USING ANIMATION TO ENHANCE LEARNING: A CASE STUDY ON PRIMARY SCHOOL MATHEMATICS

MELISA ACHOKO ALLELA

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University of Nairobi

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DECLARATION

I declare that this project entitled **"Using animation to Enhance Learning: A Case Study on Primary School Mathematics "** is my own work and to the best of my knowledge has not been presented to any other university for a degree or any other certificate.

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

MELISA ACHOKO ALLELA

B51/65020/2013

School of the Arts and Design, University of Nairobi

This research project has been submitted for examination with my approval as University Supervisor.

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

MR. MURIITHI KINYUA

School of the Arts and Design, University of Nairobi

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ABSTRACT

This project sought to develop an educational animation targeted at children ages 7-11, to evaluate its effectiveness in supporting teaching and learning of Mathematics. It was presumed that such animation can develop learners skills and competencies in understanding mathematics based problems through; storytelling, visual communication, cognition, emotion, observation and problem solving when the medium of instruction appeals to them and is both socially and culturally meaningful. According to Piagetian theories on cognitive development, children at this stage are at a 'Concrete Operational Stage', during which they learn better when more of their senses (seeing, hearing, touching, smelling and tasting) are being triggered.

A review of relevant literature revealed that there exist various animation production techniques and explored in great detail, the techniques involved in digital cut-out animation. This also yielded examples of children's shows produced using this technique, as well as the formal features and principles of animation employed therein. It also exposed the three main components of creating culturally relevant content in children's animation; language, social relevance and visual design and puts into context learning theories that cover child development psychology to provide information on the cognitive processing of visual information as relating to children and children's animation.

In the experimental design, three measures were used to evaluate the effectiveness of the animation. They include; comprehension, enjoyment assessment and socially contingent behavior. 120 children from two public and one private primary school participated in the study and were all exposed to the treatment variable after which, each was provided with a questionnaire that sought to measure their levels of compression and skill acquisition. An analysis of the ensuing data revealed that there was a statistically significant difference between the mean scores of the baseline and the post-test results at 95.0% confidence level. This therefore implies that pupils were able to able to learn from the animation.

CHAPTER 1: INTRODUCTION

1.1. Background of the Study

While Kenya has a literacy rate of 85.1 per cent, one of the highest in Africa (OECD), national literacy assessments reveal that "more children have not acquired basic competencies in literacy and numeracy after two years of primary school education" (UWEZO, 2010). Inquiry on why candidates perform poorly in Mathematics during national examinations also reveals that students find it difficult to handle questions that require higher thinking abilities: questions that involve problem solving, evaluation and application. A sample case is the difficulty experienced by primary school children in understanding money concepts where basic arithmetic principles prove challenging in their study. Cognitive obstacles such as coin size and colour, coin-cent relationship, cents as a fraction of a shilling, etc, tend to come up, making the overall process of teaching money concepts a challenge. The problem – of learning money concepts and studying mathematics in general – is further compounded by overcrowded classrooms, high teacher-student ratios and the lack of adequate learning materials.

Consequently, new policies have emerged from the Education pillar of Kenya's economic blue print, Vision 2030, to facilitate transition into a knowledge based economy. This is because, numeracy and literacy are considered "critical for any form of development" (Miheso, 2005). These strategies seek to reduce illiteracy by "increasing access to education, improving the transition rate from primary to secondary schools and raising the quality and relevance of education (Education pillar, Kenya Vision 2030). They afford many opportunities to improve the quality of primary education. Amongst the inputs being considered by the Kenya ministry of education to engage students in "modern forms of knowledge acquisition and participation" (Kenya ministry of education Report, 2012), include the provision of ICT based teaching and learning materials. Though initially met with skepticism on its potential to improve learning, technology in education has been championed by efforts to help educators realize the benefits of technology and ways of implementing them in the classroom (Geer, 2012). Learning trends show an increased use of ICT-facilitated learning materials such as educational animations, accessible on computers and mobile devices. Currently this is met by two setbacks: (i) the devices do not come pre-packaged with relevant animated and multimedia learning content and (ii) there is a shortage of locally produced animated mathematics content and although the internet has a massive array of open educational resources, they are seldom attuned to the Kenyan primary school students' curriculum needs.

For the potential of ICTs to be fully realized in improving learning, it is vital that they be applied with great sensitivity to local knowledge. As noted by Pontefract (2003), their usage must be tied to the specific needs of the country and community in question. This view supports the growing discontent with the 'one size fits all' approach of using imported resources that seldom match curriculum content and the learners' local and cultural reality. Similarly, in the EduTech World Bank blog on ICT use in education, Michael Trucano (2010) explores the inefficiency of using educational content designed for a global audience. Hence, within the context of using animation as a learning tool, this alludes to the significance of integration of content, aesthetic values and formal features in animation that function to ensure visual communication and facilitate learning and understanding of the material within a cultural milieu (curriculum, language and culture).

1.2. Problem Statement

Animation provides a medium that can combine both description and exposition in a narrative story, "visualize dynamic phenomenon that is not easily perceptible, impossible to realize in practice or is inherently visual and can enhance a learner's understanding of both concrete and abstract concepts" (Betrancourt & Chassot, 1977). According to Wilburne, Napoli, Keat, Dile, Trout, and Decker (2007), Bickmore-Brand (1993) teaching mathematics through narrative stories plays an important role in helping students comprehend, generate ideas and imagine a concrete situation that reflects the process and products of mathematics. However, adequate research on the use of digital cutout animation as a production technique to create learning materials for children ages 7-11, and its ability to relay the tacit aesthetic of Kenyan culture is scarce. Also, not much research has been conducted to investigate its potential for cognitive enrichment in learning logical-mathematical tasks amongst Kenyan Primary School children within this age range.

1.3. Objectives of the Study

The **main** objective of this research is to **create and evaluate the effectiveness of an educational animation** for a standard two mathematics topic using culturally relevant content as a strategy for cognitive enrichment amongst Kenyan primary school children.

The following specific objectives shall help attain the overall objective:

1. Explore production design considerations involved in the development of effective animated materials for learning.
2. Develop an educational animation using cut-out animation production techniques and create a methodological model for the creation of culturally relevant and socially meaningful educational animation.
3. Illustrate the cognitive effects of animated learning materials used in a mathematics classroom (Enabling, Facilitating and Inhibiting)

1.4. Research Questions

This research project proposes to make a needed contribution to the design and cognitive implication of using culturally relevant animated mathematics learning materials amongst Kenyan primary school children. The proposed investigation will try to answer the following questions:

1. What design factors are taken into consideration in the development of effective animated learning materials targeted at Kenyan primary school children?
2. What is the production process for development of a children's educational animation using digital cut-out techniques?
3. What are the cognitive implications of animated learning materials as used in a mathematics classroom setting?

1.5. Research Hypotheses

By using culturally relevant animations, this study proposed that learners could develop skills and competencies in understanding mathematics concepts through storytelling, visual communication, cognition, emotional aspects, observation and problem solving when all these elements are socially and culturally meaningful. The following research hypothesis guided the review of the relationships between the variables in the study:

> H_A: Pupils in the treatment group **will increase their effective use of mathematics process skills** (after viewing animation that address curriculum based content, address learner characteristics, contain cultural determinants and story content derived from familiar real world experiences) at a significantly higher level than the control group.

Independent Variables included the treatment variable, the animation generated for this investigation, participant's attitudes, and personal characteristics e.g. Gender, age and participants' prior knowledge. Dependent Variables included the participants' newly acquired conceptual understanding of mathematics based on cognitive outcome measures (Comprehension scores) and viewing behaviour.

1.6. Justification

A study on the use of cut-out animation to enhance 7-11 year old children's understanding of mathematics may be important for several reasons. First, children in this age range are in what Jean Piaget positions as the *Concrete Operational* stage during which a child is able to think logically about concrete events but only using practical aids and less abstract/naturalistic representations of objects or manipulatives. Hence, understanding the learner's capacity to process the animated information can help reveal the formal (production) features in media that facilitate learning as well as the cognitive processes involved in understanding a visual medium. Such knowledge informs the design and creation of animated learning materials intended for developing learners' conceptual understanding and computational fluency. This would therefore assist content creators (animators, graphic designers, instructional designers and educators) in developing effective educational animations.

Secondly, as the Kenyan Government seeks to implement policies to build practical competencies in using print and electronic media as a creative learning resource for creating teaching and learning materials, it is important to know in great detail the implication of using culturally relevant educational animation and socially meaningful animated characters with Kenyan primary school children; and its potential to positively impact multimedia learning. Finally, the outcomes of this study adds to the growing body of research on learning mathematics with animation and learning in general, by illustrating the use of an animation production technique in relaying a culturally relevant visual aesthetic for curriculum based content to address gaps in conceptual mathematics understanding.

1.7. Delimitations

This study was delimited to interviewing and observing 120 children aged 7-11 at class two levels, derived randomly from a pool of the entire population of three schools, Victoria Primary school, Kisumu (Public), Migosi Primary School, Kisumu (Private) and Highway Primary School, Kisumu (Public). The study was also confined to K.I.E approved content for the Class two mathematics topic on Money, the animation generated and the experimental design constructed to test the stated hypothesis.

1.8. Limitations

1. The time and financial resources available for this study were limited; hence even though every effort was made to cover the key elements of the research problem, it was not possible to cover each and every aspect of issues in the field of designing educational multimedia based learning materials.
2. A sampling unit in the field was substituted to avoid skewed data distribution.
3. There are several interrelated and inter-dependent factors which affect learning outcomes and their interaction was not sufficiently captured. These included; physical infrastructure, school books and other didactic material, classroom population, family economic status, teacher quality amongst others.

1.9. Assumptions

The general assumption was that animation can be used to address gaps in conceptual understanding of the Mathematics topic *Money* as taught in the standard two curriculum. In addition to this were the following underlying assumptions:

i. The participants in the study had already covered to topic *Money* with their teachers during traditional classroom instruction.
ii. Participants in the study experienced difficulty in calculating money related arithmetic due to a lack of conceptual understanding of the topic.
iii. The participants in the study were familiar with Kenyan currency as taught in the standard two curriculum.
iv. That parental consent for participants and permissions from relevant authority would be granted to the researcher.

CHAPTER TWO: LITERATURE REVIEW

2.1. OVERVIEW

This section details the literature review and project methodology that provided the researcher with a framework for the development of the animation used in this study. To begin with, the review provides a brief history of animation in Kenya, given that Kenyan Animation is much influenced by animation from foreign animation studios such as Walt Disney and Pixar. Secondly, it also provides an overview on various animation production techniques and the key production processes involved. This section also explores in great detail, the techniques involved in digital cut-out animation and provides examples of children's shows produced using this technique, as well as the formal features and principles of animation employed therein. Thirdly, it will expose the three main components of creating culturally relevant content in children's animation; language, social relevance and visual design. Lastly, it puts into context learning theories that cover child development psychology that provide information on the cognitive processing of visual information as relating to children and children's animation.

2.2. STATE OF CHILDREN'S ANIMATION IN KENYA

Although the history of animation can be traced back to Paleolithic cave paintings drawn in an overlapping manner to suggest movement(Thomas, 1958) and images depicting motion found on the surface of ancient artifacts from Egypt and Iran, it was only in the early twentieth century, during the advent of film and motion picture camera, that animators like James Stuart Blackton, Emile Cohl(Courtet),and Winsor McCay amongst others, transformed animation into a modern entertainment media. The work they created such as Blackton's *Humorous Phases of Funny Faces*(1906),*Fastasmagorie* by Cohl and McCay's*Gertie the Dinosour*, defined a new art form that inspired later animators to capture the elusive spark of life(Frank & Johnstone, 1981) and relay pragmatism in character animation, acting and cinematic composition. Generally, the animation history of non-western, non-European countries such as Japan, India, China, and most African nations were greatly influenced by the resulting western animation techniques and innovations, with varying and distinct national styles.

