learning because they could access the experiments and activities with freedom of choosing time, place and pace in learning. This helped them to do the tasks, leading to increased confidence in their ability. Simulations guarantee learners' privacy (Leigh & Steuben, 2018), and this is supported by the results as shown in figure

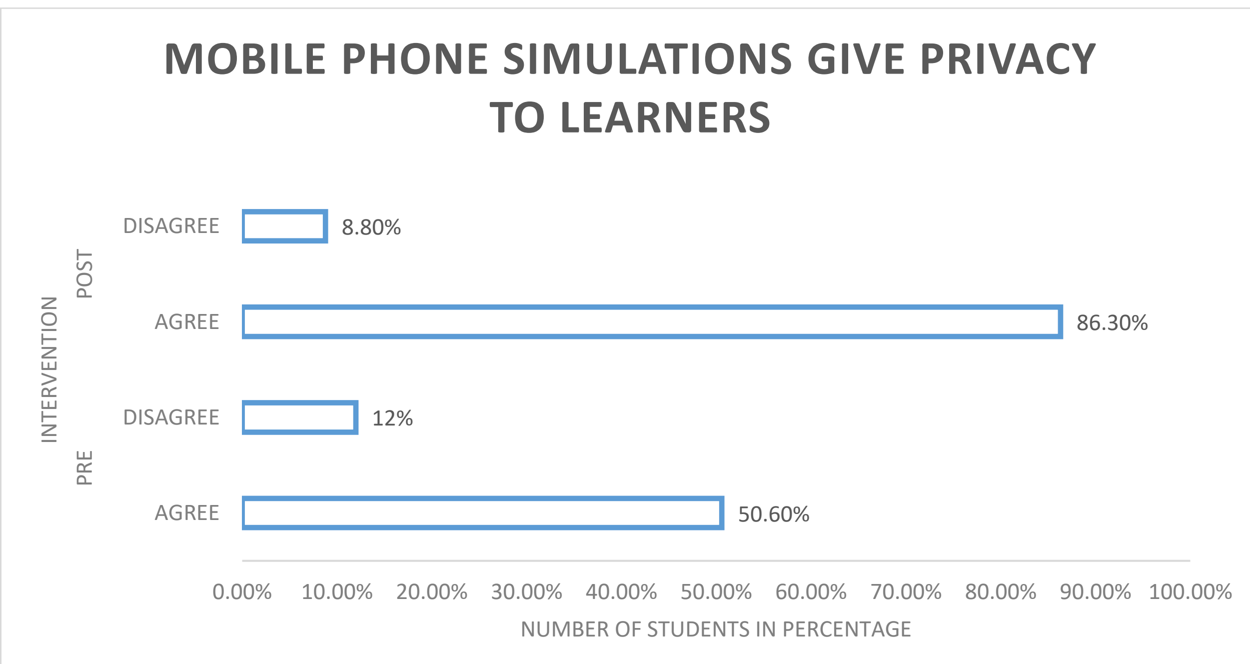


Figure 5: Mobile simulation and Privacy to Learners

From the chart above, number of students from S school who agreed to the fact that mobile phone simulations allow privacy which can be in form of students-teacher focused monitoring, and students-students' collaborative interaction increased from 50.6% during pre-intervention to 86.3% in post intervention.

It is asserted that mobile simulation's ability to support human-human physical interactions unlike online discussion boards also intensify the relationship between learners and their teachers which in turn improve confidence of students towards learning (Naismith et al., 2004). Conclusively, mobile phone simulations based on evidence shared above seems to improve students' confidence in learning and so do their attitude.

4.2.3 Mobile simulations save more time in teaching and learning

While describing how efficient is learning via applications in their portable devices, students in school S shared that mobile phone simulations take less time to accomplish an equivalent materials coverage that would take days if done using textbooks. A graph in below (see figure 6) presents this information:

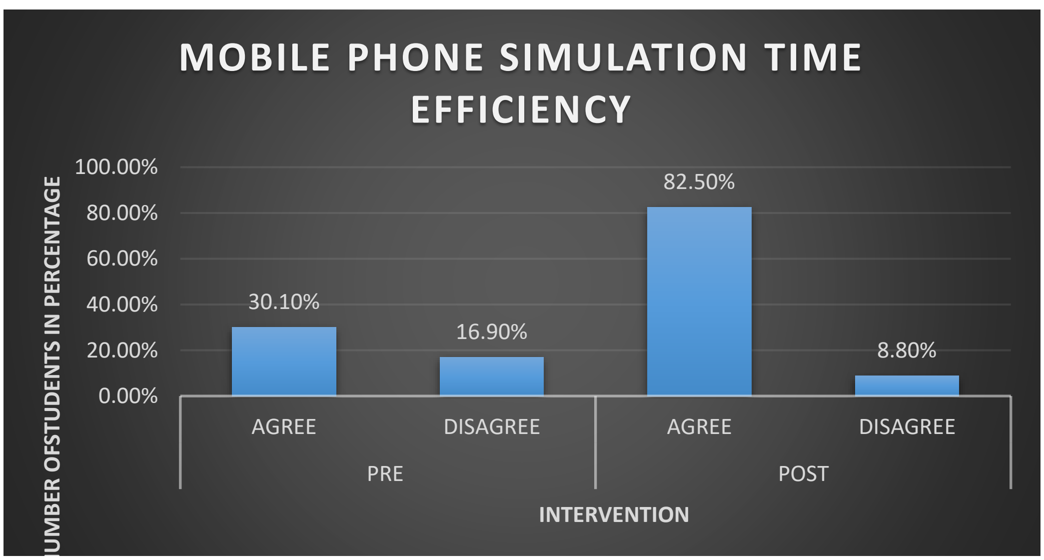


Figure. 6 : Mobile simulation and Time efficiency

Whereas only 33% (N=80) of students agreed that mobile simulation would enable more coverage while learning as compared to textbooks and notes writing, following an exposure to mobile simulations, 82% of students agreed that simulations save a lot of time used in learning. This is because learners are not required to write down details as they can access them anytime by touching their phones, meanwhile staying focused to one main goal, which is learning through experimenting.

Similarly, interviewing teacher A from F School revealed that:

> *"It takes little time to explain concepts to students using simulation applications as they are embedded with all the requirements, giving students opportunities to listen, see, review, reflect and apply"* (Teacher A, school S on 20th October, 2021)

Teacher J also had a resembling opinion regarding time used for teaching and learning during Pre interview session on 19th October, 2021:

> *"I use more time explaining a small part of the concept. However, I prepare a lot more materials in a short length of time using my phone* ***thl*** *application". Mobile phones if allowed in schools will reduce energy spent by teachers in teaching and writing on board".* (Teacher J, S school on 19th October, 2021)

Similarly, educational simulation which was created by a group of high school, undergraduate students and a pedagogical team, following the design thinking approach (DT) have enabled the learners to save time in learning but also being better at tackling questions (Chavez-Ponce et al., 2022). This correlates with results shared in this study (See Figure 6), for which amount of students who saved more time while working on simulations have increased from 30.10% to 82.50%. Additionally, simulation applications have helped students in vocational training to save more time which would have been used in consulting manuals and books (Chiang et al., 2022).

