Production of Digital Game for Teaching Solar System under Integrated Science and its Effects on Pupils' Learning in Junior High Schools in Kumasi

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy in Art Education and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

To Eddie and Violet.

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ABSTRACT

Education is vital to national development, and Science education to a ground-breaking economy. Therefore, academic performance is of utmost importance and its decline a source of worry to all stakeholders, necessitating efforts to determine its causative factors. However the greatest cause of decline presently has been attributed to educating today's technology driven learners in old ways which are no more operative. Solar System is a challenging topic that must be taught in a way that will arouse admiration and incite the attention of learners. Conversely, Digital Game-Based Learning have been proven an effective way of stimulating and optimizing students' learning performance. Thus, this study investigated the traditional methods adopted for teaching Solar System under Integrated Science and their effects on learning, pupils' knowledge and skills in digital games and devices, to produce a Digital Game to adjunct the teaching of Solar System and evaluated its effects on learning in two Junior High Schools in Kumasi. The study was guided by the descriptive and quasi-experimental research approach under the mixed method research design, with observation, interviews and questionnaire as research instruments. Convenience and purposive sampling techniques were adopted to sample two JHSs, 94 respondents– 90 form three pupils, 2 teachers and 2 head teachers. The study revealed lecture as the main teaching method employed for Solar System in both schools, which did not allow interaction, participation or hands-on activities, and made lessons uninteresting and boring leading to low performance. The developed digital game on the difficult-to-teach topic 'Solar System' proved pupils' interest when active learning was pursued and improved their performance. It was therefore recommended that pupils' knowledge and skills in digital games should be tapped on to deliver engaging, interesting, fun and active learning through digital games. It suggested that digital games be developed for all topics in Integrated Science to be used by teachers as supplementary tools during lessons.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter commences with the background to the study, the statement of the problem, objectives of the study and research questions, followed by the delimitation, definition of terms, importance of the study and the organization of rest of text.

1.1 Background to the Study

Education is vital to personal, socio-economic, scientific, political, and national development (Ololube & Egbezor 2012; Uriah & Wosu 2012; Umo 2005, as cited in Abiogu, 2014). It nurtures the skills and potential of persons for success in society (Huitt 2011). The primary goal of education, according to Aremu and Oluwole (2001) is linked to academic performance, which is the heart of educational growth, and constitutes what a learner is capable of achieving in a test (Otu-Danquah, 2000 as cited in Otoo, 2007).

Science is also viewed as one imperative subject in education that brings economic change and social progress to a country (Anamuah-Mensah 2004). According to Gluckman (2011) as cited in Agudzeamegah (2014) Science education is necessary to the acquisition of a well-informed and ground-breaking economy. As a result, the Curriculum Research and Development Division (2012) designed Integrated Science education to furnish pupils with an optimistic attitude and skills that will nurture the interest and affection for Science and serve as the basis to further scientific studies for imminent Science professions. Since Junior high school (JHS) is a defining phase for building strong outlooks and inclinations (Ameyaw-Akumfi 2004). However, despite

the importance several studies show a worrying decline in pupils' interest which ultimately leads to underperformance (Fensham 2008; European Commission 2007).

Ali et al. (2009) as cited in Mushtaq and Khan (2012) connect learners' academic performance to the socio-economic growth of every country, by creating graduates worthy of future leadership. Consequently, the phenomenon of poor academic performance has been a thing of worry to all stake-holders; increasingly occupying educationists to identify its factors and implement measures. Amongst factors, particularly hindering junior high school pupils' Science performance include those broadly classified in Table1.1. (Anamuah-Mensah 2010; Danso 2010 as cited in Azure 2015; King'aru 2014).

Table 1.1: Factors that affect pupils' Science academic performance in Ghana.

Category	Factors Identified
School Environment	Unavailable laboratories, lack of teaching resources, teacher motivation, and teacher supervision.
Student Factor	Negative learner mind-set, psychological dread, poor foundation Learners' readiness and attitude
Teacher Factor	Inappropriate teaching methods, unqualified teachers, weak subject knowledge, not enough teachers, lack of teacher effort in devising teaching aids, Teachers' preparation, familiarity with curriculum

Source: Researcher's own construct 2017.

Governments have also implemented interventions, reforms and training programmes as measures to quality Science Education. In Ghana, these interventions are manifested through the Science, Technology and Mathematics Education Programme (STME), vision 2020 agenda for Science which includes syllabus enhancement, placement of qualified Science teachers, promoting Science clubs, equipping schools with modern Science laboratories and equipment, trained laboratory technicians, and over 5,000 scholarships to Science and Maths students (Ghana Business News 2012; Amoh 2016).

However, Prensky (2001) expresses that technology invasion and the volume of interaction with it have created learners who reason, communicate, learn and process information differently from their predecessors. Mason and Rennie (2008) clarify that these learners like to interact, multitask, collaborate, get instant feedback and be involved actively. Which upsurges motivation, engagement and achievement and equips learners with analytical-thinking, team-building and problem-solving skills for the future (Oblinger & Oblinger 2005; Prensky 2006). One such approach is Digital Game-Based Learning (DGBL).

According to Coffey (2009), Digital Game-Based Learning (DGBL) is a teaching method that blends curriculum with game elements to actively involve learners in the learning process, applies to nearly all subjects and skill level, and furthermore, makes challenging and uninteresting topics manageable, appealing, fun and pleasant (Kafai 2001). Additionally, DGBL has been effective as an adjunct to the teaching of History (Watson, Mong & Harris, 2011), Mathematics (Katmada, Mavridis & Tsiatsos, 2014), Science and Motivation (Chen, Wang & Lin, 2015). It is characterized by (Patrick 2011), instructional and game elements, multimodal representations, interactivity, feedback, and rules. Accentuating on its benefits, Miller, Chang, Wang, Beier and Klischm, (2011); and Deubel (2006) as cited in Coffey (2009) affirm that it facilitates and improves teaching and learning, enhances mental focus and long-term memory retention. As well as engages and motivates learners' hours without realizing that learning is taking place (Saflano 2011). Likewise, Toprac (2011) note that it can boost learners' self-efficacy and lead to improved achievements.

1.2 Statement of the Problem

Owing to the assertion by Prensky (2001) that the greatest cause of decline in education presently has been overlooked by many, and efforts are being put into educating new generation of learners in old ways with tools that have ceased to be operative. Which is evidenced in Ameyaw-Akumfi (2004) as cited in Agudzeamegah (2014), that among the factors that caused Ghanaians of 15years and beyond an estimated scientific literacy rate of 15%, is the old-fashioned and uninspired (chalk/talk, textbook, no practical, note writing, rote, assessment) techniques used for teaching. Adunola (2011) as cited in Ganyaupfu (2013) linked pupils' consistently poor academic performance in Integrated Science to the use of unproductive instructional approaches, inadequate laboratory resource, unpreparedness of teachers, lack of qualified teachers with skills and abilities.

Given that today's learners are driven by technology, and finds the old-style of teaching boring and dry (Howe and Strauss 2000) which lower their interest and eagerness to learn making them display short attention span, becoming totally disinterested in learning and makes it difficult for teachers to keep them engaged in the classroom, which eventually, leads to poor learning outcome (Prensky 2003). Relating with them means using the technology that comes naturally to them which Reinen (2015) refers to as 'tapping into students' interests to shape their abilities and provide enriching learning opportunities.

Preliminary investigations conducted in four public Junior High Schools in the Kumasi Metropolis among twelve Integrated Science teachers revealed that:

- 92% or (n-11) of them use the lecture method in teaching because it makes teaching easier, manageable, convenient and straight to the point. Whiles the remaining 8% (n-1) add demonstration to make it more understandable.

- All 100% of them acknowledged that pupils are not eager to learn, hence, they don't pay attention and cannot sit quietly. These have resulted in average to poor performance, possibly because of the lack of interest and understanding.
- 100% of the teachers named Solar System under Integrated Science as a difficult-to-teach topic. Reasons included its abstract, complex, foreign, and technical nature.

Observation of Solar System under Integrated Science during the preliminary study confirmed points raised by available literature and interviews conducted with teachers.

1. A "chalk talk" philosophy of teaching were the teachers did the talking while pupils listened passively, with illustrations from text book.
2. Lack of learner participation in asking or answering questions.
3. Continuous repetitions of points during lessons for pupils to understand.
4. Some pupils fidget, watch passersby, chat and ask permission to go out often.

Interviews conducted with randomly selected pupils of the four schools as part of the preliminary study also revealed that teaching was boring. Eighty percent said it takes too long and the sitting makes them tired and 20% said they always feel sleepy.

Based on the findings from the preliminary observations and interviews conducted, it can be inferred that pupils were not engaged in the instruction process so there was lack of interest, which made it difficult to assimilate and often led to underperformance. This may also imply that the Solar System lessons observed under Integrated Science may be a "difficult-to-teach" topic because of its abstract and technical nature. As Funderstanding (2011) posits that, Solar System is an immense and challenging topic that must be taught in a way that will arouse admiration and incite the attention of learners.

One way of arresting this situation is the use of Digital Game-based learning (DGBL) which has been proven to be an effective intervention in stimulating and optimizing students' learning outcome (Toprac 2011). However, to the researcher's best knowledge, this has scarcely been investigated in the Ghanaian academic arena.

Therefore, this study sought to investigate the methods of teaching Solar System under Integrated Science and their effects on pupils' learning and to propose Digital Game-based learning (DGBL) as an intervention to adjunct the teaching and learning of Solar System in Junior High Schools in the Kumasi Metropolis.

1.3 Objectives of the Study

1. To analyze the existing methods of teaching Solar System and their effects on pupils' learning in two Junior High Schools in Kumasi.
2. To examine pupils' knowledge and skills in digital games and digital devices so as to produce a Digital Game to adjunct the teaching of Solar System in two Junior High Schools in Kumasi.
3. To test the effectiveness of the Digital Solar System Game on pupils' learning in the two Junior High Schools in the Kumasi.

1.4 Research Questions

1. What are the existing methods of teaching Solar System and how do they affect pupils' learning in the two Junior High Schools in Kumasi?
2. How will pupils' knowledge and skills in digital games and devices assist in the production of a digital game to adjunct the teaching of Solar System in two Junior High Schools?

3. How will the digital Solar System game affect pupils' learning in the two Junior High schools?

1.5 Delimitation

The geographical scope of this study was focused on Form Three pupils in two private Junior High schools, namely: The Ridge and The Supreme Saviour International Schools, both in the Kumasi Metropolis, Ashanti Region of Ghana.

Content wise, the study was limited to the teaching of "Solar System" under Integrated Science and its effects on pupils' learning, as well as the production of a digital game for teaching Solar System and its effects on learning.

1.6 Definition of Terms

The operational definitions of the technical terms used in this thesis are as follows:

- **Digital Game:** an activity of play that is fun and gives pleasure, solely played on/ or those that employ electronic devices like desk or laptop computers.
- **Digital device:** is an electronic tool like computers, mobile devices.
- **Game-Based Learning (GBL**): is a method of teaching that allows learners to explore important features of games in a learning context.
- **Digital Game-Based Learning (DGBL):** is an instructional method that blends educational content into video or computer games with the goal of inspiring and increasing performance.
- **Academic performance:** constitutes what a learner is capable of achieving when tested on what has been taught.
- **Solar Systems:** is an Integrated Science topic for JHS three pupils that teaches parts working together to make a whole

- **Game Design Document**: is the designer's concrete blueprint describing all the game ideas and elements to be produced.

1.7 Abbreviations/Acronyms

- JHS: Junior High School
- GBL: Game-based learning
- DGBL: Digital game-based learning
- DG: Digital game
- ID: Instructional Design
- ADDIE: Analysis, Design, Development, Implementation and Evaluation
- DGBL-ID: Digital Game-Based Learning-Instructional Design

1.8 Importance of the Study

First of all, the study will equip and inspire teachers of the need to vary their pedagogical approach in this technology age to meet today's learner needs, maximize performance, develop critical thinking, collaborative and problem-solving skills as pupils take control of their own learning by doing what they do best, which is playing games.

Again this study will be beneficial to all educational stakeholders since it will highlight on the efficacy of digital game-based learning as an approach to engage, motivate and improve pupils' learning in Solar System and even other Integrated Science topics.

Furthermore, this study will be of importance to Ministry of Education (MOE), The Curriculum Research and Development Division (CRDD), Ghana Education Service (GES) and government policy makers since they are responsible for the education needs of the country. It will inform them on DGBL as an approach to improve quality

education and inspire them to incorporate it during curriculum review and policy reforms to allocate funds for the design of DGBL in all subject areas for JHS pupils as well as provide teacher development and training programmes for its effective teaching to improve academic performance in Ghana.

Last but not the least, the study will serve as a body of knowledge and a source of reference for educators, learners and researchers who are interested in pursuing further research to improve the quality of education in Ghana.

1.9 Organization of the rest of the Text

Chapter Two provides an empirical and theoretical review of literature related to education, Integrated Science, and Game Based-Learning among others. Chapter Three comprises the research design, population studied, sample and sampling techniques, data collection tools and procedures, outline for producing the Digital Game to adjunct the teaching of Solar System under Integrated Science, as well as data analysis plan. Chapter Four focuses on the presentation and analysis of findings. Chapter Five centers on the summary, conclusions and recommendations for improving learning in Junior High Schools.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0. Overview

This chapter reviews relevant ideas documented in journals, articles, books, reports and the internet that relate to the research topic. This made it possible for the researcher to have ideas on the existing body of knowledge and be acquainted with methodologies that have been used by others to find answers to research questions similar to this study. In order to facilitate this review, the chapter has been sub-divided into:

- Concept of Education
- Integrated Science Education in Ghana
- Solar Systems under Integrated Science Education
- Concept of Teaching
- Effective Teaching of Integrated Science in Junior High School
- Effective Teaching of Solar System under Integrated Science
- Teaching Strategies Adopted for Integrated Science
- Teaching Strategies Adopted for Solar Systems under Integrated Science
- Concept of Learning
- Learning of Science in Junior High School
- Concept of Evaluation in Education
- Concept of Academic Performance
- Factors that Affect Pupils' Academic Performance in Integrated Science
- Concept of Digital Game-Based Learning
- Instructional Design Model and Game Development Methodologies

2.1 Concept of Education

Education is a society's official mode of shifting its accrued knowledge, skills, habits, customs and values from one generation to the other in a bid to progress their knowledge, skills and character (Webster dictionary, as cited in Lawal 2013) to enable them become useful adults for themselves, families and the nation. It is also viewed by Adu-Agyem and Osei-Poku (2012) as an all-inclusive growth of an individual's reasoning, physical abilities, and emotions right from school going age. According to Egbezor and Okanezi (2008) as cited in Ololube and Egbezor (2012), education can occur within an indigenous, formal, informal and non-formal settings.

In Ghana, education is managed by the Ministry of Education (MoE), which is accountable for formulating policies to meet the overall education goals, and oversees the Ghana Education Service (GES), which enacts the approved policies for pre-tertiary education, and has under it the Curriculum Research and Development Division (CRDD) which develops, implements and evaluates the national curriculum (UNESCO 2010). Education in Ghana is divided into Basic, Secondary and Tertiary.

According to Adu-Agyem and Osei-Poku (2012), basic education is made up of two years Kindergarten, six years Primary and three years Junior High schooling. Obayan (2000) as cited in Brembah (2013) identifies Junior High as a phase in education where a solid foundation for literacy and numeracy is built to instill essential skills into learning. Nuffic (2015) further adds that this phase ends the obligatory school years of every child usually at the age of 15, after learning subjects like English, Mathematics, Integrated Science, Social Studies, Basic Design and Technology, Religious and Moral Education, French and ICT and completing with a Basic Education Certificate upon examination.

Secondary education is made up of either Senior High, Technical or Vocational schooling for four years. Whiles Tertiary education constitutes the universities, polytechnics and colleges from three to four years depending on the programmes (Adu-Agyem & Osei-Poku 2012).

The official language for teaching in Ghana as mentioned by Nuffic (2015) is English. Amissah, Sam-Tagoe, Amoah and Mereku (2002) express that the education process involves teaching and learning, whereby teachers teach and learners learn in a conducive atmosphere in order for quality education goals to be achieved. This proves the value of education to every nation for development as well as human resources. Implying that in using digital game-based learning to tech difficult-to-tech topics like solar system, education goals would be met all its stakeholder's will benefit.

2.1.1 Integrated Science Education in Ghana

Science education is necessary to the acquisition of a well-informed and ground-breaking economy (Gluckman 2011 as cited in Agudzeamegah 2014). The importance attributed to it has been a benchmark to its incessant existence as a subject at all the stages of the Ghanaian school system. At the primary School level, it is named Natural Science whilst it is Integrated Science at the Junior High School level. Both exposes pupils to the world and to scientific concepts including the History of Science and Basic Scientific Vocabulary. Science Curriculum at the Senior High School treats Integrated Science which comprises Physics, Chemistry and Biology. At the institutions of higher educational, students are admitted to the Science departments according to their Senior high school programme (Hutchison n.d).

According to CRDD (2012), Integrated Science is designed to equip learners with knowledge and skills to meet the requirements of everyday living and to provide

adequate foundation for those who want to pursue further education and training in Science and its related vocation. The syllabus is designed to develop pupils' scientific life style through curiosity and exploration, and for them to appreciate the link between Science and other disciplines, and use scientific notions and principles to solve life's difficulties. It also seeks to help pupils use and maintain basic scientific tools, materials and appliances. And further seeks to help them acquire the ability to assess and interpret scientific information and inferences, recognize the vulnerability of the natural environment and manage it sustainably. Additionally, it strives to help them value the importance of energy to living and non-living things and adopt conservation methods to enhance energy sources and take precautionary actions against common tropical illnesses to live healthy (CRDD 2012).

The Integrated Science syllabus is structured to cover the three years of Junior High School education with each year's work grouped into five common themes that are related to commonly witnessed occurrences in nature that pupils can relate to in their daily experiences. These themes include: 1. Diversity of matter, 2. Cycles, 3. Systems, 4. Energy and 5. Interactions of matter, with an added theme for only Junior High School 1; Introduction to Science. Under these themes are sets of topics treated at different educational stages but in greater detail. The core purpose of the syllabus is to help pupils appreciate the connections among seemingly unlike topics and allow the eventual integration of scientific ideas, so as to develop their cognition and steadily build a mastery of scientific skills (CRDD 2012). Implying that the solar systems topic is to help pupils grow their interest in Science for future studies.

2.1.2 Solar Systems under Integrated Science Education

Solar Systems is a Junior High School three topic that can be found under the theme 'Systems' in the Integrated Science syllabus (CRDD 2012), It is aimed at helping learners' familiarize with the concept of parts working collectively to make a whole, leading to the acquisition of knowledge on the movement of bodies in the solar system. Its specific aim is for learners to describe the components of the solar system and be able to list the planets in their order, explain what a star is and describe what the Sun, Moon and Earth are composed of. As well as explain the term satellite and its uses and distinguish between natural and artificial satellites. According to Admiranto (1999) as cited in Eryanto and Prestiliano (2017), Solar System is a group of heavenly forms that are contained by the gravitational pull of a star known as the sun, and include the eight planets in an ovate orbit, dwarf planets, satellites, comets, asteroids meteorites, meteors and moon. Comprehension of the Solar System expands the perception, understanding, and realistic discerning abilities of learners' (Kıroğlu 2015), which in turn, eases other abstract concepts in science education. It also helps leaners to value the earth and conserve its natural resources. Likened to other themes under Integrated Science, the Solar System concept is especially difficult to comprehend and teach, therefore necessitates high thinking abilities (Rommel 2010 as cited in Kıroğlu 2015). Furthermore in the view of Funderstanding (2011), Solar System is an immense and challenging topic to teach, and according to Eryanto and Prestiliano (2017), the present educational practice, verbal teaching technique, text books, and the watching of videos, are less interesting to attract learners' attention. Besides, the instructional aids (solar system model-kit, video, or pictures) employed are inadequate, as a result, not all pupils understand what is taught. Digital Game Based-Learning according to Kafai (2001) is effective in making challenging topics appealing.

2.2 Concept of Teaching

Teaching has been subjected to different meanings and explanations by many authors including Morrison (1964) as cited in Sharma (2002) who say that, it is a close communiqué between a grown-up and a young personality to further education goals. Gage (1962) as cited in Sharma (2002) also expresses it as the relational guidance aimed at changing the conduct of a person. Moving forward, Amissah et al (2002) extend these two definitions by adding that teaching is an act envisioned to achieve learning and considers the learners intellect and skill in the process. The authors further maintain that teaching cannot be devoid of learning, because they work hand in hand to which Farrant (1996) agrees by stating that teaching and learning are on reverse sides, which means that teaching and learning occurs concurrently. Therefore, knowing what interests learners is key to successful teaching. According to Tamakloe, Amedahe and Atta (2005), by keeping in mind learners' interest, style of learning, age etc. and also by creating a motivating environment, increases their interest and enhance learning. Numale and Buku (2009) identify three core elements in teaching, and they are: 1.Teacher- who ought to always be set to teach. 2. Learner- who must be ready to acquire the knowledge and 3. Subject matter - which must always be accessible. Amissah et al. (2002) further describe teaching as an art, saying that it embroils the mind, heart and hand and makes room for creativity, meaning that it takes a creative teacher to plan lessons. It is worth mentioning finally, that teaching as Kochhar (2004) stated is a difficult, demanding and challenging experience that comes with a long-term personal fulfillment when learning is achieved. Therefore, teachers must create platforms that encourage and motivate learners to perform satisfactorily; a fact which Miller et al. (2011) describe as one of the benefits of digital game-based learning.

2.2.1 Maxims of Teaching

Maxims of teaching are universally recognized rules of conduct or guiding principles that are indispensable to the teaching process (Sankaranarayanan and Sindhu 2012). For effective teaching to be achieved, Chowdary (2004) states that there is the need for the teacher to have knowledge of these principles because they help increase learners' attention, engage their interest and motivation for learning and helps them to actively participate in the teaching and learning process. Both Kochhar (2004) and Chowdary (2004) elucidate some of them as teaching from: known to the unknown, Simple to Complex, Concrete to Abstract, Analysis to Synthesis, and Particular to General. According to Anderson and Armbruster (1990) maxims are connected, can overlap, may or may not be used depending on the teaching situations. Consequently, integrated science teachers must keep them handy and be in control of them during the teaching and learning process in order to ensure effective teaching of the solar system topic.

2.2.2 Effective Teaching / Teacher

The attitude and behaviour that teachers exhibit in the classroom determine to a greater extent their effectiveness, and eventually the impact they have on students' achievement. According to Coe, Aloisi, Higgins and Major (2014), effective teaching occurs when learners' outcome is improved, and this can be achieved when the structured learning experience matches the needs of the learner (Mumtaz Fatima Jafari n.d). This means that the skill of teaching lies in knowing who, what, how and when to teach (Farrant 1996). Effective teaching, according to Butt (2008) is not that which is static and automatic but lively, open and spontaneous. This suggests that a teacher's instructional process should vary in response to content and learners involved. Out of the twelve characteristics compiled by Walker (2008), an effective teacher is one who

is always well prepared for class, on and within time during class and keeps learners actively involved. Also, an effective teacher is confident in his teaching and in his learners, and always accessible to them, constantly challenges and builds learner confidence, communicates about their progress, acknowledges and commends them. It was also established that a teacher who is not imaginative and resourceful, and does not assess student's progress fairly and effectively or give equal chance to learners cannot be an effective one. Colker (2008) further reports twelve personality traits that pupils believe makes teachers effective. These include patience, perseverance, practical, passionate, risk taker, flexible, creative, genuine, loves learning, energetic and amusing. Looking at the above, most of these qualities are naturally integrated in digital game-based learning (Patrick 2011), therefore adding the teachers' personality traits will necessitate the effective teaching of the solar system topic.

2.2.3 Effective Teaching of Integrated Science in Junior High School

According to Ameyaw-Akumfi (2004), Junior high school (JHS) is a defining phase for building strong outlooks and inclinations, therefore the study of Science at this stage must be appealing and exciting because learner's interest and expertise will be a great contributing factor to choosing Science at the upper levels of education. Concurrently, the Integrated Science curriculum also aims at developing scientifically literate pupils (CRDD 2007) by equipping them for self-survival and national development.

According to Ayodele and Adegbite (2003) as cited in Agboghoroma (n.d), this can be achieved through effective instruction that will encourage growth and lead to a rewarding learning experience. Moving forward, the authors established that Science teachers need a comprehensive understanding of the subject, syllabi, learners, setting and appraisal strategies. This implies that, teachers must have good teaching abilities,

plan lesson, manage the classroom, engage learners actively, keep track of performance, stimulate learners and support team work. They further expressed that this can be done through the integration of different teaching approaches and a worthwhile learning experiences which if suitable, can lead to learners increased interest in future Science subject, as well as enhance their academic performance (Okoye 2004 as cited in Agboghoroma n.d). Furthermore, the authors expressed that Integrated Science teachers must employ the use of instructional materials to complement their teaching methods for effective learning to occur. Olumorin, Yusuf and Ajidagba (2010) express that these materials make teaching and learning simple and stress free. They also help children to comprehend better because they see and have a feel of these materials (Shankar 1980 as cited in Anini 2011). As in the case of digital games -based learning which actively involves learners in the learning process (Prensky 2001).

