21^{ST} CENTURY INNOVATION IN MATHEMATICS PEDAGOGY: ALGEBRA IN FOCUS

BY

NNEJI SAMUEL ONYINYECHI

DEPARTMENT OF SCIENCE AND COMPUTER EDUCATION

FACULTY OF EDUCATION,
ENUGU STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY (ESUT),
ENUGU, ENUGU STATE.

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CHAPTER ONE

COMPUTER-AIDED INSTRUCTION (CAI)

According to Ngoma (2013), Computer Aided Instruction (CAI) is the general term used to describe virtually any learning activity that is promoted by computer or in which a computer is involved. It is sometimes referred to as computer assisted instruction. According to Bell and Thompson (2012) a computer mode simply refers to a teaching strategy involving the use of a computer application. Bell and Thompson (2012) described three modes of computer Aided Instruction (CAI) under the following headings; computer-based learning, computer - based training and computer-supported collaborative learning. Computer Based Learning (CBL) refers to the use of computers as a key component of the educational environment while this can refer to the use of computers in a classroom, the term more broadly refers to a structured environment in which computers are used for teaching purposes. Belland Thompson explained that computer-based trainings (CBTs) are self-paced learning activities accessible via a computer or handheld device. CBTs typically present content in a linear fashion, much like reading an online book or manual. For this reason, they are often used to teach static processes, such as using software or completing mathematical equations. The term Computer-Based Training is often used interchangeably with Web-based training (WBT) with the primary difference being the delivery method. Where CBTs are typically delivered via CD-ROM, WBTs are delivered via the Internet using a web browser. Assessing learning in a CBT usually comes in form of multiple-choice questions, or other assessments that can be easily scored by a computer such as drag-and-drop, radio button, simulation or other interactive means. Assessments are easily scored and recorded via online software, providing immediate end-user feedback and completion status. Users are often able to print completion records in the form of certificates.

CBTs provide learning stimulus beyond traditional learning methodology from textbook, manual, or classroom-based instruction. For example, CBTs offer user-friendly solutions for satisfying continuing education requirements. Instead of limiting students to attending courses or reading printed manuals, students are able to acquire knowledge and skills through methods that are much more conducive to individual learning preferences. (Ohanusi, 2011). Tenty and Awe (2011) further reported that CBTs offer visual learning benefits through animation or video, not typically offered by any other means. CBTs can be a good alternative to printed learning materials since rich media, including videos or animations, can easily be embedded to enhance the learning. Another advantage to CBTs is that they can be easily distributed to a wide audience at a relatively low cost once the initial development is completed.

However, CBTs pose some learning challenges as well. Typically, the creation of effective CBTs requires enormous resources. The software for developing CBTs (such as Flash or Adobe Director) is often more complex than a subject matter expert or teacher is able to use. In addition, the lack of human interaction can limit both the type of content that can be presented as well as the type of assessment that can be performed. Many learning organizations are beginning to use smaller CBT/WBT activities as part of a broader online learning program which may include online discussion or other interactive elements.

Bell and Thompson (2012) described Computer-supported collaborative learning (CSCL) as one of the most promising innovations to improve teaching and learning with the help of modern information and communication technology. Most recent developments in CSCL have been called E-learning 2.0, but the concept of collaborative or group learning whereby instructional methods are designed to encourage or require students to work together on learning tasks has existed much longer. It is widely agreed to distinguish collaborative learning from the traditional ‘direct transfer’ model in which the instructor is assumed to be the distributor of knowledge and skills, which is often given the neologism E-Learning 1.0, even though this direct transfer method most accurately reflects Computer-Based Learning systems (CBL). Blogs, wikis, and Google Docs are commonly used CSCL mediums within the teaching community. The ability to share information in an environment that is becoming easier for the lay person, has caused a major increase of use in the average classroom. One of the main reasons for its usage states that it is “a breeding ground for creative and engaging educational endeavors”, (Lask, 2011). Using web 2.0 social tools in the classroom allows for students and teachers to work collaboratively, discuss ideas, and promote information. According to El-Amin and Husseini (2012), blogs, wikis, and social networking skills are found to be significantly useful in the classroom. After initial instruction on using the tools, students also reported an increase in knowledge and comfort level for using web 2.0 tools. The collaborative tools additionally prepare students with technology skills necessary in today’s workforce. Locus of Control remains an important consideration in successful engagement of E-learners. According to Ngoma, (2013) the continuing attention to aspects of motivation and success in regard to E-learning should be kept in context and concert with other educational efforts. Information about motivational tendencies can help educators, psychologists, and technologists develop insights to help students perform better academically. The virtual classroom also provides the opportunity for students to receive direct instruction from a qualified teacher in an interactive environment. Students have direct and immediate access to their instructor for instant feedback and direction. Lask (2011) added that the virtual classroom also provides a structured schedule of classes, which can be helpful for students who may find the freedom of asynchronous learning to be overwhelming. The virtual classroom also provides a social learning environment that closely replicates the traditional “brick and mortar” classroom. Most virtual classroom applications provide a recording feature. Each class is recorded and stored on a server, which allows for instant playback of any class over the course of the school year. This can be extremely useful for students to review material and concepts for an upcoming examination. This also provides students with the opportunity to watch any class that they may have missed, so that they never have to fall behind. It also gives parents the ability to monitor any classroom to insure that they are satisfied with the education their child is receiving.

According to Tenty and Awe (2011). In asynchronous online courses, students proceed at their own pace. If they need to listen to a lecture a second time, or think about a question for a while, they may do so without fearing that they will hold back the rest of the class. Through online courses, students can earn their diplomas more quickly, or repeat failed courses without the embarrassment of being in a class with younger students. Students also have access to an incredible variety of enrichment courses in online learning, and can participate in college courses, internships, sports, or work and still graduate with their class. In many models, the writing community and the communication channels relate with the E-learning and the M-learning communities. Both the communities provide a general overview of the basic learning models and the activities required for the participants to join the leaning sessions across the virtual classroom or even across standard classrooms enabled by technology. Many activities, essential for the learners in these environments, require frequent chat sessions in the form of virtual classrooms and/or blog meetings.

Mbunda (2012) described two other modes of CAI as Learning Management System (LMS) and Learning Content Management System (LCMS). A learning management system (LMS) is a software used for delivering, tracking and managing training/education. LMSs range from systems for managing training/education records to software for distributing courses over the Internet and offering features for online collaboration. A learning content management system (LCMs) is software for author content (courses, reusable content objects). An LCMs may be solely dedicated to producing and publishing content that is hosted on an LMS, or it can host the content itself. The Aviation Industry Computer-Based Training Committee (AICC) specification provides support for content that is hosted separately from the LMS. ALMs allow for teachers and administrators to track attendance, time on task, and student progress. LMS also allows for not only teachers and administrators to track these variables but parents and students as well. Parents can log on to the LMS to track grades. Students log on to the LMS to submit homework and to access the course syllabus and lessons.