4.2.4 Feelings of Autonomy and Enjoyment

Students' engagement with mobile phone simulations made them enjoy the learning process. Most students gave credits to visualization of PhET simulations and its reality responses depending with conditions. Students from F school had shared the following while answering questionnaire survey item using mobile simulations to access and learn chemistry is fun:

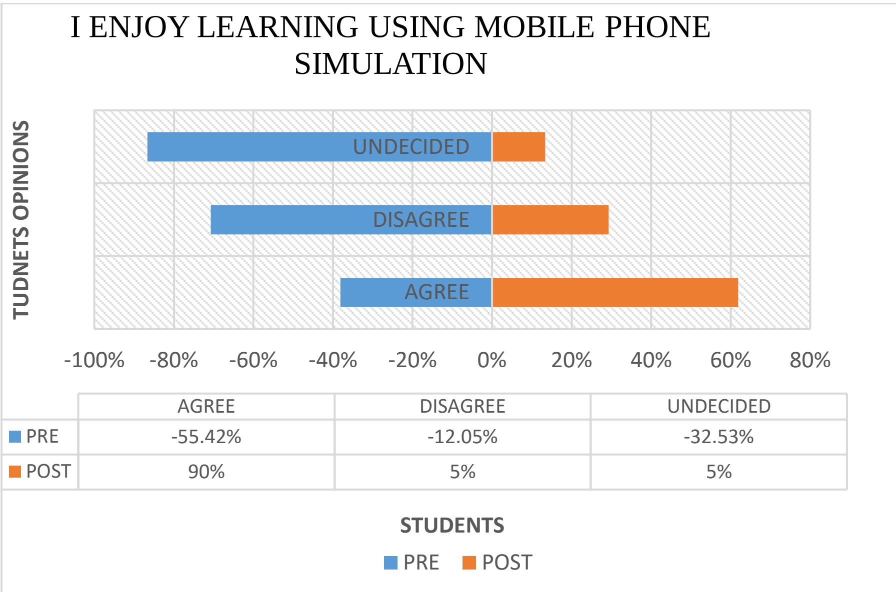


Figure 7: Mobile simulations and enjoyment.

90% (N=80) of all students who participated in questionnaire survey item indicated in a graph had fun and enjoyment learning chemistry using mobile simulations, as compared to 5% who did not enjoy learning chemistry using mobile simulations.

Similarly, results from interviews and focus group discussions with teachers and students respectively were indicative:

> *"I think simulations have improved how I view chemistry concepts, it's not that I was not understanding before but the visuals made it easier to understand"*. (student 3X on 2nd November 2021).

Additionally, describing their experiences with simulations students from S school shared the following details

> *"I really enjoy using chemi lab, and PhET, I think mobile PhET is even better than in the pc version".* (student 2X, school F on 2nd November 2021)
>
> *"with PhET I was able to pin point an end point of titration, I also saw graphical presentation of it, truly exciting.* (student 17Y, school F on 2nd November"2021)
>
> *"monster lab is better as it places me in charge of preparing standard solutions, there's one version which also has a multiplayer mode, I forgot its name"* (student 5Y, school F on 2nd November"2021).

4.2.5 Mobile simulations improve students' engagement in learning

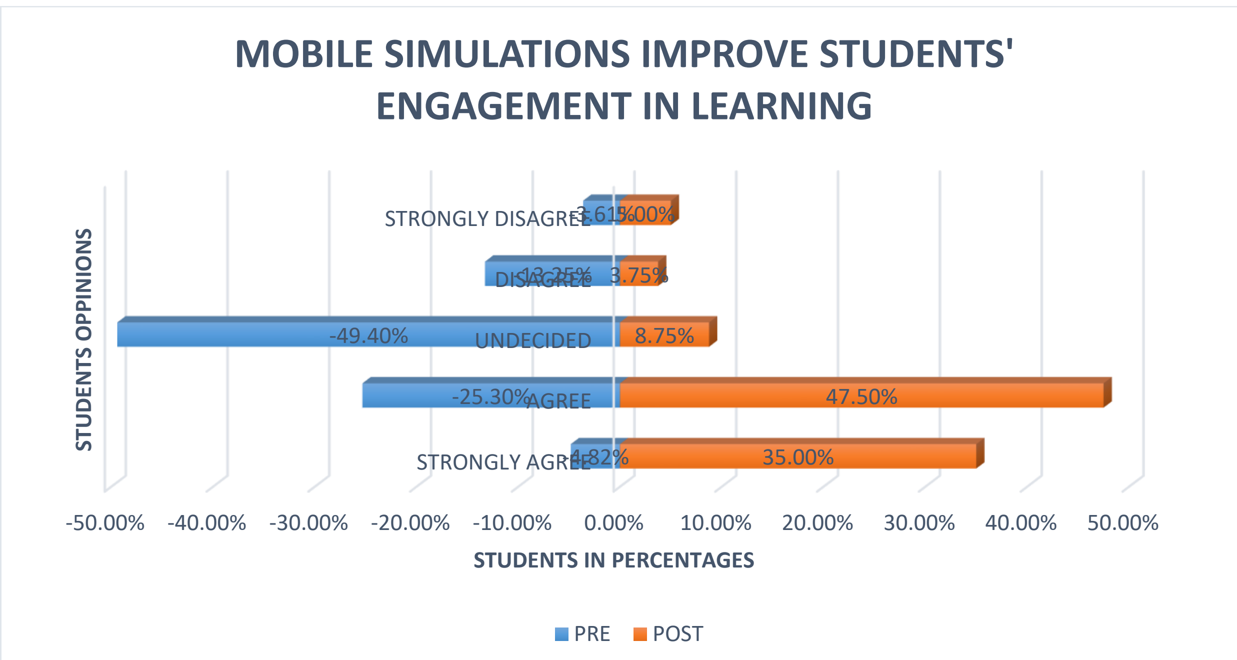


Figure 8: Mobile simulations and Students' engagement

Results from questionnaire survey revealed that 82.50% (N=80) of students were more engaged to learning when mobile simulations were used, in contrary to a pre intervention phase for which 30.12% (N=80) of students shared that they were fascinated by learning chemistry using mobile simulations. About half of all students in pre intervention phase were uncertain because they never came across simulation applications before.

During post interview with teacher J from S school, he revealed that:

> *"It is harder to engage all students while teaching. Force (corporal punishment) has to be used sometimes to keep those disturbing in line. Students would have been easily engaged if they are learning through software applications like that which challenge them"*. (Teacher J, on 3rd November, 2021)

He added that:

> *"It also gives teacher ample time to notice progress of each student during lesson. It also enables the teacher to engage students in problem solving which keep them occupied and there not bored"*

However, a significant proportion of students participated in questionnaire survey disagree with the fact that mobile simulations may replace physical labs working. This is presented in one of the questionnaire responses whether simulations can replace laboratories in figure below:

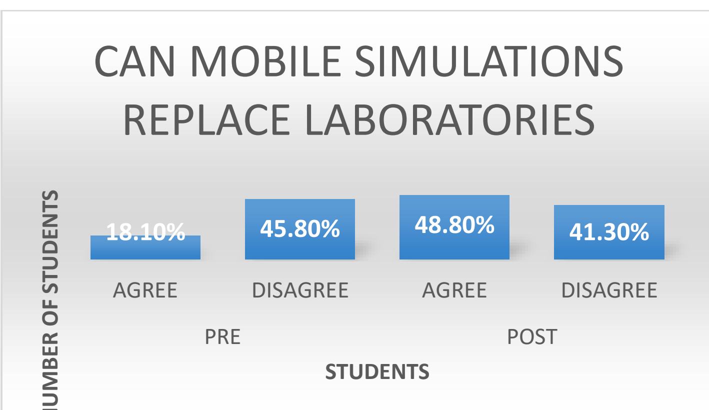


Figure 9: Mobile simulations Vs. Laboratories

Based on results indicated, it is therefore safe to confirm that mobile phone simulations truly inspired students in learning chemistry, and to a larger extent contributed to changing their attitudes towards learning the subject as findings from interviews, focus group discussions and questionnaire survey showed.

Similarly, Penn and Ramnarain (2019) asserted that students experienced autonomy and engagement while learning chemistry using mobile simulations. He also shared that virtually environments found in simulations have enabled visualizations of concepts which in turn led to conceptual understanding. Informal learning environments supported by simulations persistently attempt to put a balance between enjoyment and learning to enhance engagement which is vital to improved attitudes towards what is being studied or observed (Mallavarapu et al., 2019). Students prefer interactive materials which they can engage with at home and repeatedly (Coyne et al., 2018). For better learning experience and for budget stripped schools, it is important that teachers incorporate simulation –blended teaching and learning which is affordable and would reduce the necessity to work around expensive or limited resources reserved for summative assessments (Kalles, 2017). Adopted from de Moura Castro (2022), is a graphical presentation (See Figure 9), that shows mobile simulations become more cost effective with an increased number of students in a classroom which is a typical Tanzanian context for which science teacher student ratio is low.