2.2.4 Effective Teaching of Solar System under Integrated Science

According to Funderstanding (2011), Solar System is a captivating topic that must be taught in a way that will arouse admiration and incite the attention it deserves. Effective teaching of Solar System can be achieved through several approaches that excludes PowerPoint and lecture strategies, but hands-on and interactive ones.

Eryanto and Prestiliano (2017) also opines that the teaching of particularly Solar Systems under Integrated Science necessitates creative teachers and teaching, owing to its inadequate teaching media, and the fact that pupils have to be able to visualize it in order to understand. Asides from the inadequate instructional aids (solar system model-kit, video, or pictures) employed, which results in pupils not understanding what is being taught. The author's further opine that, Solar System lessons greatly requires an appealing and interactive media to facilitate pupils understanding better, and suggest

the use of graphical aids like animation and virtual reality as beneficial to improving the learning process due to its entertaining features which encourages pupils to study and understand the topic extensively. In the view of Grace (2015), the topic must be made visual, practical and fun by creating models, showing movies, using videos and documentaries to make it interesting and alive for leaners. CRDD (2012), also posits the use of charts and digital content, as well as a visit to the Ghana Planetarium to observe the celestial bodies.

2.2.5. Teaching Strategies

Effective teaching and learning requires that teachers be conscious of their learners' dissimilar ways and rate of assimilation just as the topics also have uniqueness and necessitate diverse approach in their delivery. Quinonez (2014) opines that an effective teacher takes on strategies to organize information for understanding and recollection, observing, appraising and rousing students' interest as well as aiding self-governing strategic learning. Kizlik (2013) also adds that these strategies clarify the activities of the set instructional objectives and the flow of information amongst tutor and learner. A combination of strategies make a lesson more effective in reaching different learners and prevent boredom. A good choice of teaching method(s) for a particular lesson rests largely on the consideration of the subject to be taught, its duration, existing resources, and the anticipated engrossment of the pupils (Sharma 2015). Teaching strategies can be broadly categorizes into Autocratic and Democratic approach.

2.2.5.1 Autocratic Approach

This is a conventional teacher, content-centered way of teaching (Sharma 2015) where the teacher does all the talking and the learner does all the listening. It involves the presentation of concepts by the teacher while pupils pay attention, take down notes and

regurgitate results. The teacher is the sole owner of the lesson and does not consider the skills, interest, capabilities, attitudes and personality of pupils, but rather knowledge is forced into the minds of learners with the focus on passing exams. Teo and Wong (2000) as cited in Ganyaupfu (2013) buttress the above by stating that the teacher-centered approach is more concerned with the area of study and rote learning than its practical application, which makes learners inactive and unengaged. Sharma (2015) listed some examples of Autocratic strategies as Lecture, Demonstration, Tutorial, Programmed Instruction.

2.2.5.2 Democratic/Permissive Approach

Democratic strategies involve the participation of both teacher and learner. It is mainly a student-centered approach that directs attention from teacher to learner with the goal of developing the learners' self-sufficiency (Jones 2007). Content and strategies are decided considering learners' ability. Maximum collaboration takes place between learners - learner or learner - teacher. Assessment involves formal and informal methods like test, group projects, portfolios and class participation. This grows the learners' positive capabilities in harmony with their interests, attitudes, skills, need and intellect. Among some examples are: Discussion, Discovery, Simulation, Project Strategy, Brainstorming, and Role-playing, Question-Answer, Computer-Aided Instruction and Independent Study (Sharma 2015; Farooq 2013). A strategy does not follow a single track all the time, but it changes in accordance to the demands of the situations such as age, level, needs, interests and abilities of the students (Farooq 2013). This means that teachers must ensure that their choice of method involves the learner to learn by doing, keeping them actively involved, stimulating their interest so as to make learning fun considering the age and interest of the JHS two pupils to ensure all learners better understand what is taught.

2.2.6 Teaching Strategies Adopted for Integrated Science

Integrated Science among Junior High School pupils, when appropriately and effectively taught, can boost their positive self-image and confidence to achieve scientific literacy and culture through good academic performance. Consequently, CRDD (2012) outlines that teachers do away with the conventional method of teaching and highlight hands-on teaching activities through group work, demonstrations, class discussions, role-play, fieldtrips and project work. However, according to Okoye (2004) as cited in Agboghoroma (n.d), most Integrated Science teachers use predominantly lecture or chalk and talk instructional strategy in their lessons because they are not privy to the suitable pedagogies that improve Integrated Science education. And in the view of Sharma (2015), the strategy has the advantage of giving information to large group of learners' in a short period of time. Even though it hardly permits teacher-learner communication, opposes the concept of hands-on and active learning in Science and makes pupils bored during Science lessons, and perceive scientific concepts as abstract and difficult (Reisman & Payne1987 as cited in Mensah 2015). There are diverse methods to the teaching of Integrated Science proposed by different Science researchers and educators which are geared towards learner-centered activities. Balasubramanian, Wilson and Cios (2005) as cited in Agudzeamegah (2014) identified some as inquiry-based, simulation, collaborative problem-solving hands-on activities. Mensah (2015) also identified in addition, observation technique, discovery and activity technique as well as discussion laboratory technique. Most of these strategies are entrenched in digital game-based learning (Gee 2007; Illeris 2009 as cited in Husain 2011). Details of two are explained below:

Inquiry-Based Teaching: This is aimed at developing knowledge, abilities and attitude based on active comparative reasoning by pupil learning on their own how to

explore and putting it into practice (Dostál 2015). Furthermore, Papáček (2010) as cited in Dostál (2015) explained that Inquiry-Based Teaching is grounded in the constructivist theory and involves learners unravelling problems or generating questions, exploring, explaining, assessing and communicating their findings. Inquiry, also problem-based learning offers a rich learning experience that incites learners' intellect and interest and helps them take possession of their own learning, a desirable skill for success in academia and future career. The teachers' role is to facilitate the processes involved (inspiredteaching.org).

Simulation: According to UNSW (2015), simulation is an investigational method to learning also in line with learner-centered and constructivist beliefs that places learners within a world or scenario to interact and accomplish anticipated outcome. Simulation may be featured in the form of games, role-play, or a figurative activity. Although simulation is costly, time consuming and evaluation is complex, it has the potential of encouraging critical and evaluative thinking, concept attainment and its understanding, and it's deeply engaging. To put it simply, Osborne and Hennessy (2003), as cited in Agudzeamegah (2014) posit that the collaborative, dynamic and graphical nature of simulation allows learners to explore otherwise hazardous, unrealistic and costly Science experiments in a school laboratory**.** The teaching of Integrated Science necessitates different teaching methods and meaningful learning (Ayodele and Adegbite 2003, as cited in Agboghoroma (n.d) because unsuitable methods can create fear in learning Science in advanced years.

2.2.7 Teaching Strategies Adopted for Solar Systems under Integrated Science

Teaching methods that can help learners' to familiarize with the Solar System concept of parts working collectively to make a whole (CRDD 2012), as well as to acquire

knowledge on the movement of the bodies in it, must according to Funderstanding (2011) be effective in a way that will awaken admiration and incite interest, since the topic is a rather abstract concept because it cannot be seen or touched (Ang & Wang 2006). There are several approaches to the teaching of Solar System (Funderstanding 2011), among the common ones are Brainstorming, discussion, demonstration and group work. CRDD (2012) further adds Project work which emphasizes its position on the use of hands-on activities. These methods are learner-centered and participatory, proof of how Integrated Science Subjects should be taught. Others include: collaborative techniques, computer animation technique, simulation, multimedia presentation and Signaling.

Collaborative Techniques are active interactions between learner-content, learner-learner, and learner-teacher during the learning process (Chou 2003 as cited in Ang and Wang 2006). According to Ang and Wang (2006) Engaged learning by means of information and communication technology (ICT) is an effective technique to teach the concept of Solar system, which supports collaborative learning, where learners share their views, discuss solutions and groups work to construct knowledge.

Multimedia presentations and Signaling are descriptions that mix words either spoken or written, with visuals like images, motion pictures, illustrations, charts or animation to teach (Schrader and Rapp 2016), making use of visual cues like underling key sentences, highlighting key words in text, diagram or graph, blocking or graying out visual information known as Signaling, to direct and focus learners attention. The above indicates that Solar Systems under Integrated Science necessitates creative teachers and teaching to make it interesting.

2.3 Concept of Learning

Learning is an intricate notion with no fixed meaning but varying views from Educationist and Researchers. Among these views, Wikipedia as cited in Orey (2010) described learning as an educational objective that is realized by getting hold of and increasing ones knowledge and understanding, retention, actions, abilities, morals, and intelligence through experience. Prensky (2003) elaborates further by stating that learning alters one's knowledge (facts, groups of facts and relationships between facts), attitude (capacities, tasks, skills, behaviors) and/or beliefs (theories, understanding of how and why things work or happen) either purposely or impulsively and involves connected and interconnected processes and engagement with a learning object. However, Farrant (1999) opines that this alteration is one that cannot be attributed to physical growth but psychological and environmental factors.

In the view of Darling-Hammond, Kim, Orcutt and Rosso (2001), learning involves encoding and storing information in one's memory, processing, categorizing and clustering material, and later retrieving it to be applied at appropriate times and situations. This means that for learning to occur, facts, concepts and ideas must first be stored, connected to others, and then built upon. Furthermore, Chingos and Whitehurst (2012) are of the view that learning is mainly an exchange between instructors, peers and learning materials like textbooks, workbooks, instructional software, web-based content, homework, projects, quizzes and tests. The authors add that the contexts within which interactions occur are of significant relevance to the outcome of the learning process. Prensky (2001) states that learning can be successful based on the kind of material being learned and the learner's previous knowledge. Farrant (1999) states that it requires readiness, motivation and involvement on the part of the learner. This means that learning cannot be alternated. The learner with the guidance of the teacher through

various stages in an efficient manner is the only way to success. According to Kochhar (2004) as cited in Siaw (2009), it is expected of every learner to portray some qualities when effective learning has taken place.

2.3.1 Learning Styles

Students have peculiar ways of accepting, comprehending, processing and responding to information using their senses (Giles, Pitre & Womack 2003; Ldpride n.d as cited in Gilakjani 2012). Although seven types can be identified, most individuals fall under the four primary learning styles mentioned by these authors. These are: visual (Spatial), auditory, reading-writing and kinesthetic/tactile or motor. Table 2.1 and Figure 2.1 best explains these learning styles.

Table 2.1 Learning Styles and Characteristics

Learning Style	**Learning Characteristics**
Visual	Picture thinkers. Process information via (graphs, flow charts, circles, hierarchies). Highlight notes or textbooks with colors, Create flashcards, and Lose focus easily, favor sitting in the front roll.
Auditory	Process information verbally by hearing and listening. Deduce via pitch, emphasis and rapidity. Talk aloud when recalling or solving problems, have study groups/mates, read out loud, respond to lectures/ discussions well, Record lectures to listen and summarize.
Reading-Writing	Process information well when presented in a written format, benefits greatly from teachers who use the blackboard, Rewrites salient points and ideas, silently read notes, organize illustrations into statements, make flashcards of words and concepts to be memorized.
Kinesthetic-Tactile	Learn actively by touching and doing. Gesture when speaking, poor listeners, so lose interest in long speeches, do not perform well if teaching is devoid of practical activities. Learn through trial and error, connected to real situations through experience (practice or simulation), do well in hands-on approaches and field experiences.

Source: Researcher's construct, 2017

Giles et al. (2003) elucidate that nearly all learners combine all the styles using its strengths and limitation, whilst others use the same tendency for more than one style, which is called the multimodal. According to Biggs (2001) as cited in Gilakjani (2012) being familiar with one's own style of learning leads to a simple, quick and successful learning and effective problem solving. On the other hand, Dunn and Dunn (1978) as cited in Gilakjani (2012) state that a teacher's familiarity of his learners' favoured style of learning offers the opportunity to integrate them into teaching activities so as to boost learner motivation and elicit positive academic performance. Therefore, considering the age range of the population for the study, it is expedient for the teacher to vary the style of teaching to increase pupils' academic performance.

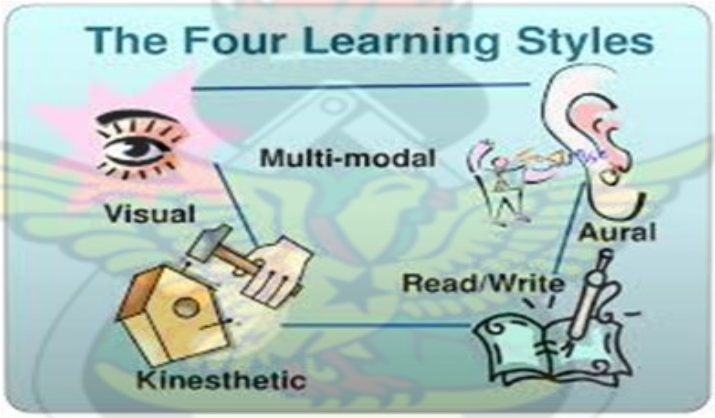

Figure 2.1: Learning Styles.

Source: slideshare.net/nmcclure/learning-styles-2011.

2.3.2 Learning Theories

According to Darling-Hammond et al. (2001), learning theories deal with queries like, how learning ensues, how stimulus occurs and what influences learner growth? It is an established principle that explains how people get hold of, hold on to, and call to mind information learnt. There are three well-known ones namely Behaviourism, Cognitivism and Constructivism (thepeakperformancecenter n.d).

- Behaviourism theory focuses without bias on the observable attribute of learning, known by (Driscoll 2000 as cited in Nimade 2015) as a new or change in behaviour when learners observe and live out the information, influenced by environmental conditions and receive reinforcement in the form of praise.
- Cognitivism theory perceives learning as a profound active mind procedure that explains how learners build meaning out of fresh information and experience (Kruse 2009 as cited in Nimade 2015). Previous knowledge is significant during the learning process, according to Lilienfeld, Lynn, Namy and Woolf (2010) and it looks past behaviour to human memory and how it works to enhance learning and understanding.
- According to Tracey and Morro (2012), the constructivist believes that learning comes about when new information is built-into an existing one and learner is actively involved in the learning process. With regards to the constructivist learning environment Wilson (1996) as cited in Barajas (2003) define it as a setting where learners can jointly work and support each other making use of different tools and information to pursue their learning goals and problem-solving activities.

Consequently Honebein (1996) as cited in Neeraja (2011) suggests that lessons should be tailored to offer learners the chance to be responsible for their learning, and encourage ownership and self-awareness of the process as well as make learning realistic and relevant based on authentic real-life activities. Furthermore, learning must be a collective experience supported by collaboration and interaction, and with multiple modes of representation, as well as rich media. However, education, psychology and cognitive Science have evolved, necessitating modification to some of these theories to suite Millennial' who are surrounded by technology which influence them Clark (2001)

as cited in Husain (2011). Among these revised theories are: situated learning, problem-based learning (PBL), task-based learning (TBL), and distributed intelligence, a collection made by Illeris (2009) as cited in Husain (2011) that particularly enhances game-based learning. These theories are characterized by learners' active involvement and hands-on experience, teamwork and sharing ideas either with peers or educator and it involves assessing learners' skill level. This means that allowing pupils to take control of their learning and be actively involved will make the difficult-to-tech solar system topic appealing and fun as proven in digital game-based learning (Kafai 2001).

2.3.3 Learning of Integrated Science in Junior High School

Junior High School Integrated Science with its duration of three (3) years, and a certificate examination known as the Basic Education Certificate Examination (BECE) is graded according to the stanine grading system, (CRDD 2012). According to Ingmire (2015), academic performance in Science is enhanced when learners actively participate in the learning process.

Beilock as cited in Ingmire (2015), opines that neither reading from a Science textbook nor witnessing a demonstration during lesson is as effective as tangibly experiencing what is being learnt. In the view of Knott (2015), even though Science lessons can be recalled when taught via text books and lectures, the practical understanding and independent learning capabilities of learners' are built when it is done through hands-on activities, which helps learners to reason by enquiring and interpreting experiential actions and its outcome, other than committing to memory right answers, and helps practice cause-and-effect thinking. That is, relying less on authority and more on practical experience, which will produce autonomous decisions makers in future.

The interactive and hands-on strategies to be adapted will according to Anderson (2006) stimulate and entice pupils' interest in learning. Motivation is known to plays a significant role in influencing learning and academic performance (Prensky 2001; Gee 2007) and often embedded in game-based learning. Motivating students to learn involves making learning fun, active, experiential as stated above in the theories of learning, and this can be achieved through the varying teaching methods, teacher effectiveness, pupils' learning style, as well as problem-based learning, collaboration and digital game-based learning in solar system.

2.4 Concept of Evaluation in Education

The need for evaluation cannot be overlooked due to its importance to the education process and performance. Some researchers have linked evaluation to effective teaching because it guides and monitors teaching and learning, develops inventions for effective instructional resources and processes, measures the legitimacy and dependability of teaching, as well as determines the wants of learners and inspires them to study (Jhunisa 2013). Therefore it is vital to the teaching of the solar system topic and the digital solar system game. Farooq (2013) defines evaluation as the incessant assessment of obtainable data regarding learners, instructors, educational programme and teaching-learning process to establish a degree of change and effectiveness. Newby (1992) as cited in Frimpong (2010) expresses it as determining the worth of a training programme to either improve or suspend it, by methodically defining, gathering, and providing evidence suitable for judgment, to obtain feedback, control, involvement and power over the educational process.

There are different types of evaluation in education, among some are: Process, Outcome, Impact, Formative, Summative and Diagnostic evaluation (Rossi & Freeman

1993 as cited in Frimpong 2010; El-Hamid 2011). Process evaluation defines and measures training resources and activities. Outcome evaluation assesses the immediate effect of a programme on partakers. Impact evaluation looks at the future effects of a programme. Formative evaluation provides continuous feedback to teachers and learners alike on progress toward learning goals with the aim of improving teaching-learning. Summative evaluations ends an instructional process by determining the degree to which learning objectives have been achieved by students. Diagnostic evaluation recognizes students' previous knowledge, understanding, skills or interests to design suitable programs for them. According to CRDD 2012, integrated science must be evaluated formatively (oral questions, quizzes, class assignments, essays, project work) and summative, however other innovative evaluation tasks can be developed. This implies that the solar system topic be measured based on the curriculum, however, the digital solar system game intervention requires all the evaluation types aside from the impact evaluation which deals with long-term effects.

2.5 Concept of Academic Performance

The Cambridge English Dictionary (1995) as cited in Osei-Mensah (2012) refers to academic performance as how well an individual or a group performs when given a learning task or activity. According to (Hawis and Hawes (1982) as cited in Dimbisso (2009), it is the successful accomplishment in a specific subject areas, which is represented by grades, marks or scores. Additionally, academic performance has been expressed as the numerical scores of pupils' knowledge, which measures the degree of adaptation to school work (Kobal and Musek 2001 as cited in Dimbisso 2009), or the determination of academic success which relies on a student's attitudes towards his own achievement as well as the attitudes of significant others towards his/her academic

success. Therefore, the concept of poor academic performance is described by Aremu (2000) as an achievement that is adjudged by examiners as falling below an expected standard or below ones actual ability. Diaz (2003) also discusses it as a situation in which the learner does not attain the expected success, resulting in an altered personality which affects all other aspects of their life. Similarly, Bakare (1994) as cited in Asikhia (2010) posits that poor academic performance is that which falls below a desired standard.

Research supports the fact that pupils' academic performance hinges on different factors which comes broadly under "learning environment" and grouped into three main categories namely: School learning environment, under which some identified factors are school type, Infrastructure, teacher qualification, teacher ratio, class-size, and availability of teaching and learning materials, teacher motivation. Home learning environment factors include: family structure, parental involvement, socio-economic status and parents education level, parent-child interaction. Whiles Individual level factors make up the learners own physical health status, social and emotional wellbeing, attitude to studies and school, and use of local language in class (Osei-Mensah 2012; Adane 2013; Abdallah Fuseini, Abudu & Nuhu 2014; Asikhia 2010; Abudu & Fuseini 2013; Lansangan, Baking, Quiambao, Nicdao, Nuqui & Cruz 2015, Engin-Demir 2009)

2.5.1 Factors that Affect Pupils' Academic Performance in Integrated Science

Irrespective of the importance and efforts that are being put into the study of Science in schools, several studies have shown an alarming decline in student's interest and academic performance. Fensham (2008) expressed that for a long time now studies have showed a reduction in learners' interest in Science. The European Commission (2007) also exports a declining trend of interest in Science. Not to talk of the 2011 Trend in International Mathematics and Science (TIMMS) organized internationally every four

years, where out of the forty two participating countries, Ghana ranked last in both Science and Maths. Factors that have contributed to this are basically:

Inappropriate teaching method: According to O'Connor (2000) as cited in Azure (2015), the methods teachers used are not hands-on and there is not much effort put into connecting concepts with instances or pictures in real life, or learners' environment. Anamuah-Mensah (2004) as cited in Agudzeamegah (2014) reiterates that these methods are unproductive and out-of-date because it involves listening to teacher talk writing notes, memorizing and reproducing in exam. The author adds that, it is reliant on textbook with no practicals involved. The most commonly used teaching methods at both basic and secondary levels have been found to be lecturing; question and answer; explanations of procedures and note giving (O'Connor 2002 as cited in Azure 2015). To which Adunola (2011) as cited in Ganyaupfu (2013), basically linked pupils' consistently poor performance in Integrated Science to the use of unproductive instructional approaches in impacting knowledge.

Lack of teaching resources: Anamuah-Mensah (2004) as cited in Agudzeamegah (2014) state that when there is not enough resource distribution for the teaching and learning of Science and Mathematics at all levels of education, it leads to ill equipped or no Science laboratories and defeats the purpose of Science being practical.

Lack of teacher preparation: this is due to the disconnection between theory and practicals during pre-service training, and the little importance given to subject matter content Anamuah-Mensah and Asabere-Ameyaw (2011). Other factors are compiled under school, teacher and leaner factors (Anamuah-Mensah 2004 as cited in Agudzeamegah 2014; Ifeoma 2013; King'aru 2014).

Table 2.2 Factors that affect Academic performance in Integrated Science.

Category	Factors Identified
School Environment	Unavailable labs, lack of teaching resources, teacher motivation, and teacher supervision.
Student Factor	Poor Science foundation, negative mind-set, psychological dread, learners' readiness and attitude.
Teacher Factor	Qualification, weak subject knowledge, not enough teachers, lack of teacher effort in devising teaching aids, familiarity with curriculum, lack of practical works, insufficient allotment of time.

Source: researcher's construct, 2017

Anamuah-Mensah, Mereku, and Ampiah (2009) identified factors such as better facilities, availability of instructional materials like books, computers, and technological support, student attitude, liking and feeling better about learning, providing engaging instructions, and early introduction and practice of Science and Maths at home, among the countries that ranked high in the programme. These reasons are not limited to junior high schools in Ghana, therefore, with quality educators and teaching, Ameyaw-Akumfi (2004) accentuates that quality Science education can be achieved. Naturally, children are captivated and inquisitive about what goes on around them. Therefore, stakeholders must capitalize on it, and inspire them to gain scientific knowledge by teaching the solar system topic in interesting ways to sustain pupils' curiosity so as to improve learning.

2.6 Concept of Digital Game-Based Learning

It is imperative as a first step towards the study of Digital Game-Based Learning (DGBL) and for the purpose of this research to examine some related terms or words and its concept that can further the understanding of this research. These terms are Game-based learning, Games and Digital games.

- **Game-Based Learning**

Game-Based Learning (GBL) has been widely explored, debated on and used in diverse disciplines to express different ideas and perspectives by researchers. First and foremost, Game-Based Learning (GBL) is a term that has been used synonymously with others like Serious Games (SG), Educational Games (EG) Computer Games (CG) and even Digital Games-Based Learning (DGBL) by many researchers (Ulicsak 2010; Corti 2006; Van Eck 2015; Naik 2014). Conversely, others like Editorial (2013) identified it as a branch of Serious Game that balances subject matter with gameplay and preserve said subject matter for use in real world situations, and is characterized with distinct learning outcomes. In the same wake of thought, Killi (2005) described it as a type of Serious Game with distinct learning outcome that leads to positive learning performance.