According to UNESCO (2005), Africa is still a receptacle for foreign children's animation programmes in spite of having "great creativity, stories to tell and a magnificent sense of aesthetics". It is therefore not uncommon to see a large dominance of foreign-made programming on the local channels even though the Ministry of Information and Communications called for a larger proportion of content to be local (Maina, 2006). Children's animation showing on major Kenyan television stations originate from American, European and South African studios such as Cartoon Network, Morula Pictures, Walt Disney Animation, Pixar, DreamWorks and Time Warner. This apparent incongruity is necessitated by the high costs of local production and also partly by audience preference. However, there have been few initiatives in the production of children's animated cartoons in the Kenya:

i. UNICEF: Sara Communication Initiative

The Sara Communication Initiative was a multimedia project that produced five animated films, in collaboration with UNICEF and PEPFAR. The animated films and comic books were infused with elements of cultural relevant real life situations and drama, blended with serious messages that aimed at imparting educational content in unique and entertaining ways. The main character was a young girl called Sara, an adolescent girl living in peri-urban Africa tackling socio cultural and economic challenges common to many girls her age. "Sara's ability to negotiate and persuade and her determination never to give up, even in desperate situations, make her a dynamic role model for girls; she inspires self-esteem and models the life skills essential for empowerment. Rather than being presented as a victim, evoking pity and sympathy, Sara emphasizes girls' potential" (Mwagoro, 2007).

ii. UNESCO: Africa Animated! (2004 -2007)

UNESCO launched the *Africa Animated!* initiative in 2004 to help "assemble resources and expertise for the production of children's animated cartoons in Africa"(UNESCO). *Africa Animated!* commenced in 2004 with a series of five-week long hands on training workshops in animation in 2004, 2005 and 2006 (UNESCO). The training was a success in growing local talent with exemplary productions that are rich in African imagery, dialogue and music such as Alfred Muchilwa's *Toto's Jouney*. Several other animations are available on the UNESCO website. The workshop series, which ended in 2007, targeted regional animators, visual artists, scriptwriters, broadcasters and other media professionals with the objective to build a critical skills base for the production of high quality animated cartoons. *Africa Animated!* sought to encourage the production of programmes that allow children and young people to "hear, see and express themselves while reflecting the regional culture, language and life experiences".

iii. TingaTinga Tales (2008-2010)

According to TigerAspect's (2008) Claudia Lloyd, the creation of *TingaTinga* tales was inspired by the visual aesthetics of paintings by *TingaTinga* artists at Morogoro stores in Tanzania, working in a painting technique originated by Edward S. Tingatinga that she perceived as suitable for creating a stylized look for animal folk stories. The production studio, TigerTinga Productions, which was to be set up in Dar es Salaam, but was eventually based in Nairobi's Homeboyz Studio; which housed a small production team that comprised of the producer, three directors, character designers, animators, tingatinga painters and video editors.

In 2005, a 10 minute pilot was created by a smaller team of Kenyan animators under the supervision of animators from Tiger Aspect which successfully pitched to CBeebies and the Disney Playhouse that eventually defined the ensuing 52 series produced between 2008 and 2010. The 52 eleven minute animated episodes that are currently being broadcast internationally on the Disney channel and BBC's CBeebies channel, have been cited as a great achievement in animation in Kenya and a significant milestone in African animation.

2.3. ANIMATION PRODUCTION TECHNIQUES

Animation production techniques are often classified differently by different people but fall into two broad categories; 2 Dimensional Production techniques (2D) and 3 Dimensional Production techniques (3D). They include:

i. **Cel animation:** Popularly known as Traditional animation or Hand-drawn animation, cel animation is a technique that involves drawing individual frames on paper and altering the drawings in a sequence to create an illusion of movement. These drawings are then traced over onto transparent acetate or celluloid sheets called cels that are eventually painted in assigned tones on the side opposite the line drawings. A motion picture camera called rostrum camera, is then used to photograph the cels one by one against a painted background.

   This technique was used widely in the 20th century but has since become obsolete with the emergence of new technologies in the 1980s that provided means for faster production. Studios that dominated animation at this time such as the Walt Disney Studios, which had predominantly used Cel animation in films such as *Little Mermaid*, moved to new computerized systems that allowed the animators to scan the line art and colour them digitally in computer software programs that could also simulate camera movement and effects. Variations of this technique include full animation using detailed realistic drawings, limited animation using less detailed and more stylized drawings, rotoscoping in which an animator traces over recorded live action movement and live action animation in which hand drawn animation is combined with live action sequences.

ii. **Stop Motion:** Refers to creating animation by physically moving real word physical objects and photographing them frame by frame to create an illusion of movement. It is a technique that developed in Europe and amongst independent artist running on extremely limited budgets looking for alternative production techniques that differed from the mainstream and often expensive celanimation process. Variations of this technique are often based on the type of media used to create them including present day software programs used to facilitate their production. Examples include puppet animation involving puppet figures interacting in a constructed environment; clay animation where figures are made of plasticine or clay and morphed to create different shapes or manipulated to get different poses; Cut-out animation, involving cutting and moving flat shapes in small steps while taking a picture of each step and eventually playing out all steps to show movement over time; silhouette animation, using cutout figures animated against a backlit stage; model animation, where stop motion characters are incorporated into a live action world and Pixilation, where human actors are the stop motion characters.

iii. **Computer Animation:** This is broad term used to categories a number of techniques created digitally using computer software programs. These techniques are loosely referred to as either Two Dimensional (2D) animation where animations are created using computerized versions of traditional animation and stop motion techniques in 2D bitmap of vector software; or Three Dimensional (3D) animation, a digital version of stop motion animation where objects (models) are built (modeled) in a software program such as 3d max and then fitted (rigged) with a virtual skeleton for virtual manipulation. A variation of computer animation, which is becoming increasingly popular, is motion capture which entails using live action actors wearing suits that are fitted with motion sensors that allow computers to copy their movements into Computer generated onscreen characters.

2.4. ANIMATION PRODUCTION PROCESSES

According to Wells (Wells, 2002), the processes involved in making an animated film depends on the technique being used. He further explores three key factors that influence the production process: the studio producing the animation, the budget and the broadcast context. Generally, the production process is made up of three distinct stages, pre-production, production and post-production with a number of activities taking place at each stage; nevertheless, significant differences exist between, for instance, the production of "puppet" animation and cel animation, or between clay animation and computer generated animation.

Pre-Production starts with a concept or, an idea that asks the questions whose answers are sought in the animated form. "The initial idea may be a desire to tell a particular story; the need to address a particular theme or topic; the imperative to test the parameters of art making for its sake; the urge to provoke" (Wells, 2002). Once the idea is determined, an iteration stage composed of research, script[1] writing, planning, design, audio recording and storyboarding[2] follows suit. At this stage, the production style is determined and acts a basis for the visual design or look of the animation. A model sheet is generated for each character in the animation, detailing the characters looks in different profiles. This is referred to as character design and conforms to the production style. Sometimes the character design may be required to conform to

[1] Script refers to the written version of a project that contains the storyline, location, descriptions, actions, dialogue, sound effects e.t.c that contains all the information for artists to illustrate and animate.
[2]A Storyboard is a visual representation of the script.

the visual design style of a particular studio such as the distinct appearance defined by Walt Disney studio in its “Golden Era” from 1928 -1941 and the stylized look in anime from most Japanese studios.

A storyboard is also common in most pre-production processes and provides the visual representation of all the scenes and actions contained in the script, dialogue, background, action notes and characters in various scenes. When audio recording accompanies the storyboard, it is referred to as an animatic (or leica) and serves to perfect the pace and timing of the animation “see if all elements work together and to eliminate errors before the sequence goes to its final stage” (Wells, 2002). Sometimes the animatic is left out when it is clear from the storyboard that the timing works well. Interestingly, some children’s animation end here at the creation of a detailed colour animatic giving the appearance of limited animation. When work proceeds beyond this level, the production team including the producer, art director, layout artist, production designer and editor, approve the sequences of the animatic recommending changes where necessary and arranging the scenes in their correct sequence for full animation in the ensuing production stage.

The production stage has the least number of activities but may take the longest time to complete since it is here that actual animation takes place. Common practice in animation production is to provide animators with scenes that have already been laid out which include the backgrounds, audio, characters that they will use in the already timed out scene. Animators will often refer to the animatic and storyboard to keep in line with the description contained therein.

Post-Production, the last stage in the production process entails adding effects required for particular scenes such as tones, highlights and shadows.

Thus, as already mentioned, though the techniques vary, the results end up reflecting the intent of the producers.

Digital Cutout Animation

Celanimation, which was the distinct technique that emerged during the era of motion picture films in the 1890s, birthed a new medium of expression of hand drawn images displayed over a sequence over time to create an illusion on movement. In the Celanimation process, animators created animations by drawing and coloring a series of images on transparent layers of celluloid. Static objects could be reused while characters had to be redrawn over and over to create movement at 24 frames per second. This Cel and Paper animation technique was popularized by North American Studios such as the Walt Disney Studios where an assembly-line style of work, involving a whole line of persons working on very specific and simple repetitive duties, was favoured.

At the same time, in Europe and amongst independent artist running on extremely limited budgets, other production techniques that differed from the mainstream processes were preferred. The experimental works of film makers such as J. Stuart Blackton in his film *Humorous faces of funny people* employed the novel cut-out animation technique having discovered that it was much easier to use cut-out than to redraw a figure frame by frame. Cut-out animation become more popular amongst film makers as shown in the steep incline of films that used this technique to produce either the entire film or merged with live actors. *The Adventures of Prince Achmed*, created by German animator Lotte Herzens, is often credited as the first full-length cut-out animation film.

During the early 1980s with the emergence of new technologies providing ways for faster production, Studios quickly adapted to new digital systems of production using computers and the word traditional was now appended to animation techniques that still used cel animation methods. At the same time, with new production tools such as cameras, scanners, computers and animation software influencing traditional cel animation, 'traditional' cutout animation morphed into a kind of digital puppetry. Before this, cutout-style animation involved cutting and moving flat shapes in small steps while taking a picture of each step and eventually playing out all steps to show movement over time. Computers running programmes specifically designed to produce cutout animation, enhanced the technique which was hitherto tedious and time consuming, to allow the production of more professional work on minimal budgets and with very small teams through the procedures of motion tween and symbols.

2.4.1. Children's Animation produced using Digital-Cut out animation

i. Blues Clues

Blues Clues, which was the first cutout animation series for preschoolers produced by Nickelodeon's digital studio, used Macintosh computers running Adobe Photoshop and Adobe After Effects to simulate construction paper and simulated textures in making a visual design that was integral to the appeal of children who would be watching the show.

ii. Charlie and Lola

The Children's show Charlie and Lola is an entertaining educational programme based on a children's picture book by Laura Child and revolves around the daily life of the two main characters, Charlie and Lola, aged 7 and 4 (almost five) respectively, three supporting characters, Marv, Lota and Soren who are their friends and a few other background characters. Interestingly, and akin to several others children's animation, Charlie and Lola's parents, as well as their friends' parents, are often mentioned, but never seen. The show is aimed at three to seven-year-olds, is voiced by children and revels in their language but most significantly, it maintained the same childlike visual design initially used in the books that had a strong appeal to children (TigerAspect). Thus, in order to accurately carry across this distinctive illustration style, the show's producers settled for a collage style of animation consisting of 2D cel animation, paper cutout, fabric design, real textures, photomontage, and film archive footage that were eventually put together and animated in a software application called CelAction (TigerAspect).

iii. TingaTinga Tales

TingaTinga tales, already discussed in the section on Kenyan produced animation, is a 52 episode, eleven minute long children's TV series made entirely using digital cutout animation techniques. In order to relay the visual style of the ornate *TingaTinga* art from Tanzania, the show's producers having also worked on the aforementioned *Charlie and Lola* children's series, settled for Cutout animation production techniques where the artwork (character design, props and backgrounds) were scanned into a photo editing software and eventually animated in the cutout animation software called Celaction. In addition, the decision to employ this kind of production technique was also largely influenced by the fact that although the team of animators from Kenya had the requisite skills in animation production, only a few had experience in full feature animation production. A one month training course was necessitated to enable the animators conform to the studio style bringing the entire production time to just under two years.