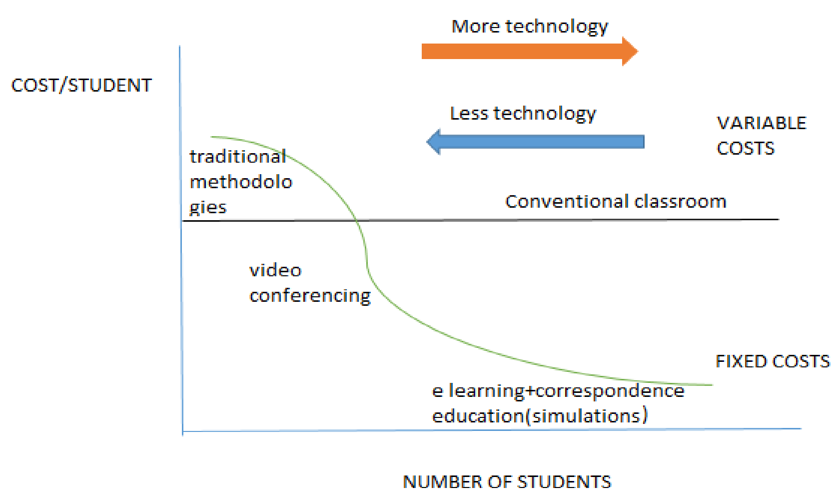


Figure 10: Cost effectiveness in Mobile simulation usage

This is because, for every additional number of students exceeding carrying capacity of a class or a point at which teaching and learning become obsolete, so is the effectiveness of a teacher needed to reach every student as an individual with a more or less similar set of learning needs. Mobile simulations in this situation not only provide consistency to every learner needs but also support efficient and differentiated learning (Santoianni et al., 2022), for which learners under minimal supervision can continue studying and without limiting their scope of learning but also giving a teacher ample time to attending particular students. Since teachers' attitudes have immense effect towards their teaching practices which in turn affect students' attitudes in learning (Papadakis & Kalogiannakis, 2022), then it is imperative that schools consider the usage of mobile simulations for effective learning experience and improved students' attitudes.

In a study that examined students' perceptions in sciences and choice of careers, it was found that simulations were responsible in improving students career aspirations regardless of their ethnicity following an exposure to the intervention. Additionally, it was found that students' perceptions were more positive towards science learning when they had time to use simulations (Gulacar et al., 2022).

4.3 What challenges do students and teachers encounter in using mobile phone simulations as tools for learning chemistry?

During interview, students reported various challenges that they encountered in learning chemistry concepts through mobile simulations, despite the advantages outlined in the previous section. These include accessibility of simulation applications, unreliable internet and network providers', low mobile devices specifications and sometimes double standards in specifications needed, availability and accessibility of mobile phones, strict school regulations, cybersecurity and ransomware threats, parents and guardians' attitudes towards phone usage. Similarly, teachers indicated concern on the same challenges, in addition to policy on mobile phone usage from national to school level and issues about curriculum not being able to embed simulations.

4.3.1 National policy and school Policy on mobile phone usage at school

Interviews with teachers A and J, identified policies being a hindrance towards usage of mobile phones in schools, including local school policy or regulations.

> *"In my school, AS and A level students are allowed to use computers at any time in classroom, but mobile phones are allowed only through special permits given by the Head or Deputy of School, from year 11 down to year 6 both phones and personal computers are not allowed in school. A student will use one while calling his or her parents before leaving school."* (Teacher A, school F on 1st November, 2021)

It was obvious during research that one could see that there is a limited chance to use mobile phones, only in major events such Science fair and study tours.

Another problem is that the school is not putting emphasis on doing home works through online learning platforms. Even if a teacher initiates sending work over emails, students' responses would seem to be low.

Similarly, teacher J shared:

> *"School policies, government policy would still discourage usage of mobile phones in learning because there is little emphasis on ICT knowledge and as a subject. Since textbooks are available no teacher is bothered to integrate ICT in his or her teaching, as it also slows down coverage"*

Debates on usage of mobile phones in secondary schools in Tanzania have long been shared by researchers and teachers. The government's commitment to delivery of high quality education also recognizes mobile phones as a potential opportunity to inform learners on day to day advancement in science and technology, giving them opportunities to show case their potentials and contribute to the national workforce (Joyce-Gibbons et al., 2018). The Education Sector Development Plan (ESDP) of 2016/2017 to 2020/2021 for Tanzania Mainland is set to ensure that children not only go through universalized education system but also acquire life skills, attitudes and knowledge to equip them while turning into fulfilled, loyal and productive citizens. Similarly, The Tanzania

Development Vision 2025 (United Republic of Tanzania, 2010) emphasizes on the advantage of preparing a well learned and educated society by 2025 which will add to the national development.

In order to achieve that we should not wait for completion of ICT infrastructural coverage as depicted in the 2007 ICT policy for Basic Education that by 2025 the Tanzanian schools will be well networked with ICT infrastructures (Barakabitze et al., 2015). Instead we should take advantage of mobile phones widespread accessibility; subscribed to over 85.75% of all Tanzanians and with roughly every 4 people out of 10 accessing the internet via mobile phone (O'Dea, 2021).

While research study was carried in two of the modern private schools in Tanzania, the reflection on findings can be different in public schools where there are no ICT facilities to support teaching and learning of sciences and other technological subjects. The 2014 ICT policy objective number 3.2.3.1 advocates universal access to ICT products and services so as to bridge the digital divide (United Republic of Tanzania, 2014) , in this case between private and public schools or between urban and rural schools but has this been implemented? While ICT as a subject is only optional even in schools with full facilities.

However, the government despite giving general policy statements there are no clear directives on how mobile phones should be used in schools. Consideration on usage of mobile phone in Tanzania could have been initiated with the implementation and the adjustment of ICT education policy which regards ICT as an optional subject in both primary and secondary schools. This leaves the decision to allow mobile phone usage in schools into the hands of administrative section of the school. There is lack of awareness among decision makers, development partners and private sectors on the importance of ICT for education as well as local and national development (United Republic of Tanzania, 2010).

4.3.2 Accessibility of Mobile phones and mobile phone simulations

Interview with Student 13X from school F shared her experiences on accessibility of mobile simulations and identified the issue accessibility among others:

> *"Premium access to top notch simulation applications such as AnyLogic, MATLAB and COMSOL Multiphysics require paid subscription, which is around 4000$ for COMSOL for example. Parents or guardians may not understand and therefore will not pay for it"*. (Student no.13X, school F, on 3rd November 2021)

There are cracked versions for each of these simulation applications, available through backdoors. However, it is not advisable as it does not guarantee safety from malware and ransomware attacks, or breach of copyrights.

Another student had to share the following:

> *"I do not have a phone, I was told that I will have one when I finish schooling"* (student 61B, School S on 22nd October, 2021).

In this study, 15% of students did not have their own phone and therefore, turns were to be taken so that everyone has access to mobile simulations. In addition to that, a researcher also carried two other mobile phones which were used by students.

During an interview, teacher J from school S shared that:

> *"My phone does not have enough storage to accommodate simulations, I would have to buy an advanced phone for that"* (Teacher J, 20th October, 2021).

From these findings, it is clear that mobile phone accessibility to students and teachers is a big challenge. Parents and elders own phones but they would not share them. Parents are therefore advised to allow their children use mobile phones while monitored but also they should be told on why they are being monitored and is considered as good practice by them.

4.3.3 Internet accessibility and availability

Before the intervention phase started, school F informed the researcher via email that he should have his own back up internet subscription to facilitate smooth learning experience with participants.

> Whilst we do have internet capability here, it is strongly advised that you make a back-up plan (e.g. using your mobile as a hot-spot) so as to not encounter any delay in your research.