Still on CAI modes, Zacky and TYoung (2013) identified computer-aided assessment and electronic performance support systems. Computer-aided Assessment (also but less commonly referred to as E-assessment), ranging from automated multiple-choice tests to more sophisticated systems are becoming increasingly common. With some systems, feedback can be geared towards a student's specific mistakes or the computer can navigate the student through a series of questions adapting to what the student appears to have learned or not learned. The best examples follow a Formative Assessment structure and are called "Online Formative Assessment". This involves making an initial formative assessment by sifting out the incorrect answers. The author/teacher will then explain what the pupil should have done with each question. It will then give the pupil at least one practice at each slight variation of sifted out questions. This is the formative learning stage. The next stage is to make a Summative Assessment by a new set of questions only covering the topics previously taught. Some will take this even further and repeat the cycle such as BOFA which is aimed at the Eleven plus exam set in the UK. The term learning design has sometimes come to refer to the type of activity enabled by software such as the open-source system LAMS which supports sequences of activities that can be both adaptive and collaborative. The IMS Learning Design specification is intended as a standard format for learning designs, and IMS LD Level A is supported in LAMS V2. e-learning has been replacing the traditional settings due to its cost effectiveness. Zacky and Young further explained that electronic performance support systems (EPSS) is a "computer-based system that improve worker productivity by providing on-the-job access to integrated information, advice, and learning experiences".

AL Gaziv (2013) talked about E-learning as another CAI mode. E-learning (Electronic Learning) comprises all forms of electronically supported learning and teaching. The information and communication systems, whether networked learning or not, serve as specific media to implement the learning process. The term will still most likely be utilized to reference out-of-classroom and in-classroom education experiences via technology, even as advances continue in regard to devices and curriculum. E-learning is the computer and network-enabled transfer of skills and knowledge. E-learning applications and processes include web-based learning, computer-based learning, virtual education opportunities and digital collaboration. Content is delivered via the Internet, instructor-led and includes media in the form of text, image, animation, streaming video and audio. Abbreviations like CBT (Computer-Based Training), IBT (Internet-Based Training) or WBT (Web-Based Training) have been used as synonyms to E-learning. Today one can still find these terms being used, along with variations of E-learning such as E-learning, e-learning, and learning.

Huntu and Pedro (2013) identified two important CAI modes namely; CAI with animations and CAI without animations. CAI with animations refers to CAIs in which the content is presented alongside a rapid display of a sequence of images to create an illusion of movement. CAI without animation refers to all CAIs in which the content of instruction is presented to the learners without any such display described above. This study was based on these two modes of CAI. Interest of the researcher was on finding out the effects of CAI with animation and CAI without animations on secondary school students' achievement, interest and retention in algebra.

CHAPTER TWO

COMPUTER ANIMATION

According to Kim, Jex and Mogul (2012), animation is the rapid display of a sequence of images of two-dimensional (2-D) or three-dimensional (3-D) artwork or model positioned to create an illusion of movement. The effect is an optical illusion of motion due to the phenomenon of persistence of vision, and can be created and demonstrated in several ways. The most common method of presenting animation is as a motion picture or video program, although there are other methods. AL-Aminand Husseni (2012) defined animation as the techniques of filming successive drawings or positions of model figures, to create a film giving an illusion of movement. The word animation derives from latin "'animatio" meaning "the act of bringing to life" from "animo" ("to animate" or "give life to") "atio" ("the act of").

According to Ngoma (2013), early examples of attempts to capture the phenomenon of motion drawing can be found in Paleolithic cave paintings, where animals are depicted with multiple legs in superimposed positions, clearly attempting to convey the perception of motion. Historically, a 5,000-year-old earthen bowl found in Iran in Shahr-I Sokhta has five images of a goat painted along the sides. This has been claimed to be an example of early animation. However, since no equipment existed to show the image in motion, such a series of images cannot be called animation in a true sense of the word. (AL-GAZIR 2013). Michelle (2012) reported that a Chinese zoetrope-type device had been invented in 180 AD. The phenakistoscope, praxinoscope, and the common flip book were early popular animation devices invented during the 19th century. These devices produced the appearance of movement from sequential drawings using technological means, but animation did not really develop much further until the advent of cinematography. There is no single person who can be considered the "creator" of film animation, as there were several people working on projects which could be considered animation at about the same time.

According to Mbunda (2012), George Melies was creator of special-effect films; he was generally one of the first people to use animation with his technique. He discovered a technique by accident which was to stop the camera rolling to change something in the scene, and then continue rolling the film. This idea was later known as stop-motion animation. Melies discovered this technique accidentally when his camera broke down while shooting a bus driving by. When he had fixed the camera, a hearse happened to be passing by just as Melies restarted rolling the film, his end result was that he had managed to make a bus transform into a hearse. This was just one of the contributors to animation in the early years. Mbunda (2012) also asserted that the earliest surviving stop-motion advertising film was an English short by Arthur Melbourne-Cooper called Matches: An Appeal (1899). Developed for the Bryant and May Matchsticks company, it involved stop-motion animation of wired-together matches writing a patriotic call to action on a blackboard.

Hook and Charles (2012) stated that J. Stuart Blackton was possibly the first American film-maker to use the techniques of stop-motion and hand-drawn animation. Introduced to film-making by Edison, he pioneered these concepts at the turn of the 20th century, with his first copyrighted work dated 1900. Several of his films, the Enchanted Drawing (1900) and Humorous Phases of Funny Faces (1906) were film versions of Blackton's "lightening artist" routine, and utilized modified versions of Melies early stop-motion techniques to make a series of blackboard drawing appear to move and reshape themselves, "Humorous Phases of Funny Faces' is regularly cited as the first true animated film, and Blackton is considered the first true animator. Zacky and Yound (2013) narrated that a French artist, Emile Cohl, began drawing cartoon strips and created a film in 1908 called Fantasmagorie. The film largely consisted of a stick figure moving about and encountering all manner of morphing objects, such as a wine bottle that transforms into a flower. There were also sections of live action where the animator's hands would enter the scene. The film was created by drawing each frame on paper and then shooting each frame onto negative film, which gave the picture a blackboard looks. This makes Fantasmagorie the first animated film created using what came to be known as traditional (hand-drawn) animation.

According to Marcellio and Haroldei (2011), following the successes of Blackton and Cohl, many other artists began experimenting with animation. One such artist was Winsor McCay, a successful newspaper cartoonist, who created detailed animations that required a team of artists and painstaking attention for detail. Each frame was drawn on paper; which invariably required backgrounds and characters to be redrawn and animated. Among McCay's most noted films are Little Nemo (1911), Certie the Dinosaur (1914) and the Sinking of the Lusitania (1981). The production of animated shot films, typically referred to as "cartoons", became an industry of its own during the 1910s, and cartoon shorts were produced to be shown in movie theaters. The most successful early animation producer was John Randolph Bray, who, along with animator Earl Hurd, patented the cel animation process which dominated the animation industry for the rest of the decade. El Apostol (Spanish: "The Apostle") was a 1917 Argentine animated film utilizing cutout animation, and the world's first animated feature film.

Traditional animation (also called cel animation or hand-drawn animation) was the process used for most animated films of the 20th century. The individual frames of a traditionally animated film are photographs of drawings, which are first drawn on paper. To create the illusion of movement, each drawing differs slightly from the one before it. The animators' drawings are traced or photocopied onto transparent acetate sheets called cels, which are filled in with paints in assigned colors or tones on the side opposite the line drawings. The completed character cels are photographed one-by-one onto motion picture film against a painted background by a rostrum camera.

The traditional cel animation process became obsolete by the beginning of the 21st century. Today, animators' drawings and the backgrounds are either scanned into or drawn directly into a computer system. Various software programs are used to color the drawings and simulate camera movement and effects. The final animated piece is output to one of several delivery media, including traditional 35mm film and newer media such as digital video. The “look” of traditional cel animation is still preserved, and the character animators’ work has remained essentially the same over the past 70 years. Some animation producers have used the term “tradigital” to describe cel animation which makes extensive use of computer technology, (Terry, 2011). Example of traditionally animated feature films include Pinocchio (United States, 1940), Animal Farm (United Kingdom, 1954), and Akira (Japan, 1988). Traditional animated films which were produced with the aid of computer technology include the Lion King (US, 1994) Sen to Chihiro no Kamikakushi (Spirited away) (Japan, 2001), and Les Triplettes de Belleville (France, 2003).