Other software such as ToonBoom Animate, ToonBoom Studio and open source alternatives such as Creatoon and MonkeyJam, are now available to enable independent animators and amateurs alike create animation using this technique.

2.4.2. Formal Features in Production

In addition to production process, the success of cutout animation technique for instructional purposes relies heavily on the use of visual and auditory production features, known as formal features, that can readily be used to instruct and teach children even as they are being entertained (Calvert, 1999). At a macro level, they include action (physical movement) and pace (rate of scene or character change) while at a micro level they include visual camera techniques and special effects. In addition, at a micro-auditory level are elements such as sound effects, character vocalization, non-speech sounds, foreground and background music, narration and dialogue all of which vary in perceptual salience i.e. ability to capture attention, and stimulus properties i.e. ability to trigger a reaction. In a study conducted by PBS Kids to investigate the elements of effective education TV for the Ready to Learn Programme, it emerged that the child focused formal features that appeared most effective in motivating children included the use of bright colours, lively music, goofy characters and repetition of activities.

2.4.3. Principles of Animation Applied to Digital Cut-Out Animation

Most of the traditional principles of animation were developed in the 1930s by animators at the Walt Disney studios(Frank & Johnstone, 1981)and continue to offer a basis for remediation in emerging production techniques. For instance, early research in 2D computer animation attempted to apply the celanimation process on paper by adopting techniques such as storyboarding, keyframe animation and pans(Lasseter, 1987). In a paper presented to SIGGRAPH in 1987, exploring principles of traditional animation applied to 3D computer animation, Lasster argues that the main reasons for the production of 'bad' computer animation at that time, and even today, was due to the animator's unfamiliarity with fundamental animation principles that had been used in tradition animation. These principles are:

1. **Squash and Stretch:** Considered the most important principle (Frank & Johnstone, 1981), it refers to defining the rigidity and mass of an object by distorting its shape during an action (Lasseter, 1987) to give a sense of weight.

2. **Anticipation:** This is the preparation of an audience for action using a planned sequence of actions that make the resulting action appear realistic. To achieve surprise, anticipation is often reversed ‘surprise gig’.
3. **Staging:** Johnson and Thomas (1981) define staging as "the presentation of any idea so that it is completely and unmistakably clear". It is a borrowed concept from theatre and serves to direct the audience's attention, and make it clear what is of greatest importance in a scene; what is happening, and what is about to happen (Lightfoot).
4. **Straight ahead action and pose to pose:** These two are different approaches to creating movement. "Straight ahead action" refers to animating a scene frame by frame from beginning to end, while "pose to pose" involves starting with poses/key frames, and then filling in the intervals later. A combination of these two is often used in digital cut-out animation whereby the key poses are created by the animator and the computer software automatically fills in the missing sequence.
5. **Follow through and overlapping action:** Are two closely related techniques used to depict movement more realistically by giving the impression that characters follow the laws of physics. Similar to Newtonian Laws of motion, "Follow through" means that separate parts of a body will continue moving after the character has stopped. "Overlapping action" on the other hand, is the tendency for parts of the body to move at different rates (an arm will move on different timing of the head and so on).
6. **Slow in and slow out:** Also referred to as ease-in and ease-out, this principle refers to the acceleration and deceleration of moving objects and parts. The spacing of in-between frames (drawings) defines the timing of the animation.

7. **Arcs:** The implied path of action followed for natural movement. Examples are a limb moving by rotating a joint, or a thrown object moving along a parabolic trajectory.
8. **Secondary action:** This refers to adding actions to the main action that helps to both support the action it and make it look more realistic. They serve to emphasize, rather than take attention away from the main action.
9. **Timing:** refers to spacing actions by determining the number of drawings or frames for a given action, which translates to the speed of the action on film (Lightfoot) and define the weight, size and personality of character as well as mood, emotion, and reaction.
10. **Exaggeration:** This refers to accentuating the essence of an action(Lasseter, 1987)
11. **Solid drawing:** This refers to depicting volume and weight by taking into account the appearance of forms in three dimensional space. It requires an understanding of three-dimensional shapes, anatomy, weight, balance, lighting and shadow.
12. **Appeal:** Refers to creating a design or an action that the audience enjoys watching. In explaining the concept of appeal, Preston Blair (1985) explores various character design construction formulas that have come to be distinctively referred to as 'cute', 'dopey', 'screwball type', 'pugnacious type' amongst others.

2.5. CULTURALLY RELEVANT CONTENT

According to UNESCO, culture refers to a "set of distinctive spiritual, material, intellectual and emotional features of society or a social group", and that it encompasses, in "addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs." This definition, although broad as merits a political institution and intended to satisfy member states, implies that culture is a summation of all human endeavor. Thus, the culture of a particular social group can be based on demographic characteristics including language, age and ethnicity. When narrowed down to children, this also entails children's media, artifacts and literature that abound around the notion of childhood (University of Gothenburg).

Since the advent of film and television, the creation of content that is culturally relevant to children is still an ongoing discourse that has spurred numerous studies on remediation of television content to "stimulate the intellectual and cultural growth" in children (Cooney, 1967). For instance children's animated series such as *Dora the Explorer, Blues Clues*, animated segments in *Knowzone* have been used successfully to deliver culturally-relevant and engaging content that develops students' conceptual thinking; with research indicating that these shows benefited children's attitudes towards learning, improve school readiness, boost children's feelings of academic competency (Sesame Workshop) and improve comprehension (Mediae Report, 2008-9. In research finding from these children's animations, three main cultural referents emerge: Language, Social Relevance and Visual design (costume and scenery).

2.5.1. Language

Sociolinguistic research on performance of language in formal settings such as animated films, indicate that such discourse differs significantly from day-to-day speech (Coupland, 2007). This is because a formal performance seeks to express a purpose and meaning. In the production process discussed earlier, the script writing pre-empts the tone of the ensuing sound recording session. It is here that the language used is carefully styled to achieve the desired effect. Language in this sense encompasses dialect and accent.

Githiora (cited from Gacheche 2010), observes that Kenya is a multilingual and multiethnic country with an estimated population of 40 million people who speak about 50 -70 languages and dialects. In Kenya, the use of dialects as an aid is characterization is common in locally produced television series such as *Papa Shirandula* and in most stand-up comedy showssuch as *Kenya Kona* where the dialects carry with them clear and identifiable social meanings that are linked to societal stereotypes of their speakers and are a potential resource for quickly enhancing a character's portrayal with additional meaning. Similarly, locally produced children's series including *TingaTinga tales,* animated segments in *Junction Junior* and UNESCOs *Sara,* are laden with linguistic variations and accents that aid in the characterization.

Lippi Green's (1997) account of linguistic variations and accents in children's animated films from the Walt Disney studios, alludes to the fact that since there is often inadequate time to build characters through action, stereotypical accents associated with a particular group are often used. Such accents heighten social meaning and further understanding of character's personalities.

However, in selecting the language of choice as a strategy for culturally relevant animated content for children, there lies a challenge in which language to use. To mitigate the negative impact of Language submersion[3] and rote learning as a result, Language in Education (LiE) policies were implemented in the Kenyan primary school curriculum in 1978 to create learning materials that are contextually located and locally accessible. The intent of these policies was to conduct instruction in a language a child specks most at home and understand well enough to understand academic content through. In spite of this, there is still as high preference in using English over mother toungue based instruction. It has been argued that this would only work effectively in ethnically homogenous school and would require increasing the lexical capacity on indigenous languages to express the realities of modern science and technology (Gacheche, 2010) in order to be effective for classroom instruction.

[3]Language submersion refers to a system where instruction is carried out in a language children do not speak. It is referred to as submersion, as it is comparable to forcibly holding a child under water (Skutnabb-Kangas 2000, cited in (Gacheche, 2010)).

Local language strategies employed in classrooms that also permeate entertainment media in Kenya include code switching and the use of hybrid codes. Code switching refers to teachers and students using a different language to facilitate communication while hybrid codes refer to 'nativised' versions of official language such as *sheng*[4] *(Cheki mtuwangz - Look my here friend)*and *Engsh*[5]*(Did you ambia Cele where we are endaring?- Did you tell Cele where we were going?)*. There is however a growing concern on the use of such local strategies by proponents who insist that when using language, no concessions should be made for the learners proficiency. This is contrary to studies that show that people learn best when they are taught or addressed in a language they understand well (Summer Institute of Linguistics).

2.5.2. Social Relevance

In a study conducted in 1969 by the producers of the childrens' show *Sesame Street*, segments of the show that contained non-human characters called *Muppets* were found to score higher than human only segments. This early success of the *Muppet* segment as effective teaching tools for children, contrary to the advice of child psychologists who warned that children would be confused if human actors and Muppets were shown together, was attributed to children's ability to easily recognize them, since they (the Muppets) were stereotypical and predictable, and appealed to adults as well as older siblings (Morrow, 2002) - in short, they were socially relevant.

Krcmar (2010) considers social relevancy as composed of two concepts: social meaningfulness and social contingency. Both have been found to be important in Children's

[4]*Sheng* is a mixed language that is principally used among the youth, that it is based on Swahili grammar but uses resources from other Kenyan languages to create a dynamic, mixed code.(Githiora, 2002)
[5]*Engsh* has English as the dominant language, which also provide most of the grammatical framework within which words from other language are blended. Abdulaziz&Osinde 1997: (Ogechi)

learning through animation and other entertainment media since they play an integral role on the viewer's willingness to accept information (Moyer-Guse, 2008).

Socially meaningful characters in media evoke a sense of familiarity as a result of an established parasocial relationship, a one-way emotional attachment that develops between an audience member and a media character that the audience seeks guidance from and perceive to be part of their social world (Horton & Wohl, 1956). In children's' animation, parasocial relationships are established through identification, perceived similarity and parasocial interactions with the animated character.

Identification in this sense is defined as an emotional and cognitive process whereby a viewer takes on the role of a character in a narrative, temporarily forgets his or her own reality by temporarily becoming the character, taking on the character's perspective (Cohen, 2001). It involves: empathy (ability to share feelings with a character); cognition (sharing the character's perspective); motivation (internalizing the character's goals); and absorption (the loss of self-awareness during exposure; Cohen, 2001). Perceived similarity also referred to as homophily, is the tendency of individuals to associate and bond with similar other. Such a similarity can be attributed to age, gender, physical attributes, demographic variables, beliefs, personality and value, and is regarded as an essential requirement for identification.

Social contingency is the other aspect of social relevancy. Horton and Wohl (1956) defined a situation in which the audience members respond in some fashion to the actions and verbalizations made by the media character as a socially contingent parasocial interaction characterized by the causal engagement behavior with one another. For example, when one partner asks a question, he/she pauses and waits until the other social partner responds (Calvert& Wilson, 2011). This kind of social contingency where the animated character prompts the audience to respond contingently to their requests, is considered a critical factor in children's media as it enhances interactivity and communication of video material. Shows designed for young children often have characters look directly at the audience through a camera lens, speak to the audience, pause for a reply, and then act as if the child has made a reply. This is another common example of the types of contingent character behaviors that may engage a child in a communicative interaction perceived as ''real'' or, at the very least, ''realistic'' (Calvert et al., 2007).