Mr. M, Deputy Head, F school, 25/10.2021

As of 2020, it is reported that 28.5 million people have internet access in Tanzania. This is about 49% of all Tanzanian having access (O'Dea, 2021). However, accessibility does not mean applicability. According to reports shared in 2021 by Band Width Place, Tanzania internet speed clocks at 2.21 Megabytes per second (2.21Mbps) download rate against 1.81Mbps upload rate across mobile phones, tablets and personal computers. It does not ensure smooth video streaming services which require at least 3Mbps. Neither does it ensure usage of online simulations or online video games which are said to improve mental health and physical fitness in children during this time of COVID isolation (De Pasquale et al., 2021).

Students from S school also described the internet fluctuation as a cause of distractions while learning:

> *"The internet is really slow around here at school; it becomes faster late at night which means you need to stay awake beyond midnight"* (Student 78Y, school F on 25th October 2021).

Both teachers on separate occasions described internet being overly expensive.

> *"Sometimes I wish to connect my PC to mobile internet so that I can download materials in large volume but I cannot afford it"* Teacher J, school S on 25th October, 2021

Either, teacher A from F school shared his opinion on internet costs:

> *"At home I am not accessing anything to do with work, it is until I am here that's when I use the school Wi-Fi"* (Teacher A, school F on 3rd October, 2021)

4.3.4 Students, Teachers, Parents and Guardians Negative perceptions about mobile phone usage in schools

Generally speaking, not all students in this study agreed with the move towards mobile learning which seemed inevitable during the pandemic crisis. Zunckel et al. (2022) in his findings about students perception towards mobile learning found that while 66% of respondents used smartphones for their learning, less than half of the population could actually utilize the technology effectively. Similarly Karim et al. (2022) found that in a medical course students did not have skills to operate smartphones properly. Parents too have been resistant to allow their children let alone making a follow up on what is done in mobile learning, and this is attributed to lack of skills which make them distance themselves from it (White, 2022).

In an interview with Teacher J shared that:

> *"Parents may have been a major cause for it as they started telling their children from tender age that mobile phones will make them lose concentration and fail in examinations*". (Teacher J, school S 27th October, 2021)

Student from school F describing how annoying are the notifications:

> *"I hate endless notifications whenever I am online trying to use my phone for studying, this is why I prefer it for fun only. Not for studies"* (student 69X, school F on 25th October, 2021).

Students shared during FGD that their parents prohibit usage of mobile phone at school as they believe it distracts attention. Student from S school also said that:

> *"Me and my brother were caught using phones at school, from there on the two phones were confiscated by Father"* (student 39B, on 25th October,2021)

Similarly, Kafyulilo (2014) in his findings shared an incident that happened in Kibasila secondary school for which teachers shared their experiences

"...in our school, students are not allowed to use a mobile phone. It happened before that students were sending SMSs to each other while they are in the classroom..."

Kafyulilo's findings also revealed Dar es salaam University College of Education (DUCE) instructors who declared that they only use mobile phone to contact their colleagues but not students.

While doing interviews in school S, a physics teacher was quoted saying:

"Students' deliberately or unknowingly may flirt with a teacher. This is why it is better to avoid contacting them unless under very necessary situations. In case of anything it is advisable to contact parents"

From the above findings, teachers, parents and guardians' belief on mobile phone usage in school has truly contributed to endless debates on placement of mobile phones in schools. School administrators are overly cautious on the consequences of uncontrolled mobile phone usage in school. As revealed by teachers J and A, the government does not provide support towards mobile learning. It is imperative that school administrators, prominent policy makers and members from relevant ministry are taken through seminars to let them realize how good outweighs bad in as far as mobile usage in school is concerned.

4.3.5 Cyberbullying, Ransomware and Malware Threats

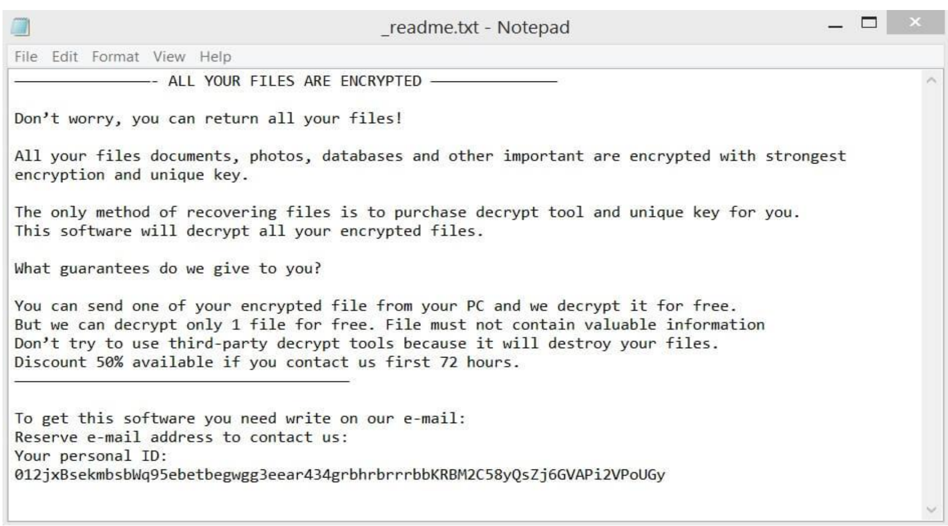
Through the internet, an enormous amount of information is being shared between users on a world on world wide scale. The internet has made teaching and learning to be accessible from any part of the world, a benefit which had helped immensely during the COVID 19 crisis (Taufiq et al., 2022), but also helping people pursuing multiple responsibilities in life. However, at some point users have been or will be facing serious threats such as malware, ransomware attacks and cyberbullying coming with the internet usage.

Ransomware attacks affect operating systems of the user's device(s), restricting access to the files in the device through encryption. The attacked files are also included with a text which informs the user about the status of his device and files and that any attempt to decrypt the files beside the one given by the senders of ransomware will result to damage of the files (Shemitha & Dhas, 2020). This has become more serious with an increasing number of useful software which were not having their premium version free of charge. These versions can be downloaded via backdoors in illegal online marketplaces.

Malware attacks are associated with software programs that interfere with the optimal functionality of device operating systems (Dutta et al., 2022). Such programs may be found associated with genuine programs, so while one downloads an intended virus free software, it comes with another and because both were available from a genuine site, users usually are less concerned.

While downloading a suitable mobile simulation, one student from F school came across the following experience.

> *"All my downloaded files were encrypted as soon as I finished installing the PC version of the application, while trying to figure out what is happening I saw this message"* (Student 31Y, 3rd November, 2021).


_readme.txt - Notepad

File Edit Format View Help

————————- ALL YOUR FILES ARE ENCRYPTED ——————

Don't worry, you can return all your files!

All your files documents, photos, databases and other important are encrypted with strongest encryption and unique key.

The only method of recovering files is to purchase decrypt tool and unique key for you.
This software will decrypt all your encrypted files.

What guarantees do we give to you?

You can send one of your encrypted file from your PC and we decrypt it for free.
But we can decrypt only 1 file for free. File must not contain valuable information
Don't try to use third-party decrypt tools because it will destroy your files.
Discount 50% available if you contact us first 72 hours.

To get this software you need write on our e-mail:
Reserve e-mail address to contact us:
Your personal ID:
012jxBsekmbsbWq95ebetbegwgg3eear434grbhrbrrrbbKRBM2C58yQsZj6GVAPi2VPoUGy

Figure 11: Ransomware template

Signature based detection of malware in mobile phones has been the solution since all applications, files, software have a digital footprints or signatures which are unique to respective property and therefore can be detected and isolated (Oluchi et al., 2022).

However, malware advancement has proven a way to bypass anti malware recognition through encoding the payload as asserted by Zuhair (2022) or sometimes by manually introducing software into systems in which virus will replicate changing its footprints just like a biological virus will change sequence of its genetic (DNA or RNA) code while inside a host cell. A payload can be described as a malicious attachment embedded in an email received from random sources, and so as the user downloads it he or she gets infected.