Based on the above, it is apparent that Game-Based Learning is a subset of Serious Games, therefore the need to look into the meaning of Serious Games, which according to Chen and Michael (2005), is that which have education as its principal objective and entertainment as its minor. This means that Game-Based Learning (GBL) is largely focused on education, with a spice of entertainment. Poulson (2010) explained it best by stating that, it is a method of teaching that allows learners to explore vital game features in a learning environment. Naik (2014) states that Game-Based Learning (GBL) is classified under two main forms: the popular Digital Game-Based Learning (DGBL), on which this study is based, and the less popular Non-Digital Game-Based Learning (NDGBL) which involves physical no-technology based serious games like board, and card game-based learning. The diagram below best explains the terms visually.

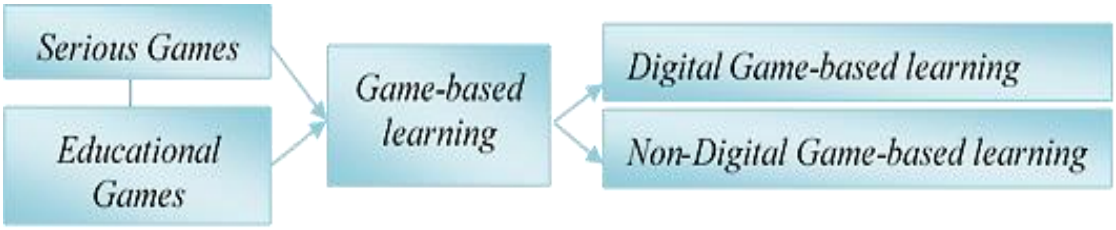

Figure 2.2: Graphical concept of GBL based on the definition.

Source: Researcher's construct 2017.

After establishing Game-Based Learning (GBL) as a type of Serious Game (SG) or Educational Game (EG) And Digital Game-Based Learning (from here on DGBL) as the more popular of its two main forms, the researcher continues with a review on the terms 'game' and 'digital game'.

- **Games**

Game have been associated with lots of meanings and implication. Basically, Prensky (2001) defined it as "an organized play" because of its embedded rule component for pleasure. Salen and Zimmerman (2004) also termed it as an un-natural encounter with clear instructions that absorbs players and its aftereffects is measurable. Whilst Kolko (2005) elucidate further by saying that they are interactive and has the sole purpose of entertainment. However, there are four important elements recognized by McGonigal (2011) that guides a game and these are goals, rules, partaking willingly, and system feedback. Literature has revealed that there is not one agreed definition for the term 'games', however, it is evident from the definitions above that there are some basic components that define a game. Based on these component the researcher defines games as an organized play that absorbs willing players in an interactive activity with a measurable outcome and a sole purpose of entertainment guided by goals, rules and system feedback. According to Prensky (2001) children are always impatient when it comes to playing games and can spend limitless hours at it, due to the thrill and the

immersive effects they derive from it and the fact that naturally children like to get and stay involved in things.

- **Digital Games**

Digital games, also known as 'computer games' (Whitton 2011) or 'video games' (Turkay, Hoffman, Kinzer, Chantes and Vicari 2014) is a field with varied documented definitions, yet one underlining theme, which is: digital devices also known as electronic devices or technologies) running through all. For instance, Kolko (2005) defined digital games as the running of a mainstream game, with its (rule feature, player representation, and environment) via electronic means. Wolf (2001) as cited in Keeble (2008) also elucidated it as video, console or computer games with an element of conflict, rule, and player ability with an outcome. Whitton (2014) also simplified it as games played solely on electronic devices like desk or laptop computers, video consoles, mobile devices like phones and tablets. According to Prensky (2001), video games retain the attention of players more than anything else, which is why a study conducted in America revealed 97% of youngsters aged 12 to 17 years were inclined towards the use of computer, handheld device, net, or console to play video games. With 73% playing on desktop or laptop computers (Lenhart et al. 2008 as cited in Shearer 2011). Therefore, Junior High School pupils must have the skills to enable them use this device to enhance their learning.

- **Digital Game-Based Learning (DGBL)**

Owing to the effects the flood of technology has brought on education and learning, DGBL (the main focus of this research) has caught the attention of both researchers and educationist alike, and advocates of DGBL, (Van Eck 2007; Chen and Chan 2010) have defined the term differently. According to Coffey (2009) DGBL is a teaching method that merges curriculum with video game elements and can be applied in almost

all subjects and skill level to actively involve learners in the learning process and get them ready for the 21st century technological society. Furthermore, Connolly and Stansfield (2007) stated that this teaching approach supplements and enriches instruction, learning, assessment and appraisal. It also offers learners additional clarification and deeper understanding of concepts presented in class through continuous practice till proficiency is attained (Gillipsie et al. 2009). Likewise Prensky, (2007) opines that the outcomes can either be similar to or improvement of the old teaching-learning approach. Because it is practical and allows learners create knowledge while playing, which leads to sustenance of interest (Chen and Wang 2009) and helps in applying knowledge gained to real-life problems. Therefore, DGBL simply put is a form of student-centered approach to teaching that uses digital games for educational purposes (Swearingen 2011). Concluding with de Freitas (2006) definition which describes DGBL as a presentation that makes use of video and computer games features to create an appealing and immersive learning experience to convey clear learning objectives, results and potential. Considering the definitions and descriptions above, it is expedient to say that DGBL can be used for both teaching and learning methods, to make learning fun for Junior high school pupils. The operational definition for DGBL is summarized visually in Figure 2.3. Video game element + Educational content = Digital Game-Based Learning.

Figure 2.3: Graphical concept of DGBL.

Source: Researcher's construct 2017.

2.6.1 Characteristics of Digital Game-Based Learning (DGBL)

The engaging effects of games, be it educational or entertaining that submerge players into a state of deep absorption during game play, referred to as the "Flow" experience by (Csikszentmihalyi, as cited in Prensky 2001) can be achieved through some defining characteristics, of which Prensky (2001) identified six and Whitton (2007) ten main ones. Both of them exclude fun: which is enjoyment and pleasure and play: an intense and passionate involvement, because they can only be observed from the game player's perspective. These characteristics have been explained in the table 2.3.

Table 2.3: Combined features of Digital game and their meaning

Characteristics	Meaning
Goals/Objectives	Explicit targets and intents, with a motivating purpose, that should not be too easy, too difficult to achieve or predictable.
Rules	Limits of play, confines or restraints. Rules govern the game for its duration. Tell apart one game from other kinds of play.
Competition / Challenge / Conflict / Opposition / Difficulty	These are the problems players try to solve in a game. Opposition for adrenaline could be against best score. Competition inspires learners and challenge is embedded within the game levels, by means of mounting its difficulty through speed or advance stages. The level of difficulty within a game must be proportional so as to maintain learner interest.
Interaction	Playing between either player and device or other players.
Story	What the game is about, that's the description or storyline of the game and also includes the element of fantasy.
Problem solving	That which elicits creativity.
Control	A game should provide effective control so that the individual feels completely in control of the activity.
Fantasy	An imaginary atmosphere where game activities are entrenched. Has no influence on the real world, and outside the game everything is immaterial.
Outcome/ Feedback	Measured results from game play (scores). Feedback for learning such as how close the player is to achieving the goal.
Safety	Absence of penalties of the game in the real world.

Source (Prensky 2001; Whitton 2007).

According to Patrick (2011), games are also characterized by instructional goals, game layout, multimodal depictions (tactile, auditory or visual), instruction for play, tools to track players knowledge and ability, adaptive instructional strategies, 2D and 3D technologies. Miller and Robertson (2010), as cited in Felicia (2011) also associate it to single-player mode were learning is operative when players compare achievements which helps in stimulating them to compete amongst themselves or in a multi-player mode (Dickey 2007 as cited in Felicia 2011) that promotes association amongst players. According to Felicia (2011) DGBL usually comprises several or all of the characteristics, to which Whitton (2007) reiterates that the more the characteristics are embedded, the more game like it becomes. This means that designing the digital solar system game with consideration for all or those characteristics that will make it engaging to junior high school pupils' will spur their interest and motivation that can lead to a positive learning outcome.

2.6.2 Benefits of Digital Game-Based Learning (DGBL)

Games provide a perfect opportunity to infuse liveliness, inspiration and innovative thinking into the old-style of teaching to supplement and offer variety to the method Fuszard (2001) as cited in Boyle (2011). Accordingly, DGBL attracts, inspires and provides learners with a conventional learning experience (Deubel 2006 as cited in Coffey 2009) while promoting experiential learning that leads to lasting recall, and enhanced mental focus. Additionally, Chang, Wu, Weng and Sung (2012) affirm that it imitates real-life situation and trains learners on how to apply the acquired knowledge to real-life issues. Digital Game-Based Learning (DGBL) enhances learner motivation and promotes effective learning (Miller et al. 2011), interactivity and engagement that lead to active and deeper learning (Oblinger 2004), with people of all ages (Saulter

2007). Blending digital games with curricular for learning, (Griffiths 2002) opines that it develops and increases the computer literacy skills of learners and the ability to improve the 21st century skills namely, problem solving, collaboration, multitasking and communication skills of learners. Arnab et al. (2012); and Prensky (2007) enunciates that DGBL affords educators the opportunity to speak the language of today's generation and bridge the gap between learners and teachers. Of which (Rosas et al. 2003 as cited in Panoutsopoulos and Sampson 2012) agrees with Prensky by stating its ability to improve the interaction and association between learners and tutors, and further identifies with DGBL's positive effects on students discipline, attentiveness, peer association and determination of task completion. It restores the sensation of fear and apprehension of learners in traditional learning environment with a desire to play, study and succeed (Gillipsie et al. 2010), which leads to increased self-efficacy (Toprac 2011) and in turn increase academic success.

Last but not the least, Griffiths (2002) addresses DGBL's benefit to children with special-needs, and young people with 'attention deficit disorder'. He points out the calming effects of DGBL on an autism child and improved grades, sociability and organizational skills of attention deficit disorder of adolescents (Griffiths 2003). This goes to prove the effectiveness of DGBL to learning and outcome.

2.6.3 Game Genre-Classification of Games

Digital Game-Based Learning is categorized into genres, and it is important for this research to identify the genres available since it will be of outmost importance to the Junior High School pupils in the two schools. According to Sherriff (2014), games can be classified according to the device it will be played on (Computer, console, arcade, handheld devices, and mobile device) or the way it will be played. Circa (2000) as cited

in Prensky (2001) documented eight classified genres namely (Action, Adventure, Fighting, Puzzle, Role-playing, Simulations, Sports and Strategy games). Whilst Gross (2007) classified seven which included all of Prensky's except Puzzle games and stated Platform games as another name for Action games. Whitton (2007) also categorizes eight genres taken out from different literature and into a representation. These included all of Prensky's except Fighting Games which was replaced by Shooter games and Action which was represented by Platform games. Excluding simulation game altogether (Deubel, 2006 as cited in Coffey 2009) listed all the rest as game genres. A representation of the genres identified by (Prensky 2001; Gros 2007; Whitton 2007; Deubel 2006 as cited by Coffey 2009) is classified as followed:

Table 2.4: Nine genres classified and described with examples.

Genre	Description	Examples
Action/ Platform	Reaction based game, accentuates physical challenge, aims at negotiating movement between a series of platforms, avoiding obstacles, battle enemies and collecting treasure. based on hand-eye coordination	PacMan, Sonic the Hedgehog, Super Mario
Adventure	Exploring a virtual world by a player who solves a series of quest or puzzle by performing actions and manipulating objects to achieve the aim of the game.	Myst, Riven, The Hobbit, Zelda
Fighting	Combat alongside either computer-controlled characters or other players, involving intense speed with athletic and balletic moves matched concurrently to see which wins.	Mortal Kombat Virtua Fighter
Puzzle	Visual problems devoid of story pretense to be solved. Involves logic puzzle-solving.	Tetris, Lemmings
Role-play	Games in which a player assumes a fantasy role through adventures within a fantasy world, usually to the rescue of someone or something and acquiring equipment and experience via action and fighting.	Dragon Quest, Never winter Nights
Simulation	Games that imitate real life situation, through virtual environments where players interact within simplified recreation place or situation to achieve a particular goal.	Sim City, The Sims

Sports	Games on sports with players taking on virtual sporting activities and can control one or more players at a time.	FIFA Football, Alpine skiing
Strategy	Games that restructure imaginary situations to allow players devise suitable approach to realize a goal. Players make strategic decisions in order to meet overall goal.	Chess, Dungeon Keeper, Civilization
Shooter	Focuses on exploring virtual worlds with weapons and combat to overcome adversary and meet games goal. Players win by shooting their adversaries either by standing or moving. Tests player speed and reaction time.	Doom, Quake Re-Mission

Source: Researchers' construct 2017.

According to Gross (2007), some of these genres overlap, and Sherrif (2014) further states that, there is pleasurable to be derived in a game when different genres are combined. In choosing games for learning, Deubel (2006) as cited in Coffey (2009) suggests that learners age, gender, previous game experience, competitiveness should be considered. As was done in designing the Science game for the junior high pupils so as to be able to select the appropriate choice of genre or a combination.

2.6.4 Digital Games and Learning

It is important to look at the theories that support Digital Game-Based Learning, how it can be implementation and some of its successful practices. To be able to blend games, which has the sole purpose of entertainment together with learning, depend on the incorporation of recognized learning theories (Baranowski et al. 2008; Whitton 2012). Several theories have been known to support game based learning. These include constructivist, cognitive and situated learning theories. The concept of constructivism (Tracey and Morro 2012) and the principles of the constructivist learning environment (Honebein 1996 as cited in Neeraja 2011) as stated above can be found in digital games, in that games provide learners the opportunity to explore, and find their way around

imaginary worlds by means of multi-model (video, audio, text), and can create an atmosphere for practicing skills that can be transferred to the real world, and for problem-solving. This can be seen by comparing the constructivist theory and the characteristics of games above. It is worth noting that the collaborative, realistic, authentic, interactive principle found in the constructivist environment (Honebein 1996 as cited in Neeraja 2011) can also be seen in the characteristics, benefits and genres of games. Behavioural, cognitive and situated learning theories are also reflected in games (Kim, Park & Baek 2009; Cuenca López & Martín Cáceres 2010).

Approach to Game Implementation: According to Van Eck (2006), DGBL can be employed successfully into classroom setting in three ways. That is teachers can direct learners to create their own games, learning content and programming, and developing problem solving skills in the process. However, it is time-intensive, difficult to incorporate into class time, teachers lack the expertise needed to guide learners, and quality is low, which makes it improbable to be commonly employed. Secondly, teachers can use commercial-off-the-shelf (COTS) games. These are games that were not developed primarily for educational purposes but can assist, carry out, or evaluate learning. The approach is effective in terms of cost and time, and quality is high. Nonetheless game content does not align to learning objectives and subject matter is partial or inaccurate. The third approach is when teachers use specially designed games for education in class (games developed purposely for education, by other educators, instructional designers, and developers). This is an effective approach because it aligns with specific learning objective(s). Therefore developing the digital solar system game from scratch to align with the difficult-to-teach solar system objectives will be effective to its implementation in the Junior high schools.

Digital Games and Learning (DGBL) in Practice: The efficacy of DGBL in recent years cannot be overemphasized. Researchers have been successful in this field looking out for outcomes like learner motivation, interest and learning achievements in various subjects and skill areas in the three educational levels (Annetta, Minogue, Holmes & Cheng 2009; Huizenga et al. 2009; Papastergiou 2009). Again, this has been applied in different disciplines such as History (Watson, Mong & Harris 2011), Nutrition (Jui-Mei, Chun-Ming, Hwang, &Yueh-Chiao 2011), Mathematics (Katmada, Mavridis & Tsiatsos 2014), Science and Motivation (Chen, Wang & Lin 2015).

2.6.5 Limitations to the implementation of Digital Games and Learning

Even though the benefits of digital game-based learning cannot be overemphasized, there are various impediments to its implementation in classrooms. Both Rapini (2012) and Shapiro et al. (2014) identified some of these as the high purchasing and maintenance cost of games, lack of tech resources as well as the lack of professional development needed by teachers to integrate games into lesson plan and the mandate to cover the full curriculum on time, as well as the difficulty in implementing games within lesson time. Furthermore, finding quality games that fit the curriculum, that is games that have goals which align with learning goals (in the case of commercial-off-the-shelf games COTS).Most important is the lack of administrative and parental support for games due to its likely negative effects like violence, obsession and excessively competitive behaviour (Baek 2008) on children. However, just as these limitations exist, researchers have also found strategies to overcome some of them. For instance, Mitgutsch and Alvarado (2012) as cited in Rapini (2012) proposed the use of free browser games, while Squire (2011) as cited in Rapini (2012) suggested creating applications for the smartphones that many of the students already own, as well as

pairing students to a computer as a means of dealing with cost, technological resources, purchasing and maintenance. Sites like Graphite, Playful Learning, and Educade have been recommended as where quality games can be found (Shapiro et al. 2014).

2.7 Instructional Design and Game Development Models

Instructional Design (ID) or Instructional System Design (ISD) is an organized way of identifying the needs of learners, planning and developing teaching strategies to address those needs, and assessing the efficacy of the strategy (Kruse 2004 as cited in Management Association Information Resources 2011), Instructional Designs guarantee valuable learning experience that is resourceful, actual and motivating to knowledge and skill acquisition. This involves identifying learner needs, setting up goals of instruction and creating intervention to aid growth (Forest 2014). These processes are guided by principles that according to Merrill (2002) as cited in Brown and Green (2015) involve learners previous knowledge as basis for new knowledge, engaging learner in solving real issues, demonstrating new knowledge, integrating it into learners world and allowing learner to apply knowledge gained. Brown and Green (2015) state the use of models as guide to arranging suitable instructive set-ups to achieve instructional objectives. Among some of these models are ADDIE model, Dick and Carey System Approach model, Assure model, Backward Design, Kirkpatrick Model, amongst others (Forest 2014).

- **ADDIE Model**

ADDIE is an acronym that stands for the five phases of the model namely: Analysis, Design, Development, Implementation and Evaluation. It is branded as the basis for most ID models, with its flexible cyclical process that permits each phase to be revisited, reviewed and refined if need be, with each phase result feeding into the

successive one (Management Association Information Resources 2011). The ADDIE model aids educators, instructional designers and training experts in building variety of instructions from teaching students to teaching professionals (Gardner 2011).

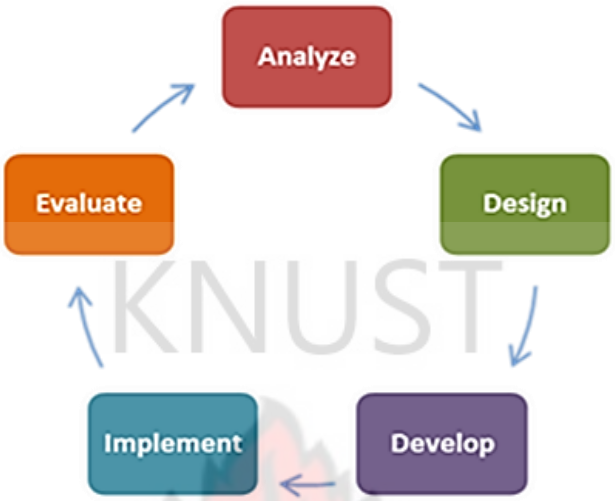

Figure 2.4: The Addie Model (Source: Morgan 2011).

- **Dick and Carey Instructional System Design (ISD)**

The Dick and Carey model (Figure 2.5) is a well-known system approach to instructional design which was developed in 1978. It addresses instruction as an all-inclusive system, which focuses on the relations between its various components namely teacher, student, resources, teaching activities, delivery method, learning and performance setting, working concurrently towards an expected outcome with each having an input and output (Dick, Carey and Carey 2005). It has ten major procedures made up of nine basic iterative cycle steps and a concluding summative evaluation for efficacy.

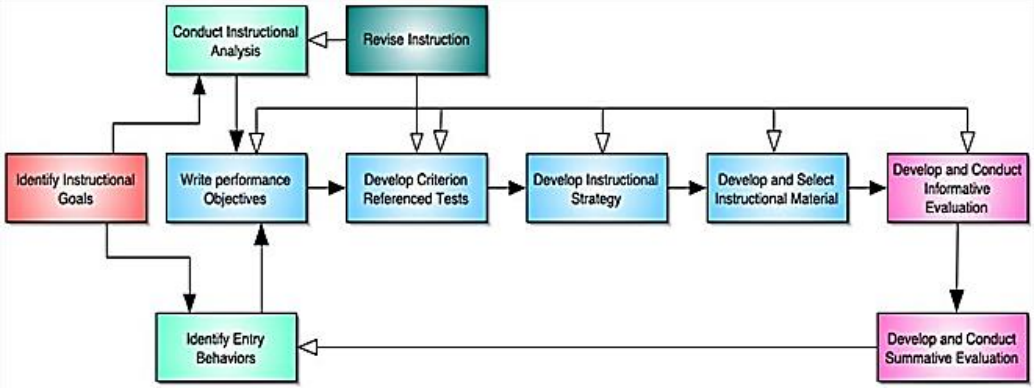

Figure 2:5 Dick and Carey ID Model (Dick, Carey and Carey 2009).

- **Kirkpatrick's Model**

Introduced in 1959 and updated over the years, is the famous, highly opposed and criticized, yet continued to be popular, influential, widely accepted and highly employed model for assessing the success of education, training and development programmes (Phillips 2003; Gill & Sharma 2013 as cited by Ulum 2015). The Donald Kirkpatrick's four-level evaluation model is celebrated for its simplicity, flexibility and practicality, as well as being the basis for most evaluation models. It measures: Reaction- level 1: responds to training. Learning- level 2; if learning has occurred. Behaviour- level 3: use of what is learned on the job, and Results- level 4: impact on the organization (Kirkpatrick and Kirkpatrick 2006). The model is applied before, during and after training to both maximize and demonstrate training value.

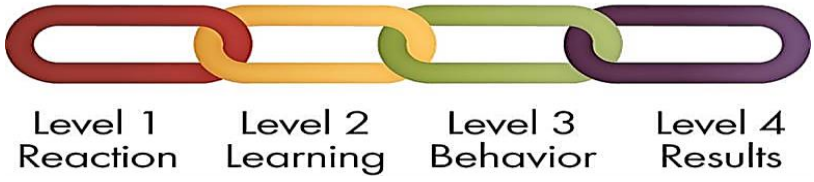

Figure 2:6: Kirkpatrick's evaluation model

2.7.1 Game Development Models

Game methodology on the other hand defines the chain of practices involved in developing games (Sykes and Fedeoiffroff 2006), it consists of a game development team and the processes to be followed. According to Chamberlin, Trespalacios and Gallagher (2012), for educational games to be effective there must be a development team generally made up of game developers and content experts working together throughout the process. Ibrahim and Jaafar (2009) as cited in Ahmad, Rahim and Arshad 2015) further break them down to include stakeholders such as programmers, teachers, instructional designers and students, because each one brings on board their expertise to make it both educational and fun. When it comes to the development process, Sykes and Federoff (2006) articulate that it generally follows a three phase procedure namely: pre-production, production and post-production, with sub-phases like concept creation, game design document (GDD), prototyping, design, programming, testing, marketing, and maintenance (Khumansinh 2016). Development models can mainly be classified under linear or iterative, Che Pee (2011) identified some development models as the waterfall, DGBL-ID Model, spiral, simulation-Games instructional systems design (SG-ISD) and value at play (VAP) model amongst others.

- **Waterfall Model**

Waterfall is a traditional linear model with a chronological process that is non-overlapping (Bates 2004), as shown in figure 2.7. The model is simple, easy to understand, manage and use, but only effective for very small projects with well specified requirements (McGuire 2006). The model allows for functionality only at the end of development when evaluation can be possible. Meanwhile, it is a known fact that in game designing, no matter how thought–out the design, it is always possible that the prototype might not work as perfectly or might not satisfy the customer, in which

case going back is impossible. Getting to the final stage before being able to evaluate a product is not an efficient way to develop games. (Cook 2015; McGuire 2006.)

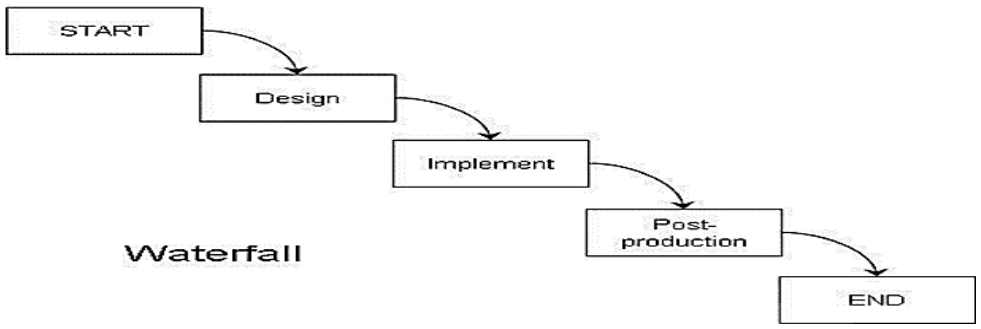

Figure 2:7 Waterfall model (Source:gamedesignconcepts.files.wordpress.com/).