2.5.3. Visual Design

In animation, visual design refers to the design of the character, costume and scnery.

is apparent in two form; the character design as relating to the appearance of the animated characters and the 'environment" design as encompassing backgrounds, props and other visual elements present in a scene.

2.6. Advantages of using culturally relevant animation to improve learning outcomes

Animated educational children's series such as *Dora the Explorer, Blues Clues*, animated segments in *Knowzone*, and characters such as *Elmo* from *Sesame Street*, have been used successfully to deliver socially meaningful, culturally-relevant and engaging learning material that develops students conceptual thinking. Research indicates that these shows benefited children's attitudes towards learning, improve school readiness, boost children's feelings of academic competency (Sesame Workshop) and improve comprehension (Mediae Report, 2008-9) by using characters and contexts that represent their own culture, language and their heritage (Betancourt, 1998). Similarly, by exploring how learners construct mental models of animated learning materials, Betancourt (2005) attributes the learning gains to the ability to "visualize dynamic phenomenon that are not easily perceptible, impossible to realize in practice or are inherently visual" and thus enhance a learner's understanding of both concrete and abstract concepts. Thus, the key determinant of the potential of animation to positively impact learning as part of multimedia instruction is the learner's capacity to process the animated information successfully (Lowe, 2004).

2.4. Cognitive Processing of Visual Information

According to (Mayer 2004), the effectiveness of multi-media learning materials depends on whether learners have sufficient cognitive resources to perceive and process the essential information in the dynamic visualizations". This requirement for visual literacy – ability to 'read', interpret and understand information presented in a pictorial or graphical format – becomes apparent for learners to construct meaning of the information presented. As a learning style, visual literacy has been explored along with three other styles based on optimal scenarios that influence cognition in processing new information. Based on Neil Fleming's VARK model they include; Visual, Auditory, Representational and Kinaestheic learners. In this model, Fleming hypothesized that visual learners have a preference for seeing; auditory learners learn best through listening while tactile/kinaesthetic learners learn best through tangible experience. New studies however indicate that although there appears to be distinguishing characteristics in these grouping, children tend to exhibit varying preferences for learning at different ages and the preferences also tend to overlap. Gibbons, Anderson, Smith, Field, and Fischer(1986) found that although preschool children (4-year-olds) remembered actions better when they were conveyed visually than when they were described by a narrator, the difference disappeared in older children (7-year-olds) who produced more elaborations with the visual presentation than with the audio alone and also remembered dialogue better.

In processing visual information, the cognitive processes involved include; (a) identifying their important features of a visual display (also referred to as surface-level processing or external identification, (b) relating the visual features to their meaning, i.e., semantic processing, and (c) constructing the communicated message, i.e., pragmatic processing (Bertin 1983; Kosslyn 1989; Schnotz 2002; Shah and Hoeffner 2002: Plass, 2009). These levels are based on the working memory and "assume that visual information is processed in a visual working memory, while verbal information is decoded and processed in a verbal working memory" (Plass, 2009).

Similarly, according to Allan Paivio's*Dual coding* theory, cognition consists of two representational codes which allow for the formation of mental images as an aide to learning. These are: (i) analogue codes that mentally represent images by retaining the key recognizable features of what is represented, and (ii) symbolic codes that are mental representation of words and bear no semblance to the words or ideas.

In the same way, the *Cognitive Theory of Multimedia* makes reference to a learner's ability to process information via two channels. In this model however, the two channels are visual and verbal channels such that auditory information is classified in the verbal system and animation would be categorized in the visual system. This theory further suggests three distinct cognitive processes through which information is processed; (i) Learnersfirst select relevant visual and verbal information from the stimulus, (ii) organize that information into coherent verbal and visual mental representation, and then (iii) integrate these mental representations with one another and with prior knowledge (Mayer 2001).Accordingly, this occurs in the three key cognitive processes. The model has yielded five other principles that are often applied in the design of multimedia based learning materials based on the learner's capacity to process visual and verbal messages. They include; Multiple Regression that addresses the modality used to present the information; Split Attention and Contiguity which address the temporal and spatial arrangement of visual and verbal information, Coherence and Individual learner differences which address clarity and redundancy in the information.

2.7. Learning Theories

A study on designing animated learning materials is not complete without an investigation into the learning theories that influence the use of learning materials. Since the time Plato stated that "children are born with knowledge that simply awaits activation", learning theory has developed from simple behaviorists view to focus on cognitive learning, and to more recently, an understanding of the role of the learners' interactions in social and cultural environments in influencing constructivist learning. *Constructivism* views learning as a process in which the learner actively constructs new ideas based on current and past experiences. In Mathematics education, there has been a shift from pure constructivist approaches towards socio-constructivist and socio-cultural approaches that integrate of all places of interaction of the learner that constitute their learning environment including reference to past experiences. Learning is thus facilitated by observation, verbal instruction and symbolic representation.

Cognitivism theory was first forwarded by Jean Piaget as reaction to previous child development studies that implied that children passively absorb information around them. Piaget suggested that, quite contrary to this belief, children actively work to make sense of the world around them and classified the domains of cognition into four stages: *Sensorimotor stage* (Age Birth to 2) during which children experience the world solely through movement and use of their five senses. At this stage, they are unable to perceive the world from another person's view point, *Preoperational Stage* (Age 2-7) during which the child acquires motor skills and are able to use language, *Concrete-Operational-Stage* (Age 7-11) during which a child is able to think logically about concrete events but only using practical aids and lastly, the *Formal Operation Stage*(Age 11-16) during which children are able to think logically about abstract concepts.

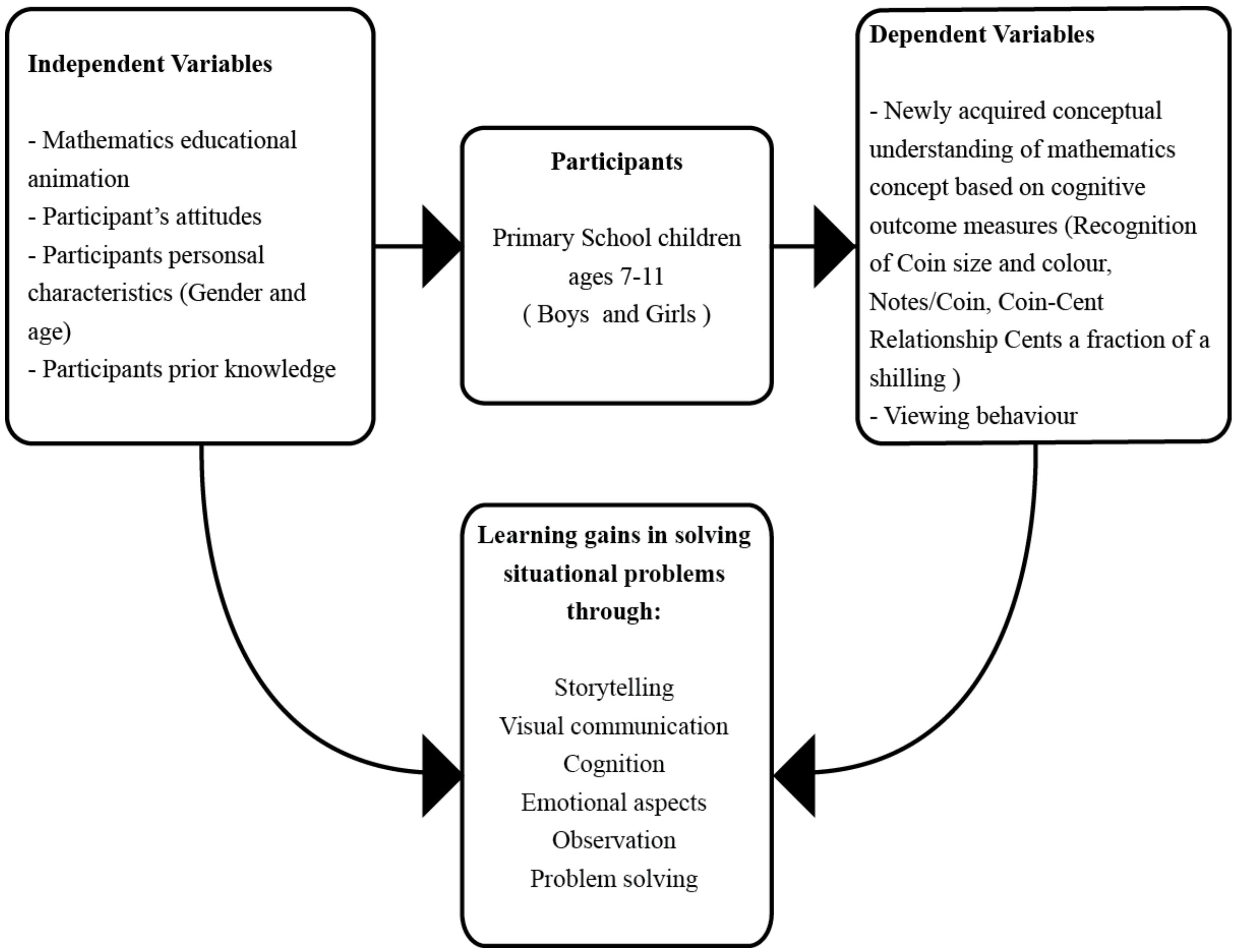
While these theories focused largely on how new knowledge is acquired, Blooms taxonomy of cognitive development goes further to identify six levels of skills in the cognitive domain that delineate a hierarchy of educational objectives. At the lowest level in this hierarchy is *Knowledge*, defined as the ability to remember previously learned material. Secondly is *Comprehension*, referred to as the ability to grasp the meaning of material demonstrated by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), and by extrapolation (predicting consequences or effects). Thirdly is *Application*, the ability to use new knowledge to solve problems through application. Fourth is *Analysis*, defined as the ability to examine and break down material into its component parts to understand its' composition. Fifth is *Synthesis*, defined as the ability to put parts together to form a new whole. Sixth and highest in the hierarchy is Evaluation, defined as the ability to judge the value of material based on definite criteria and contains elements of all the other categories.

Project Methodology: Digital Cutout Animation

Digital cutout production techniques shall be used to create the artifact (animation) for use in the proposed project. This technique provides a unique aesthetic medium for visual communication of story based learning materials and has been widely popularized with the onset of digital production tools and animation software in creating educational animation for children. The production process comprises of three key stages including:

i. Pre-production phase (Research, Script Writing, Planning , Audio Recording, Storyboarding),
ii. Production (Design and Animation)
iii. Post production (Editing and Sound Effects).

CONCEPTUAL FRAMEWORK



CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Overview

This investigation primarily employed a mixed methods approach since it involved the collection and analysis of both quantitative and qualitative data obtained through questionnaires and interviews. In addition, being a practice based enquiry, the study required the creation of an educational animation, the artefact, which through content analysis was reviewed to deduce its capacity to address gaps in conceptual mathematical understanding.

Practice research, in general, is one of many methodological and theoretical forms of qualitative research (Finley, 2005) that has evolved for pursuing research in art, design and architecture, media, and creative writing. It is a process of interrogating and refining ideas through cycles of practical experimentation and critical reflection (Schon, 1983; 22 Scrivener, 2000:), by means of practice (iteration) and the outcomes of that practice (artefacts). The resulting data was then analysed and the results compared to finding from similar studies.