With such complexity in play, it is advisable for educators, students and teachers to install genuine anti malware, or spyware programs (and not trial versions) in their digital devices or institution servers. These genuine programs are widely available in stores selling computers and its accessories. Additionally, a thorough deep scan conducted twice a week, which takes hours to finish plus a device restart would often help keeping the antimalware definitions up dated.

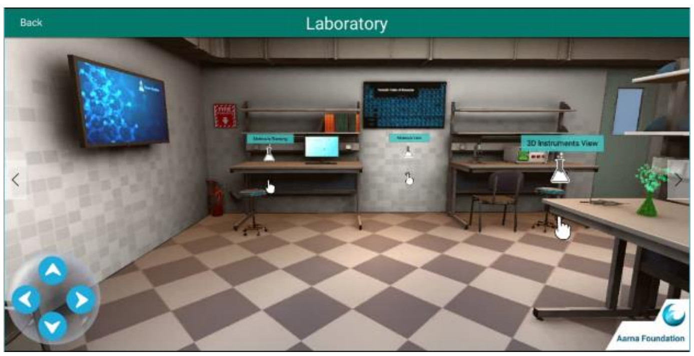
No participants reported signs of being cyberbullied during the entire period of the study. Moreover, studies on cyberbullying indicate that it is possible to contain cyberbullying by using serious games which are highly motivational and changes users' attitudes instantly. They also serve as alarming tools to let users in this case students detect which particular site has cyberbullying reputation (Calvo-Morata et al., 2020).

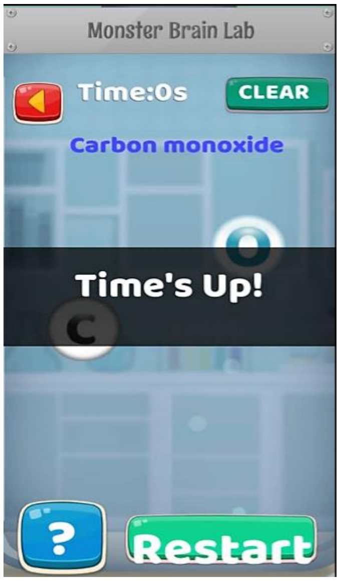
4.4 Researcher's observation on Students and teachers' interactions with Simulations during Intervention Phase

4.4.1 Interactive and explorative learning

The researcher observation in school S has revealed that teacher J intensively incorporated hands on, real world activities to provide feedback to his students through asking them questions based on models created but also answering theirs. Teacher A had been using passive learning for which presentations are done by him upfront and students are listening. Teacher J used explorative learning through letting students discover from their models and between themselves that which of the created models closely matched with explanations given in theory. Explorative learning as a pedagogical approach requires student to take charge of their own learning under natural circumstances, while interactive learning is important for knowledge acquisition and development of not only physical skills such as endurance, agility and coordination; but also core skills students' brain can use to think, read, remember, reason and pay attention (Barker, 1994). Figures below show interactive and explorative nature of mobile phone simulations:

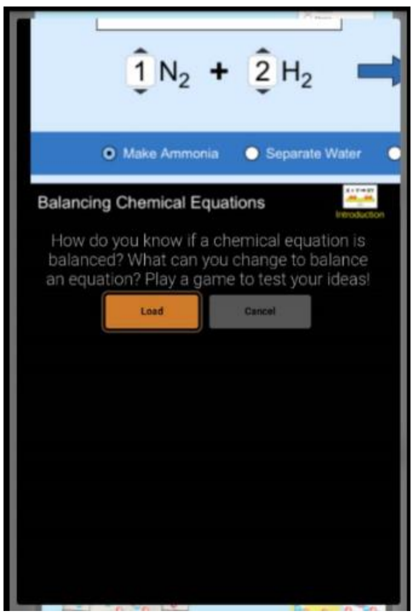
SIMULATION	IMPACT
Name: Chemi Lab	Students' interaction Brings endurance and coordination. Screen sharing and perform an experiment for example constructing molecular models and naming them. Students' exploration How elements bond, a chance to discover VSEPR theory on their own.
Name: Monster lab	Students' interaction Brings persistence, agility and coordination Discussions on what are the bonds, how bond formation occurs, why is it occurring? How electronic configuration affect bond formation?





Students' exploration

Persistence and agility in answering different questions against time.



Students' interaction

Brings endurance, coordination and agility

Students' exploration

Principle of conservation of mass on their own.

Name: PhET Interactive

Figure 12: Simulation images

4.4.2 Technological Pedagogical Content Knowledge (TPACK) of Teachers

The researcher has observed the impact of Technological Pedagogical Content Knowledge(TPACK) of teachers A and J who are from school F and S, and its influence to Students Attitudes towards learning Chemistry.

TPACK refers to the understanding of how to use technology to teach concepts in such a way that students' learning experiences are strengthened. It forms basis of effective teaching with technology and demands for an understanding of the representation of concepts; pedagogical techniques that constructively use technologies to teach content; knowledge that simplifies concept and make them understandable easily, and in what ways technology can remedy problems that students are facing while learning for example in trying to understand the relationship existing between forms of matter at both micro and macro levels; and knowledge on how technology can rebuild on existing knowledge (Mishra & Koehler, 2006). Both teachers A and J demonstrated in depth understanding of subject matter they have been teaching, which include knowledge on central facts, theories and procedures in chemistry subject. While teacher J had been using models in his lessons, which are made by students using the materials around the school, teacher A solidly relied on existing technology facilities in his school F to teach students and these include power point projection, learning management systems (google classroom). He never used displayed models which are plentiful in the laboratory. Therefore, while teacher A demonstrated good Technological Content Knowledge (TCK), teacher J demonstrated good Pedagogical Content Knowledge (PCK). Both teachers demonstrated fair Technological Pedagogical Knowledge (TPK) as teacher J only use his smartphone to prepare lesson notes but not bringing it to classroom, and teacher A does not involve students' own models to let them learn, instead he used technologies available in the school.

CHAPTER FIVE

SUMMARY, CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Summary of the study

The present study aimed at using mobile phone simulations to improve students' attitudes towards learning chemistry. Specifically, the study aimed at answering two research questions: How do the use of mobile simulation influence students' attitudes towards learning chemistry? and What challenges do students and teachers encounter in using mobile phones (simulation) as tools for learning chemistry? To answer these questions, the study examined whether the intervention or simulation applications would have an influence in students' attitudes towards learning, but also examined the challenges students and teachers were facing while using mobile simulation applications. The study gathered students' opinions via pre and post focused group discussions and self-administered pre and post survey questionnaires, and more information from their teachers via pre and post interviews.

Results collected from focus group discussions reveal that students demonstrated positive attitudes towards learning chemistry via mobile phone simulations. Teachers from school S and F also showed a positive feedback towards teaching chemistry via mobile simulation as compared to traditional methods by indicating how much of their problems are resolved when simulated applications are used in their teaching, as students are able to hear, view and practice the real life scenarios posed by the simulations. The following section gives a discussion on the findings of this study.

5.2 The effect of mobile simulations on students' attitudes towards learning chemistry

Results from this study showed that students demonstrate high confidence while working with simulations and tend to answer correctly the questions which seemed difficult before the intervention was conducted. Little is being shared in literature describing simulation as a pedagogical tool which improves students' confidence in learning. Abundant amount of effort has been made in Nursing Education and Medicine in which students work more confidently when they know there would be no repercussions in case errors or accidents happen as it would have been while working on a real thing (Cummings & Connelly, 2016; Khalaila, 2014; Muniandy et al., 2015; Walker et al., 2015). Results of this study also conform to the findings as students were able to prepare and standardize Acid solutions without fear of getting corroded by the chemicals.