2.7.2 DGBL-ID Model

Digital Game-Based Learning-Instructional Design Model (DGBL-ID) is an educational game design and development model that blends game and instructional design processes when designing educational games to be incorporated in classrooms (Che Pee 2011). DGBL-ID is a blend of ADDIE model, game development process and the 5E instructional model. It consists of five main phases, each including all the key activities for teaching and game that aids learning while having fun. These phases are made up of steps that leads to the next phase, as shown in Figure 2.8. According to Zin, Jaafar and Yue (2009), the DGBL-ID model is as follows:

Analysis Phase:

During this phase, instructional and digital games components are nurtured under five important sub-phase through interviews with stakeholders.

a. Problem and requirement analysis which entails the identifying the problems or needs of by learners so as to design DGBL to suit those needs.
b. Learning / learner analysis involves finding out learner characteristics such as prior knowledge and learning style. Gardner (2011) points out that knowing where learners stand concerning a subject helps in the preparation of the lesson

and this can be done through interviews and surveys. As mentioned earlier by (Deubel 2006 as cited by Coffey 2009), in game design, learners' age, gender, previous game experience and competitiveness should be considered. Forest (2014) also suggests pertaining to ID that this step must answer learners' demographic background, needs and interests.

c. Determining learning goals involves the clear definition of the goal or objectives of the game, which is a blend of the instructional goals.
d. Determining game idea includes game components that need to be considered during designing. These include among others the game mechanics, game characters and in-game challenges.
e. Definition of teaching environment via game: That is the types of game platform (such as television platform, computer platform or mobile and game features (Zin, Jaafar & Yue 2009).

Design Phase

The Design phase consists of two divisions namely: instructional design and game design. The instructional design according to Zin, Jaafar and Yue (2009) embraces delivery technique, instructional approach, learning theories and information processing model needed to attain the learning outcome, which is included in the lesson plan, aside from the teaching syllabus and teaching plan which also needs to be defined and inserted in the game. The game design involves determining the storyboard, multimedia elements (text, graphic, audio and video), type of game, the role of the player in the game, how player plays game (e.g. shoot an enemy, game design must define if a mouse click or joystick will be used), how the game's character, its features and motion, game environment, and game object such as car, gun, ball and ship, need to be determined before development phase. Additionally, game level, game technical

specifications like type of tools (hardware and software), as well as suitable programming language needs to be determined.

Development Phase

This is the phase where the game prototype based on the information gathered in the previous phases is produced. In this phase the type of game technology and software are determined, game character is modeled; game engine is selected for the development, sound is added, game's level is developed, player's data and score is saved in database of the prototype.

Quality Assurance Phase

The developed game prototype is tested in this phase for its quality. Testing is done by means of Playtesting, alpha testing to check the game's playability (start to finish), and beta testing to check for errors in the game's interactivity. Testing is done to guarantee an error free game play and make sure that game's content fulfills learning outcome and learning content based on the curriculum. After which game's features will be enhanced by solving the identified errors (Schell 2008 as cited in Viktorov 2015).

Implementation and Evaluation Phase

Implementation basically sees the developed game launched in the classroom (Zin, Jaafar and Yue 2009) and it involves what (PC), how (compact disc), and where (computer lab) it will be launched. Gardner (2011) also recommends the training of instructors for them to be familiar with the objectives, activities, media and assessment strategies. Preparing the learner to make sure they have the tools and knowledge necessary for the lesson. Along with arranging the learning space to be certain that all equipment and tools needed for and within the learning space are available and tested for smooth running of the course or lesson. Evaluation involves testing the effectiveness

and usability of the prototype game (Zin, Jaafar & Yue 2009). The adapted DGBL-ID mode is illustrated in Figure 2.8.

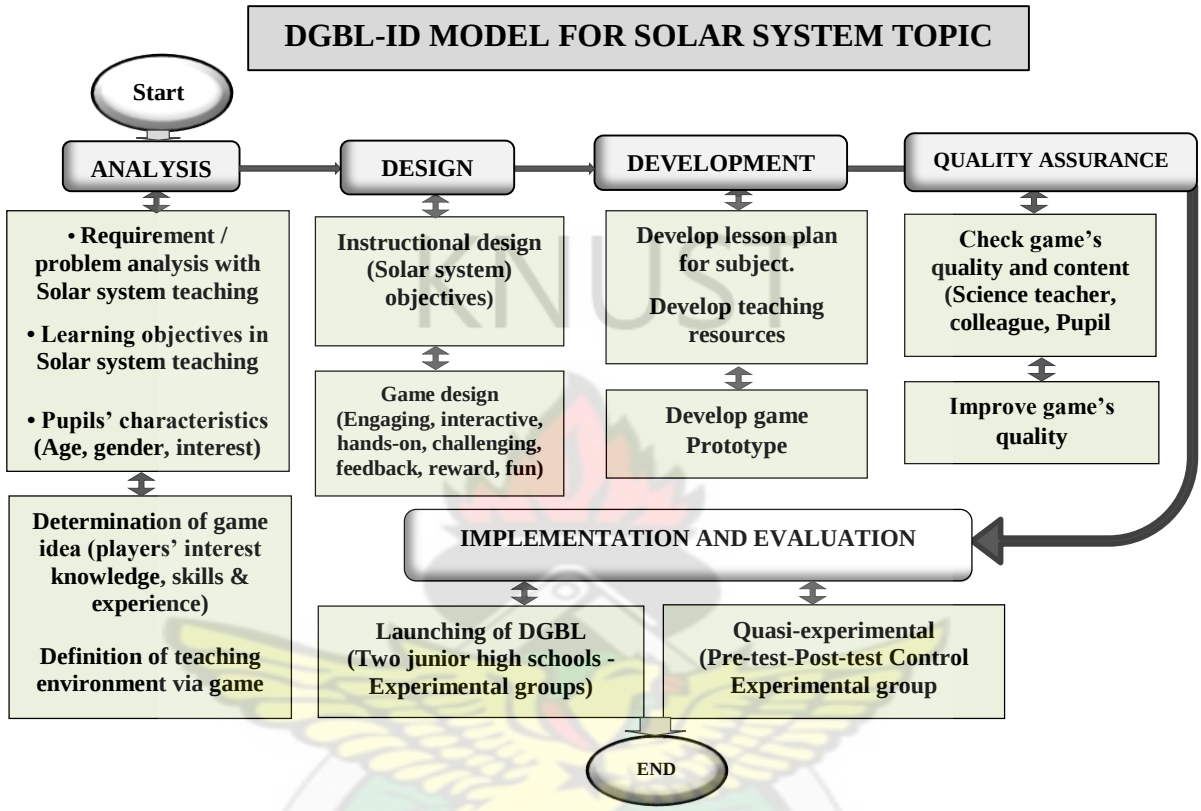

Fig. 2.8: Researcher's Construct, 2017

(Adapted DGBL-ID Model from, Zin, Jaafar and Yue 2009).

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter specifies the entire strategy employed to collect data for the study, and includes the research design, research methods, population, sampling techniques, instrumentation and the sources of data, as well as data handling procedures and ethical considerations.

3.1. Research Design

Research Design, according to de Vaus (2001) is a researcher's general approach to meticulously put together the various components of a study to ensure that data acquired will answer research questions with the least doubt possible. It is dependent on the nature and extent of the information intended to be obtained, and it involves strategies for assembling, measuring and analyzing data.

Mixed method research design was employed for this study making use of the descriptive and quasi-experimental research methods. Johnson et al. (2007) as cited in Teddlie and Tashakkori (2011), define mixed method research as a blend of qualitative and quantitative stance, data gathering, analysis and interpretations for an extensive and intensive understanding and validation of a study, which occurs at some point within a study to gain a detailed perception into a phenomenon. This corroborates Creswell and Plano Clark (2011) elucidation that mixed method research is characterized by gathering and analyzing both qualitative and quantitative data, combining the two forms in different ways, or prioritizing one or both forms of data. Mixed method, according to Creswell, Klassen Clark and Smith (2011) draws on the potency of/and reduces the

limitations to both qualitative and quantitative research, enriching and offering a stronger understanding of what a single approach would not have produced

Qualitative research, in the view of Williams (2007) is an all-inclusive method, involves unearthing issues, and concerns itself with the opinions, feelings and experiences of persons to yield subjective data. It describes social phenomena as they occur naturally without influence (Hancock 2002). And its strength lies in gaining new insights, developing new concepts and discovering problems that exist within a phenomenon to produce rich and in-depth data that leaves the participants view intact and offers a background for their behaviour (Osuala 2005).

- **Reasons for Employing the Qualitative Research Design**

The qualitative method was purposely employed in the study to document in detail the existing methods used by teachers, how they are used and pupils' response to their use in the classroom for the teaching and learning of Solar System under Integrated Science in the selected Junior High Schools. It also enabled the researcher to identify and analyze the knowledge and skills pupils had in digital games and devices. The researcher embraced it particularly because the situation studied were based in pupils' natural settings that is classroom and ICT lab environment. Again, the data gathered were a true reflection of participants need, to help design the digital game to adjunct the teaching and learning of Solar System under Integrated Science in the selected junior high schools.

Quantitative research on the other hand, is an experimental or observable inquiry that gathers, examines and displays data statistically (Given 2008). It aims at determining, confirming, or validating the relationship between variables (independent and dependent) within a population (Leedy & Ormrod 2001 as cited in William 2007; Babbie 2010). Its strength lies in greater number of subjects, generalizing results (across

groups or towards clarification of a phenomenon), greater objectivity, accuracy and replicating findings (Babbie 2010).

- **Reasons for Employing the Quantitative Research Method**

The quantitative research was also employed to identify and analyze the knowledge and skills of pupils in the study schools as well as to quantify the pretest and posttest scores statistically.

Mixing qualitative and quantitative data, according to Creswell (2014) occurs by way of merging, connecting and embedding the two data sets, taking note of its timing (concurrent or sequential) and weight; whether equal or unequal. Creswell and Plano Clark (2007) as cited in Creswell (2014) name the convergent parallel, sequential explanatory, and sequential exploratory as the three fundamental mixed method designs (explanations in table 3.1), upon which more advanced designs namely the transformative, multiphase and embedded can be built.

Table 3.1.: The three basic mixed method design

Mixed Methods Design	Procedure
Convergent Parallel	Collect both data sets concurrently, analyze separately, merge result, and compare to see if the findings confirm or disconfirm each other.
Explanatory Sequential (two-phase project)	Collect quantitative data, analyzes results (phase one), use results to plan / build (phase two), qualitative phase. Quantitative results inform the participants and questions for the qualitative phase.
Exploratory Sequential (two-phase project)	Explore qualitative data, analyze result (phase one), use findings to build in a second quantitative phase

Source: Researcher's construct, 2017

Embedded mixed method design is described by (Creswell and Plano Clark 2007 as cited in Creswell 2014) as the use of either convergent or sequential design, as well as nesting qualitative, quantitative or both data within an experiment (before, during or

after), with a data source acting as support in the entire design. This study adopted the convergent embedded approach which is illustrated in Figure 3.1.

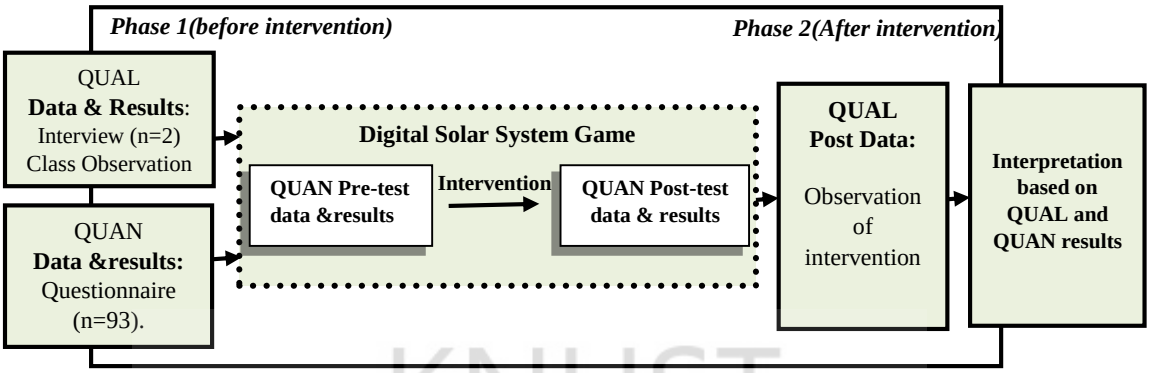

Figure 3.1: Adapted Concurrent embedded Mixed Method Design.
(Source: www.CopenHeart.org)

Employing mixed methods for a study according to Creswell (2014) is dependent on the purpose for which the mixing of approaches was deemed necessary. For this study integration was necessary to compare the results from the concurrent data collected for objective one and two (first phase) to validate the reliability of the data and to inform the development of the Solar System Science game. A quantitative pre-test and post-test measure were embedded within the DGBL intervention trial to compare the Experimental and Control Groups. And a qualitative post intervention data was collected on the effectiveness of the game.

3.1.1 Research Methods

The researcher employed the Descriptive and Quasi-experimental research methods.

3.1.1.1 Descriptive Research Methods

According to Shuttleworth (2008), descriptive research offers researchers the opportunity to logically explain the observed behaviour of a subject devoid of influence in any way. Berg (2004) opines that it is situated to explain the normal occurrence within a data in question. The main aim of descriptive research is to make known accurate and credible account of the factors that are pertinent to the research questions.

It is worth noting that the most unique feature of a descriptive research method as Leedy and Ormrod (2005) put it, lies in the researcher's inability to control the variables being studied given that it has to be portrayed as it prevailed at the time of the study.

- **Reasons for Employing the Descriptive Research Method**

The descriptive research method afforded the researcher the opportunity to give an in-depth account of the existing methods that teachers use, its strength and weaknesses, and pupils' response to their use in the classroom for the teaching and learning of Solar System under Integrated Science, pupils' knowledge and skills in digital games and devices, as well as the observations on the effectiveness of the produced game in the selected junior high schools.

3.1.1.2 Quasi-Experimental Research Method

According to Creswell (2014), it is a form of experimental research design that takes place in a natural environment like the classroom and utilizes naturally formed groups that is non-randomized, through pretest and posttest of a Control and Experimental Group with only the experimental group receiving an intervention. Hashemi (2014) further states that this is to approximate the causal impact of the intervention. In the view of Leedy and Ormrod (2005) it involves manipulating a variable, while maintaining all others to determine its effects on a study.

- **Reasons for Employing Quasi-Experimental Research Method**

This method enabled the researcher to evaluate the effectiveness of the digital game intervention on teaching and learning in the two junior high schools, and to do a better comparative analysis of the Control and Experimental Group test. It also afforded the use of the non-randomized classes in both schools in order not to disrupt the schools' settings.

The pre-test post-test, two group design under quasi-experimental was used. Both Control and Experimental Groups took a pre-test and post-test, however, only the experimental group received game intervention. The pre-test provided the researcher with some idea of how similar the Control and Experiment Groups were before the experimental.

3.2 Population for the Study

Population is the entire collection of well-defined study groups, having similar attributes, it always comprises a total combination of the elements which interests the researcher (Explorable.com 2009). Based on this, the population for this study included all JHS Three pupils (160), JHS Science teachers (4) and head teachers (4) in the two Junior High Schools in Kumasi, totaling 168. This is further explained in Table 3.2.

Table 3.2: Population for the Study.

School	JHS Three Pupils		JHS Science Teachers	JHS Head Teachers
School A	Form Three A Form Three B	21 23	1	2
School B	Form Three A Form Three B Form Three C Form Three D	24 25 32 35	3	2
Total		160	4	4

Hence, the Population for the study was 160+4+4 = 168.

3.2.1 Target Population

According to Hayes (2011), a target population is the entire group of people or objects of interest to which the researcher generalizes the results of the study. Since the entire population for this study was obviously unreachable, a portion that included JHS Three Pupils from 2 Classes (93), JHS three Science Teachers teaching the 2 Classes (2) and

JHS head teachers (2) in both schools were chosen using convenience and purposive sampling (as discussed in the ensuing pages), making = 97 as shown in table 3.3.

Table 3.3: Target Population for the Study

School	JHS Three Pupils from 2 Classes		Science Teachers Teaching the 2 Classes	JHS Head teachers
School A	Form Three A Form Three B	23 21 **44**	1	1
School B	Form Three A Form Three B	24 25 **49**	1	1
Total		**93**	**2**	**2**

Thus, the Target Population for the Study was 93+2+2 = 97.

3.2.2 Accessible Population

Accessible population is a subset of the target population to which the researcher has reasonable access, and from which samples are drawn and conclusions applied (Explorable.com 2009), also known as the study population. The accessible population for the study was the same as the target population since according to (Essel 2009; Manor 2013), for a population less than 100, the entire population should be surveyed.

3.2.3 Sample and Sampling

A sample is the realistic way out of the difficult task of learning about an entire population (Ruane 2005). Samples permit researchers to look at a small number, so as to make generalizations. Sampling is the process of selecting a portion (sample) from the over-all (population) so as to make inference about the whole (Osuala 2005). Sampling is done to decrease the effort, time and cost that would be involved if the entire population is being studied. For this study the researcher did not select a portion

since all the pupils in the accessible population partook in the study, as supported by (Essel 2009; Manor 2013) for a population less than 100.

3.2.4 Sampling Design

Sampling design is defined by Saunders, Lewis and Thornhill (2007) as the process by which a handier sample of a study is chosen from a population. An employed sampling design affects the extent to which its results can be generalized. Sampling design can be classified under Probability or Non – Probability of which forms like simple random, systematic, cluster, stratified, convenience, quota, purposive and multi stage sampling can be identified (Popoola 2011). For the purpose of this study, the convenience and purposive sampling techniques were employed to choose a sample from the population.

3.2.4.1 Convenience Sampling Technique

According to Lucas (2012), in convenience sampling individuals are selected for a study based on their ease of access. And in the view of Hayes (2011), selection is based on the most readily available. This technique was used to select the Junior High Schools because it guaranteed easy access and proximity between the schools, researcher's work place and residence, as well as saved time and money. Both schools had streams of classes at all levels which made it convenient to use the A(s) and B(s).

3.2.4.2 Purposive Sampling Technique

In the view of Oliver (2006), purposive sampling is a non-probability sampling technique where persons to be included in a sample are considered based on their expert knowledge of the research topic, or ability and readiness to participate in the research. The purposive sampling technique was adopted to select:

• The Science teachers based on their specialist knowledge in Science.

• Junior High School Three (3) pupils because: 1. the Solar System topic is taught at that level. 2. They've had a much longer and extensive experience to answer truthfully and confidently Objectives one and two of the study.

Junior High School Three 'A' and 'B's in both schools were randomly assigned to Control and Experimental groups by balloting, which ensured that each group had an equal chance of being in either the Control or Experimental Groups.

3.3 Data Collection Instruments

Data collection is a significant part of any research study. Gray (2004) emphasizes that a study's success is vastly reliant on the data collection instrument employed. It is therefore prudent that the choice of tools fit the nature of the enquiry. The research adopted triangulation of data collection tools namely: observation, interview and questionnaire to collect data from pupils, teachers and head teachers in the selected Junior High Schools under study. According to Malterud (2001), triangulation "increases the understanding of complex phenomenon, in which agreement among different sources confirm validity". The study was in two phases; the first phase was to collect data using observation, interview and questionnaire to inform the Production of the Digital Game for teaching Solar System and the second phase was to collect data on the effectiveness of the digital game in the selected Junior High Schools.

3.3.1 Observation as a Tool for Gathering Data

Leedy and Ormrod (2005) describe observation as gathering information directly on the field of research using one's sense of touch, sight, smell, hearing to learn about a phenomenon of interest. According to Lemanski and Overton (2011), it involves

explaining events, measures, behaviours, relational exchanges, procedures and aspect of individual experience. Observation is a powerful research tool for validating gathered data in an interview or questionnaire by not allowing the views of the people to cloud the reality of what the researcher sees happening directly in the natural setting (Chaleunvong 2009). There is the participant observation which includes the observer in the group to be observed making it easier for the group to lower their guard and make researchers gain deeper, richer and more accurate information. On the other hand, non-participant observation which involves observer staying out of the confines of the group to avoid bias.

- **Justification for Choosing Observation as a Research Tool**

Participant observation was used in both phases of the study. In the first phase it was used to carefully gain insight and verify data collected through interview and questionnaire into the existing methods used for the teaching and learning of Solar System and pupils' knowledge and skills in digital games and devices in the two junior high schools. In the second phase it was used during the implementation of the developed digital Solar System game to the experimental group in both schools.

As a participant observer in phase one: which lasted three weeks in October 2016 in both schools, observations were done every Mondays, Wednesdays and Fridays in School 'A' and Tuesdays, Thursdays and Fridays in school 'B' with each session lasting 80 minutes. The researcher took on the role of a teaching assistant, taking part in activities that formed their daily routine. This created the needed familiarity that curtailed the likelihood of teacher's and pupils putting on an act because they were being observed. Observation were done on the Solar System topic with particular attention on the teaching methods used, their strengths and weaknesses, pupils' attitude and behaviour during lessons.

• The researcher also observed pupils' skills in digital games through three (3) digital fun games namely: Temple run, Shoot-em-up and Zuma. These assisted in looking out for their ability to play, involvement, interest and ease of computer use.

In the second phase: observations lasted for three weeks in May, 2017 after each school day, on the experimental intervention of the Digital Solar System Game, focusing on pupils' participation, interaction attitude, interest and outcome. All data were documented via written note, photographs and audio recording techniques. Observation were done with the help of an observation checklist (See Appendix D).

- **Designing an Observation Checklist**

The researcher, guided by the objectives of the study, designed a less structured checklist to guide the collection of data. It was made up of a total of 32 questions that sought information on existing methods of teaching and learning Solar System under Integrated Science, pupils' knowledge and skills in digital games and the implementation of the digital game (intervention) to the experimental groups in both schools. The designed checklist was vetted by colleagues from the Department of Educational Innovations in Science and Technology for corrections and inputs before it was submitted to the research supervisor for final vetting and approval. The checklist was piloted to ensure error – free and its appropriateness to the data being sought.

3.3.2 Interview as a Tool for Data Collection

According to Patton and Cochran (2002), interview is a verbal interrogation with a set of pre-planned questions. Vinay (2014) further revealed that this conversation happens between two persons with the aim of gathering relevant information for a research. Interview, according to Silverman (2000) is the most appropriate data instrument when perceptions, experiences, beliefs and opinions on specific issues need to be explored in

detail. It is also an important way for researchers to verify the accuracy of the impressions gained during observation (Driscoll 2011).

Interviews may be structured, semi-structured or unstructured. For the purpose of this research, the semi-structured interview was used to seek answers to questions relevant to the study from Science teachers and head teachers in phase one, employing an informal (conversation) face-to-face approach to ensure comfortability and willingness to share information freely as explained by (Hancock 2002). Science teachers were interviewed on their methods of teaching, how they affect pupils' learning, pupils' behaviour during teaching and learning sessions whiles head teachers were interviewed on the general management of the school. Both were then interviewed on their knowledge and perceptions of Digital game-based learning and its possible integration into Junior High School Science education. An interview guide was however used to streamline the various discussions.

- **Designing Interview Guide**

Two sets of interview guides, one for Science teachers and the other for head teachers were designed to answer the research questions (See Appendix A and B). Both guides had four sections (A, B, C, and D) comprising school information, background information for both, while Science teachers' section C comprised- teaching and learning and D- game/digital game based-learning. And head teachers' section C comprised overview of school and D- Research questions, both making a total of 17 and 15 questions respectively. To guarantee the validity of the interview guides' copies were given to colleagues' for vetting before submitting them to the thesis supervisor for final corrections.

- **Conducting the Interviews**

Prior notification was given to interviewees after the interview guides were designed and appointments were scheduled. The researcher was punctual to all dates and scheduled times and documentations were in the form of written note and audio recording. The head teachers were interviewed before the Science teachers in both schools, interview was in a conversational manner in-order to reduce tension and create a comfortable atmosphere. Interviews were conducted on 3rd and 4th October, 2016 in schools 'A' and 'B' respectively.

3.3.3 Questionnaire as a Tool for Data Collection

Questionnaire is a set of carefully arranged queries, chosen with the intent of eliciting responses that are reliable from a research sample (Meyer, Becker and Vandenberghe 2004) and aimed at discovering what participants think, feel or do. The use of questionnaire as conferred by Debois (2016) affords flexibility, time and money saving, a quick and easy way of collecting data as well as the ability to cover all topics under the study. Both open and close-ended questions can be used in designing questionnaires for data gathering. A close-ended questionnaire was used in gathering data from pupils in the two Junior High Schools. These questions were used to control pupils' responses (See Appendix C) and ensured that respondents completed the copies of the questionnaire themselves.