3.2. Research Design

Findings from the pilot indicated that an experimental design containing two groups exposed to different treatments was ineffective owing to individual learner differences. The researcher therefore deduced that a single subject experimental design (baseline-treatment and posttest) was most appropriate since it would expose all participants in each school to all levels of the independent variable thereby; have them act as their own control. Single-case experimental research designs are popularly used to conduct classroom-based research (Birnbrauer, Peterson, Solnick, 1974: Gay & Airasian, 2000: Neuman & McCormick, 1995: Richards, Taylor, Ramasamy, & Richards, 1999, cited from Hynd, 2006). This is because they allow for a more personalized data collection process where data is collected on each participant, and is individually analyzed. Similar studies also indicate that such an experimental design has more statistical power, since it makes it possible to compare the score of a participant in one treatment to the scores of the same participant in another treatment allowing the researcher to detect effects of the independent variable.

3.3. Study Population, Sampling and Sampling Techniques

Participants

120 Children participated in the study. Participants were aged between 5- 9 years at the time of time of testing (mean age was 7 years). They comprised 56 boys and 64 girls drawn from the three participating schools.

Population

In order to obtain a sample representative of pupils attending public primary schools, the population was drawn from schools located within the urban and peri-urban areas of Kisumu County. Initially, participants were to be selected from urban and rural primary schools however, based on the finding from the pilot it was established that participants from rural primary school may yield skewed data. The participants were recruited from the following primary schools; Victoria Primary School (Classroom Population = 80), Migosi SDA primary school (Student Population = 40), and Highway primary school (Student Population = 40). Hence the total population estimated at 160 individuals. Standard two pupils were selected since they provided a cohort for the target age group (7 -11). In addition, after completing two years of schooling, a pupil is expected to have acquired basic competencies in literacy and numeracy.

Sample Size

A small but carefully chosen sample was used to represent the population. The researcher used Priori Power Analysis to determine the sample size to, "ensure that the size of each treatment group provides the greatest sensitivity that the effect on the outcome actually is due to the experimental manipulation in the study" (Creswell, p, 18). This was determined as follows:

3.4. Instruments

In order to operationalize the variables in this study, the researcher recognized that well-designed, high quality, realistic and appropriate test material are essential in any research that seeks to make judgments about learning. Multiple methods of data collection from both secondary and primary sources were therefore used to facilitate a relationship that allowed for in-depth portrait of the informants and the population. These will include:

3.4.1. Questionnaire

Clearly formulated, simple and straightforward Questionnaires with open ended and close ended questions were administered to both pupils and teachers. They were pre-tested for clarity of understanding and modified accordingly for the final fieldwork.

Pre-testing the Questionnaire

The researcher pre-tested the questionnaire twice. First on a selected sample of 17 pupils aged 7-11 from Migosi estate in Kisumu attending the following schools, Migosi Primary, Victoria Primary, Kondele Primary, MM Shah Primary and then on 60 standard two pupils at Victoria Primary School. These children were not included in the sample being studied; rather their participation was required to test their ability to easily understand the questionnaire. The pre-test was conducted on December, 2012 and January 2012 and ran for about an hour. The following observations were noted:

i. The game format of the questionnaire was appealing and engaging to all the children. However, it was not possible to obtain all the answers corresponding to each question from all participants.

ii. The one page paper based format worked best and made it possible to hand out to a large audience.

iii. There was a stronger preference for the questionnaire that had graphics over those with text only.

iv. Text based questionnaires were not answered completely.

v. Although there was a stronger preference for full colour questionnaires, it was not financially feasible to reproduce all 120 questionnaires in full colour.

3.4.2. Animation Development:

It took two months to conceptualize, design, test and refine the animation used in this study. Since the animation was created by the researcher specifically for this study, it placed emphasis on both aesthetics and production techniques as well as had a cognitive focus to test the stated hypothesis. As the sole designer and animator for this project, the researcher developed the animation according to her creative and aesthetic preference with the intent of creating content that would have great appeal to children.

The target audience for the animation was 7-11 year old boys and girls and as a result, the character design needed to reflect an equal representation of both genders.

3.4.2.1. Learning Objective

The main Learning objective of the animation was to address gaps in conceptual mathematics understanding of money with content constrained to the standard two curriculum.

Review of relevant literature revealed that primary school children typically have their first formal learning experience with money in class one; however, children become aware of money and its role in our economy before reaching school-age.

In a survey conducted by UWEZO Kenya that sampled numeracy and ethno mathematics tests, twenty percent of 6 -16 year old children who were able to do real life mathematics in money related arithmetic could not do abstract mathematics of the same difficulty level. During consultations with teachers as well as findings from studies in children's mathematics, it emerged that students often experience difficulty learning money concepts due to a lack of understanding in the key underlying arithmetic concepts such as counting on, base-ten concepts, part-whole thinking, place value and visual representation of coins and notes. Other cognitive obstacles that arise when teaching children about money in a mathematics classroom include: Coin size and colour, Coin-Cent Relationship, Cents as a fractional part of a shilling, meaningful examples in the curriculum and misunderstandings of the economic use of money.

The educational objective of the animation was therefore to make the subject, mathematics, more meaningful to children by including mathematical tasks that "relate to children's everyday lives (Brenner, 1998)". This involved acknowledging the cultures that children bring into the classroom by relaying content that they could relate to both socially and culturally; and making this central to their learning process. This was done in three ways:

i. Use of Curriculum Based Content:
ii. Character Design: A character design style sheet of the characters is included in Appendix A.
iii. Production Technique: This includes both the animation technique employed as well as the formal features that were deliberately used to aid instruction.

3.4.2.2. Tools and Technologies Used

The researchers used the following; A Graphics Tablet, Image Editing Software, Sound Editing Software, Video Editing Software and Animation Software. A Graphics Tablet is a computer input device that uses as drawing stylus to transfer digital data directly onto a user's computer. It offers increased efficiency in creating graphics on a computer with pressure sensitive feature that function in a similar manner as a pen on paper. The researcher used a

Manhattan Graphics tablet for refine the character design, compositing and animation using Adobe Illustrator, Adobe Photoshop and ToonBoom Animate. Adobe Illustrator and Adobe Photoshop are industry standard image editing software while ToonBoom Animate is an animation software for professional and amateurs alike. ToonBoom Animate allows for the creation of both tradigital and digital cut-out animation. Avid, an open source sound editing software, was used to record and edit the sound and the final video output was put together in Adobe Premiere Pro.

3.4.2.3. Storyline

The story was based on an activity that children in this age group would engage in either during pretend play or in real life. It revolves around three friends, Kena Bint and Tosh who are age 7 and 8. It is a school holiday and the three are collecting eggs to take to the market. Kena, the main character explains that this is something she does every school holiday to help her mother. They collect the eggs from the chicken coup and count them then proceed to the market where they have to decide on a price for each egg. Tosh, who acts as comic relief proposes that they sell each egg at one shilling so that they can buy many sweets. Kena interjects and states that since her mother always sells the eggs at nine shillings, they will do the same. A customer soon stops at the stall and asks for four eggs and they have to then figure out how much these will cost and how much change to return. Once they do so, they then have to count the correct change and return this to the customer. As the animation ends, Bint jumps in to ask the audience what they learnt and together, the audience and the characters recite the counting exercise as well the lesson on adding and subtracting money. This storyline is relayed visually in the storyboard in Appendix B. It is important to note that the storyboard was later revised during production stage.

3.5. Procedure

Consent to obtain the data was obtained from the Head of Schools and Class Teachers in each school. The Heads of the Schools included in this study were approached by the researcher and presented with a letter from the School of the Arts and Design, University of Nairobi, explaining the nature of the study, anticipated outcomes and request for their participation. This letter is included in Appendix C. The researcher further gave an explanation of the study, showcasing research materials that would be used in the study and scheduling possible dates in which the data could be gathered. The Researcher was then introduced to the Class Teachers to discuss available dates and requirements for the study.

The Class Teachers were provided with Parental Consent forms, included in Appendix D, to be given to each child in the study as well as a copy of the letter describing the study and requesting their participation. Parents were given a one week period to respond to the letters and were instructed to return the forms to the Class Teacher from whom the researcher then collected the forms.

The procedure for the study included baseline, treatment and posttest stages for each participant. The Baseline for the study included an assessment of the participants' knowledge of the concept explored in the animation that measured their comprehension of the topic.

The treatment administration involved watching the animation and since it was anticipated that using the classroom as a viewing environment would provide a familiar setting and elicit natural responses from the participants. The entire session was therefore conducted in the participants' classrooms. The dependent variables identified for this study were therefore the participants' comprehension and skill acquisition, engagement behavior as well as enjoyment behavior.

Dependent variables were measured as follows: Each group of participants was shown the animation twice after which, the researcher gave each participant a questionnaire containing comprehension, skills acquisition and enjoyment questions. This questionnaire is included in Appendix E. The entire viewing session lasted about 20 minutes and it took the participants about 30 minutes to complete the questionnaires. The participants were then thanked for their participation and were each given sweets for their break time session and pencils were given to the teacher to store in the Class library.

Anderson and Lorche define attention as the proportion of time a participants gaze is directed towards a media object (cited from Hynd 2006). Attention data was therefore determined through participant observation.

Engagement behavior on the other hand was measured by monitoring verbal and non-verbal behaviours. Verbal behavior included responses elicited that directly related to the animation, verbal response to questions posed by onscreen characters, repetition of words, singing, laugher and tunes heard in the animation.

In order to rate the participants enjoyment of the animation, each participant was presented with a five point face scale that rated their levels of enjoyment form they "like it very, very much" to I felt "it was very, very boring". The Face scale is shown at the end of the participant questionnaire in Appendix E.

3.6. Validity

Internal validity refers to the extent to which any observed difference between participants in the experimental group can be attributed to the independent variable rather than to another factor. External validity on the other hand refers to any observed effects that can be generalized to other populations.

Potential threats to internal validity included the experimental procedures, treatments and experiences of the participants which threatened the researcher’s ability to draw correct inferences from the data collected in the study.

On the other hand, threats the external validity included drawing incorrect inferences from the sample data to other persons, other settings as well as future situations.

The single subject design explained earlier in the research design was therefore preferred because of its ability to control threats to internal validity. This is because each subject acted as his/her own control and as a result, the conditions remained the same within each participant.

It has been observed that children tend to influence the viewing behavior of their co-viewers (Andrew et al,1981 cited in Hynd, 2006) hence, while it would have been ideal to have each child view the animation individually, this would reduce the external validly since children seldom watch animations alone at home where they may be in the company of a family member. Hence in-order to be able to generalise of the findings, participants watched the animation in their classroom as a group and answered their questionnaires in the same way they would their class work.

CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

Overview

This chapter details the findings and analysis of data obtained from this study that sought find out the ability of an educational animation to enhance learning. Three measures were used to evaluate the effectiveness of the educational animation on children's understanding of basic arithmetic concepts involved when using money. They include; comprehension, enjoyment assessment and socially contingent behavior. The researcher therefore used these to assess the programme's ability for cognitive enrichment amongst the participants as constrained to the topic covered by the animation. 120 children participated in the study and were all exposed to the treatment variable after which, each was provided with a questionnaire that sought to measure their levels of compression and skill acquisition. All questionnaires were adequately answered.

The resulting data was then analysed using frequency distribution tables and graphs generated using a statistical program as well as the comparison the means of the baseline to the treatment (ANOVA).

4.1. Demographic Characteristics

Age

It was the intent of this research to included participants in the 7-11 age brackets which defines children in the Concrete Operational development stage. In addition, since the animation generated for this study was based on a topic extracted from the standard two curriculum, it was established that the participants would be drawn from class two in each participating school. The age bracket was therefore expanded to include younger participants who are also in class two. At the time this study was conducted, the participant's ages ranged from Age 5 to Age 11 with

46.7% being age 7, 35% were age 8, 7.5% age 6 ,7.5% age 9, 1.7% age 10, 0.8% age 11 and 0.8% age 5. This age distribution is indicated in Table 1 below.