On the other hand, students shared that usage of mobile phone simulations in learning chemistry help them remember concepts learnt for a long period of time, as compared to traditional learning for which it is easy to forget. Other studies show that students show keen interest on the usage of mobile phone as both a social connectivity and a collaborative tool to enable improving their memory but also accommodates flexibility and personalized learning activities (Ahmad, 2020). Simulations aided students in this study in breaking down concepts which seemed complicated to them into small chunks which allow student to learn at a pace they like. Described as scaffolding by Roll et al. (2014) is a technique used to re-shape students' attitudes towards learning as it also looks back on their previous experiences and memory.

Students intrinsically evolved the tendency to referring to their digital devices looking for more information for effective understanding. It is therefore inefficient to rely on teacher centered learning as it only works for a minor proportion of students. This was observed throughout the intervention period for which teachers A and J relied heavily on providing information instead of letting students find it for themselves. Discussed in chapter 1 of this study, teacher centeredness which gradually build ups as children progress from lower primary classes to higher classes, does not invest in creating independent learners and this practice continue to higher education for which students rely on being given materials and directives from their teachers or lecturers (McClary & Bretz, 2019; Montes et al., 2018) .

Teacher centeredness does not exhaust on learning outcomes. It is limited to what the teacher is willing to cover. Any content provided to the students will have to be relevant with them no matter how badly conceived. The learner therefore is provided with limited sets of knowledge for example via memorizing content or rehearsing formulae, without putting to use the actual process-skills as part of professional practice (Schön, 1983). Researcher's experience as a student some years back revealed that it was common to hear students talking about notes given by a certain teacher being complete as compared to other teachers. Students limit themselves by referring to someone's own writing rather than using multiple sources such as textbooks, educational platforms and discussion forums. Bring Your Own Device (BYOD) movement would improve exploitation of learning outcomes as students become independent researchers, quenching their intellectual demand for appropriate and updated information through studying different sources. (Nuhoğlu Kibar et al., 2020). Moreover, in teacher centered settings students are neither facilitated nor encouraged on their freedom to acquire life-long skills (Trilling & Fadel, 2009).

5.3 Challenges associated with usage of mobile phones

Among challenges mentioned by the teachers while using mobile phone simulations in the post interview session was the fact that school policy does not allow student's usage of mobile phones. In school S, the administration is more examination results oriented and therefore the attention to whether there is ICT usage or not is not a concern to them. Students and their teacher have reached a high level of rote learning in which memorization of materials is achieved by giving students numerous exam like questions so that by answering them in many occasions they get used to how questions appear and therefore pass so well. Students become overly used to summative assessments and this is reflected as success in the school. What is expected by the administration is that syllabus is finished much earlier so that students have time to re do examination questions. While discussing with teacher J, he said that A'level chemistry which is a two-year duration learning is covered in one year, just before students are starting their final year. The rest of the time will be invested in doing examinations and referring to specific parts where usually questions are originated from. Doing this over time make students experts at predicting and recalling how questions come and which way to answer them. Conclusively, there is little emphasis on ICT integration for school S that has its all focus on ranking as among the best schools in Tanzania where as teachers do not use ICTs to radically change their pedagogical practices, instead they use it sustain their traditional practices (Mwalongo, 2011) as suggested by teacher J during the post interview session.

While other studies have indicated lack of ICT integrations in African context being caused by poverty-led factors including the absence of reliable electrical power, the absence of technological facilities, the lack of reliable internet connectivity and remoteness (Mathevula & Uwizeyimana, 2014; Mbodila[1] et al., 2013; Samarakoon et al., 2017), schools which a researcher has visited are all equipped with at least a kind of running ICT facility such as a computer labs in school S, iPad, personal computers, smartphones, projectors, free local area networks (LAN) in school F but it is the school policy which does not foresee the usage of these facilities regularly or at a certain standard that ensures effective learning of students. Moreover, teachers' personal uptake of integrating ICT to teaching is low. This is also reflected in countries which are already developed for example South Africa, where teachers' uptake of widely available ICT facilities ranges between 21% to 41% (Padayachee, 2017).

Additionally looking at ICT Integration in Tanzanian context, poor skills and inefficient support on basic usage of ICTs hardware, software and their associated parts could a reason behind why schools' administrators are not giving full support towards the move to mobile and technological learning (Kihoza et al., 2016). These people went to school before computers' era and probably did not go for professional development courses on ICT. In another study done in Shanghai it was found that e-leadership as enforced the school principals significantly influence the ICT transformation in schools. School leadership is stated as among factors for an ICT transformation in a school setting (Chen, 2013).

5.4 Future of technology in relation to mobile phone usage in education

During a post interview with teacher A from F school, a discussion on the future of technology highlighted areas, which have immense impact towards moving to simulated learning of science subjects. The dynamic nature of technological advance which has so far surpassed scientific advancements tends to offer new opportunities to experimentation with mobile phone usage in teaching and learning of science subjects. Smart technologies such as internet of things which are still new to our developing world can best cater for the inadequate man power and at the same time allowing teachers to monitor students' learning progress in real time (Khan et al., 2019). Moreover, teachers can evolve from the traditionally paper and pen writing and save more time to uncovering their teaching strategies while using "SMART" lesson plans, translated as specific, measurable achievable relevant and time bound. Edge computing which is common in other fields of science such as engineering and construction, can be adopted to learning, enabling students to for example isolate sub atomic particles in simulated application or rather instigate water infiltration characteristics given by the cacti plants in a simulator application available in their mobile phone. Conclusively, as learners are becoming more aware of what can be accommodated by their mobile applications, it would not only enhance their understanding of scientific concepts, but also giving a brighter career path in which more explorations can be harnessed.

5.5 Conclusion

Based on discussions above, it can be concluded that students' attitudes towards learning chemistry can significantly be influenced by the usage of mobile phone simulations as they engage a student in all aspects of his or her abilities to learn. While the debate had been on transferring the learning to students, this research suggests practicability or experimentation as core function for a successful ICT integrated teaching and learning in which both students and their teacher play an active role. While extensive usage of technology can lead to better learning experiences and improve students' attitudes towards learning abstract concepts in chemistry in school setting A or person a, it may not produce similar results `if same effort is made in another school or to students from another setting. The dynamic nature of teaching and learning should be approached accordingly with the type and nature of those who are being taught or the nature of their environment. The research recognizes and advocates usage of simulation applications and other technological platforms but with a keen look to where it should be used and where it should not. Looking back on the case of teacher A who is teaching in a prestigious school with enriched facilities for teaching with technology, we find that students are actually more engaged to what technology had offered and less engaged with the intended objectives of the lesson as extracts indicated in post focused discussion. A balance between teacher and students' involvement in a learning should be considered for a successful ICT integrated learning and for an improved attitude towards learning chemistry.

The researcher encourages differentiated teaching and learning in which students get to experience different modes and tones by different teachers through team teaching and also having well differentiated materials with levels of understanding, reasoning, endurance and agility so that what does not work for one student may work another.

5.6 Implications of the study

Doing a concurrent mixed methods study has been a challenging experience as I had to handle large amount of activities and data at an instance which made me extra vigilant and keen to details. It has also been a useful learning experience in my capacity as a chemistry teacher, newbie video game developer who plans to take simulation programming to a new level and last but not least as a researcher.

Simulated learning can positively impact students' attitudes towards learning scientific concepts in general, and that adds to researcher's personal interest of creating gaming applications which have a mix of learning and recreational activities.

Finally, as a researcher it made me learn why the particular design of research was convenient with my study area. I have learnt how good data collection resonates with better findings, in this case findings that were obtained through usage of different set of tools but all have given matching results. I have also learnt that the whole research process is not as smooth as it is done theoretically during lectures, it actually involves a lot more interactions with different personalities which are all happening against time. As researcher I recall moments I had to work extra hours or during weekends with participants in order to realize the significance of the study and its findings. With the experience obtained while doing this study I am at a position to declare my strong conviction that my coming research endeavors will be awe-inspiring.