Mayo (2011) distinguished between full and limited animation as follows; Full Animation refers to the process of producing high-quality traditionally animated films, which regularly use detailed drawings and plausible movement. Fully animated films can be done in a variety of styles, from more realistically animated works such as those produced by the Walt Disney studio. Many of the Disney animated features are examples of full animation, as are non-Disney works such as The Secret of NIMH (US, 1982), the Iron Giant (US, 1999), and Nocturna (Spain, 2007). Limited Animation involves the use of less detailed and/or more stylized drawings and methods of movement. Pioneered by the artists at the American studio United Productions of America, limited animation can be used as a method of stylized artistic expression, as in Gerald McBoing Boing (US, 1951), Yellow Submarine (UK, 1968), and much photo realistic animation, is used primarily for animation that attempts to resemble real life. Using advance rendering that makes detailed skin, plants water, fire, clouds, etc. to mimic real life. Examples include Up (2009, USA), Kung-Fu Panda (2008, USA), Ice Age (2002, USA). 2-D animation techniques tend to focus on image manipulation while 3-D techniques usually build virtual worlds in which characters and objects move and interact. 3D animation can create images that seem real to the viewer. Mark (2011).

Hiz (2012) listed the following Animation techniques;

Paint-on-glass animation: a technique for making animated films by manipulating slow drying oil paints on sheets of glass, for example by Aleksandr Petrov.

Erasure animation: is a technique using tradition 2-D medium, photographed over time as the artist manipulates the image. For example, William Kentridge is famous for his charcoal erasure films, and Piotr Dumala for his auteur technique of animating scratches on plaster.

Pinscreen animation: makes use of a screen filled with movable pins, which can be moved in or out by pressing an object onto the screen. The screen is lit from the side so that the pins cast shadows. The technique has been used to create animated films with a range of textural effects difficult to achieve with traditional cel animation.

In Sand animation: sand is moved around on a back- or front-lighted piece of glass to create each frame for an animated film. This creates an interesting effect when animated because of the light contrast.

Flip book: (Sometimes, especially in British English, called a flick book) is a book with a series of pictures that vary gradually from one page to the next, so that when the pages are turned rapidly, the pictures appear to animate by simulating motion or some other change. Flip books are often illustrated books for children, but may also be geared towards adults and employ a series of photographs rather than drawings. Flip books are not always separate books, but may appear as an added feature in ordinary books or magazines, often in the page corners. Software packages and websites are also available that convert digital video files into custom-made flip books.

Kim et al (2012) defined computer animation as the generation and manipulation of images by means of a computer to create moving images. Computer animation encompasses a variety of techniques, the unifying factor being that animation is created digitally in a computer. It takes less time than previous traditional animation.

According to Mayo (2011) computer animation is the process used for generating animated images by using computer graphics. The more general term computer generated imagery encompasses both static scenes and dynamic images, while computer animation only refers to moving images.

Hiz (2012) narrated that some of the earliest animation done using a digital computer was done at Bell Telephone Laboratories in the first half of the 1960s by Edward E. Zajac, Frank W. Sinden, Kenneth C. Knowlton, and Michael Noll. Early digital animation according Hiz was also done at Lawrence Livermore Laboratory. Another early step in the history of computer animation was the 1973 movie West-world, a science-fiction film about a society in which robots live and work among humans, though the first use of 3D Wireframe imagery was in its sequel, Future World (1976), which featured a computer-generated hand and face created by then University of Utah graduate students Edwin Catmull and Fred Parke.

Hiz further held that developments in CGI technologies are reported each year at SIGGRAPH, an annual conference on computer graphics and interactive techniques, attended each year by tens of thousands of computer professionals. Developers of computer games and 3D video cards strive to achieve the same visual quality on personal computers in real-time as is possible for CGI films and animation. With the rapid advancement of real-time rendering quality, artists began to use game engines to render non-interactive movies. This art form is called machinima. The first feature-length computer animated film was the 1995 movie Toy Story by Pixar. It followed an adventure centered around some toys and their owners. The groundbreaking film was the first of many fully computer animated films. Computer animation helped make blockbuster films such as Toy Story 3 (2010), Avatar (2009), Shrek 2 (2004), and Cars 2 (2011)

According to Mark (2011) 2D animation figures are created and/or edited on the computer using 2D bitmap graphics or created and edited using 2D vector graphics. This includes automated computerized versions of traditional animation techniques such as of, interpolated morphing, onion skinning and interpolated rotoscoping. 2D animation has many applications, including analog computer animation, flash animation and Power-point animation. Cinemagraphs are still photographs in the form of an animated GIF file of which part is animated. Power point animations were mostly used in this study.

Michelle (2012) explained that 3D animation is digitally modeled and manipulated by an animator. To manipulate a mesh, it is given a digital skeletal structure that can be used to control the mesh. This process is called rigging. Various other techniques can be applied, such as mathematical function (eg. Gravity, particle simulations), simulated fur or hair, effects such as fire and water and the use of motion capture to name but a few, these techniques fall under the category of 3D dynamics. Well-made 3D animations can be difficult to distinguish from live action and are commonly used as visual effects for recent movies. Toy Story (1995, USA) is the first feature-length film to be created and rendered entirely using 3D graphics. Michelle added that Cel-shaded animation, is used to mimic traditional animation using CG software. Shading looks stark, with less blending colors. Examples include, Skyland (2007, France), Appleseed Ex Machina (2007, Japan), The Legend of Zelda: Wind Waker (2002, Japan). Machinima, are films created by screen capturing in video games and virtual worlds. Motion capture, is used when live action actors wear special suits that allow computer to copy their movements in CG characters. Examples include Polar Express (2004, USA), Beowulf (2007, USA), A Christmas Carol (2009, USA), The Adventures of Tintin (2011, USA).

Modern computer animation usually uses 3D computer graphics, although 2-D computer graphics are still used for stylistic, low bandwidth, and faster real-time renderings. Sometimes the target of the animation is the computer itself, but sometimes the target is another medium, such as film, (Hiz, 2012).

Mark (2011) adduce that to create the illusion of movement, an image is displayed on the computer screen and repeatedly replaced by a new image that is similar to it, but advanced slightly in time (usually at a rate of 24 or 30 frames/second). This technique is identical to how the illusion of movement is achieved with television and motion pictures. For 3D animations, objects (models) are built on the computer monitor (modeled) and 3D figures are rigged with a virtual skeleton. For 2D figure animations, separate objects (illustrations) and separate transparent layers are used, with or without a virtual skeleton. Then the limbs, eyes, mouth, clothes, etc. of the figure are moved by the animator on key frames. The differences in appearance between key frames are automatically calculated by the computer in a process known as tweening or morphing. Finally, the animation is rendered.

For 3D animations, all frames must be rendered after modeling is complete. For 2D vector animations, the rendering process is the key frame illustration process, while tweened frames are rendered as needed. For pre-recorded presentations, the rendered frames are transferred to a different format or medium such as film or digital video. The frames may also be rendered in real time as they are presented to the end-user audience. Low bandwidth animations transmitted via the internet (e.g. 2D Flash, X3D) often use software on the end-users computer to render in real time as an alternative to streaming or pre-loaded high bandwidth animations.