Table 1: Age Distribution in Years

Age in years

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5	1	.8	.8	.8
	6	9	7.5	7.5	8.3
	7	56	46.7	46.7	55.0
	8	42	35.0	35.0	90.0
	9	9	7.5	7.5	97.5
	10	2	1.7	1.7	99.2
	11	1	.8	.8	100.0
	Total	120	100.0	100.0	

In addition, as indicated in table 2 below, the average age of the participants was 7.49 years at 0.898 standard deviations.

Table 2: Mean Age of Participants

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age in years	120	5	11	7.49	.898
Valid N (listwise)	120				

Gender

The study sought to have an equal measure of male and female participants from each School. Table below shows that there female participants were 46.7% were the male participants were 53.3%. This also enabled cross tabulation and Chi square analysis further evealed that the percentage of boys and girls in the treatment groups was insignificant

Table 3: Gender

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	56	46.7	46.7	46.7
	Male	64	53.3	53.3	100.0
	Total	120	100.0	100.0	

4.2. Comprehension

Comprehension was analysed in this study to understand how much of the educational animation content was understood by the participant. As applied in similar studies on children's television, three elements of comprehension were analysed. These are; recall, recognition and skill acquisition. The recognition question was included in part two of the questionnaire given to participants and entailed still graphics obtained from the animation. The participants were then asked to them to correctly identify, by naming, the images they had seen. The portion of the questionnaire that tested recall, asked the participants to recount specific content such as characters, characters name, events, objects and activities in the animation. According to Rice et al (cited from (Hynd, 2006), skills acquisition assess the generic abilities that a programme seeks to improve. This section was structured to test if the participants had gained basic understanding of the arithmetic principles involved when using money such as addition, subtraction and multiplication. The question was thus formulated in an assessment manner in the same way the participants are often tested during normal classroom instruction.

Participants were asked a total of 10 comprehension questions which were systematically tabled as follows:

Recall of Characters from the Animation

The participants were provided with images of six characters, three were from the animation generated for this study, one was Dora from Dora the Explorer, the other was Blue from Blue's Clues and the last one was an illustration created for this purpose. The participants were then asked to circle the character they had seen in the animation. 81.67% of the responses indicated correct recall of the characters, 7.5% were able to recall two characters, 5.8% were able to recall one character and the remaining 5% recalled zero characters or identified wrong characters.

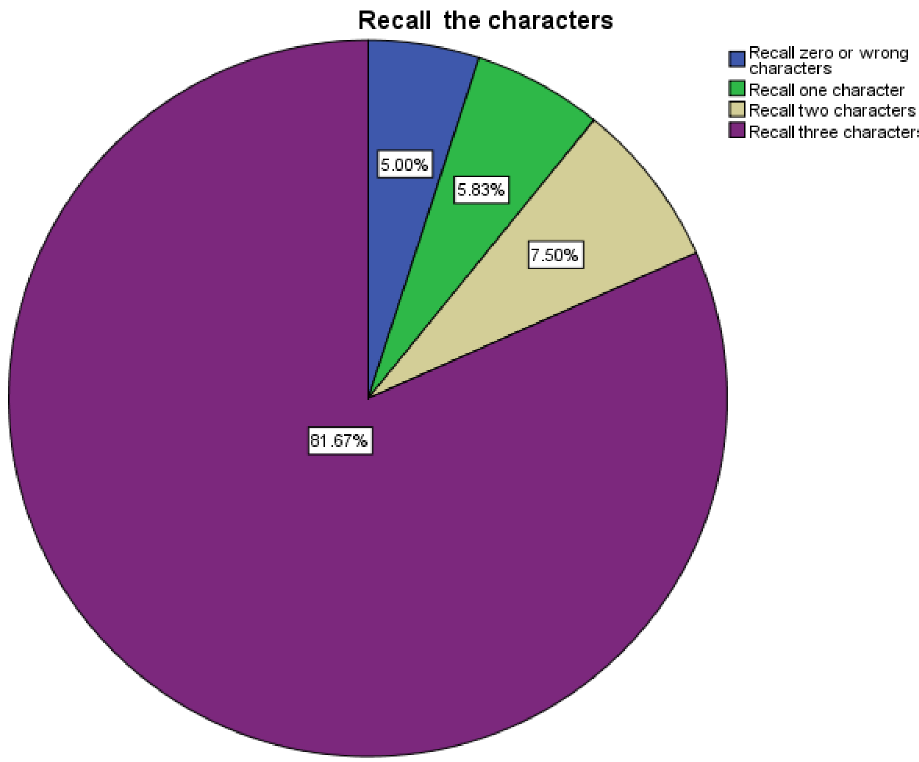


Figure 1: Recall of Characters from animation

As indicated in Table 4 below, further analysis revealed the following relationships between various categorical variables; 93.8% of the girls attending Migosi SDA Primary school could recall the characters they saw in the animation and the remaining 6.2% could recall only two characters. Of the boys, 95.8% could recall all three characters and the remaining 4.2% could not recall or incorrectly identified the characters. At Victoria Primary School, 94.7% of the girls correctly identified the characters and the remaining 5.3% could only identify two characters. At Highway primary school, 71.4% of the girls could correctly identified all three characters, 14.3% could only recall one character and the remaining 14.3% correctly identified only one character. Of the boys, 78.1% correctly identified all three characters, 6.2% identified two characters, 6.2% identified one character and 9.4% could not identify or incorrectly identified the characters they saw.

A chi-square analysis included in Appendix C, reveals that the relationship between gender and comprehension levels existed in only one school, Highway Primary School where the significance level was 0.025

Table 4: Crosstab of Gender and Comprehension Level by School

Name of School				Recall the characters				Total
				Recall zero or wrong characters	Recall one character	Recall two characters	Recall three characters	
Migosi SDA Primary School	Gender	Female	Count	0		1	15	16
			% within Gender	0.0%		6.2%	93.8%	100.0%
		Male	Count	1		0	23	24
			% within Gender	4.2%		0.0%	95.8%	100.0%
	Total		Count	1		1	38	40
			% within Gender	2.5%		2.5%	95.0%	100.0%
Victoria Primary School	Gender	Female	Count			1	18	19
			% within Gender			5.3%	94.7%	100.0%
		Male	Count			2	19	21
			% within Gender			9.5%	90.5%	100.0%
	Total		Count			3	37	40
			% within Gender			7.5%	92.5%	100.0%
Highway Primary	Gender	Female	Count	0	3	3	15	21

School			% within Gender	0.0%	14.3%	14.3%	71.4%	100.0%
			Count	5	4	2	8	19
		Male	% within Gender	26.3%	21.1%	10.5%	42.1%	100.0%
			Count	5	7	5	23	40
	Total		% within Gender	12.5%	17.5%	12.5%	57.5%	100.0%
			Count	0	3	5	48	56
		Female	% within Gender	0.0%	5.4%	8.9%	85.7%	100.0%
	Gender		Count	6	4	4	50	64
Total		Male	% within Gender	9.4%	6.2%	6.2%	78.1%	100.0%
			Count	6	7	9	98	120
	Total		% within Gender	5.0%	5.8%	7.5%	81.7%	100.0%

Recall of Characters names

Upon identification of the characters that were in the program, the participants were asked to further identify them by writing down their names. 69.27% of the participants' correctly labeled all three characters, 17.5% could not recall any name, 8.33% could recall the main characters name (Kena), 4.17 could recall the supporting characters name (Tosh) and the remaining 0.83% could recall the other supporting characters

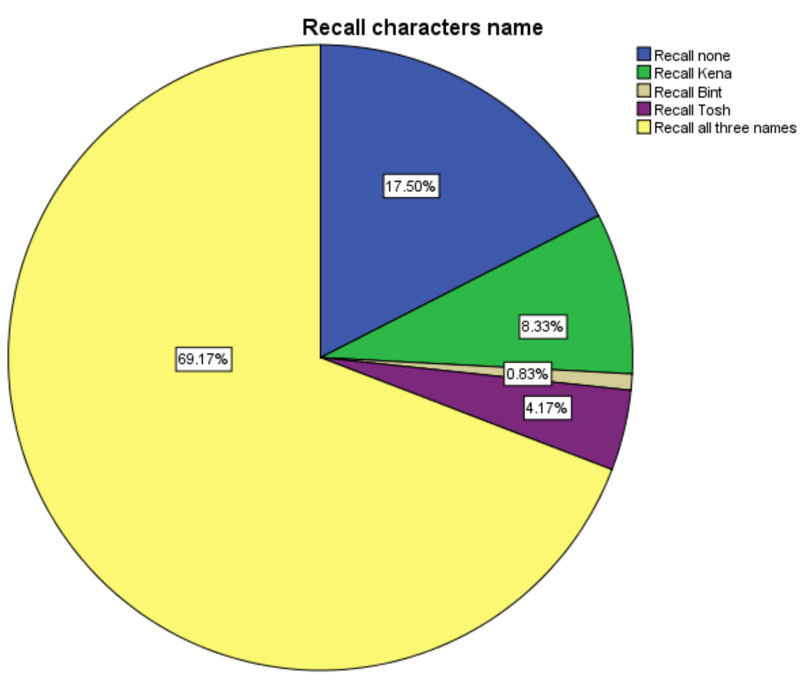


Figure 2: Recall of Characters names

name (Bint).

As shown in table 5 below, further analysis of the data was conducted to determine relationship the two variables comprehension and gender. It reveals

25% of the girls attending Migosi SDA Primary school could not recall the names characters, 6.2% could recall Tosh and 68.8% could recall all three names. 87.5% of the boys could recall all three names and the remaining 12.5% could not recall any name. At Vicotira Primary School, 78.9% of the girls could recall all three names, 10.5% could recall only one name and the remaining 10.5% could not recall any name. At Highway Primary school, 61.9% of the girls could recall all three names, 4.8% could recall Tosh only, 19.0% could recall Kena only, and 14.3% could not recall any name. Of the boys, 50% could recall all three names, 10% could .recall Tosh, 17.5 could recall Kena and 31.6% could not recall any names

Table 5: Cross-tabulation of Comprehension (Recall of Characters Name) and Gender

Name of School				Recall characters name					Total
				Recall none	Recall Kena	Recall Bint	Recall Tosh	Recall all three names	
Migosi SDA Primary School	Gender	Female	Count	4			1	11	16
			% within Gender	25.0%			6.2%	68.8%	100.0%
		Male	Count	3			0	21	24
			% within Gender	12.5%			0.0%	87.5%	100.0%
	Total		Count	7			1	32	40
			% within Gender	17.5%			2.5%	80.0%	100.0%
Victoria Primary School	Gender	Female	Count	2	2	0		15	19
			% within Gender	10.5%	10.5%	0.0%		78.9%	100.0%
		Male	Count	3	1	1		16	21

			% within Gender	14.3%	4.8%	4.8%		76.2%	100.0%
	Total		Count	5	3	1		31	40
			% within Gender	12.5%	7.5%	2.5%		77.5%	100.0%
Highway Primary School	Gender	Female	Count	3	4		1	13	21
			% within Gender	14.3%	19.0%		4.8%	61.9%	100.0%
		Male	Count	6	3		3	7	19
			% within Gender	31.6%	15.8%		15.8%	36.8%	100.0%
	Total		Count	9	7		4	20	40
			% within Gender	22.5%	17.5%		10.0%	50.0%	100.0%
Total	Gender	Female	Count	9	6	0	2	39	56
			% within Gender	16.1%	10.7%	0.0%	3.6%	69.6%	100.0%
		Male	Count	12	4	1	3	44	64
			% within Gender	18.8%	6.2%	1.6%	4.7%	68.8%	100.0%
	Total		Count	21	10	1	5	83	120
			% within Gender	17.5%	8.3%	0.8%	4.2%	69.2%	100.0%

Chi-square analysis revealed no relationship between the comprehension question that tested the participants' ability to recall the characters names and their gender.