5.7 Recommendations

This study recommends school management teams to develop and enforce the Teacher-Learner integrated ICT policy that strictly demands for daily involvement of technological facilities in teaching and learning at school, and in particular students who took chemistry to help alleviating their perceptions towards learning the subject. Since both teachers and students agreed to moving towards mobile learning and usage of mobile simulation as a way forward to their learning, the administrative force in the school should allow and closely monitored project to see whether blended learning would work better in their school.

Secondly, curriculum developers in Tanzania should consider embedding mobile based simulation learning in the chemistry subject to make teachers adjust to that. Moreover, professional development opportunities should be provided periodically to let teachers craft well their abilities to use ICT facilities.

Thirdly, parents should allow their children interact with a specified range of applications for learning under their supervision or from teachers.

Finally, based on the intended objectives of this study, which are focused on Students attitudes towards learning chemistry using mobile phone simulations, findings of this study, however limited to this context, can be used to inform future studies related areas such simulations, technology and students' attitudes towards learning chemistry.

It is therefore recommended that further studies be done in public schools, single sex boys and girls school and also in other subjects to see whether the findings would be similar or different so as to correctly inform the policy makers and public at large, more so, a scaled up study would do. I would like also to add the fact that studies involving usage of mobile phones to students need prior preparation especially in seeking approval from parents, guardians and schools. My case therefore may or may not serve as a generalized result of what would happen on a large scale where public schools dominate and students have no access to phones let alone being allowed to have one at school.

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APPENDIX A: ETHICAL CLEARANCE CERTIFICATE

THE AGA KHAN UNIVERSITY

Ref.: *AKUIED/EA/2021/004/fB/10* **Date:** *October 4th, 2021*

Ahmed Mbaruk Nyenga,
Aga Khan University,
Institute for Educational Development East Africa (IED EA),
P.O Box 125,
Dar es Salaam,
Tanzania.

ETHICAL CLEARANCE CERTIFICATE

Dear Ahmed Mbaruk Nyenga,

This is to certify that your research project entitled, ***"Students' Attitudes Towards Learning Chemistry Using Mobile Phone Simulations"*** undertaken as part of the dissertation project in the master of education program at IED EA has been approved for Ethical Clearance.

Yours Sincerely,

Dr. Fortidas Bakuza
Chair ERC - Tanzania

Cc: Dissertation Supervisor: Dr. Winston Massam

Salama House, 344 Urambo Street, P.O. Box 125, Dar es Salaam,
Tanzania Tel: +255 22 215 2293, 22 215 0051, Fax: +255 22 215
0875; Email: iedea@aku.edu www.aku.edu

APPENDIX B: DAR ES SALAAM REGIONAL& KINONDONI DIDTRICT RESEARCH PERMIT

JAMHURI YA MUUNGANO WA TANZANIA
Ofisi ya Rais
TAWALA WA MIKOA NA SERIKALI ZA MITAA

MKOA WA DAR ES SALAAM
Anwani ya Simu:
Simu: 2203156/2203158
Barua pepe: ras@dsm.go.tz
Unapojibu tafadhali taja

OFISI YA MKUU WA MKOA,
3 BARABARA YA RASHIDI KAWAWA
S.L.P. 5429,
12880 DAR ES SALAAM.

Kumb. Na. EA. 260/307/01/13

13 Oktoba, 2021

FEZA International School,
DAR ES SALAAM.

St. Anna Secondary School,
DAR ES SALAAM.

YAH: KUMTAMBULISHA BW. AHMED MBARUKU NYENGA

Tafadhali husika na somo tajwa hapo juu.

2. Ofisi Katibu Tawala Mkoa imepokea barua isiyo na kumbukumbu ya tarehe 5 Oktoba, 2021 kutoka The Aga Khan University ikimtambulisha na kumuombea kibali cha kufanya utafiti Bw. Ahmed Mbaruku Nyenga.

3. Mtafiti huyu anafanya utafiti kuhusu **``Attitudes towards Learning Chemistry Using Mobile Phone Simulations".** Kwa barua hii, kibali kimetolewa cha kufanya utafiti huo katika Shule tajwa hapo juu.

Ninashukuru kwa ushirikiano.

Nyange M. D.
Kny. KATIBU TAWALA MKOA
DAR ES SALAAM

Nakala:- Katibu Tawala Mkoa,
DAR ES SALAAM. - *Aione kwenye jalada*

APPENDIX C: CONSENT FORM FOR HEAD OF SCHOOL F

CONSENT FORM FOR THE HEAD OF SCHOOL

I have read the information sheet, and the nature and purpose of the study has been explained to me by Ahmed Mbaruku Nyenga a student from the Aga Khan University. I now agree that:

He can visit the school because I have understood the purpose of the study. He has my consent to carry out the study. The researcher can also request students to have their mobile phones during the day of intervention for the purpose of giving student best experience as stated in the study.

I as the head of school have right to seek for clarification or advance concerns on matters to do with the research through the Head of Training Programs at Aga Khan University using the address provided.

This consent is given provided that;

i. The school has the right to withdraw from this study as and when it may deem necessary.
ii. Confidentiality of all involved shall be upheld and the image of the school shall be projected.
iii. The study findings will be made known to the school.

I hereby accept that my school will be part of your study:

Name [illegible] Position Principal

Institution FIS Signature [illegible]

Date 25/10/21

Researcher signature [illegible] Date 3/11/2021

APPENDIX D: CONSENT FORM FOR THE HEAD OF SCHOOL S

CONSENT FORM FOR THE HEAD OF SCHOOL

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This consent is given provided that;

i. The school has the right to withdraw from this study as and when it may deem necessary.

ii. Confidentiality of all involved shall be upheld and the image of the school shall be projected.

iii. The study findings will be made known to the school.

I hereby accept that my school will be part of your study:

Name GRADIUS NDYETABULA Position HEAD OF SCHOOL

Institution ST ANNE MARIE ACADEMY Signature [signature]

Date 03/11/2021

Researcher signature [signature] Date 3/11/2021

HEADMASTER
P.O. BOX
MBEZI KWA MSUGURI
DAR ES SALAAM
ST. ANNE MARIE ACADEMY

APPENDIX E: STUDENTS' CONSENT FORM

STUDENTS' CONSENT FORM

Aga Khan University

Institute for Educational Development, Eastern Africa

P.O. Box 125

Dar –Es- Salaam

Date ..02/11/2021.....

HEADMASTER
P. O. Box 31373
MBEZI KWA MSUGURI
DAR ES SALAAM
ST. ANNE MARIE ACADEMY

Head of School

ST. ANNE MARIE ACADEMY

....

Re: REQUESTING FORM 3 & 4 **TO TAKE PART IN A STUDY**

My name is Ahmed Mbaruku Nyenga, a student at Aga Khan University. I am conducting a study on students' attitudes towards learning chemistry subject using Mobile phone simulations as part of my masters' degree course. You will be given a form to fill to your best of feelings or understanding. But also there will be a group discussion involving six (6) students on issues pertaining to how you as student perceive learning in the current situation and when given opportunity to learn via mobile phone simulation applications. Your valuable participation to the study is instrumental to the generation of this research work and will contribute to further learning in the present world of science and technology.

If you have read and understood the intent and purpose of the study and accepted to take part, please append your name and signature below.

Students' name (Monitor).. Signature or thumb impression ...

....

Students' name(Monitress) .... Signature or thumb impression

....

Date ....

APPENDIX F: RESEARCH INFORMATION SHEET

RESEARCH INFORMATION SHEET

INFORMATION SHEET

Title of the study: STUDENTS'ATTITUDES TOWARDS LEARNING CHEMISTRY USING MOBILE PHONE SIMULATIONS. A study in a Secondary School in Dar es Salaam.

Introduction

I am Ahmed Mbaruku Nyenga, a Master of Education student at Aga Khan University. I would like to carry out a research in your school. The title of the study is STUDENTS' ATTITUDES TOWARDS LEARNING CHEMISTRY USING MOBILE PHONE SIMULATIONS.