Bell and Thompson (2012) demonstrated an example of computer animation as follows; the screen is blanked to a background color, such as black. Then, a goat is drawn on the right-hand side of the screen. Next, the screen is blanked, but the goat is re-drawn or duplicated slightly to the left of its original position. This process is repeated, each time moving the goat a bit to the left. If this process is repeated fast enough, the goat will appear to move smoothly to the left. This basic procedure is used for all moving pictures in films and television. The moving goat is an example of shifting the location of an object. More complex transformations of object properties such as size, shape, lighting effects often require calculations and computer rendering instead of simple re-drawing or duplication.

Bell and Thompson explained that to trick the eye and brain into thinking they are seeing a smoothly moving object, the pictures should be drawn at around 12 frames per second (frame/s) or faster (a frame is one complete image). With rates above 70 frames/s no improvement in realism or smoothness is perceivable due to the way the eye and brain process images. At rates below 12 frame/s most people can detect jerkiness associated with the drawing of new images which detracts from the illusion of realistic movement. Conventional hand-drawn cartoon animation often uses 15 frames/s in order to save on the number of drawings needed, but this is usually accepted because of the stylized nature of cartoons. Because it produces more realistic imagery computer animation demands higher frame rates to reinforce this realism. Movie film seen in theaters in the United States runs at 24 frames per second, which is sufficient to create the illusion of continuous movement. For high resolution, adapters are used. In the design of the animated CAI used in this study, attributes of both 2D and 3D animation. Techniques were utilized, though mainly 2D, specifically, the power point techniques were used.

CHAPTER THREE

ANIMATING VIRTUAL CHARACTERS/CREATING CHARACTERS AND OBJECT ON A COMPUTER

In the words of Hiz (2012), in most 3D computer animation systems, an animator creates a simplified representation of a character's anatomy, analogous to a skeleton or stick figure. The position of each segment of the skeletal model is defined by animation variables, or Avars. In human and animal characters, many parts of the skeletal model correspond to actual bones, but skeletal animation is also used to animate other things, such as facial features (though other methods for facial animation exist). The character "Woody" in Toy Story, for example, uses 700 Avars, including 100 Avars in the face. The computer does not usually render the skeletal model directly (it is invisible), but uses the skeletal model to compute the exact position and orientation of the character, which is eventually rendered into an image. Thus by changing the values of Avars over time, the animator creates motion by making the character move from frame to frame.

Terry (2011) observed that there are several methods for generating the Avar values to obtain realistic motion. Traditionally, animators manipulate the Avars directly. Rather than set Avars for every frame, they usually set Avars at strategic points (frames) in time and let the computer interpolate or 'tween' between them, a process called key-framing. Key-framing puts control in the hands of the animator, and has roots in hand-drawn traditional animation. In contrast, a newer method called motion capture makes use of live action. When computer animation is driven by motion capture, a real performer acts out the scene as if they were the character to be animated. His or her motion is recorded to a computer using video cameras and markers, and that performance is then applied to the animated character.

Mark (2011) noted that each method has its advantages, and as of 2007, games and films are using either or both of these methods in productions. Key-frame animation can produce motions that would be difficult or impossible to act out, while motion capture can reproduce the subtleties of a particular actor. For example, in the

2006 film Pirates of the Caribbean: Dead Man's Chest, actor Bill Nighy provided the performance for the character Davy Jones. Even though Nighy himself doesn't appear in the film, the movie benefited from his performance by recording the nuances of his body language, posture, facial expressions, etc. thus motion capture is appropriate in situations where believable, realistic behavior and action is required, but the types of characters required exceed what can be done through conventional costuming.

Mayo (2011) hinted that 3-D computer animation combines 3-D models of objects and programmed or hand "key-framed" movement. Models are constructed out of geometrical vertices, faces, and edges in a 3-D coordinate system. Objects are sculpted much like real clay or plaster, working from general forms to specific details with various sculpting tools. A bone/joint animation system is set up to deform the CGI model (e.g., to make a humanoid model walk). In a process called rigging, the virtual marionette is given various controllers and handles for controlling movement. Mayo added that animation data can be created using motion capture, or key-framing by a human animator, or a combination of the two.

In the same vein, Michelle (2012) stated that 3D models rigged for animation may contain thousands of control points – for example, the character "Woody" in Pixar's movie Toy Story, uses 700 specialized animation controllers. Rhythm and Hues studios labored for two years to create Aslan in the movie the Chronicles of Narnia: The Lion, the Witch and the Wardrobe which had about 1851 controllers, 742 in just the face alone. In the 2004 film The Day After Tomorrow, designers had to design forces of extreme weather with the help of video references and accurate meteorological facts. For the 2005 remake of King Kong, actor Andy Serkis was used to help designers pinpoint the gorilla's prime location in the shots and used his expressions to model "human" characteristics onto the creature. Serkis had earlier provided the voice and performance for Gollum in J.R.R. Tolkien's The Lord of the Rings trilogy, (Hiz, 2012).

Kim et al (2012) stated computer animation can be created with a computer and animation software. Some impressive animation can be achieved even with basic programs; however, the rendering can take a lot of time on an ordinary home computer. Because of this, video game animators tend to use low resolution, low polygon count renders, such that the graphics can be rendered in real time on a home computer. Photorealistic animation would be impractical in this context. Professional animators of movies, television, and video sequences on computer games make photorealistic animation with high detail. This level of quality for movie animation would take tens to hundreds of years to create on a home computer. Many powerful workstation computers are used instead. Graphics workstation computers use two to four processors, and thus are a lot more powerful than a home computer, and are specialized for rendering. A large number of workstations (known as a render farm) are networked together to effectively act as a giant computer. The result is a computer-animated movie that can be completed in about one to five years (this process is not comprised solely of rendering, however). A workstation typically very costly with the more expensive stations being able to render much faster, due to the more technologically advanced hardware that they contain. Professionals also use digital movie cameras, motion capture or performance capture, bluescreens, film editing software, props, and other tools for movie animation, (Kim et al 2012).

According to Stone, Zubby and Bill (2011). The realistic modeling of human facial features is both one of the most challenging and sought after elements in computer-generated imagery. Computer facial animation is a highly complex field where models typically include a very large number of animation variables. Historically speaking, the first SIGGRAPH tutorials on state of the art in Facial Animation in 1989 and 1990 proved to be a turning point in the field by bringing together and consolidating multiple research elements, and sparked interest among a number of researchers. Stone et al added that the Facial Action Coding System (with 46 action units such as “lip bite” or “squint”) which had been developed in 1976 became a popular basis for many systems. As early as 2001 MPEG-4 included 68 facial animation parameters for lips, jaws, etc., and the field has made significant progress since then and the use of facial micro expression has increased. In some cases, an affective space such as the PAD emotional state model can be used to assign specific emotions to the faces of avatars. In this approach the PAD model is used as a high-level emotional space, and the lower-level space is the MPEG-4 Facial Animation Parameters (FAP). A mid-level Partial Expression parameters (PEP) space is then used to in a two-level structure: the PAD-PEP mapping and the PEP-FAP translation model.

Bell and Thompson (2012) averred that realism in computer animation can mean making each frame look photorealistic, in the sense that the scene is rendered to resemble a photograph, or making the animation of characters believable and life-like. This study adopted on the second definition, that is, making the animation of characters believable and life-like computer animation can be realistic with or without photorealistic rendering.