- **Design and Administration of Questionnaire**

The questionnaire was structured in a 3 point Likert scale format, were respondents were required to indicate a "0-Yes, 1-No" and 2-Sometimes" to a series of statements on their knowledge and skills in digital games and devices. The questionnaire comprised two sections, pupils' demographic data in section A and B made up of five

themes with sub-questions under each of them on digital games and devices, making a total of 14 items in all. To improve the appeal of the questionnaire, it was given a clear, brief and expressive title, typed, section headings highlighted, well-spaced out and easy to read. The drafted questions were vetted by colleagues and thesis supervisor to ensure clarity, and revised to make them error-free before being used.

Copies of the Questionnaires were personally administered to pupils in both schools: 44 in School 'A' on the 18th of November, 2016 and 49 in School 'B' on the 17th of November, 2016. Out of the total 93 questionnaires administered in both schools, 90 (98%) were retrieved. Results of observation interviews and questionnaires are presented in Chapter 4.

3.4 Ethical Considerations

The moral integrity of this study was maintained by being mindful of the two vital issues of consent and confidentiality as suggested by Bricki and Green (2007). Consequently a letter of introduction from the Head of the Department of Educational Innovations in Science and Technology, College of Art and Built Environment, KNUST explaining the purpose of the research and seeking for assistance in collecting data for this thesis was submitted to the heads of the participating schools. After approval, researcher was introduced to the Science teachers. Anonymity was of utmost importance to both schools so the researcher gave pseudonyms to participating schools. With this assurance in place, research intentions were discussed, schedules were drawn, dates were proposed and approved and class time tables were given to researcher for commencement of the study.

3.5 Types of Data

The types of data that were gathered for this research were primary and secondary data. Primary data collected included field notes from observation, interviews and questionnaire. Secondary data were gathered from books, journals, online documents, published and unpublished thesis, school records and other documents that related directly to teaching methods and digital game-based learning.

3.6. Methodology for Executing the Digital Game for Teaching and Learning Solar System under Integrated Science

In executing the game, the DGBL-ID Model which consists of Analysis, Design, Development, Quality Assurance and Implementation-Evaluation phases was adapted because it was better suited for the study. It integrates the ADDIE instructional processes which has been the basis for all other models and has been proven effective, with game design and development processes, and clearly indicates its use in education and in the direction of evaluation.

3.6.1 Analysis Phase

According to the DGBL-ID model, this phase required a critical analysis of the problem and requirement, learning, learner, and, their previous knowledge in games, which was satisfied in objectives one and two.

3.6.1.1 Execution of Activities for Objective One

Objective One was to document and analyze the existing methods of teaching Solar System and their effects on learning in two Junior High Schools in Kumasi.

First, interviews were conducted with the class teachers in both schools on their methods of teaching Solar System under Integrated Science, and their effects on learning. After which the Solar System lessons were observed in both schools to witness firsthand how its teaching and learning unfolds, and then concluded with a pre-test to measure the impact of the lessons on pupils' learning in both schools.

3.6.1.2 Execution of Activities for Objective Two

Objective two sought to identify and analyze pupils' knowledge and skills in Digital Games and Devices so as to produce a Digital Game to adjunct the teaching of Solar System in two Junior High Schools in Kumasi.

In order to achieve this, questionnaire was first used to find out from pupils their familiarity with, interest in, preference to Digital Games and Device, as well as the frequency with and reasons for playing games. After which observation on digital fun games was conducted to ascertain pupils' knowledge and skill level in Digital Games to aid in the designing of the digital game to adjunct the teaching and learning of the difficult-to-teach Solar System topic. Findings are shown in Chapter Four.

3.6.2 Design Phase

During this phase, analysis of results from the interviews and observations at the previous phase were used. It also informed a critical study of both teachers' lesson objectives and the JHS Integrated Science syllabus to determine the specific goals of the Solar System topic (CRDD 2012), and how it can be merged with game elements to create an actively engaging and interesting Solar System Game to adjunct the teaching of the topic. Based on this, a criteria was set as follows to aid the designing.

3.6.2.1 Criteria for Designing the Digital Game for Teaching and Learning Solar System

1 Suitability to the target group which is JHS pupils between ages 12 to16. Not losing sight of their needs (active learning), interests (computer-action, adventure, shooting games) and experience, the activities and skills needed for the game as well as the level of language to be used was linked to pupils level as proposed by (Patrick 2011).

2 Appropriateness of the educational content for its intended purpose. The digital Solar System Game was designed to support the learning objectives in the Integrated Science syllabus and balanced both education and entertainment qualities. This ensured that pupils were prevented from paying too much attention to the fun while ignoring the learning aspect.

3 Supports Game Goal(s): this is a major motivator to play according to Prensky (2001) which functions as a measure for player achievement and advancement. It also informed the development of the Digital Solar System Game. Considering the age and experience of the pupils, the goals were not too easy or too difficult for them, but clear enough to be well understood by learners.

4 Competition and challenge is another feature most coveted in game development because these are the problem-solving bit of the game, without which there is no game. These are manifested in the form of anything that hinders the progress of players in reaching their goal (Whitton 2007). While having fun, these were the main interest of pupils in both schools.

5 Interactivity in digital games is relevant to fulfilling the needs of pupils to learn by doing. It is one of the most important factors in the design and development of

games. Learners wish to directly manipulate materials which arouses their interest and curiosity to learn on their own.

6 Feedback and rewards cannot be overlooked in developing the game since learning occurs through feedback when players instantly know how close or further away they are to/from their goal, or whether they are within or breaking the rules (Whitton 2007). Feedback can take the form of numerical or graphical scores, oral or joking game reporters. By means of the feedback players either get rewarded or get failed and have to keep trying until its perfected. Rewards such as scoring and sound effects can be effective for motivation.

7 Usability of Game Interface was considered, being the only link between player and game, where choices and responses to events are made, and upon which the success or failure of the game is dependent (Fox 2005). Therefore, it was clear and pleasing, easy to use and fun, as suggested by Patrick (2011) so that players won't struggle and be discouraged from playing. Colour could not be left out of the interface design since children in particular are generally fascinated by especially bright ones which easily attract their attention and help facilitate their learning process (Rongalerios 2009). Consequently, the colours used were light and bright to match the feel of the game.

3.6.2.2 Design Process of Digital Solar System Game

The researcher began this process by creating a storyline in a setting that blends with the topic of instruction. In order for the objectives of the lesson to be achieved, it was integrated into the missions the player will embark on, so that by achieving it and its goals, the lesson objectives will also be met. The researcher then based on the storyline to determine an overall goal for the game ("to save our universe"), and coined the name

"SaveSpace" to instil the feel of gameplay and not learning, and used it as the name for the 'Digital Solar System Game' (from here on 'SaveSpace), designed a simple, attractive and colourful logo with it for the game. Bearing in mind the behaviour of pupils during the fun games, the researcher considered an automatic voice over instruction to prevent players from playing the game without knowing their mission. However with flexibility and interactivity in mind, it was also designed to be manipulated. As part of knowing if players were into the game and learning was occurring, a formative assessment in the form of a quiz was designed to be taken before each game level, which was to be seen as access to playing the game and a challenge to outwit the highest score and get the fastest, powerful and most equipped spaceship. The researcher also determined that player spaceship is characterised by different specifications like speed, agility and armor. The levels were designed such that, the higher it goes, the tougher the challenges. And that each levels specific gaol will be to destroy alien actions, which would ultimately lead to achieving the games overall goal. Illustrations were created for the levels. Provision was also made for feedback within the game and at each completed level, for player to know their progress and be challenged to do better. Researcher then designed a game play flow chart. Details of the above and more can be found in a prepared Game Design Document (see appendix F) which according to Dobbe (2007) is a concrete blueprint that describes all the game ideas and elements on which a game is produced.

3.6.3 Development Phase

This is where the designs and descriptions created in the game design document (GDD) by the researcher were converted into the actual game by the programmer as purported by (Sykes and Fedeoiffroff 2006). This phase describes the tools, the gameplay and sections of the game.

Tools: "SaveSpace" was produced with the Unity 3D Game Engine, which is a cross-platform computer software game-engine use to create games for desktop, consoles, web and mobile platforms. Chosen for its ease of use, intuitive interface for creating easy graphical user interface, rich documentation and plenty of tutorials, which makes it a perfect choice for beginners and expert developers.

Adobe Photoshop is an image editing, enhancing, manipulating and graphics application tool with a wealth of powerful painting and selection tools, multiple layers, special effects filters and lighting effects. The application was chosen for its relative ease of use to the researcher during the logo, interface and CD label designs. The final game was rendered and burned unto a rewritable CD.

"SaveSpace" Gameplay

Overview: SaveSpace is a 3D action-adventure, single-player, shooter PC game in which the player is on a mission to save the world before it is destroyed by aliens. It is made up of three levels with each one tougher than the previous. The gameplay involves controlling a spaceship within a space world, on and across orbits, with the challenge of maneuvering between planets and other heavenly bodies, overcoming and avoiding collision with obstacles, idetifying and collecting health boosters, dodging alien weapons, destroying alienships, mothership and finally alien base.

Core Game Play /Game Flow

The game begins after loading with a command to press any key to continue. This takes player to the main interface with a "start or quit" option (see fig 3.2) which when started, results in player selecting "new game" and leads to a level selection interface with all three levels as options (see fig 3.3).

Figure 3.2: Screenshot of Main Interface

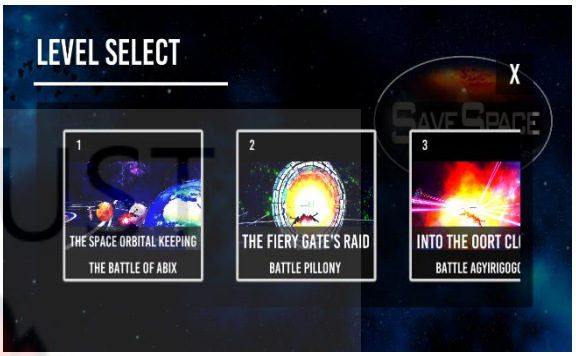

Figure 3.3: Screenshot of Level Selection Interface

Upon entering a level, an automatic voice over of a Captain (General Owusu) gives instructions which includes: the goals, missions, overview of game evironment and rules (see fig 3.4), to which players can "stop"and read by themselves for clarification. And proceed to take a tour of the game environment for familiarization (see fig. 3.5).

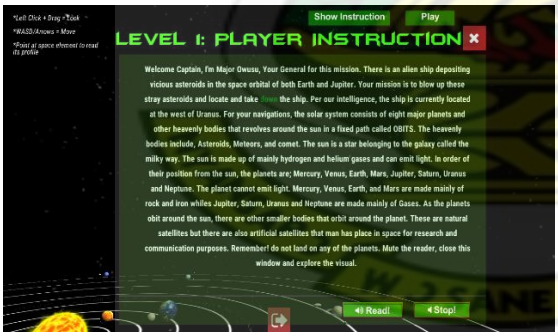

Figure 3.4: Screenshot of Instruction Interface

Figure 3.5: Screenshot of Game Environment

Upon completion, player is taken to a 30 seconds quiz interface after pressing "play", which can be submitted or resit (see fig. 3.6) depending on the performance satisfaction of player. This progreses to a selection interface to view the specifications (speed, agility and armor power) of automatically selected spaceship (see fig.3.7) based on the quiz score. After which player can enter the level.

Figure 3.6: Screenshot of Quiz Interface

Figure 3.7: Screenshot of Player Selection Interface

In level one for instance, player must clear vicious asteroids between Earth and Jupiter while en-route to Uranus to take-down the alien ship depositing them (see fig. 3.8). First, they will locate Earth and Jupiter's orbit, blow up stray asteroids, move to Uranus and take down the ship. Bearing in mind not to land on any planet, lose health or be shot at, else game ends and player must restart. Upon winning however, player goes back to the main interface to select the next level and go through the processes again.

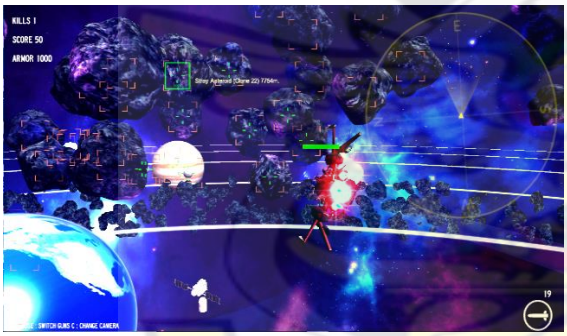

Figure 3.8: Level one Game Interface

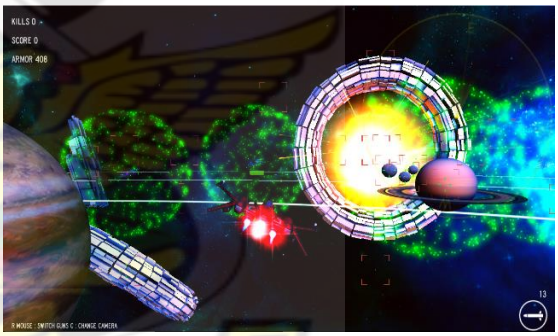

Figure 3.9: Level two Game Interface

Level two requires player to destroy alien invisible wall with fiery gate that is shielding their base and can only be activated via Saturn's Titan moon (see fig. 3.9). They must locate the moon as they dodge to shoot defending ships, and avoid hitting the planets.

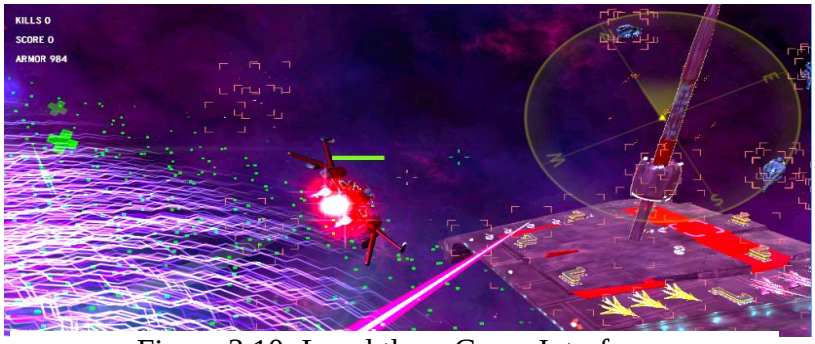

Figure 3.10: Level three Game Interface

The level three player destroys alien secret base after taking down the guard ships surrounding it (see fig. 3.10). Player must locate the base in the Oort cloud beyond the Kuiper belt, shoot the ships faster to prevent them from scattering, avoid being shot at, losing health or coming into contact with the planets. And must locate and refill health.

3.6.4 Quality Assurance Phase

This phase defines the testing of SaveSpace for playability (start to finish), errors, and suitability to learning content. Playtesting was done by three gamers, specifically a Science teacher, colleague, and a pupil. Their written comments revealed the following:

- Suitability of game content to learning goals.
- Voiceover not corresponding to writings and there were omissions in text.
- Instruction board obscures the view of the exploring game environment.
- Mouse and keyboard controls not flexible and Player spaceship not destroyable.
- Some menus were malfunctioned (armor, game over).

These corrections were then effected as indicated by Schell (2008) as cited in Viktorov (2015), to improve the quality of the Digital Solar System Game for effective teaching and learning before its implementation at the two Junior High Schools.

3.6.5 Implementation and Evaluation Phase

At this stage, the game was tested on the Experimental Groups in both Schools, whiles the Control Groups were taken through revision of the topic in the traditional way. The implementation process involved preparing computer labs and training the teachers.

Preparation of Computer Labs: this was done by transferring 'SaveSpace' onto the available computers and testing for its smooth running, as well as connecting and testing projectors and screens.

Training of Science Teachers: The Teachers were trained on how the game works. However, since they had been part of the team, and were familiar with the topic and its learning objectives, understanding the game was easy for them.

3.6.5.1 Testing of the Solar System Game on Experimental Groups in the Two Junior High Schools.

The experimental groups of both schools were introduced to the game by the researcher after sitting in groups of two's and three's behind a computer. After which pupils booted and located the "SaveSpace" icon on their desktops and then started interacting with the game on their own, receiving instructions, goals and rules for playing the game, with the researcher facilitating, clarifying issues and observing. Each pupil however, did an independent game quiz to determine who plays first amongst the group, which was the one with the highest score. The pupils, now players, took turns playing the game until the end of the lesson. Intervention continued twice a week for three weeks, 45minuits after school. Groups were changed each lesson day and pupils were instructed to collaborate amongst themselves on the third week. After the last day's intervention, pupils were informed of a test. (Plate 3.1a-d and 3.2a-f) show School 'A' and 'B' experimental group gameplay respectively.

Plate 3.1a: Pupils interacting with game

Plate 3.1b: Pupils waiting their turn

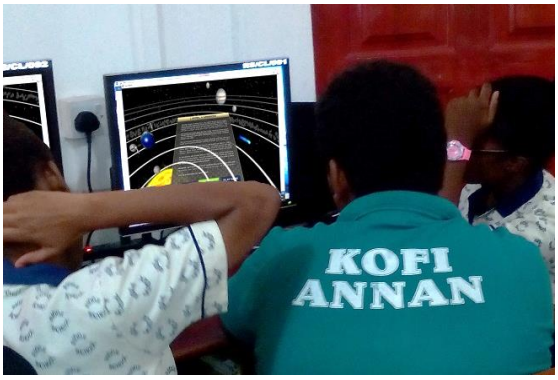

Plate 3.1c: Pupils exploring game view

Plate 3.1d: Researcher directing pupils

Plate 3.1. School 'A' experimental group gameplay

Source: Researcher's field data 2017.

Plate 3.2a: Pupils playing game

Plate 3.2b: Researcher introducing game to pupils

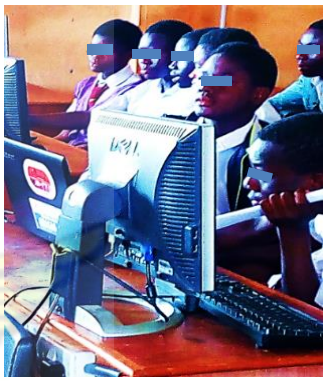

Plate 3.2c: Pupils concentrating on gameplay

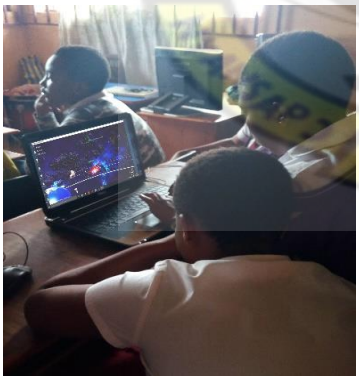

Plate 3.2d: Some girls playing game

Plate 3.2e: Researcher explaining portion of game

Plate 3.2f: Pupils collaborating with friends

Plate 3.2. School 'B' experimental group gameplay

Source: author's field data 2017.

3.6.5.2 Challenges Encountered During Game Intervention

The main problem the researcher encountered was difficulty in managing pupils because of their excitement and willingness to continue playing the game all the time, which made it difficult to control them and took away some class time.

3.6.5.3 Evaluation: Execution of Activities for Objective Three

To evaluate the effectiveness of the Digital Solar System Game on learning in the two Junior High Schools in the Kumasi.

After the SaveSpace intervention, the Experimental and Control Groups were combined for a 30 minutes test (post-test) with the same questions as was in the pretest but jumbled up. It was scored with the help of Science teacher 'B' and the marks recorded. This offered researcher the opportunity to measure the effectiveness or otherwise of the intervention to establish whether the learning objectives and game goals were achieved. Post-test results are shown in chapter four.

3.7 Data Analysis Plan

The data collected in phase one through observation, interviews and questionnaire were transcribed into narrative and descriptive forms, synthesized, analyzed and interpreted. Based on the findings the Digital Solar System Game was designed and developed to adjunct the teaching of the topic.

The phase two reported data collected from the Pre-Test / Post-Test Control and Experimental Groups intervention of the Game. The Microsoft Office Excel application was used to generate charts, graphs and tables representing the results in percentages and frequency tabulations.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.0 Overview

This chapter presents the analysis and interpretation of the findings obtained through interview, observation and questionnaires, as well as the evaluation of the effectiveness of the Designed Solar System Game.

4.1 Characteristics of Sampled Schools

To ensure confidentiality and good ethical practice of research the names of the Junior high schools were replaced with the letters 'A' and 'B'.

- **School A**

School A is an international day school originally founded in 1959 by 24 foreign companies, re-registered in 1966, now under the authority of a Board of Governors and located at Danyame in Kumasi. The school is open to all Primary and Junior High School pupils in Ghana within the age range of 4 to 15 years. The primary school caters for children aged between 4-11 years and comprise of a reception class for 4 and 5year olds, and classes 1-6 for 5-11year olds. Whilst the JHS caters for children aged between 11 and 14 years and comprise of two streams each (A and B) for Forms One, Two and Three. The school has a learner population of about 386 (260 Primary and 126 JHS) pupils of different nationalities, with 20 teaching staff (12 Primary, 8 JHS), 10 additional support staff and headed by a headmistress for the Primary section and a headmaster for the JHS section.

The school is equipped with a well-stocked library/resource center and a fully operational ICT lab for both primary and JHS sections. The school also has a well as a well-maintained purpose-built play area for the primary section. Science Lab, Home

Economics Department and Pre-Tech Workshop for the JHS section, as well as a Sports Field, Basket and Volleyball Court. The school also aims to support pupils through guidance and counseling.

- **School B**

School B is an international private day and boarding school located at Tanoso in Kumasi. It was established in 1990 and registered with the Ghana Education Service in 1992. The school is open to all kindergarten, Primary and Junior High School pupils from all over Ghana. Its Junior High Section has a pupil population of 307, comprising four streams "A, B, C, D" each in Forms One, Two and Three, with a 15 member teaching staff, managed by a headmaster and an assistant headmaster.

The school has adequate and spacious classrooms with other notable facilities like ICT and Science Lab, Library, Sick Bay, Dining Hall, Boarding Facilities and a Sports Complex. Additionally, extra-curricular activities in the school include Police and Military Cadet, Readers and Soccer Club. The school is committed to quality and holistic education for all.

4.2 Presentation and Analysis of Findings on Objective One

4.2.1 Findings from Interview with Integrated Science Teachers

The Science teachers interviewed in the two schools were both males (ST1 and ST2). Science teacher one (ST1) has been teaching Science at the Junior high school for forty years and a Post-Secondary Certificate holder above 54 years, whilst Science teacher two (ST2) who is below 30years, has been teaching Science at the Junior high school for only two years and holds a Bachelor degree. Both teachers mentioned the use of their classrooms as the place for their lessons because according 'to ST1 *"it is very convenient for me*". Whilst ST2 said "*our Science Lab is too small and not fully*

equipped…it looks just like the classroom". ST1 stated that he uses mostly lecture and demonstration when he is teaching, whiles ST2 cited the use of solely lecture method. Both said that it's easy and convenient to use particularly the lecture method because it doesn't waste class time, and helps them finish the syllabus on time. Both however agreed that the lecture method doesn't involve pupils in the teaching and learning process. Science Teacher One (ST1) said he uses pictures in the text book or charts provided by the school to support his teaching and sometimes illustrates on the white board. Science Teacher Two (ST2) however, said the school does not have Teaching and Learning Materials (TLMs) and the packed academic calendar does not permit him to produce some of these materials. Therefore, he sometimes does illustrations on the board or uses those in the text book. Both teachers agreed that their method of teaching and the lack of appropriate TLMs make lessons un-interactive, uninteresting, non-participatory, and less involving for pupils. They again expressed that these make pupils easily distracted, lose focus, bored and disinterested sometimes.

According to ST1 *"my pupils show this by going out of class often, looking outside and fidgeting*". Whereas ST2 said *"...oh they fake all kinds of illnesses so they can sleep or go out of class, they whisper, or they fidget and play with anything available to them*". Due to this both teachers said they resort to impromptu questioning, and random name calling to keep them focused, active and interested during lessons. In addition to these, ST1 said "I *sometimes take them out of their comfort zones, on excursions to experts with the technical knowhow on certain topics, or invites them to my class as a change from seeing me always*". ST2 also mentioned that he asks them to tell the whole class what they were doing, and sometimes make them answer questions by writing on the white board, and this keeps them in check. According to both teachers, Science is perceived as a difficult, complicated, boring and uninteresting subject by pupils, that's

why they repeat severally for their understanding. According to ST1, this is the reason why he uses demonstrations, or pictures when necessary because seeing and doing enhances learning. Both teachers mentioned that the Solar System topic is a difficult, abstract and technical topic to teach. . Science Teacher One (ST1) said *"this topic is not related to pupils' immediate environment, so no matter how I teach it, my pupils find it difficult to understand"*. Furthermore, ST2 said "*the whole concept seems to them like a movie, a make believe, something unreal and out of the world, so they just memorize it because they can't relate to it"*.