This study shall seek to study the extent at which students' attitude towards learning of chemistry as a subject can be improved through the use of mobile phone simulations. The study therefore will gather students' attitudes via use of questionnaires and interview questions in learning the subject when taught via traditional way/lecturing (pre intervention) and when they will be taught using mobile simulation in same group of students (post intervention). Also a teacher will be interviewed on experience and challenges he/she has with mobile phone simulations.

I request to involve 80 students and 1 teacher as participants.

Procedure

In this study I wish to do the following:

First round (first visit)- pre intervention (This will take 40 minutes).

- Have a focused group discussion with one group of six (6) students on how they perceive learning chemistry via existing methodologies (lecturing/teacher centred). Giving them opportunity to mention troubles or difficult areas/topics/sub topics that they face while learning chemistry. Recording their responses through a tape recorder (laptop or mobile phone).
- Distribute questionnaire surveys to eighty (80) students (who are studying chemistry) for them to fill in and collect them.

- Have an interview with one chemistry teacher who is teaching those students.

Second round (next visit) – Intervention (This will take ideally 40 minutes).

- Using mobile phone simulations to tackle similar problems discussed in the first round.
- Giving students opportunity to interact with simulation applications (while guiding/teaching them) to tackle the mentioned problems in the previous set up.
- Conduct an FGD with two groups, each having 6 students and record their responses having been exposed to simulation applications in learning chemistry.
- Distribute questionnaire surveys to students to fill in and collect them
- Have an interview with one teacher, who was previously interviewed in pre intervention.

All the findings will be used for the sake of this study not outside the study.

Possible risks or benefits

There is no risk involved in this study. The research findings will be shared to the principal and the participants (students). Results of the study may be used to initiate a positive move towards educational technology and its inclusion in teaching and learning.

Right of refusal to participate and withdrawal

You are free to choose to participate in the study. You may refuse to participate without any loss of benefit which you are otherwise entitled to. You may also withdraw at any time from the study without any loss of benefit which you are otherwise entitled to. You may also refuse to answer some or all the questions if you don't feel comfortable with the questions.

Confidentiality

The information obtained from your school will remain confidential. Nobody except principal investigator will have access to it. The name and identity of your school and students will also not be disclosed at any time. However, the data may be seen by Ethical review committee and may be published in a journal or and elsewhere without giving your name or disclosing your identity.

Second round (next visit) – Intervention (This will take ideally 40 minutes).

- Using mobile phone simulations to tackle similar problems discussed in the first round.
- Giving students opportunity to interact with simulation applications (while guiding/teaching them) to tackle the mentioned problems in the previous set up.
- Conduct an FGD with two groups, each having 6 students and record their responses having been exposed to simulation applications in learning chemistry.
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Confidentiality

The information obtained from your school will remain confidential. Nobody except principal investigator will have access to it. The name and identity of your school and students will also not be disclosed at any time. However, the data may be seen by Ethical review committee and may be published in a journal or and elsewhere without giving your name or disclosing your identity.

Authorization

You will be asked to sign a consent form to indicate your voluntary participation. You will receive a copy of the form. Your consent does not take away any legal rights in the case of negligence or other legal fault of anyone who is involved in this study. Nothing in the consent form is intended to replace any applicable national, state, or local laws.

Available sources of information

For further questions, you may contact Principal investigator: Ahmed Mbaruku Nyenga

Phone number: +255768889777/+255783888184

Email: ahmed.nyenga@scholar.aku.edu and meddix905@gmail.com

APPENDIX G: QUESTIONNAIRE FOR PARTICIPANTS

PRE AND POST QUESTIONNAIRE

(ATTITUDE/PERCEPTION TOWARDS LEARNING CHEMISTRY)

The scale below is assigned with numbers in ascending order from 1 to 5 in accordance with your choice. Numbers used indicate the following levels of your perceptions about a statement shared.

Number	1	2	3	4	5
Meaning (Perception)	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Your choice					

In all statements shared, choose one response representing your perception or understanding about a statement shared by simply putting a tick (√) in the relevant box provided.

For example, in the question below:

Learning chemistry via text books consume longer time.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice			√		

This reads: I neither agree or disagree with the fact that learning chemistry text books consume longer time.

PLEASE INDICATE WHAT YOU THINK ABOUT THE FOLLOWING

---

1. Learning chemistry using textbooks only is boring.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

2. Using mobile phones to access and learn chemistry is fun.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

3. Attempting to answer chemistry questions through doing practical activities in the laboratory can be confusing.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

4. Mobile phone simulations can be helpful in answering chemistry questions

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

5. Moving to mobile phone learning as opposed to traditional pen and paper learning can be interesting

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

6. Learning chemistry concepts via textbooks only is repetitive and can be boring.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

7. I take longer to finish up a practical procedure in the laboratory.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

8. Doing study revision using textbooks and print outs is very tiresome.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

9. I can easily catch up when learning chemistry via mobile simulation as opposed to textbooks.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

10. Moving to learning chemistry via mobile phone simulation give more privacy to learners.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

11. Assessments (quiz, exercise) in chemistry textbooks do not reveal results right away as compared to simulation applications.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

12. Textbooks are wordy and are not direct to the point/objective.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

13. Simulation or game learning of chemistry is very direct to the intended objective/point

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

14. Learning chemistry using word play or word puzzle in simulated mobile phone applications are more interesting.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

15. Textbooks used in learning chemistry do not consider learning via word plays/puzzles which are fun

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

16. Learning chemistry via practical or demonstration put us in risk

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

17. I understand better when learning chemistry via animations.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

18. Self-learning chemistry via textbooks is fun.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

19. I need to go through several textbooks to understand a concept.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

20. I do not need to visit libraries to be able to read and find materials for my project because I can do it via mobile simulation applications.

Perception	Strongly Disagree	Disagree	Undecided	Agree	Strongly agree
Scale/number	1	2	3	4	5
Your choice					

21. Learning chemistry via using textbooks is challenging.

Experiences	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Scale/number	1	2	3	4	5
Your choice					

22. Learning chemistry via mobile simulation is challenging

Experiences	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Scale/number	1	2	3	4	5
Your choice					

23. Learning chemistry via traditional/existing methods takes longer to grasp a point.

Experiences	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Scale/number	1	2	3	4	5
Your choice					

24. Learning is effective and more engaging while using mobile phone simulations as compared to using textbooks, pen and paper reading.

Experiences	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Scale/number	1	2	3	4	5
Your choice					

25. Mobile learning gives learners/students freedom of choosing when to learn, how to learn and where to learn.

Experiences	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Scale/number	1	2	3	4	5
Your choice					

THANK YOU FOR YOUR TIME AND CONTRIBUTION IN FILLING UP THIS QUESTIONNAIRE. YOUR CONTRIBUTION WILL MAKE THE SUBJECT MORE UNDERSTOOD, FUN AND INTERESTING

APPENDIX H FOCUSED GROUP DISCUSSION QUESTIONS TO STUDENTS

Pre FGD

1. What challenges do you encounter while learning chemistry via traditional methods (lecturing)?
2. How confident are you in learning chemistry via traditional methods (lecturing)?
3. Any idea about learning chemistry and any other subjects through mobile phone simulations.
4. What is your opinion towards moving to mobile learning and usage of mobile phone simulations as a compulsory part of your learning?

Post FGD

1. What challenges do you encounter while learning chemistry using mobile phone simulations?
2. How confident are you in learning chemistry via mobile phone simulations?
3. What is your opinion towards moving to mobile learning and usage of mobile phone simulations as an alternative approach towards chemistry learning?

APPENDIX I: INTERVIEW QUESTIONS TO TEACHERS

Teachers

Pre interview

1. Have you been using mobile phone simulations in your teaching?
2. What challenges have you been encountering while teaching via traditional methodologies?
3. What is your opinion towards moving to mobile learning and usage of mobile phone simulations as a compulsory part of your teaching?

Post interview

1. What was your experience in using mobile phone simulations in your teaching?
2. What challenges did you face while teaching using mobile phone simulations?
3. What is your opinion towards moving to mobile learning and usage of mobile phone simulations in chemistry teaching?