AL-Gazir (2013), observed that one of the greatest challenges in computer animation has been creating human characters that look and move with the highest degree of realism. Many animated films instead feature characters that are anthropomorphic animals (finding Nemo, Ice Age, Over the Hedge), machines (Cars, WALL-E, Robots), fantasy creatures (Monsters Inc., Shrek, TNMT), or humans with nonrealistic, cartoon-like proportions (The Incredibles, Despicable Me, up. Part of the difficulty in making pleasing, realistic human characters is the uncanny valley: a concept where, up to a point, people have an increasingly negative emotional response as a human replica looks and acts more and more human. AL-Gazir added that some materials that commonly appear in a scene like cloth, foliage, fluids, and hair have proven more difficult to faithfully recreate and animate than others. Consequently, special software and techniques have been developed to better simulate these specific elements.

According to Zacky and Yound (2013), in theory, realistic computer animation can reach a point where it is indistinguishable from real action captured on film. Where computer animation achieves this level of realism, it may have major repercussions for the film industry. The goal of computer animation is not always to emulate live action as closely as possible. Computer animation can also be tailored to mimic or substitute for other types of animation, such as traditional stop motion animation. Some of the long-standing basic principles of animation, call for movement that is not strictly realistic, and such principles still see widespread application in computer animation objects. There are both proprietary and open, non-commercial and commercial, peer-reviewed repositories of learning objects such as the Merlot repository.

Kwme and Dante (2013) stated that an excellent example of computer animation that relates to knowledge management and reusability is Navy Animation which is available to Active Duty, Retired, or Disable Military members. This on-line tool provides certificate courses to enrich the user in various subjects related to military training and civilian skill sets. The e-learning system not only provides learning objectives, but also evaluates the progress of the student and credit can be earned toward higher learning institutions. This reuse is an excellent example of knowledge retention and the cyclical process of knowledge transfer which this study makes case for.

CHAPTER FOUR

ALGEBRA

According to Stone, Zubby and Bill (2011), Algebra (from Arabic al-jebr meaning "reunion of broken parts") is the branch of mathematics concerning the study of the rules of operations and relations, and the constructions and concepts arising from them, including terms, polynomials, equations and algebraic structures. Together with geometry, analysis, topology, combinatiorics, and number theory, algebra is one of the main branches of pure mathematics. Also, Kofi (2012) states that algebra originated from the Arabic "al-jabr" meaning "the mending of broken parts". Hence, He defined algebra as the part of mathematics in which letters and other general symbols are used to represent numbers and quantities in formulae and equations. Letter and symbols used to represent numbers and quantities, in formulae and equations are usually called "unknowns". Algebra may therefore, be defined as a system of representing numbers and quantities with unknowns in equations based on given axioms.

Kwame & Damtez (2012) observed that elementary algebra, often part of the curriculum in secondary education, introduces the concept of variables representing numbers. Statements based on these variables are manipulated using the rules of operations that apply to numbers, such as addition. This can be done for a variety of reasons, including equation solving. However, Algebra is much broader than elementary algebra and studies what happens when different rules of operations are used and when operations are devised for things other than numbers. Addition and multiplication can be generalized and their precise definitions lead to structures such as groups, rings and fields, studied in the area of mathematics called abstract algebra.

EL-Anin and Husseini (2012) narrated that by the time of Plato, Greek mathematics had undergone a drastic change. The Greeks created a geometric algebra where terms were represented by sides of geometric objects, usually lines, that had letters associated with them. EL-Anin and Hussein, further held that Diophantus (3rd century AD), sometimes called "the father of algebra", was an Alexandrian Greek mathematician and the author of a series of books called Arithemtica. These texts deal with solving algebraic equations.

While the word algebra comes from the Arabic language (al-jabr "restoration") and much of its methods from Arabic/Islamic mathematics, its roots can be traced to earlier traditions, which had a direct influence on Muhammad Ibn Musa al-Khwarizmi (c. 780-850). He later wrote The Compendious Book on Calculation by Completion and Balancing, which established algebra as a mathematical discipline that is independent of geometry and arithmetic, According Zackly and Yound (2013) the roots of algebra can be traced to the ancient Babylonians, who developed an advanced arithmetical system with which they were able to do calculations in an algorithmic fashion. The Babylonians developed formulas to calculate solutions for problems typically solved today by using linear equations, quadratic equations, and indeterminate linear equations. By contrast, most Egyptians of this era, as well as Greek and Chinses mathematicians in the 1st millennium BC, usually solved such equations by geometric methods, such as those described in the Rhind Mathematical Papyrus, Euclid's Elements, and The Nine Chapters on the Mathematical Art. The geometric work of the Greeks, typified in the Elements, provided the framework for generalizing formulae beyond the solution of particular problems into more general systems of stating and solving equations, though this would not be realized until the medieval Muslim mathematicians. Kofi (2012).

Ajom and Agbenyi (2013) asserted that the Hellenistic mathematicians Hero of Alexandria and Diophantus as well as Indian mathematicians such as Brahmagupta continued the traditions of Egypt and Babylon, though Diophantus' Arithmetica and Brahmagupta's Brahmasphutasiddhanta were on a higher level. For example, the first complete arithmetic solution (including zero and negative solutions) to quadratic equations was described by Brahmagupta in his book Brahmasphutasiddhanta. Later, Arabic and Muslim mathematicians developed algebraic methods to a much higher degree of sophistication. Although Diophantus and the Babylonians used mostly special adhoc methods to solve equations. According to Rofi (2012) Al-Khwarizmi was the first to solve equation using general methods. He solved the linear indeterminate equations, quadratic equations, second order indeterminate equations and equations with multiple variables.

Stone et l al (2011) further reported that in 1545, the Italian mathematician Girolamo Cardano published Ars magna – the great art, a 40-chapter masterpiece in which he gave for the first time a method for solving the general quartic equation. The Greek mathematician Diophantus has traditionally been known as the "father of algebra" but in more recent times there is much debate over whether al-Khwarizmi, who founded the discipline of al-jabr, deserves that title instead. Those who support Diophantus point to the fact that the algebra found in Al-Jabr is slightly more elementary than the algebra found in Arithmetica and that Arithmetica is syncopated while Al-Jabr is fully rhetorical. Those who support Al-Khwarizmi point to the fact that he introduced the methods of "reduction" and "balancing" (the transposition of subtracted terms to the other side of an equation, that is, the cancellation of like terms on opposite sides of the equation) which the term al-jabr originally referred to, and that he gave an exhaustive explanation of solving quadratic equations, supported by geometric proofs, while treating algebra as an independent discipline in its own right. His algebra was also no longer concerned "with a series of problems to be resolved, but an exposition which starts with primitive terms in which the combinations must give all possible prototypes for equations, which explicitly constitute the true object of study." He also studied an equation for its own sake and "in a generic manner, insofar as it does not simply emerge in the course of solving a problem, but is specifically called on to define an infinite class of problems. More-so, Zack and Yound (2013) held that the Persian mathematician Omar Khayyam is credited with identifying the foundations of algebraic geometry and found the general geometric solution of the cubic equation. Another Persian mathematician, Sharaf al-Din al-Tusi, found algebraic and numerical solutions to various cases of cubic equations. He also developed the concept of a function. The Indian mathematicians Mahavira and Bhaskara II, the Persian mathematician Al-Karaji, and the Chinese mathematician Zhu Shijie, solved various cases of cubic, quartic, quintic and higher-order polynomial equations using numerical methods. In the 13th century, the solution of a cubic equation by Fibonacci is representative of the beginning of a revival in European algebra. As the Islamic world was declining, the European world was ascending. And it is here that algebra was further developed.