Recall of what was sold at the market

This question listed four items, an egg, a bag , a mango and a banana and asked the participants to circle the item that the characters in the program took to sell at the market. 95.83 of the participants correctly labeled the egg and the remaining 4.17% did not respond to this question or circled all the items.

Further analysis as indicated in table 6 below indicated that 93.8% of the girls at Migosi SDA could recall what was the characters in the animation were selling and 6.8% could not correctly recall what was being sold. Of the boys, 100% were able to correctly recall what was being sold. At Victoria Primary, 94.7% of the girls could recall what was being sold while 5.3% could not recall or made an incorrect selection. 100% of the boys were able to correctly recall what was being sold. At Highway Primary, 85.7% of the girls could recall what was being sold while the remaining 14.3% could not recall what was being sold. 100% of the boys were able to recall what was being sold.

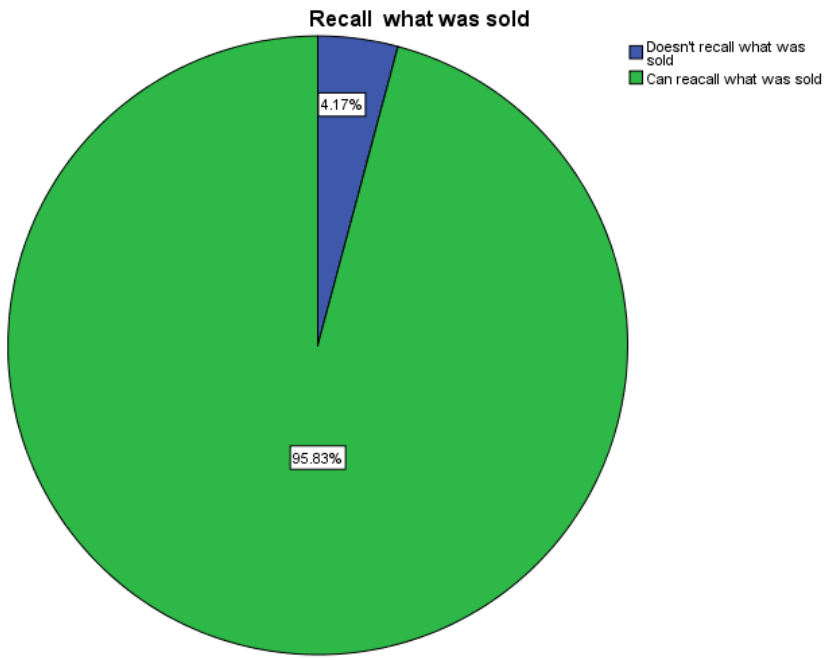


Figure 3: Recall what was sold at the market

Table 6: Cross-tabulation of Gender, Recall of what was sold , Name of School

Name of School				Recall what was sold		Total
				Doesn't recall what was sold	Can recall what was sold	
Migosi SDA Primary School	Gender	Female	Count	1	15	16
			% within Gender	6.2%	93.8%	100.0%
		Male	Count	0	24	24
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	1	39	40
			% within Gender	2.5%	97.5%	100.0%
Victoria Primary School	Gender	Female	Count	1	18	19
			% within Gender	5.3%	94.7%	100.0%

		Male	Count	0	21	21
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	1	39	40
			% within Gender	2.5%	97.5%	100.0%
Highway Primary School	Gender	Female	Count	3	18	21
			% within Gender	14.3%	85.7%	100.0%
		Male	Count	0	19	19
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	3	37	40
			% within Gender	7.5%	92.5%	100.0%
Total	Gender	Female	Count	5	51	56
			% within Gender	8.9%	91.1%	100.0%
		Male	Count	0	64	64
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	5	115	120
			% within Gender	4.2%	95.8%	100.0%

Further analysis revealed that there was no statistical significance in comprehension levels in gender within the schools. However, significance value of 0.20 existed amongst the three schools which indicated a relationship between comprehension levels and the school type.

Recall of the Cost of each Item

This section of the questionnaire tested the participants' recall of the cost of each item as correctly identified in the previous question. 76.67% of the responded could recall that each egg was sold at nine shillings while 23.33% could not correctly recall the cost of each egg.

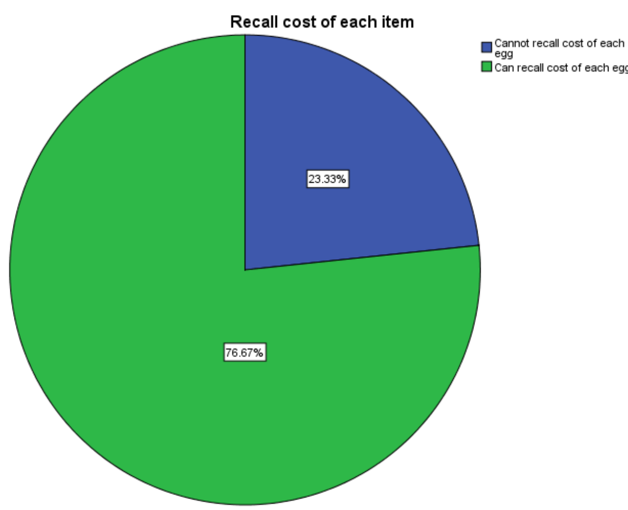


Figure 4: Recall Cost of each item

Further Cross tabulation analysis as indicated in table below revealed that 75% of the girls at Migosi SDA could recall the cost of each item and the remaining 25% were unable to recall the cost of each item. Of the boys, 58.3% could recall the cost of each item and the remaining 41.7% were unable to do so. AT Victoria Primary, 89.5% of the girls could recall the cost of each item and the remaining 10.5% were unable to recall the cost of each item. 100% of the boys were able to recall the cost of each item. At Highway Primary 78.6% of the girls could recall the cost of each item while 21.4% were unable to recall the cost. Of the boys, 75% could recall the cost of each item while 25 could not recall the cost of each item.

Table 7: Cross tabulation of Gender, Recall cost of each item and Name of School

Name of School				Recall cost of each item		Total
				Cannot recall cost of each egg	Can recall cost of each egg	
Migosi SDA Primary School	Gender	Female	Count	4	12	16
			% within Gender	25.0%	75.0%	100.0%
		Male	Count	10	14	24
			% within Gender	41.7%	58.3%	100.0%
	Total		Count	14	26	40
			% within Gender	35.0%	65.0%	100.0%
Victoria Primary School	Gender	Female	Count	2	17	19
			% within Gender	10.5%	89.5%	100.0%
		Male	Count	0	21	21
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	2	38	40
			% within Gender	5.0%	95.0%	100.0%
Highway Primary School	Gender	Female	Count	6	15	21
			% within Gender	28.6%	71.4%	100.0%
		Male	Count	6	13	19
			% within Gender	31.6%	68.4%	100.0%
	Total		Count	12	28	40
			% within Gender	30.0%	70.0%	100.0%
Total	Gender	Female	Count	12	44	56
			% within Gender	21.4%	78.6%	100.0%

	Male	Count	16	48	64
		% within Gender	25.0%	75.0%	100.0%
Total		Count	28	92	120
		% within Gender	23.3%	76.7%	100.0%

The variation in levels of comprehension amongst boys and girls in each school and total comprehension against other school revealed no relationship.

Recall Number of items sold

80.83% of the participants could recall the number of eggs that were being sold and the remaining 19.17% could not recall the total cost of the items.

Further data analysis revealed that 81.2% of the girls at Migosi SDA could recall the quantity of items being sold and the remaining 18.8% were unable to recall the correct number of items being sold. Of the boys, 70.8% were able to correctly recall the number of items being sold and 29.2% were unable to do so. At Victoria Primary, 100% of the girls and 100% of the boys were able to recall what was being sold. At Highway Primary , 57.1% of the girls were able to recall the total number of items being sold and the remaining 42.9% were unable to do so. 78.9% of the boys could recall the total number of the items being sold and 21.1% could not recall the total number of items.

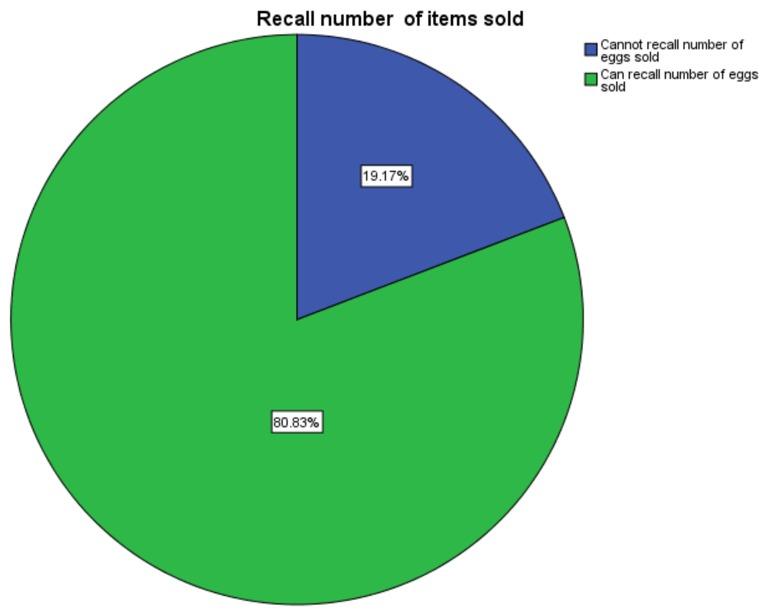


Figure 5: Recall number of items sold

Chi square tests further revealed that there was no relationship in either variable.

Table 8:Cross-tabulation Gender, Recall number of items sold and Name of School

Name of School				Recall number of items sold: Cannot recall number of eggs sold	Recall number of items sold: Can recall number of eggs sold	Total
Migosi SDA Primary School	Gender	Female	Count	3	13	16
			% within Gender	18.8%	81.2%	100.0%
		Male	Count	7	17	24
			% within Gender	29.2%	70.8%	100.0%
	Total		Count	10	30	40
			% within Gender	25.0%	75.0%	100.0%
Victoria Primary School	Gender	Female	Count		19	19
			% within Gender		100.0%	100.0%
		Male	Count		21	21
			% within Gender		100.0%	100.0%
	Total		Count		40	40
			% within Gender		100.0%	100.0%
Highway Primary School	Gender	Female	Count	9	12	21
			% within Gender	42.9%	57.1%	100.0%
		Male	Count	4	15	19
			% within Gender	21.1%	78.9%	100.0%
	Total		Count	13	27	40
			% within Gender	32.5%	67.5%	100.0%
Total	Gender	Female	Count	12	44	56
			% within Gender	21.4%	78.6%	100.0%
		Male	Count	11	53	64
			% within Gender	17.2%	82.8%	100.0%
	Total		Count	23	97	120
			% within Gender	19.2%	80.8%	100.0%

Recall of total cost of all the items

69.17% of the participants correctly recalled the total cost of all the items while 30.83% answered incorrectly. Cross tabulation revealed that 81.2% of the girls at Migosi SDA were able to correctly recall the total cost of the items and the remaining 18.8% were indicated a wrong total.