According to ST1, Game-based learning *"is something like if the children are playing whilst learning…like when they go on an educational trip…it's fun and they learn",* however Digital game based-learning to him is *"the games children play on phones"*...he has not used the method before, but based on the little knowledge he has, he states that "*I believe it will be fun and can encourage pupils to learn since game is something they love to do*.

On the other hand, ST2 *said "well intellectually, I can say it is a fun way of learning, although I have not read about it before, I have heard of games in Maths but have not played or used it in teaching before".* He also believes that it can impact learning since pupils like to play games already. Both teachers agreed that Digital Game-Based Learning is not practiced in their schools. When asked which topic they would like to use this method to teach, they both said the Solar System.

4.2.1.1 Analysis of Findings from Interview with Integrated Science Teachers

It was interesting to note that with all the years of experience in teaching junior high school Science and the age difference between the two male teachers, the findings revealed that the major teaching method used by both Integrated Science teachers was

the lecture method, which confirmed what Okoye (2004) as cited in Agboghoroma (n.d) said that most Integrated Science teachers use predominantly one instructional strategy which is the lecture or "chalk and talk" for lessons. And contrary to what Ayodele and Adegbite (2003) as cited in Agboghoroma (n.d) expressed concerning the integration of different teaching approaches for the study of Integrated Science to ward off any possible causes of learners fearing Science subject in future.

According to the findings, the lecture method is easy and convenient, doesn't waste class time, and helps finish the syllabus on time. This inveterate the statement made by Reisman and Payne (1987) as cited in Mensah (2015) that lecture helps in the completion of subjects within a short period of time, and also by Brown et al. (1982) as cited in Mensah (2015) that it is cost-effective because no laboratory or apparatus is needed, and time is well managed.

Both teachers said they normally use chalkboard and textbook illustrations, even though ST1 adds the use of picture charts to enhance his teaching. This is expected of any Integrated Science teacher according to Okoye (2004) as cited in Agboghoroma (n.d) to supplement other methods to manage and control their classes for effective learning of Integrated Science.

The teachers also established that the lecture method makes lessons un-interactive, non-participatory, uninteresting, and less involving for pupils. This lends support to Reisman and Payne (1987) as cited in Mensah (2015) opinion that this method hardly permits teacher-learner communication, and opposes the concept of hands-on and active learning in Science. And also confirmed the assertion by Teo and Wong (2000) as cited in Ganyaupfu (2013) who postulates that the approach is more concerned with the area of study and rote learning than its practical application, which makes learners inactive and unengaged. Further findings also revealed some forms of distractions, loss

of focus and disinterest which are always accompanied by various behaviours which make both teachers resort to impromptu questioning, and random name calling as a means to keep pupils focused, active and interested during lessons.

Furthermore, both teachers said that Science is perceived by pupils as a difficult, complicated, boring and uninteresting subject and mentioned that Solar system is a difficult, abstract and technical topic to teach. This is deep-rooted in the statement that, students perceive scientific concepts as abstract and difficult (Reisman and Payne 1987 as cited in Mensah 2015). Therefore, the question that remains unanswered is, how can Science teachers with their experience make an abstract topic like the Solar System realistic, easy, interesting and participatory at the Junior High Schools.

4.2.2 Findings from Observations of the "Solar System" Lessons in School 'A'

At exactly 8:00am on Monday 24th October, 2016, the Science teacher (ST1) entered a class of 44 pupils which was made up of twenty three males and twenty one females, greeted and wrote the topic 'Solar System' on the board. He then asked several pupils their nuclear family size and their position in terms of number in the family. And further invited 5 volunteers to come up front, named them the 'Addo' family. He then asked one of them to go out of the class, and asked the class if the family is whole without the one outside. This was used to explain the Solar System as a portion of the whole universe. He asked pupils to show by hand if they have not seen the sun, moon or stars before. This was met with silence, so he continued by asking pupils to describe them since they have all seen them before. Pupils gave answers for sun as being big, yellow, bright, huge, and hot, you can't look at it. Answers by pupils for moon were that it was big, gives light in the night, round, has a drum in it, human being in it and moves around. And answers for Stars were that they are small, shines, sparkles, plenty and come in

different shapes and sizes. These responses were used to explain the components of the solar system. The teacher asked pupils to mention names of the planets since they learnt it in Primary Five, but no one could answer so he started mentioning names. However, out of the four names he mentioned, only one was able to name the planet earth, so the teacher wrote them on the board. The concept of the Solar System was introduced using a picture chart. After explaining their order from the sun and characteristics, pupils were made to repeat them, after which notes were given, followed by oral examination. The lesson ended at exactly 9:20am that day.

At the next scheduled date and time, the lesson began with 39 on roll; twenty three males and sixteen females. Class duration was forty minutes (one period) to make way for sports rehearsals. The teacher taught 'Stars' under Solar System. He began by asking pupils about the previous lesson. Besides a hand full of pupils who answered correctly when called, the rest were silent. Teacher taught without TLM, and kept repeating himself. Pupils were distracted with music from the playing ground, some mimed along and made dance moves when the teacher's back was turned. Others fidgeted and whispered with friends whilst lesson was on going. The general atmosphere that day was boredom. No notes nor assessment were given because time was up and teaching and learning session had to end.

After the sports and midterm break, observation continued on the Solar System lessons. Generally, class attendance was always full with only one or two absentees occasionally. The teacher was always on time and he uses the GES syllabus as a guide for teaching. The teacher reviewed previous lesson before he continued and the only medium of communication was the English Language. The teacher kept pupils focused throughout the lesson with a stern look, and shouted at them as a form of discipline. He mentioned them by name as a means of calling them to attention and repeat for

understanding. However, there was no active participation on the part of pupils during teaching, hence, pupils could not interact with the picture chart provided. There were always movement and fidgeting whenever the teacher wasn't looking and pupils continuously went out to the washroom or to drink water, which caused distractions. Plate 4.1a and b shows the existing method of teaching Solar System in School A.

Plate 4.1a: Teacher explaining Solar System with a picture chart

Plate 4.1b: Some unconcerned pupils during Solar System lesson

4.2.2.1 Analysis of Findings for Observations of Solar System Lessons in School A.

The teaching method used was lecture and demonstration with textbook, picture chart and whiteboard illustration. Endorsing the view of Okoye (2004) as cited in Agboghoroma (n.d) that Integrated Science teachers must employ teaching resources to complement their teaching methods for effective learning of Integrated Science.

Strengths: The view of Sharma 2015, which states that information is completed in a short period of time during lecture method was witnessed as lessons were always on and within time. Pupils were able to visualize the Solar System and its components from the picture chart presented, which confirmed Eryanto and Prestiliano (2017) view that pupils have to be able to visualize it in order to understand. Chalkboard illustration provided pupils with an idea of how the heavenly bodies move around the sun.

Weaknesses: The method did not allow for pupil-teacher or pupil-pupil interaction and critical thinking, which defeated the purpose of growing learners' positive capabilities in harmony with their interests, attitudes, skills, needs and intellect (Sharma 2015). This also lent support to the assertion that the lecture method hardly permits teacher-learner communication, and opposes the concept of hands-on and interactive learning of Solar System (Funderstanding (2011). Pupils were not also actively involved in the lesson since there was no hands-on activity. This reinforces Teo and Wong (2000) as cited in Ganyaupfu (2013) view that the teacher-centered approach is more concerned with the area of study and rote learning than its practical application, which makes learners inactive and unengaged. And further supports Anderson (2006) claim that interactive and hands-on strategies stimulate and entice pupils' interest in learning as it again defeats CRDD (2012) purpose for teachers to highlight hands-on teaching activities for Integrated Science. All these negative activities distracted most pupils from the teaching activates in the classroom as most of them were enjoying the music outside and some mimed along and made dance moves. Others fidgeted and whispered to friends when the teacher's back was turned. Lastly, the picture chart used for the lesson were not interactive, and this left pupils just stirring at them.

All of the above discussed weaknesses made the teaching and learning of Solar System boring, therefore teaching and learning could not be very effective.

4.2.3 Findings from Observation of the "Solar System" Lessons in School 'B'.

A class of 49 pupils made up of twenty five males and twenty four females, on the 25th October, 2016 at exactly 10:50 am, greeted their Science teacher and waited for the lesson to start. The teacher introduced the topic by asking pupils to name what they see when they look into the skies during the day and at night. Responses from pupils included: sun, moon, stars, satellite, rainbow, darkness, amongst others. The teacher based on these examples to explain the components of the Solar System. He related Solar System to their class, which is a part of the whole school. The concept of the planet in their order from the sun and their characteristics was introduced using an illustration on the white board (refer to Plate 4.2). The teacher also demonstrated the concept of rotation and revolution by going around his desk. Notes were given to pupils, followed by oral examination before the class was brought to an end for that day.

On the next scheduled date and time for observation, the teacher had to virtually teach the previous lesson again after realizing that most pupils could not answer questions correctly before moving on to the sub-topic for the day.

Subsequent lessons went through the same process with a consistent attendance of 49 pupils. The teacher came to class without a text book but had command over his teaching, and uses both the English Language and the Local language (Twi) for communication. He retained pupils focused and attention by constantly asking them questions by names to serve as a form of discipline. He repeated frequently for better understanding. The teacher gave notes after each lesson and asked pupils what they have learnt from the lesson. These questions were always met with silence until names were mentioned, then an attempt were made to respond.

Pupils had no text books to refer to and so depended only on the notes the teacher gave out. They were not actively involved in the lessons, they only listened and watched, and

therefore they turned to whispering to each other, fidget in their seats, dosing off, whereas others were writing other subject notes, draw or just playing with their pens, pencils and anything handy, besides constantly asking permission to go out.

Plate 4.2a and 4.2b shows the Solar System class session.

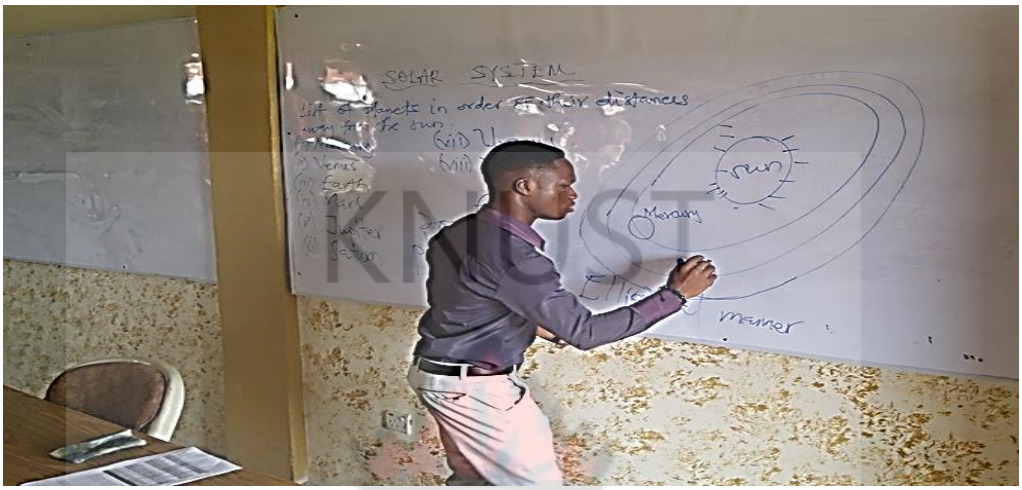

Plate 4.2a: Teacher using chalkboard to illustrate topic.

Plate 4.2b: Some Pupils dosing off and others doing other things.

At the end of the Solar System topic, pupils were given a 30 minutes class test (Pre-test) to assess their understanding of the lesson taught. Pretest questions can be found in (Appendix E).

4.2.3.1 Analysis of Findings for Observation of Solar System Lessons in School B.

As in the view of Sharma (2015), the presentation of ideas or concepts by the teacher while pupils pay attention and take down notes to regurgitate results is the lecture method and this was witnessed in school B, with chalkboard illustrations as teaching aid, which also validates the view of Ololube, Egbezor and Kpolovie (2008) as cited in Agboghoroma (n.d), that Integrated Science teachers must employ the usage of teaching resources to complement their teaching methods for effective learning of Integrated Science

Strengths : The characteristics of an effective teacher being one who professionally is always well prepared for class, on and within time during class, as Walker (2008) stated, was evident during lesson. English and 'Twi' languages were mixed intermittently during lessons and chalkboard illustration provided pupils with an idea of how the Solar System looks like. The teacher gave notes from his prepared lesson notes.

Weaknesses: The method did not allow for pupil-teacher interaction or critical thinking, because pupils were spoon-fed with information. This reinforces Sharma (2015) expression that the teacher does all the talking and the learner does all the listening. Which also confirmed why the teacher had to virtually teach the previous lesson again after realizing that pupils could not answer questions accurately. Echoing the constructivist believes that learning comes about when new information is built-into an existing one and learner is actively involved in the learning process (Tracey & Morro 2012). Digital Game-Based Learning has proven to have the ability to resolve the interaction and association between learners and tutors (Rosas et al.. 2003 as cited in Panoutsopoulos and Sampson 2012).

Furthermore, there was no use of textbook either by teacher or pupils and the TLM used which was chalkboard illustration was not interactive since pupils just looked at it,

making the lesson difficult to understand. As noted by Eryanto and Prestiliano (2017) that, lessons on Solar System greatly requires an appealing and interactive media to facilitate pupils' understanding better. And also confirms the assertion that instructional materials help learners to comprehend better because they see and have a feel of the materials themselves (Shankar 1980 as cited in Anini 2011). Additionally, pupils were not actively involved in the lesson, there was no practical activity. This defeated CRDD (2012) drive for teachers to highlight hands-on teaching activities for Integrated Science, and reinforced Knott (2015) view that even though scientific concepts can be recalled when taught via text books and lectures, it builds the practical understanding and independent learning capabilities of learners when done through hands-on activities. And supported Anderson (2006) claims that interactive and hands-on strategies stimulate and entice pupils' interest in learning.

Butt (2008) made a claim that effective teaching is not that which is static and automatic but lively, open and spontaneous. This was not the state of affairs in School B, since most of the pupils only listened and looked on, therefore fidgeted a lot. Supporting the claim by Reisman and Payne (1987) as cited in Mensah (2015) that lecture makes pupils bored during Science lessons as most pupils perceive scientific concepts as abstract and difficult.

4.2.4 Findings on Pre-Test Performance in Both Schools

Table 4.1 shows the frequency distributions of the pre-test results for both the Control and Experimental Group performance and Figure 4.1 shows the graphical representation of the total pre-test percentages in both schools on the effects of the existing methods of teaching and learning Solar System under Integrated Science.

Table 4.1: Pre-test scores in both schools.

Score %	Schools 'A'						Schools 'B'					
	Control		Experimental		**Total**		Control		Experimental		**Total**	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0-29	7	35	10	48	**17**	**42**	8	33	10	40	**18**	**37**
30-49	12	60	9	43	**21**	**51**	14	58	12	48	**26**	**53**
50-69	1	5	2	10	**3**	**7**	2	8	3	12	**5**	**10**
70-89	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
90-100	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
Total	**20**	**100**	**21**	**100**	**41**	**100**	**24**	**100**	**25**	**100**	**49**	**100**

Source: Fieldwork data (2017).

The mean score of pupils were (32.6 with a standard deviation of 8.51) in school 'A' Control Group and 33.76 to standard deviation of 9.61 for the Experimental Group. Whiles in school 'B', the Control Group had a mean score of 34. 5 and a standard deviation of 8.76 to an Experimental Group mean of 34.32 to 9.25 standard deviation.

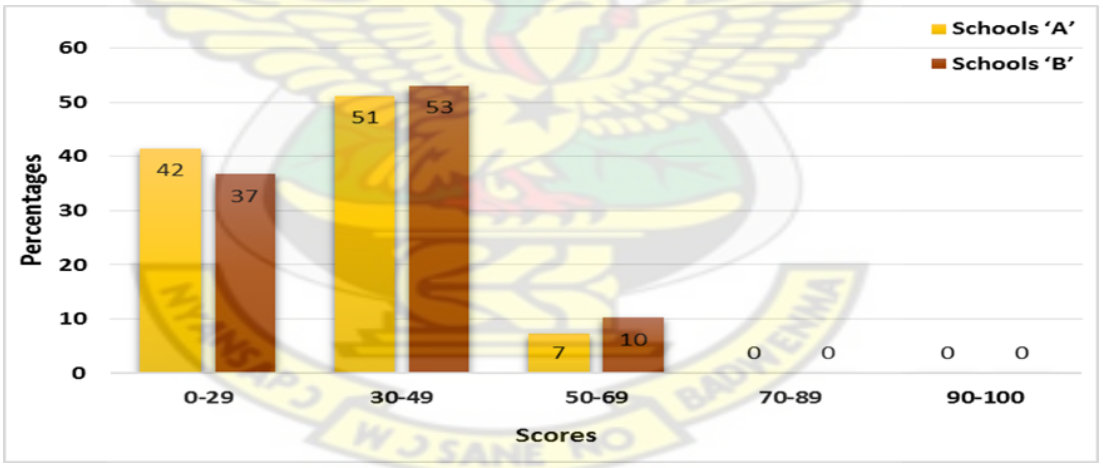

Figure 4.1: Total pre-test percentage score in both schools

4.2.4.1 Analysis of Pre-Test Performance of Pupils in Both Schools

As evident from Table 4.1, performance ranged from 0% to 69% in both schools and in both groups, showing an equal level of understanding of the topic between Control and Experimental Groups. Majority 38 (93%) out of 41 pupils and 44 (90%) out of 49 pupils had grades below 50% in both schools respectively, and the remaining few 3 (7%) and

5 (10%) within 50 and 69%. This implies that pre-test performance was below average in both schools, meaning that the disparities found in the qualification, age, and teaching experience of the Science teachers had no impact on pupils' performance, however, same could not be said as far as the effectiveness of the teaching method is concerned. Since the view that Science performance is enhanced when learners actively participate in the learning process (Ingmire 2015) was not the case, and buttresses Adunola (2011) as cited in Ganyaupfu (2013) that pupils' consistently poor performance in Integrated Science is linked to the use of unproductive instructional approaches.

4.3. Presentation and Analysis of Findings for Objective Two

4.3.1: Findings from Questionnaire Administered on Pupils' Knowledge and Skills in Digital Games and devices in Both Schools

Out of the 93 administered questionnaires, 44 in School 'A' and 49 in School 'B', 90 representing 96.77% of pupils responded and returned the copies. That is 41 and 49 were returned from Schools 'A' and 'B' respectively. Some demographic data included 50% (n=45) were males and 50% (n-45) were females Out of the 90 respondents, Eighty six representing 95.55% were 12-15 years whilst (n-4) making 4.44% were 16 years and above.

Findings revealed that out of the 90 respondents, (81%, n=73) that is n-33 or 37% from school 'A' and n-40 or 44% from 'B' said they like playing games, while none indicated contrary, the rest (19% or (n=17); n-8 or 9% from school 'A' and n-9 or 10% from 'B' said they play digital games sometimes.

Questions on how often pupils played digital games revealed that (n-28 or 31%) out of the 90 respondents play each day, (n -9 or 10%) from school 'A' and (n -19 or 21%)

from school 'B', played digital games. However, (n-41 or 46%) representing (n-20 or 22% and n-21 or 23%) from both Schools 'A' and 'B' respectively, don't play at all. whiles (n-21 or 23%) with (n-12 or 13%) from school 'A' and (n-9 or 10%) from school 'B' played sometimes.

On Weekends (26%, n-23) with (20%, n-18) from school 'A' and (6%, n-5) school 'B' played digital games, (46%, n-41) with (0%, n-0) school 'A' and (46%, n-41) from school 'B', don't. Whiles (29%, n-26): (26%, n-23) school 'A' and (3%, n-3) school 'B' play sometimes on weekends. Furthermore, 100%, n-41 and n-49 from both schools respectively, play digital games on vacations.

It also revealed that (n=59) signifying 66% of the 90 respondents liked to play Adventure Games, (n-12 or 13%) don't play it, and (n-19 or 21%) play it sometimes. (n-48) representing 53% of these same pupils indicated that they like to play Action Games too, (20%, n=18) don't like it and (27%, n=24) said sometimes. When it comes to Shooter Games, (n-57, 63%) play it, (n-7, 8%) don't and (n-26, 29%) does sometimes. For Puzzle Games, (n-44 or 49%) said yes, (n-37 or 41%) no, and (n-9 or 10%) sometimes. (n-28) representing 31% of the pupils in both schools said they like to play Sports Games, (n=41 or 46%) don't play it and (n=21 or 23%) play sometimes.

Table 4.2: Respondents' game preferences in the two schools.

Indicators	Yes		No		Sometimes	
	Schools		Schools		Schools	
	'A'	'B'	'A'	'B'	'A'	'B'
Adventure	25(28%)	34(38%)	3(3%)	9(10%)	13(14%)	6 (7%)
Action	27(30%)	21(23%)	3(3%)	15(17%)	11(12%)	13(14%)
Shooter	30(33%)	27(30%)	0(0%)	7(8%)	11(12%)	15(17%)
Puzzle	18(20%)	26(29%)	23(26%)	14(16%)	0(0%)	9(10%)
Sports	9(10%)	19(21%)	20(22%)	21(23%)	12(13%)	9(10%)

Source: Field Data, August (2017)

Findings into the devices pupils use for playing Digital Games revealed that out of the 90 respondents, 64% (n-58): (n-27, 66%) from school 'A' and (n-31, 63%) from school 'B' uses Computers, whiles 11% (n-10) with (15% or n-6) from school 'A' and (8% or n-4) School'B' don't use it, and 25% (n-22) with (19%, n-8) and (29%, n-14) from schools 'A' and 'B' respectively using computers sometimes. According to the respondents, 41% (n-37) of which (51 % n-21 and 33% n-16) were from both schools respectively also use Mobile devices. 39% (n-35), that is (20% n-8 and 55%, n-27) from both schools don't use it, and 20% (n=18); (29%, n-12 and 12%, n-6) does use it sometimes. All respondents 100%, 41 and 49 said they play games for fun, challenge and to win.

4.3.1.1 Analysis of Findings from Questionnaire Administered on Pupils' Knowledge and Skills in Digital Games and devices in Both Schools

- **Demographic data**

The respondents' demographic data revealed an overall balanced gender representation in the two schools, were males and females complimented each other to make it an unbiased gender depiction for the study, as presented in Table 4.3 and Figure 4.2.

Table 4.3: Frequency Distribution of Gender in Both School

Gender	**Schools 'A'**		**Schools 'B'**		**Total**	
	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Males	20	49	25	51	**45**	**50**
Females	21	51	24	49	**45**	**50**
Total	**41**	**100**	**49**	**100**	**90**	**100**

Source: Field Data, August (2017)

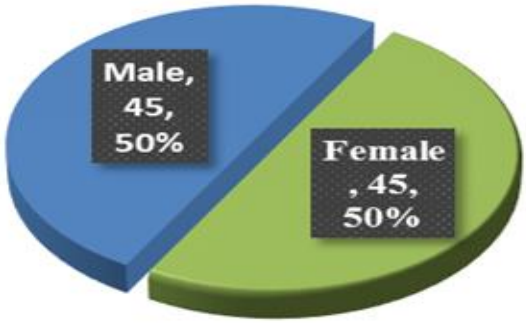

Figure 4.2: Total Representation of Gender of Pupils

It also revealed that respondents' age ranged from 12 to 16 years, with majority in both schools between 12-15 years, as shown in Table 4.4 and Figure 4.3: This confirms the view of Nuffic (2015) that JHS ends the obligatory school years of every child usually at the age of 15. And also places respondents' among the 97% of youngsters inclined towards the use of computer, handheld device, net, or console to play video games (Lenhart et al. 2008 as cited in Shearer 2011).

Table 4.4: Frequency distribution of pupils' age range

Ages	**Schools 'A'**		**Schools 'B'**		**Total**	
	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
12-15 years	40	98	46	94	86	96
16 and above.	1	2	3	6	4	4
Total	**41**	**100**	**49**	**100**	**90**	**100**

Source: Field Data, August (2017)

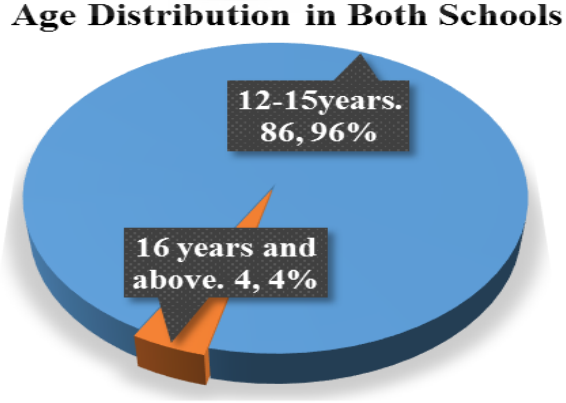

Figure 4.3: Frequency Distribution of Pupils Age Range.