For Ajom and Agbenyi (2013), Francois Viets's work at the close of the 16th century marks the start of the classical discipline of algebra. In 1637, Rene Descartes published La Geometrie, inventing analytic geometry and introducing modern algebraic notation. Another key event in the further development of algebra was the general algebraic solution of the cubic and quartic equations, developed in the mid-16th century. The idea of a determinant was developed by Japanese mathematician Kowa Seki in the 17th century, followed independently by Gottfried Leibniz ten years later, for the purpose of solving systems of simultaneous linear equations using matrices. Gabriel Cramer also did some work on matrices and determinants in the 18th century. Permutations were studied by Joseph Lagrange in his 1770 paper Reflexions sur la resolution algebrique des equations devoted to solutions of algebraic equations, in which he introduced Lagrange resolvents. Paolo Ruffini was the first person to develop the theory of permutation groups, and like his predecessors, also in the context of solving algebraic equations. Kwame and Damte (2012) further related that abstract algebra was developed in the 19th century, initially focusing on what is now called Galois Theory, and on constructability issues. The "modern algebra" has deep nineteenth-century roots in the work, for example, the works of Richard Dedekind and Leopold Kronecker have profound interconnections with other branches of mathematics such as algebraic number theory and algebraic geometry. George Peacock was the founder of axiomatic thinking in arithmetic and algebra. Augustus De Morgan discovered relation algebra in his Syllabus of a Proposed System of Logic. Josiah Willard Gibbs developed an algebra of vectors in three-dimensional space, and Arthur Cayley developed an algebra of matrices which is a noncommutative algebra, (Kwame et al 2012).

According to Stone et al (2011), Algebra may be divided roughly into the following categories:

Elementary Algebra, in which the properties of operations on the real number system are recorded using symbols as “place holders” to denote constants and variables, and the rules governing mathematical expressions and equations involving these symbols are studied. This is usually taught as school under the title algebra (or intermediate algebra and college algebra in subsequent years). University-level courses in group theory may also be called elementary algebra.

Abstract Algebra, sometimes also called modern algebra, in which algebraic structures such as groups, rings and fields are axiomatically defined and investigated.

Linear Algebra, in which the specific properties of vector spaces are studied (including matrices);

Universal Algebra, in which properties common to all algebraic structures are studied.

Algebraic number theory, in which the properties of numbers are studied through algebraic systems. Number theory inspired much of the original abstraction in algebra.

Algebraic geometry applies abstract algebra to the problems of geometry.

Algebraic combinatorics, in which abstract algebraic methods are used to study combinatorial questions. In some directions of advanced study, axiomatic algebraic systems such as groups, rings, fields, and algebras over a field are investigated in the presence of a geometric structure (a metric or a topology) which is compatible with the algebraic structure. The list includes a number of areas of functional analysis. From the above classification, this work was based on elementary algebra which is the algebra studied at secondary education level.

Stone et al (2011) further elaborated that elementary algebra is the most basic form of algebra. It is taught to students who are presumed to have no knowledge of mathematics beyond the basic principles of arithmetic. In arithmetic, only numbers and their arithmetical operations (such as +, -, x, ÷) occur. In algebra, numbers are often denoted by symbols (such as a, x, y, p,q, etc). This is useful because of the following reasons;

1. It allows the general formulation of arithmetical laws (such as a + b = b + a for all a and b), and thus is the first step to a systematic exploration of the properties of the real number system.
2. It allows the reference to "unknown" numbers, the formulation of equations and the study of how to solve these. (For instance, "find a number x such that 3x + 1 = 10" or going a bit further "find a number x such that ax + b = c". This step leads to the conclusion that it is not the nature of the specific numbers that allows us to solve it, but that of the operations involved.)
3. It allows the formulation of functional relationships. (For instance, "if you sell x tickets, then your profit will be 3x – 10 naira, or f(x) = 3x – 10, where f is the function, and x is the number to which the function is applied.")

(Zacky and Yound (2013). From the review presented above it is evident that algebra is one of the major, if not the most important branch of pure mathematics. Of greater interest to this study is the fact that algebra constitutes over 46 percent of secondary school mathematics curriculum in Nigeria. yet secondary school students tend to fear and avoid algebraic topic, (Ajom and Agbenyi, 2013). Consequently, the choice of algebra as the branch of mathematics used for this study is justified.

CHAPTER FIVE

ACADEMIC ACHIEVEMENT IN MATHEMATICS

AL-Gazir (2013) asserted that the word “achievement” is the noun form of the verb “achieve”. Hence, achievement is the process of bringing about or accomplishing something through effort, skill or courage. In this work, achievement strictly refers to academic achievement and more specifically, academic achievement in senior secondary school algebra. Academic achievement generally suggests an achievement relating to education and scholarship. (Bell and Thompson 2012).

According to Tenty and Awe (2011), academic achievement depicts students’ performance on a standard of measurement such as performance test, skill test, analytical thinking test, etc. It is therefore, not out of place to describe academic achievement as the gain in knowledge of students as a result of taking part in a learning activity or programme. Learning here refers to changes in a person’s behavioural repertoire rather than just a change in behaviour. Academic achievement is a result-oriented construct that encapsulates the extent of performance of a desired task. (Kuntu and Pedro, 2013).

Kofi (2012) argued that since academic achievement is a measure of students’ success in an academic setting, it is therefore, the goal of parents, teachers and school administrators to foster achievement. Adejumo (2012) stated that students’ achievement in mathematics, just like every other school subject is usually done using assignments, projects, tests and examinations. These achievement measurement tools are used to assess (evaluate) the worth of the students’ learning and as well predict their future academic endeavors. In this study, students’ achievement in algebra was measured using the Algebra Achievement Test (ALAT) (Appendix A). Kofi (2012) affirmed the validity of the use of achievement tests especially in research studies designed to determine the effectiveness of two or more instructional strategies and or methods.

Similarly, Olurami and Ajao (2012) advanced that the major advantage of use of achievement tests is that apart from estimating the relative effectiveness of an innovation, achievement tests also identify areas of weaknesses in innovative techniques, thereby paving way for remedial action(s). This study therefore, did not only use the Algebra Achievement Test to infer on the efficacy of the methods under study, but it as well use its results or findings to proffer veritable ways of maximizing the use of those teaching methods in circumstances where any of them becomes the most appropriate.

Tenty and Awe (2011) identified some factors that could determine students' achievement. They include teacher-qualification, teacher's knowledge of the subject matter and ability to deliver effectively, environment, students' state of mind, students' readiness, teaching method, availability, utilization and suitability of instructional aids and teacher motivation. In the same vein, AL-Gazir (2013) grouped the factors under three broad sub-headings viz; teacher-related, student-related and environmental factors. Further-more, Adejuma (2012) classified the factors as follows; Knowledge-oriented, economic-oriented, psychological and environmental. The list is endless. However, this study restricted itself to only teaching method as a determinant of students' achievement. Hence, concerted efforts were made to ensure that any observation made in the students' achievement can genuinely be attributed to the treatment administered. In specific terms, this study intended to ascertain the effect of Animated and Static CAI modes on students' achievement in algebra.

CHAPTER SIX

STUDENT'S INTEREST IN ALGEBRA

AL-Gazir (2013) defined interest as inward state of the mind towards something. Oluremi and Ajao (2012) described interest as a disposition, attitude and feelings of an individual towards an activity which shows behaviorally, the extent the person liked to participate in an activity. Kofi (2012) defined interest as "the state of wanting to know about something or someone", "the quality of making someone curious or attentive" and "subject about which one is concerned or enthusiastic". Similarly, Ayuba (2012) submitted that interest viewed from a generalized perspective is the feeling of one whose attention, concern or curiosity is particularly engaged by something. Alternatively, Michelle (2012) saw interest as that which concerns, involves or draws the attention of or arouses the curiosity of a person. Michelle further defined interest as the feeling of intentness, concern or curiosity about an object.

More-so, Zacky and Young (2013) defined interest as the likes and dislikes of an individual. While Stone, Zubby and Bill (2011) defined interest as the quality which arouses concern or curiosity which holds a child's attention on an object. Interest therefore is the power of exciting such concern and involvement that draws the attention of a person. Interest in algebra viewed from the afore-cited conceptual perspectives may be regarded as the mental and emotional disposition of individuals to engage in algebra-related topics and activities. Hanks (2011) identified four interest types namely; manifested interest, tested interest, expressed interest and inventoried interest. According to him when an individual participates in an activity, his interest is manifested. Fro instance, a student listening and carrying out class activities along with the teacher has manifested his/her interest. When achievement is measured, the scores indicate the scorer is interest in the subject, hence, this illustrates tested interest. Expressed interest is seen when an individual declares his interest verbally. Inventoried interest is used to rate an individual's interest where many items or groups of items are involved. In this study, the instrument that was be used to collect data on the students' interest in algebra is the Algebra Interest Inventory (ALII) which combines the attributes of these four interest types.

Additionally, Terry (2011) hinted that interestingness is not a unitary concept, rather at least two different types of interest can be distinguished, namely; emotional interest and cognitive interest. Emotional interest is created by events that are arousing. Cognitive interest on the other hand is produced by the relationships between incoming information and background knowledge. He explained further that interest can be generated by the intellectual activity of resolving incongruity, such as that entailed in making inferences. This explanation suggests that static CAI are more likely to increase cognitive interest than animated CAI because the former require the learner to generate more inferences to fill the gaps between them. On the other hand, the later are more likely to increase emotional interest because animation may induce higher arousal levels. Hence, Mark (2011) warned about what he referred to as "seductive details" in the use of learning materials such as CALs. These seductive details may make a learning/teaching aid more attractive but they are generally irrelevant. Hiz (2011) further validated this claim when he asserted that seductive details show a negative effect on learning. Kofi (2012) observed that adding entertaining graphics to a scientific or mathematical text increased emotional interest but not cognitive interest. One possible explanation for the absence of effects of seductive details on cognitive interest is that the additional information may cause cognitive overload and distract the learner from the important information. Seductive details may not require the cognitive resolution that is the basis for cognitive interest. Ajom and Agbenyi (2013), criticized the use of the term "seductive" to qualify animated CAI and maintained that the efficacy of Animated CAI in eliciting both emotional and cognitive interest cannot be neglected. One of the major challenges of this study was to strike a balance between these controversial reports.

Another important aspect of a learner's motivation and interest is controllability or interactivity. Clauss (2011) observed that one strategy for enhancing the learner's motivation is to increase his sense of control and self-determination by providing choice or locus of control. It has been well documented that individuals offered choice show more enjoyment, better performance, and greater persistence at a variety of activities due to increased interactivity or controllability, (Naoma, 2013). Controllability and interactivity may differ among different CAI types. It is expected that the controllability and interactivity attributes of both Animated and static CAIs should influence the students' interest.

CHAPTER SEVEN

RETENTION OF ALGEBRA CONTENTS LEARNT

Michelle (2012) defined retention as the act of "absorbing and holding" or "to continue having or holding". Stone, Zubby ad Bill (2011) asserted that failure to provide enough applications to real life activity and social usage cum poor teaching techniques are strong limiting factors to students' retention in mathematics. Similarly, Hooke and Charles (2012) contended that for improvement of retention of learned materials in mathematics, programmed learning is indispensable. Retention, thus, depends mainly on teaching strategy adopted by the teacher.

Retention and memory can hardly be separated. This because anything retained is stored in the memory. Sometimes people who retain poorly are said to have poor memories.

Memory and learning are so closely related in meaning and functions that sometimes they are used interchangeably. For example, the definition of Learning as adopted by most educators describes it as "a relatively permanent change in potential behaviour which is acquired through practice or experience. The word "relatively permanent" in the definition connotes something stored or locked up somewhere and this is exactly what the memory is all about. Also, the word "potential behaviour' implies something for a "later use" and this is the retrieval aspect of memory. Therefore, learning implies memory and memory implies learning Mbunda (2009).

About memory, if there is any living organism that can use the past to live the present and shape the future that organism is human being. His capacity to store experience and retrieve it for use in daring situations places him above all other living creatures. According to Ohanusi (2011) memory is the storage and retrieval of things learned earlier. It is simply the ability or the power to store facts in the conscious mind and recall them for use in a later situation.

Ohanusi further enumerated the following functions of memory;

1. It allows the storage of information, that is, preservation of past experience.
2. It allows the retrieval of stored information for use when needed.

The other functions derive directly from functions 1 and 2 above.

3. It allows human beings to organize their lives
4. It saves people from danger through recognition
5. It places human beings above other creatures
6. It enhances our innovativeness and creativity through convergent and divergent thinking.
7. It allows human beings to control their lives.

On how the memory operates, Kuntu and Pedro (2013) stated that experience get stored in stages. Precisely they mention a sequential – three – stage process, starting with Sensory Register Short Term Store and then the long term store illustrated by (the figure) adapted from Morgan et al (1979) and shown below;

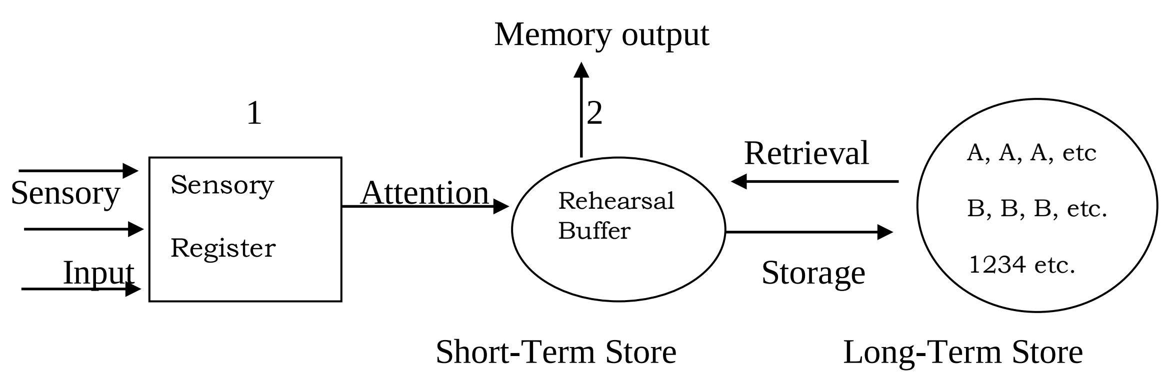

Figure 1: Morgan et al (1979) memory three – stage process model.

Stage 1: Sensory input is received. Here the sense organs of sight (eye), hearing (Ear), touch (Skin), smelling (nostril) and tasting (tongue) are active in the sense that they receive stimulation from the environment and briefly store it for about one to few seconds. In a nutshell, the sense organs are the Sensory Registers for sensory inputs from the environment. The sensory register receives, processes and sends to the second stage. The processing done by the sensory register is simple giving attention to the input. Any input not giving attention is ignored, discarded, or forgotten. It is only those held briefly for one to few seconds (attended to) that are pushed to the next stage.