- **Analysis of Response to Knowledge and Skills in Digital Games and Devices.**

The three-point Likert scale responses as shown in figure 4.4 revealed that all the respondents had played video games at some point before. Whiles majority (81%) like playing it, the few 19%, played it occasionally. This offers strong evidence that this is a group that engages with video games. It may be as a result of their backgrounds since the two study schools are considered as first class schools in Kumasi by GES standards. Hence, it can be said that most pupils have access to video games and devices.

Figure 4.4: Pupils' Response on Interest in Video Games

○ Pupils' response to how often they played video games as indicated in both schools in figures 4.5 and 4.6 showed that most pupils in School 'A' indulge in games on weekly basis than on daily basis, whiles their counterparts in School 'B' somehow played video games daily. However, they were all inclined to playing games during vacations.

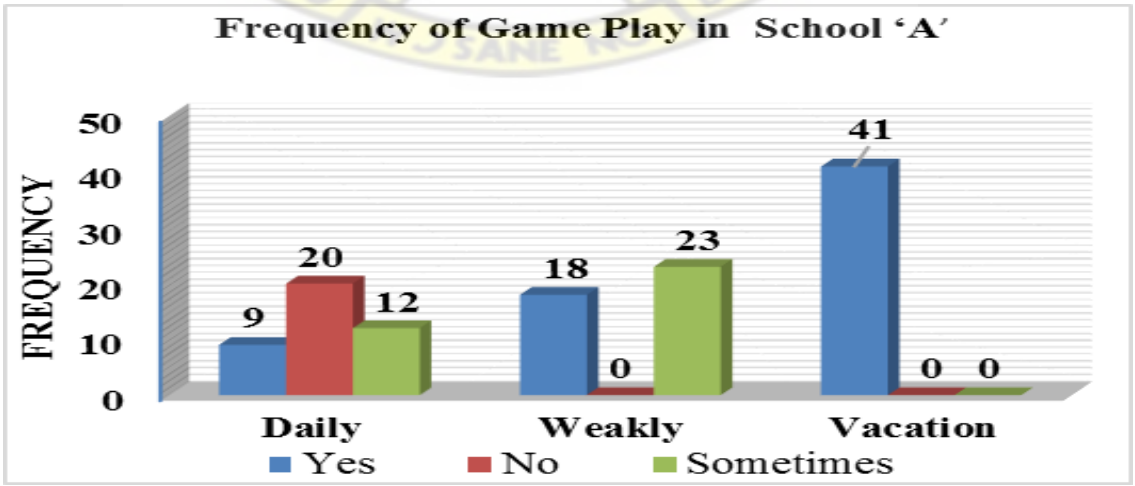

Fig. 4.5: Gameplay in School 'A'

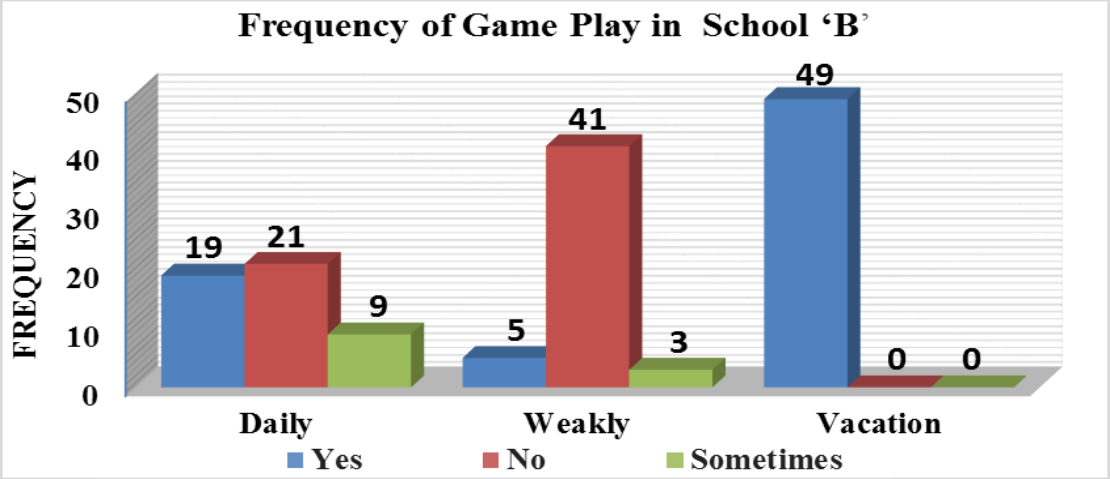

Fig. 4.6: Gameplay in School 'B'

This variations could be attributed to the fact that School 'A' is an all-day school and "B' is a day and boarding school. It can then be deduced from the above that the respondents with this experience have knowledge about games.

○ Findings also revealed that respondents preferred certain types of games as captured in Figures 4.7 and 4.8 for both schools. It is interesting to note that while the three most commonly favoured games were adventure, action and shooter in both schools, there was much move toward shooter games in School 'A' and adventure in School 'B'.

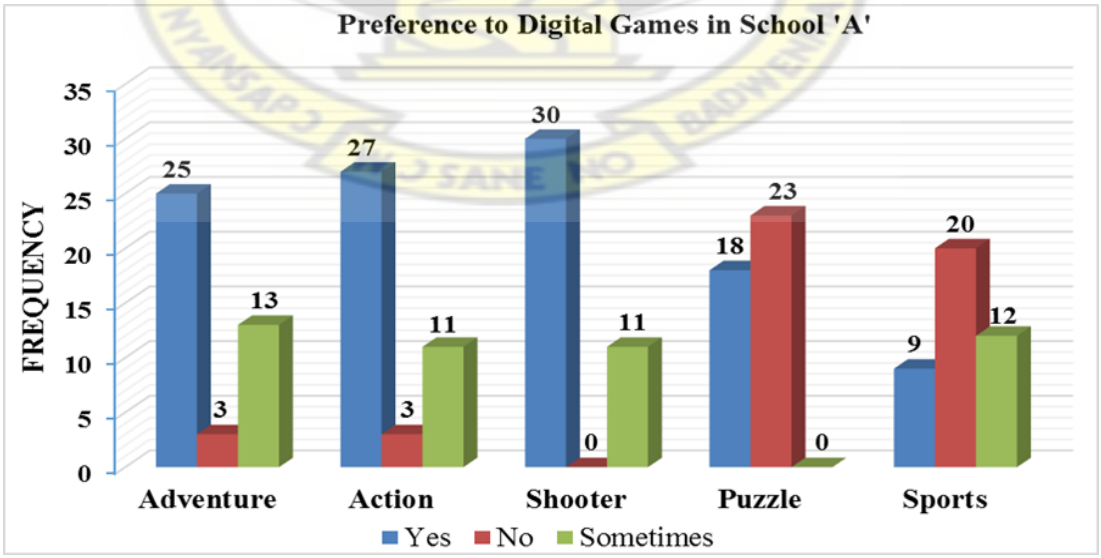

Figure 4.7: Preferred types of games by pupils in School 'A'.

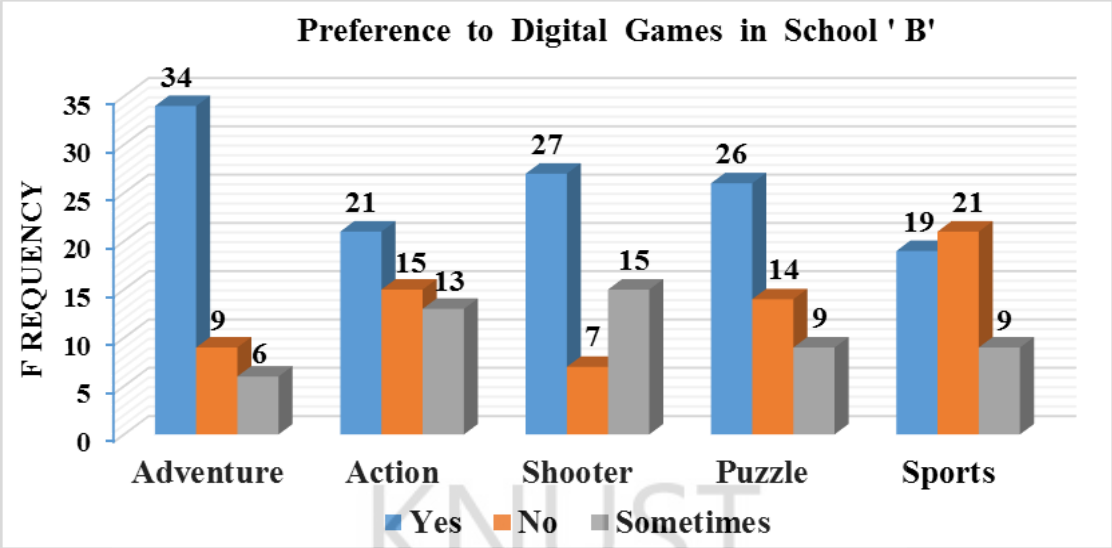

Figure 4.8: Preferred types of games by pupils in School 'B'.

There was also an inclination towards puzzle games in School 'B' and a great disinterest in puzzle games in School 'A'. Also worth noting is the general indifference to sports games, with majority in School 'A' not playing it. This means that respondents were inclined towards adventure, action and shooter games, therefore mixing these genres would be appropriate in satisfying the interest of the learners as confirmed by Sherriff (2014) who articulates that there is a lot more pleasurable to be derived in a game when different genres are combined.

○ Pupils' response to the medium they use to play games indicated that a greater portion of the respondents (89%) representing (n-80) in both schools, use computers in playing games. It is fascinating that quite a number 62% or (n-55) also use mobile devices. Figure 4.9 and 4.10 show the breakdown in both schools.

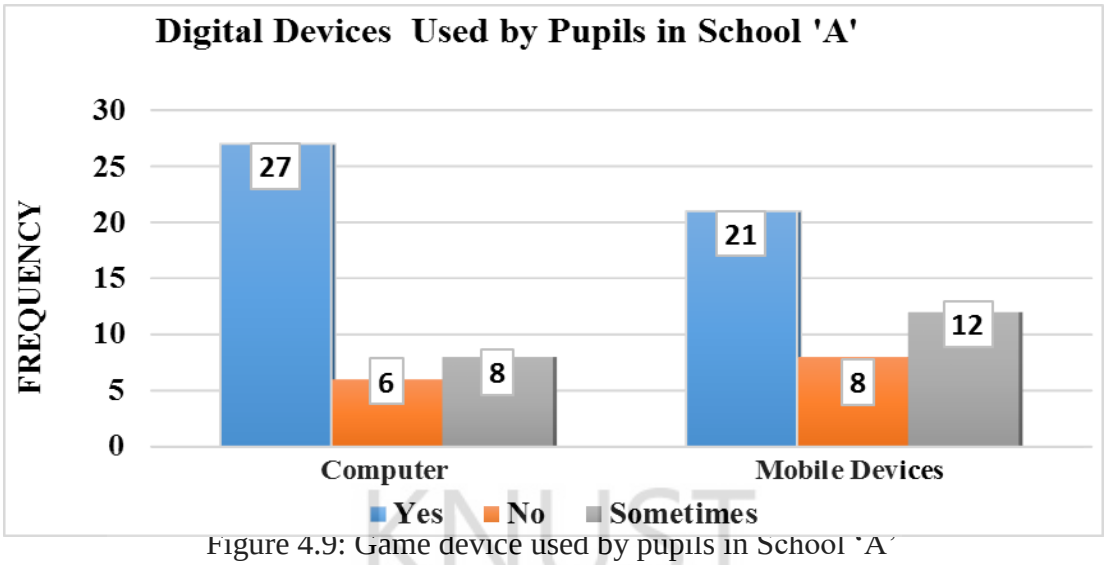

Figure 4.9: Game device used by pupils in School 'A'

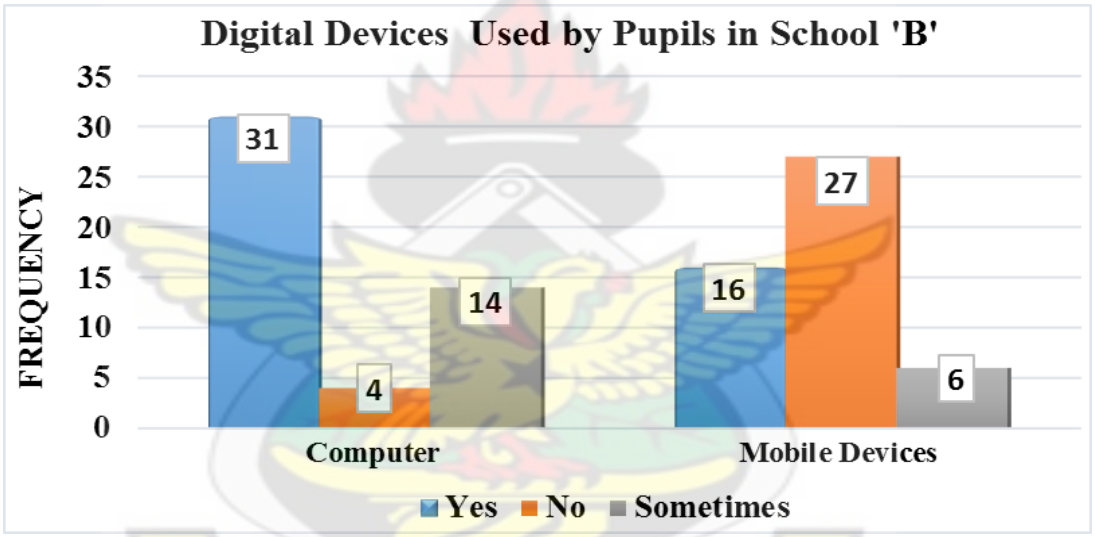

Figure 4.10: Game device used by pupils in School 'B'

This makes it an all device game plying respondents. It is worth stating that a larger number (n-27) of respondents in School 'B' make up those who are not keen on using mobile devices. Therefore, it was appropriate for the digital game to be designed for a computer platform, so as to benefit all respondents.

4.3.2 Findings from Observations on Digital Fun Games (Temple Run, Zuma and Shoot-em-up) played by pupils to determine their skills in Digital Games and Devices in Both Schools.

Pupils got excited just upon hearing that they will be playing games, and this was expressed by jumping and cheering. In School 'A' pupils were seated at the computer laboratory before the researcher entered. In School 'B' pupils beside the Form Three's selected for the study wanted to join. Pupils were made to boot the computers, copy the games from a pen drive onto the computers, delete it and log off by themselves. They were divided into three groups, each to a computer in both schools with each person performing one of these tasks.

The pupils gathered around each other wanting to see how the one playing is progressing, and giving directions as to what to do. Each group member took turns in playing and couldn't wait for the other to finish. They all played without instructions and advanced levels within few minutes. Leaving the computer laboratory was difficult since pupils where engrossed in the activity of plying the digital fun games. Attendance varied depending on the time parents picked their wards in School 'A' and the time pupils finished launch in School 'B'.

4.3.2.1 Analysis of Findings from Observation of Digital Fun Games in the Schools.

The opinion of Prensky (2001) that children are always impatient when it comes to playing games and can spend limitless hours at it was confirmed when pupils could not contain their enthusiasm and excitement to play and were seated in the computer laboratory before the researcher went in. This was also manifested in the way other pupil aside from the study sample wanted to join and enjoy playing the fun games with them. They eagerly awaited their turn, played without instruction and advanced levels within minutes.

The interactivity and games sole purpose of entertainment Kolko (2005) was also witnessed when the pupils gathered around each other wanting to see how the one playing is progressing, and giving directions as to what to do. This gave them the chance to further interact with other pupils in the other two groups. Leaving was difficult since pupils where engrossed. This endorsed Csikszentmihalyi as cited in Prensky (2001) flow experience that submerge players into a state of deep absorption during game play, due to the thrill and the immersive effects that they derive from it. Pupils booted and copied the games from a pen drive onto computer, and logged off by themselves after the digital fun game session. This implied that pupils were knowledgeable and skilled in games and devices.

4.3.3 Observations during Digital Solar System Game Intervention in the Schools.

- Pupils reported to the lab promptly after school and in the case of school 'B' forfeited lunch with excuses like, they don't like the food, are satisfied or will eat later. There was always rush for computers, not overlooking the disappointment and quick recovery when asked to sit in groups of twos and threes to make room for others.
- Pupils were exceptionally excited, couldn't contain or restrain themselves from laughing, talking, chattering, playfully hitting each other and competing for who to hold the mouse.
- Pupils always don't want to leave even after constantly reminding them its time unless the computers are shut down. Not to mention all group members scoring 10/10 for the quizzes within the second week, and the excitement when one attains a higher level, score, or completed the game over another. Hence, it encouraged healthy competition among pupils.

- Pupils had difficulties in overcoming the game challenge initially but after the second day only one or two questions were asked. Pupils had fun individually, within groups and outside their groups and learning occurred without their realization as was reflected in their post-test scores after the intervention.

4.4 Presentation and Analysis of Findings for Objective Three

4.4.1 Findings on the Evaluation of Post-test in Both Schools

Table 4.5 indicate a frequency distribution of the post-test performance of both Experimental and Control Groups, which was conducted after the game intervention and topic revision in both groups respectively.

Table 4.5: Frequency distribution of post-test learning performance of pupils.

Score %	**School 'A'**						**Schools 'B'**					
	Control		Experimental		**Total**		Control		Experimental		**Total**	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0-29	0	0	0	0	**0**	**0**	8	33	0	0	**8**	**16**
30-49	8	40	1	5	**9**	**22**	9	38	3	12	**12**	**25**
50-69	11	55	9	43	**20**	**49**	7	29	11	44	**18**	**37**
70-89	1	5	11	52	**12**	**29**	0	0	11	44	**11**	**22**
90-100	0	0	0	0	**0**	**0**	0	0	0	0	**0**	**0**
Total	**20**	**100**	**21**	**100**	**41**	**100**	**24**	**100**	**25**	**100**	**49**	**100**

Source: Fieldwork data (2017).

The mean score for School 'A' Control Group post-test was 46.6 with a standard deviation of 8.88, and their Experimental Group had 64.904 and SDV of 9.358, whereas in School 'B' the Control Group had 36.66 with 9.836 STDV and Experimental Group had 62.16 mean with 11.05 standard deviation.

4.4.1.1 Analysis of Findings on Evaluation of Post-Test in Both Schools.

The results showed a percentage score from 30 - 89 in School 'A' with (60% or n-12) out of 20 pupils in the Control Group scoring above 50%, whiles (95%, n-20) out of 21in the Experimental Group scored same. It is worth noting that whiles only (n-1, 5%) had between 70-89% in the Control Group, (n-11, 52%) had 70-89% in the Experimental Group. In School 'B' however, scores ranged from 0 - 89% with (29%, n-7) between 50-69% and no one scoring 70 upwards in the Control Group. With an Experimental Group score of (88%, n-22) above 50% out of which (44%, n-11) had between 70-89%. Admirably, in both Experimental Groups, no one had between 0-29% and only (n-1, 5%) and (n-3, 12%) scored 30-49% in both Schools.

Comparing the pre-test and post-test performance in both groups of the schools, it was realised that even though the Control Groups increased their performance in the post-test, the Experimental Groups upon using the Digital Solar System Game to supplement their teaching, performed exceptionally better in both school. Figure 4.11 and 4.12 shows the Pre-test-Post-test performance of the Control and Experimental Groups in the two schools.

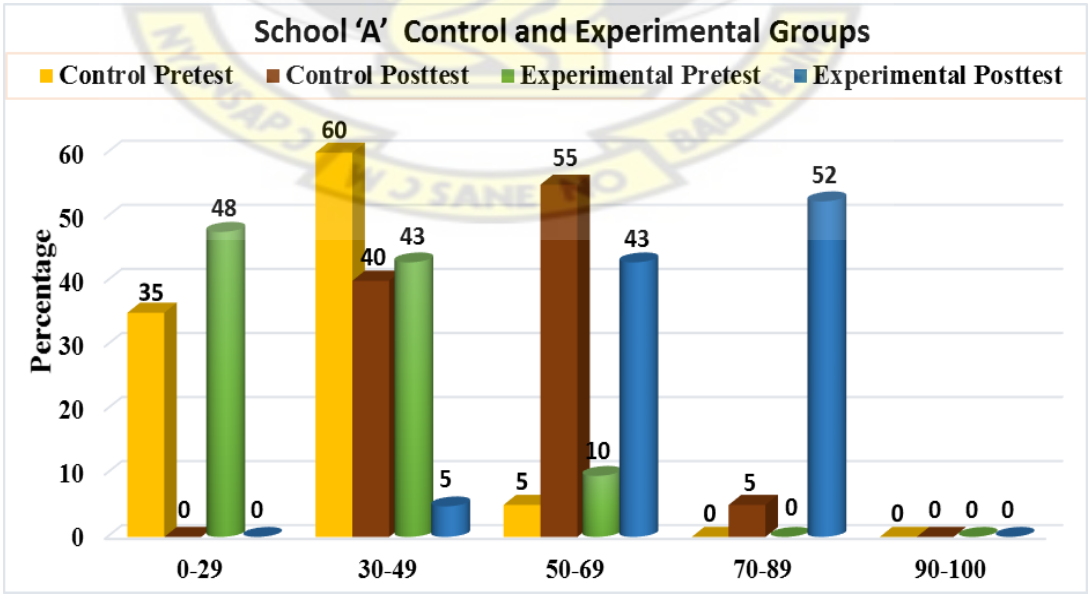

Figure 4.11 Control and Experimental Pretest-Posttest Performance in School 'A'.

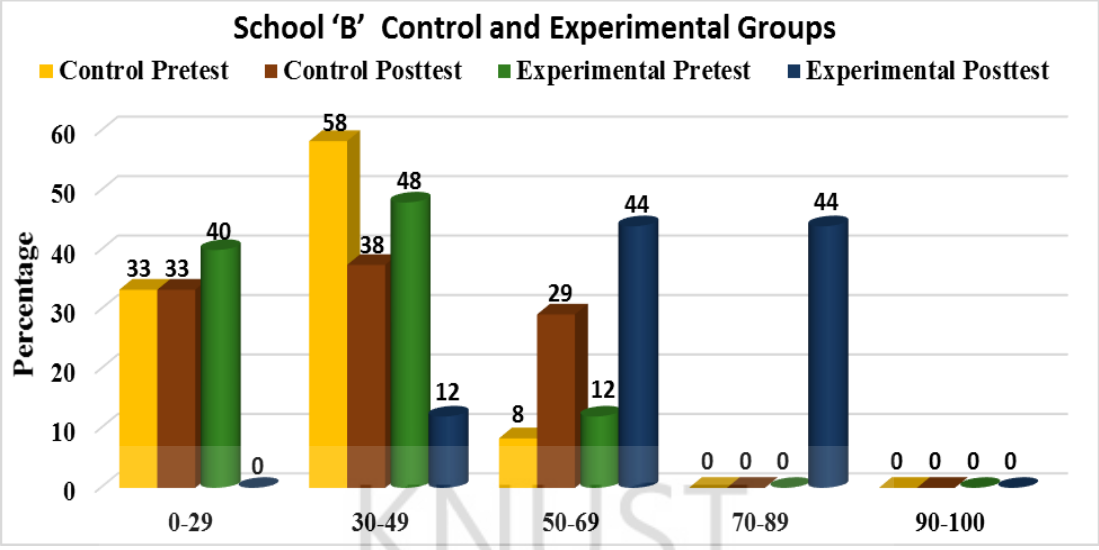

Figure 4.12 Control and Experimental Pretest-Posttest Performance in School 'B'.

This proved that the introduction of the Digital Solar System Game had a positive effect on pupils' leaning in the two schools.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter deals with the summary of the main findings, conclusions derived from the findings and recommendations for the study.

5.1 Summary of the Study

This research was aimed at investigating traditional methods adopted for teaching the difficult-to-teach topic Solar System under Integrated Science and their effects on pupils' learning and Digital Game-Based Learning (DGBL) as an intervention to adjunct the teaching and learning of the topic in two Junior High Schools in the Kumasi Metropolis. The objectives guiding the research were to document and analyze the existing methods of teaching Solar System and their effects on pupils' learning, identify and analyze pupils' knowledge and skills in Digital Games and Devices to produce a Digital Game to adjunct the teaching and learning of Solar System and evaluate its effectiveness on pupils' learning in two Junior High Schools in Kumasi. The mixed method research was used, adopting the descriptive and quasi-experimental design with observation, interview and questionnaire as research instruments.

- **Main Findings**

- The study established that lecture was the teaching method employed for Solar System under Integrated Science in both schools. It was found that this teacher-centered method did not allow pupil-teacher or pupil-pupil interaction, participation or hands-on activities, which made lessons uninteresting and boring, steadily reducing pupils' interest and eagerness to learn and making learners less critical thinkers.

- Likewise, it was found that, the instructional materials that aided the teaching of Solar System were chalkboard, textbook, and picture chart in School 'A' and only chalkboard in School 'B'. These were found to be un-interactive and inadequate to support the teaching and learning of Solar System, making the teaching and learning of concepts difficult.
- Moreover, it was realized that the negative attitude, behaviour and response to the lessons indicated that pupils were distracted, bored and lacked interest. This resulted in 95% and 90% of pupils in Schools 'A' and 'B' respectively to score below 50% during the pre-test. This implies that, there exist rote, chalkboard and textbook approaches to Solar System which were devoid of hands-on activities.
- It was also discovered that pupils liked to involve in hands-on activities like playing, especially adventure, action and shooting games at any convenient time, using both computers and mobile devices. That is, pupils played games for fun, to win and for competition. Again, they could boot and shut down a computer just like they can play games without help, hence, they had extensive knowledge and skills in playing digital games.
- Furthermore, it was revealed that the Produced Digital Solar System Game during implementation in both schools proved an appropriate and effective supplement for the teaching and learning of the topic because of the eagerness, excitement and involvement exhibited by pupils during the playing of the game which revealed pupils' interest and willingness to learn when they are involved. Further, post-test scores revealed an exceptionally better Experimental Group performance as compared to their Control Group counterpart. This means that

the interactive, participatory and hands-on nature of digital games can arouse and improve the learning of Solar System among junior high school pupils.

- Additionally, it was also revealed that the Digital Solar System Game was interesting and captivating, fun, challenging, and took away dullness.
- Last but not the least, the study exposed other challenges like teaching Science lessons in classrooms, lack of Science equipment, teachers' determination to complete syllabus. These prevented the use of learner-centered approaches.

5.2 Conclusions

Although the study was done in only two junior high schools, it can be concluded that: The teaching method employed for Solar System under Integrated Science in both schools which was the teacher-centered lecture method did not allow pupil-teacher or pupil-pupil interaction, participation or hands-on activities, and made lessons uninteresting and boring. Therefore, it reduced pupils' interest and eagerness to learn and produced less critical thinking learners.

The instructional materials that aided the teaching method, which were chalkboard, textbook and picture chart were un-interactive and inadequate to support the teaching and learning of Solar System and made the learning of concepts difficult.

The negative attitude, behaviour and response to the lessons were indications that pupils were distracted, bored and lacked interest, thus, resulting in majority scoring below 50% during the pre-test in both schools. It was however, concluded that the existence of rote, chalkboard and textbook approaches to Solar System do not encourage hands-on activities during teaching and learning sessions.

Moreover, it was concluded that pupils are extensively knowledgeable and skilled in digital games and devices because they like to involve in hands-on activities like playing, especially adventure, action and shooting games at any convenient time, for fun, to win and for competition, using both computers and mobile devices; as well as have the ability to boot and shut down a computer just like they can play games without external help. Therefore, actively involving pupils in the Solar System lesson through digital games will boost learning since they will have fun whiles learning.

To add to this, the Digital Solar System Game is an appropriate and effective supplementary tool for the teaching and learning of the topic since it increased pupils' eagerness, excitement and involvement during testing; and improved the Experimental Groups post-test performance as compared to their Control Group counterpart after evaluation, through its interactive, participatory and hands-on nature.

The Digital Solar System Game was interesting, captivating, fun, challenging, and took away dullness when employed for teaching and learning of Solar System.

Last but not the least, the choice of teaching method is essential in creating a thriving teaching and learning experience, other challenges like teaching Science lessons in classroom, lack of Science equipment, teachers' determination to complete syllabus prevent learner-centered approaches from being used.

5.3 Recommendations

The following recommendations will help resolve and improve pupils' interest and learning of Solar System under Integrated Science education in Ghanaian schools:

- Integrated Science teachers should shift towards learner centered strategies and engage creative ways of livening up their teaching with various dynamics to make their lessons interactive, enjoyable, interesting and understandable.
- Management of JHS should collaborate with sister schools for their Science teachers to exchange effective teaching ideas on topics and current trends in education to implement for learning to be achieved.
- Integrated Science teachers should supplement their teaching with interactive instructional materials to enforce active involvement of pupils, remove boredom and improve the interest and understanding of concept.
- The Ministry of Education (MOE), Ghana Education Service (GES), and School heads should provide interactive instructional materials and design systems of monitoring and supervising Integrated Science teachers to ensure the use of appropriate strategies and instructional materials to improve learning quality.
- Teachers should identify pupils' knowledge and skills in digital games, to be well informed on their game preferences to select or develop games to ensure active engagement and excitement during learning.
- GES and School Heads should prioritize digital games over textbooks, teacher guides and writing boards since pupils are interested in games and learning will occur without their realization.
- Ghana Education Service (GES) should adopt Digital Game-Based Learning as an adjunct to Solar System and other difficult-to-teach topics under Integrated Science to enhance pupils' interest and performance, and cultivate active,

interactive and self-learning critical thinkers and problem solvers for national development.

- The Government, through the Ghana Education Service (GES) and policy makers should formulate policies to allocate funds in support of developing digital games to adjunct difficult-to-teach Integrated Science topics and provide adequate resources and infrastructure to support its integration in schools, as well as organize workshops to insight teachers and training programmes to help in its implementation.
- Curriculum developers in collaboration with instructional designers and game developers should be employed to produce digital games to be used by teachers as supplementary tools for difficult-to-teach Integrated Science topics.
- GES and head teachers should ensure that when using digital games in Integrated Science education, teachers should have mastery of the topic they teach so as to enable them use the games to suit the content of each topic.

Suggestions for further studies:

- Further research could be conducted on digital games for other subjects such as English, Mathematics and other Integrated Science topics. It can also focus on motivation, engagement and interest, at different levels in education and on larger samples. Or on the effectiveness of Commercial-off-the-shelf games among primary, JHS or SHS education sector. Last but not the least, on teacher perception of the use of digital games in education.

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APPENDICES
Appendix A

Interview Guide for JHS Science Teachers on Production of Digital Game for Teaching Solar System under Integrated Science and its Effects on Learning in Two Junior High Schools in Kumasi.

Any information provided shall be used sorely for academic purposes and you are assured of confidentiality.

SECTION A: INFORMATION ON THE SCHOOL

Name of School: ……

Location of School: ……

Category of School: (a) Government [ ] (b) Private [ ]

SECTION B: TEACHER'S BACKGROUND INFORMATION

i. Gender: (a) Male [ ] (b) Female [ ]

ii. Age: (a) Below 30 [ ] (b) Between 30 and 39 [ ]
(c) Between 40 and 49 [ ] (d) 50 and above [ ]

iii. Qualification: (a) Higher National Diploma (HND) [ ]
(b) Bachelor Degree [ ] (c) Post-Graduate Degree [ ] (d) If others, please specify. ….....

iv. Years of teaching: (a) Between 1 and 5 [ ] (b) Between 6 and 10 [ ]
(c) Between 11 and 15 [ ] (d) 16years and above [ ]

v. Years of teaching in Junior High School**:** (a) Between 1 and 5years [ ]
(b) Between 6 and 10years [ ] c) Between 11 and 15years [ ] (d) 16 and above [ ]

SECTION C: TEACHING AND LEARNING

1. What does the Integrated Science subject entail and how should it be taught?
2. How do you perceive the Solar System topic under Integrated Science, and why?
3. How do you teach the Solar System topic? (Method(s), why that preference.
4. How do you sustain the interest and attention of pupils with your teaching method(s)?
5. How do pupils respond to the teaching of the topic with this/these methods?

6. . Does this method encourage active participation in class? Explain
7. What instructional materials help you deliver the Solar System topic?
8. How effective re these instructional materials?
9. How do pupils perceive Integrated Science in general and Solar System in particular?
10. What are the difficult-to-teach topics under Integrated Science, and why are they considered difficult?
11. How do you teach these difficult topics for pupils to understand?
12. How do you assess the Solar System topic?

SECTION D: GAME / DIGITAL BASED-LEARNING

1. What are some of the digital resources that you are familiar with use in teaching?

2.What knowledge do you have on Game Based / and Digital Game Based Learning?

3.How have you ever used this strategy before and how did it impact pupils learning? Or why haven't you used this strategy before?

4. What is your perception on the use of DGBL in the teaching and learning of Science?

5. What DGBL activities is your school engage and benefit from?

Thank You

Appendix B

Interview Guide for Head Teachers on Production of Digital Game for Teaching Solar System under Integrated Science and its Effects on Pupils' Learning in Junior High Schools in Kumasi**.**

Any information provided shall be used sorely for academic purposes and you are assured of confidentiality.

SECTION A: INFORMATION ON THE SCHOOL

Name of School: ……..……..…

Location of School: ……..…

Category of School: (a) Government [ ] (b) Private [ ]

SECTION B: HEAD TEACHER'S BACKGROUND INFORMATION

i. Gender: (a) Male [ ] (b) Female [ ]

ii. Age: (a) 35 and 44 [ ] (b) 45 and 54 [ ] (c) 55 and above [ ]

iii. Qualification (a) Higher National Diploma (HND) [ ] (b) Bachelor Degree [ ] (c) Post-Graduate Degree [ ] (d) If others, please specify. .....

iv. How long have you been a head teacher? .....

v. Do you still teach aside your duties as head? (a) Yes (b) No

SECTION C: OVERVIEW OF SCHOOL

1. Brief history of school.
2. Digital resources available in the school.
3. Pupils' access to resources and phones usage on school premises.
4. Dominant economic background(s) of pupils.

SECTION D: QUESTIONS

1. How do you recruit science teachers and what qualifications do you require?
2. What is the schools procedure for supervising its science teachers, and whose responsibility is it?
3. How important is instructional materials to the school when it comes to integrated science topics?

4. What provision is done by the school when it comes to instructional materials?
5. Have you received complaints from teachers that pupils are disinterested in some topics or approach? Please explain
6. Specifically, what does administration do to improve Solar System education in the school?
7. What do you know about Game Based Learning or Digital game based learning?
8. How beneficial are they in education?
9. What are the game-based learning activities employed in your school? How beneficial has it been to learning?
10. What is your perception on the use of DGBL as an adjunct to the teaching and learning of Science?
11. What impediments do you foresee in the way of its implementation?

Thank you.

Appendix C

Questionnaire for Pupils on: Production of Digital Game for Teaching Solar System under Integrated Science and its Effects on Pupils' Learning in Junior High Schools in Kumasi.

School Information

Name of School: …….....…

Location of School: …….....……...

Please Tick [√] the correct answer

SECTION A: Demographic Characteristics

1. Gender: a) Male [ ] b) Female [ ]
2. Age: a) Less than 12 [ ] b) between 12 – 15 [ ] c) 16years and above [ ]
3. Class: a) JHS 2A [ ] b) JHS 2B [ ] c) JHS 2C [ ] d) JHS 2D [ ]
4. Are you a border or a day student? (a) Border [ ] (b) Day [ ]

Indicate: [√]

"0" – Yes "1"- No "2"- Sometimes

	SECTION B: Knowledge in Digital Games and Devices			
	Interest	0	1	2
1.	Do you like playing video games?			
	Frequency			
2.	I play games each day			
3.	I play games week ends			
4.	I play games on vacation			
	Types			
5.	I play adventure games most often			
6.	I play action games most often			
7.	I play Shooter games most often			
8.	I play puzzle games most often			
9.	I play sports games most often			

	Reason			
10.	I play for fun			
11.	I play to win			
12.	I play because of the challenge			
	Device use			
13.	I use computer in playing games			
14	I use mobile devices (smart phone, Tablet / Ipad etc) in playing games			

Absolute confidentiality is assured.

Thank You.

Appendix D

Observation Checklist for Production of Digital Game for Teaching Solar System under Integrated Science and its Effects on Pupils' Learning in Junior High Schools in Kumasi.

Name of School: ……

Location of School: ……..…….……..

Class: ..... No. On roll: .....Date: …..... Lesson Duration: .....

Qualities of a Good Teaching

- Teachers ensure understanding of concepts?
- Teachers are skilled in using available resourceful?
- Teachers are always creative?
- Teachers assist pupils when teaching?
- Teachers boost pupils' interest in the subject?

Teaching Strategies Adopted	**Yes**	**No**
1. Different methods of teaching were combined during Lesson.		
2. Science teacher employed one method for the whole lesson.		
3. Teaching methods were suitable for the topic.		
4. Solar System was taught using hands-on activity.		
5. Teaching methods employed were learner-centred.		
6. Solar System was taught using L1 and L2.		
7. Do pupils have interest in lesson?		
8. Are pupils encouraged and motivated to learn?		
9. Are pupils eager for the Lesson?		
10. Do pupils pay attention during the Lesson?		
11. Do pupils understand topics taught with teacher's method?		
12. Do pupils answer correctly questions posed in class?		

Teaching and Learning

13. Objectives of the topic. .....…….
14. Teaching method(s) used by the teacher.....…….....
15. Instructional materials used ……..
16. Pupils' interactivity during lessons.....
17. Pupils' response to questions.....……....
18. Pupils' behaviour during lesson.....
19. Forms of assessment given.....
20. Pupils' attitude during evaluation.....

Pupils' Knowledge and Skills in Digital Games

1. Where pupils able to play the fun games given to them?
2. How involved and interested where pupils in playing the fun games?
3. What was their interactivity level?
4. How did they participate in the fun games?
5. Which type of the fun games where pupils most interested in?
6. What were pupils' reaction to fun game?

Pupils' Response to DGBL Intervention in Science

7. Are pupils interested in lessons?
8. Are pupils encouraged to learn Science?
9. Do pupils exhibit enthusiasm for Science?
10. Do pupils' actively participate in the fun games?
11. Do pupils demonstrate understanding of DGBL during play?
12. How do pupils perform after using the intervention?

Thank You.

Appendix E
SOLAR SYSTEM PRE-POST TEST

Name…… Class…….…… Date: ……..……

SECTION A (***Tick the right*** answer***)*** **(10min) (40 marks)**

1.	Which of the following bodies is closest to the sun?	Comet ○ Mars ○ Mercury ○ Moon ○
2.	Which of the following is the odd one?	Uranus ○ Comets ○ Venus ○ Earth ○
3.	The following planets are terrestrial planets except?	Mercury ○ Pluto ○ Earth ○ Mars ○ Venus ○
4.	Which of the following planet is the coldest?	Meteors ○ Mercury ○ Neptune ○ Saturn ○
5.	Which of the following heavenly body is a star?	Sun ○ Venus ○ Asteroids ○ Earth ○
6.	What is the name of the force that holds the planets and satellites in their obit?	○ Centripetal force ○ Electromagnetic force ○ Electrostatic force
7.	Which planet is the hottest?	Mercury ○ Earth ○ Venus ○ Mars ○
8.	Which of the following statements about a star is **NOT** true?	○ They are made up of gasses. ○ They are like planets ○ They come in various colors
9.	Which heavenly body can be found between Mars and Jupiter?	Asteroids ○ Comet ○ Dwarf planet ○ Star ○
10.	The complete movement of a planet around the sun is?	Orbit ○ Rotation ○ Elliptical ○ Revolution ○
11.	Which of the following bodies is closest to earth?	Meteors ○ Mercury ○ Sun ○ Moon ○
12.	Which of the following is **NOT** a satellite?	Explorer ○ Sun ○ Moon ○ Sputnik ○
13.	All these bodies **do not** produce light **except**?	Sun ○ Moon ○ Planet ○ Satellite ○
14.	How long does it take the earth to rotate on its axis?	$365^{1/4}$ days ○ 32hrs ○ 366 days ○ 24hrs ○
15.	Where is the sun located in the solar system?	Beside ○ Edge ○ Center ○ Side ○
16.	The earth and moon is made up of?	Plastic ○ Layers ○ Metals ○ Gasses ○
17.	In which year was the satellite Explorer launched?	1956 ○ 1957 ○ 1958 ○ 1959 ○

18.	A ball of dust and frozen gases moving round the sun in stretch-out path is?	Planet ○ Comet ○ Dwarf planet ○ Star ○
19.	The first artificial satellite was sent into space by?	America ○ China ○ Russia ○ Ghana ○
20.	Scientist who study the universe and other heavenly bodies are?	Meteorologist ○ Astronaut ○ Geologist ○

SECTION B

(Answer all questions) **(20 Min) (60 marks)**

1. a) List the **INNER** planets in order **TO** the sun and the **OUTER** planets in order **FROM** the sun.

Inner planet i. …….. ii. …….. iii. …….. iv. …….
Outer planets i. …… ii. …….. iii. …….. iv. …….

b) **Name** three **other heavenly bodies** in the solar system **aside** from the Sun and the 8 planets and **define** them.
1. ……
2. ……
3. ……

(15 marks)

2 a) What is a satellite? ……...
……

b) State three uses of a satellite. (i) ……..……..
(ii) …….. (iii)…….……

c) How many moons/satellites does the following planet have? Give one example of each. (i) Jupiter …..... (ii) Uranus …… (iii) Saturn……..

(20 marks)

3 a) List four differences between a star and a Planet.
(i)…….. (ii)……...……..
(iii)…… (iv)……..……....

b) Match the following planets to their correct characteristics:

a) Series of rings around it	Jupiter
b) Red Planet	Venus
c) Blue Planet	Mars
d) Highest moons	Earth
e) Morning Star	Saturn

(25 marks)

THANK YOU.

Appendix F
Game Design Document

SAVESPACE

Game Overview
Digital Solar System game → 3D Action-adventure, single-player, shooter, computer game

Storyline
You have been chosen by the GSSTC to end a well-orchestrated alien invasion, destruction and takeover of our universe. It is a deadly mission but you will be equipped with the best spaceship and weapons to defeat them and be recognition worldwide.

Game interaction model: Avatar-based spaceship
Game Mechanic (player's responsibility**)** **Core Mechanic:** Shooting

Level one: Alien spaceship at Uranus is depositing vicious asteroids between earth and Jupiter. **Goal:** **Destroy Alien Ship** **Mission:** Clear stray asteroid/ locate Alien Ship.	
Rules:	• Locate Earth & Jupiter's orbit •Blow-up any stray asteroids • Find Uranus •Avoid touchdown on or collision with planets •Avoid losing health or being killed.
Level two: Aliens have created an invisible wall with fiery gate to hide their base from humans. **Goal:** **Destroy the wall with fiery gate** ***Mission:*** Locate Titan moon on Saturn.	
Rules:	• Dodge enemy missiles •Shoot anything that shoots you • Avoid landing on, or colliding with planets • locate and refill health.
Level three: Aliens have stationed ships around their base to defend it from humans. **Goal:** **Destroy Alien base** ***Mission:*** Kill all defending alien ships surrounding it.	
Rules:	• Locate the base • shoot ships faster to prevent them from scattering •Avoid being shot at, losing health or coming into contact with the planets.

Music: • During Quiz-low • Player selection – medium • Gameplay – battlefield
Sounds: • Correct quiz answer- cheery • wrong answer – distress • Win quiz – joyous •Loose– sorrowful • Shoot-weapon sound

Art work

Game Interface: •Colours (Bright) •Typeface (Legible) • Appearance (clear, pleasing, usable)

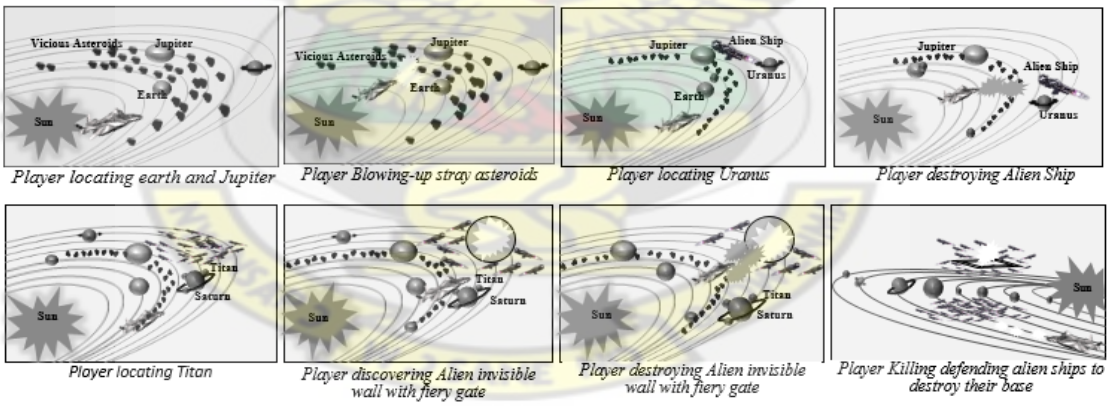
Title screen:
• Game name, •Slogan, •Images

Level screens:
• Automatic voice over • Goals, missions, rules, game scenery

Quiz screens:
• 5 questions •30 seconds •high score

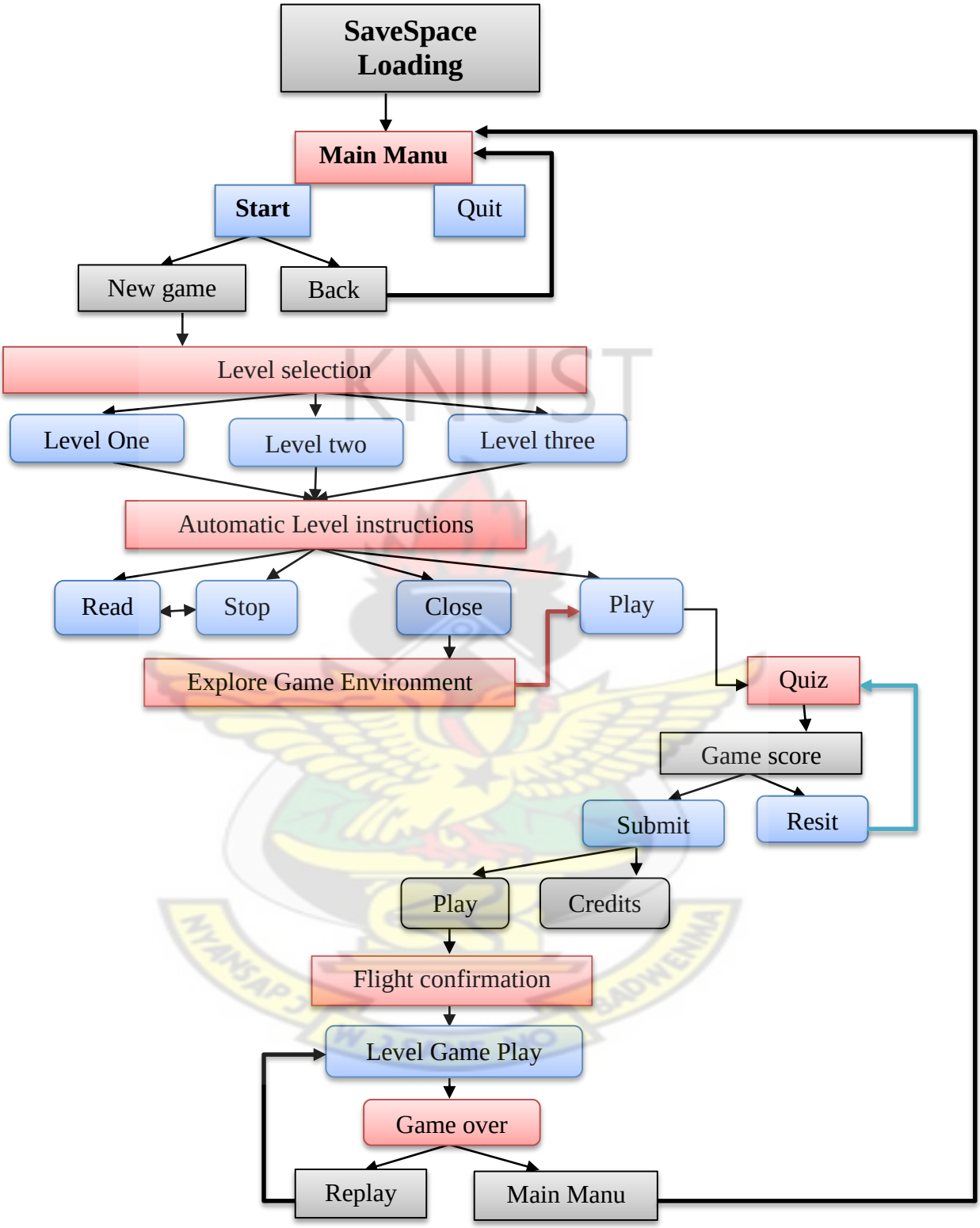
Game logo design samples – Corel Draw, Adobe Photoshop, and word.

Game level Illustrations



Game Characters: (alien mothership, alien ship, player ship)

Game Flow Chart



Technical description:	Platform- PC • Engine – Unity 3D •Programming language – C#
Demographics:	Age – 12-16 • Sex – male/female •Players – JHS 3 Pupils