Stage 2: the second stage is the short term store or short term memory. As soon as the input is received from sensory register (stage 1) the short term store processes it by rehearsing it. This is why this second stage is referred to as rehearsal buffer. It is holding stage where input is held for about 30 seconds. To rehearse is to repeat over and over. After rehearsal, the information in input is pushed to the third stage which is the long term store. For information to pass to the third stage, it has to be processed, that is, rehearsed, if not, such information is lost or forgotten.

Stage 3: This stage belongs to the Long-term store. It receives well rehearsed information from the short-term store. Its function includes receiving and organizing information into categories. This categorization could be done alphabetically or chronologically. Such as all A^s together, all B^s together, all C^s together or in the order of 1,2,3,4,5 etc. The Long term memory can hold information for days, for weeks, for months, for years or for life time.

In the words of Mbunda (2012), it is a fact that our memory (LTM) has a tremendous capacity for encoding information. But then, how do we know that something at all is in our memory. This is done by measuring retention. According to Zacky and Young (2013) we measure retention through:

Recognition, Recall and Relearning

In recognition a correct answer within other answers is presented to a subject (a person) who is expected to recognize and select the correct answer among the available.

In recall subjects or respondents are not presented with any answers at all, whether right or wrong. They are expected to supply the answers.

While in relearning if a subject is to relearn already learned materials, he is expected to relearn this same material using lesser time than when he first learned it. The time saved (saving time) is result of practice effect. It is measured thus:

$$\text{Saving Time} = \frac{\text{Original Learning Time} - \text{Relearning Time}}{\text{Original Learning Time}} \times 100$$

The retention here is the time saved in relearning. Kofi (2012) added a fourth one as reproduction. He explained reproduction as a measure of learning (retention) that involves remembering accurately in order to recall verbatim.

Kofi further explained that retrieval fit is possible because it is aided by retrieval cues. The cues play the role of reminders. For example, chair could be a retrieval cue for table, soldier a retrieval cue for war, husband for wife and rice for stew. Ohanusi (2011) submitted that the retrieval cue or reminder to be effective, it should be coded with the learned material at the point of learning. This approach he described as “encoding specificity principle.” It should be noted that people tend to provide their own retrieval cues even when non is readily available.

Another submission by Kuntu and Pedro (2013) say retrieval is possible through “tagging” and “cueing.” This theory, - generation, recognition or tagging theory – says a tag is giving to an item to be remembered at the time it is being encoded for storage in LTM. The retrieval process starts with a cue. This cue makes us to generate a search for the tagged item through the portion of memory to which we have been directed by the cue. The ALAT used to measure retention in this study perfectly combines the recognition, recall and reproduction techniques expounded above.

Undoubtedly, what is not retained is forgotten. It follows therefore, that we cannot not explain retention fully without the mention of forgetting.

Curve of Forgetting

Bell and Thompson (2012) concluded that the general pattern of loss of retention is that greatest loss do occur immediately after acquisition, with the rate of loss diminishing after that. This has come to be known as curve of forgetting.

The figure below amply illustrates this.

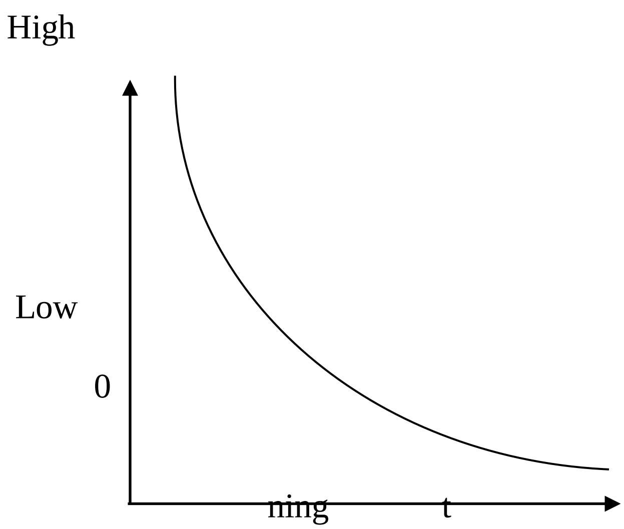

Figure 2:Herman Ebbinghaus Curve of Forgetting model.

On Problems in Retention, Bell and Thompson (2012) wrote that two major problems exist concerning our effort to retrieve learned materials from long term memory. They are:

Tip-of-the-tongue phenomenon and Confabulation

These two problems make retrieval difficult.

In Tip-of-the-Tongue Phenomenon sometimes we try to remember something e.g. a name. We have such names at the tip of the tongue but not in the memory. The name keeps going back. We may sometimes remember the starting alphabets Fa……….. something or sometimes the sound of the name. This is what Bell and Thompson described as the tip-of-the-tongue phenomenon.

They explained that confabulation**:** Is due to over-excitement or high motivation to remember something. In the process we excitedly manufacture a report that seems appropriate and we tend to believe it to be true, whereas it is false or wrong. Confabulation is therefore facts mixed with fictions which is believed to be true. Everyone confabulates to some extent. We have the ability to close gaps in perceptual situations. Therefore, we simply get few key features and fill in the rest. These two problems of retention discussed above, (Tip of the tongue phenomenon and confabulation) are very vital especially in the design of the CAL modes used in this study. This is because the major interest of this study was to proffer solutions to problems of retention, that is, finding out ways of improving retention or memory.

CHAPTER EIGHT

PARTING WORDS

Mathematics educators, Computer Aided Instruction (CAI) designers and secondary school students have veritable lessons to learn from the highlights of this monograph. To the mathematics educators, the findings imply that teaching mathematics is not just transmitting an immutable body of knowledge that students have to accept as a perennial fact without any reasoning.

Mathematics educators should bear in mind that it is often possible for learners to learn the 'how' (that is procedures) mechanically without understanding 'why' it works (that is concept and knowledge). Procedures learnt this way are often forgotten easily. Conceptual and procedural understanding actually help each other. Conceptual knowledge is important for the development of procedural fluency. While fluent procedural knowledge, supports the development of further conceptual understanding. The findings of this study show that Computer Aided Instruction in Mathematics can facilitate both conceptual and procedural understanding when properly utilized.

To Computer Aided Instruction designers the highlights made in this study and the conflicting results of reviewed empirical studies imply that well designed CAI mode's have the potentials to promote students' achievement, interest and retention in mathematics. Hence, designers should bear in mind that the arousal features of CAIs need not overshadow the intended lessons.   CAI modes should be designed as simple as possible. Hence, with minimum computer literacy or proficiency, a mathematics teacher can use it to teach profitably.

Adequate provisions (both financial and human) must be made to ensure that students are taught algebra with CAIs. This is because the CAI mode, as a constructivist process, is a student-centered mode. In student-centered modes, generally, the students are in charge. The teacher offers minimal guides and allows the students to construct their own understanding by seeing relationships between incoming information and their previous knowledge. Students thus, determine their own knowledge based on their own way of processing information and according to his or her own beliefs and attitudes towards learning. From the foregoing, students taught mathematics with CAIs are expected to develop skills for in-depth analysis of any given problem. These skills will enable them think reflectively, creatively and productively. Since CAI mode is student-centered, it implies that if the process fails, students should bear commensurate blames.

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