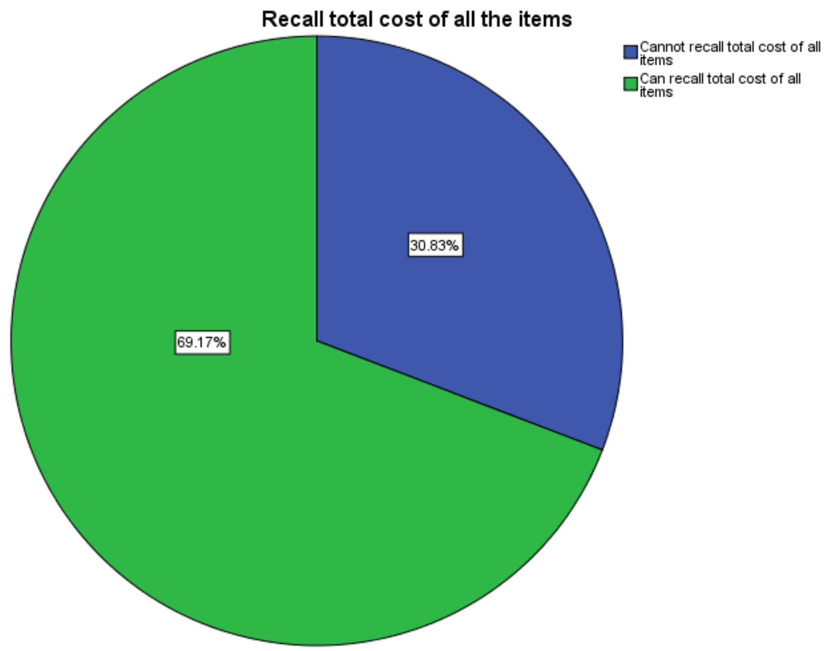


Figure 6: Recall total cost of all items

100% of the girls could correctly recall the total cost of the items and 100% the boys were also able to correctly recall the total cost. At Highway primary school, 47.6% of the girls could recall the total cost with remaining 52.4% unable to recall the total cost. 41.6% of the boys could recall the total cost of the items while the remaining 35.9% could not recall what was being sold.

Table 9: Cross tabulation Gender, Recall total cost of all the items and Name of School

Name of School				Recall total cost of all the items		Total
				Cannot recall total cost of all items	Can recall total cost of all items	
Migosi SDA Primary School	Gender	Female	Count	3	13	16
			% within Gender	18.8%	81.2%	100.0%
		Male	Count	10	14	24
			% within Gender	41.7%	58.3%	100.0%
	Total		Count	13	27	40

			% within Gender	32.5%	67.5%	100.0%
Victoria Primary School	Gender	Female	Count		19	19
			% within Gender		100.0%	100.0%
		Male	Count		21	21
			% within Gender		100.0%	100.0%
	Total		Count		40	40
			% within Gender		100.0%	100.0%
Highway Primary School	Gender	Female	Count	11	10	21
			% within Gender	52.4%	47.6%	100.0%
		Male	Count	13	6	19
			% within Gender	68.4%	31.6%	100.0%
	Total		Count	24	16	40
			% within Gender	60.0%	40.0%	100.0%
Total	Gender	Female	Count	14	42	56
			% within Gender	25.0%	75.0%	100.0%
		Male	Count	23	41	64
			% within Gender	35.9%	64.1%	100.0%
	Total		Count	37	83	120
			% within Gender	30.8%	69.2%	100.0%

Recall of how much money the customer gave

The participants were asked to recall how much money the customer gave Kena and an image of the customers hand with a blank note was provided. 76.67% of the participants' correctly recalled the fifty shilling note handed to Kena and went further to clearly illustrate a fifty shilling note in the blank rectangle. 23.33% of the respondents could not recall.

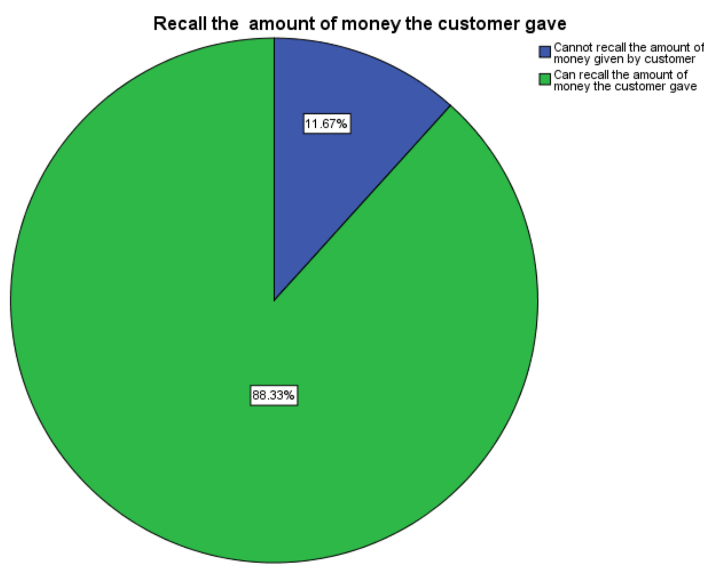


Figure 7: Recall how much money the customer gave

Cross tabulation revealed that 93.8% of the girls at Migosi SDA were able to identify correctly recall the amount of money the customer gave and 6.2% were unable to do so. Of the boys, 91.7% could recall the amount of money while 8.3% were unable to do so. At Victoria Primary, 94.7% of the girls could correctly recall the amount of money the customer gave and 5.3% could not do so. Of the boys, 95.2% could recall the amount of money the customer gave while 4.8% could not recall the amount of money the customer gave. At Highway primary school, 71.4% of the girls recall how much money the customer gave while 28.6% could not recall. 84.2% of the boys could recall while the remaining 25.8% were unable to do so.

Table 10: Cross tabulation of Gender, Recall the amount of money the customer gave and School

Name of School				Recall the amount of money the customer gave		Total
				Cannot recall the amount of money given by customer	Can recall the amount of money the customer gave	
Migosi SDA Primary School	Gender	Female	Count	1	15	16
			% within Gender	6.2%	93.8%	100.0%
		Male	Count	2	22	24
			% within Gender	8.3%	91.7%	100.0%
	Total		Count	3	37	40
			% within Gender	7.5%	92.5%	100.0%
Victoria Primary School	Gender	Female	Count	1	18	19
			% within Gender	5.3%	94.7%	100.0%
		Male	Count	1	20	21
			% within Gender	4.8%	95.2%	100.0%
	Total		Count	2	38	40
			% within Gender	5.0%	95.0%	100.0%
Highway Primary School	Gender	Female	Count	6	15	21
			% within Gender	28.6%	71.4%	100.0%
		Male	Count	3	16	19
			% within Gender	15.8%	84.2%	100.0%
	Total		Count	9	31	40
			% within Gender	22.5%	77.5%	100.0%
Total	Gender	Female	Count	8	48	56

		% within Gender	14.3%	85.7%	100.0%
	Male	Count	6	58	64
		% within Gender	9.4%	90.6%	100.0%
Total		Count	14	106	120
		% within Gender	11.7%	88.3%	100.0%

Recall of amount of change returned

With the aid of diagrams as multiple choice questions, the participants were asked to correctly circle the image that showed the correct change. 78.33% of the participants correctly circled the fourteen shilling and 21.67% were unable to correctly recall and count the change.

Cross tabulation revealed that 81.2% of the girls could recall and correctly indicate the amount of change returned to the customer while 18.8% could not recall the amount of change

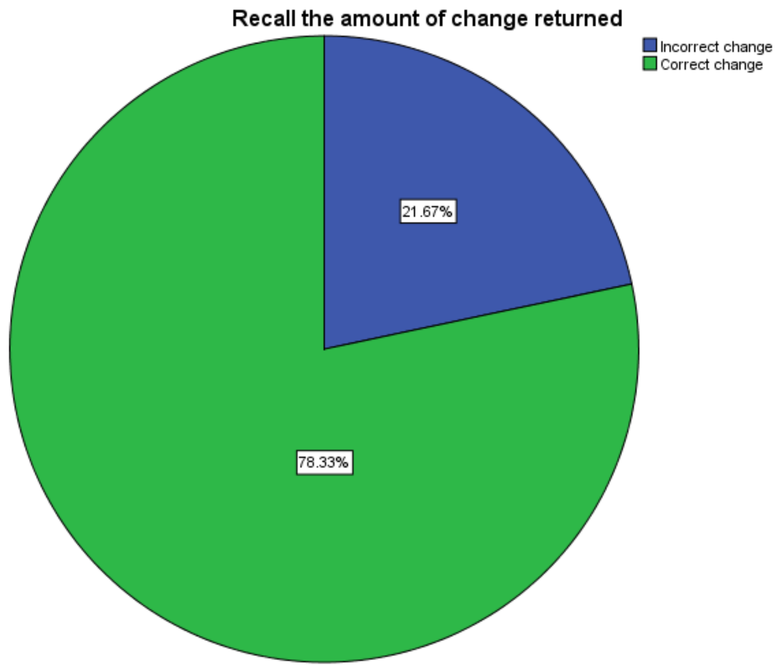


Figure 8: Recall the amount of change returned

returned. Of the boys, 41.7% were able to correctly identify the correct change that was returned while 58.3% indentified an incorrect amount. At Victoria Primary, 94.7% of the girls could recall the correct change while 5.3% could not recall the correct change. On the other hand, 100% of the boys were able to recall the correct change. At Highway Primary, 76.2% of the girls were able to recall the correct change and the remaining 23.8% were unable to do so. Of the boys, 84.2% were able to correctly recall the change and the remaining 25.8% recalled an incorrect amount.

Table 11: Cross tabulation of Gender, Recall of amount of change returned and School.

Name of School				Recall the amount of change returned		Total
				Incorrect change	Correct change	
Migosi SDA Primary School	Gender	Female	Count	3	13	16
			% within Gender	18.8%	81.2%	100.0%
		Male	Count	14	10	24
			% within Gender	58.3%	41.7%	100.0%
	Total		Count	17	23	40
			% within Gender	42.5%	57.5%	100.0%
Victoria Primary School	Gender	Female	Count	1	18	19
			% within Gender	5.3%	94.7%	100.0%
		Male	Count	0	21	21
			% within Gender	0.0%	100.0%	100.0%
	Total		Count	1	39	40
			% within Gender	2.5%	97.5%	100.0%
Highway Primary School	Gender	Female	Count	5	16	21
			% within Gender	23.8%	76.2%	100.0%
		Male	Count	3	16	19
			% within Gender	15.8%	84.2%	100.0%
	Total		Count	8	32	40
			% within Gender	20.0%	80.0%	100.0%
Total	Gender	Female	Count	9	47	56
			% within Gender	16.1%	83.9%	100.0%
		Male	Count	17	47	64
			% within Gender	26.6%	73.4%	100.0%
	Total		Count	26	94	120
			% within Gender	21.7%	78.3%	100.0%

Skill Acquisition: Addition of Items bought

In order to assess the level of comprehension of the animation as well as skills acquired, the participants were provided with a hypothetical question structured in a similar format as their textbook assessments. The question asked for the total cost of buying two eggs at nine shillings and was a measure of their ability to correctly deduce the arithmetic operation to use, in this case addition or multiplication. 67.5% of the participants correctly calculated the total cost while 32.5% were unable to do so.

Cross tabulation revealed that 81.2% of the girls at Migosi SDA were able to apply the appropriate arithmetic operation and correctly calculate the total cost of two eggs. 18.8 percent of the girls however, were unable to correctly deduce the total. Of the boys, 79.2% were able to correctly calculate the total cost of the two eggs and 20.2% were unable to do so. At Victoria Primary 63.2% of the girls could correctly calculate the total cost of the eggs while 36.8% could not correctly calculate the total cost of the eggs. Of the boys, 90.5% were able to correctly calculate the totals while 9.5% could not do so. At Highway primary, 57.9% of the girls could correctly calculate the total cost of the eggs while 42.1% could not correctly do so. Of the boys, 45% could correctly calculate the total cost of the eggs and 55% were unable to do so.

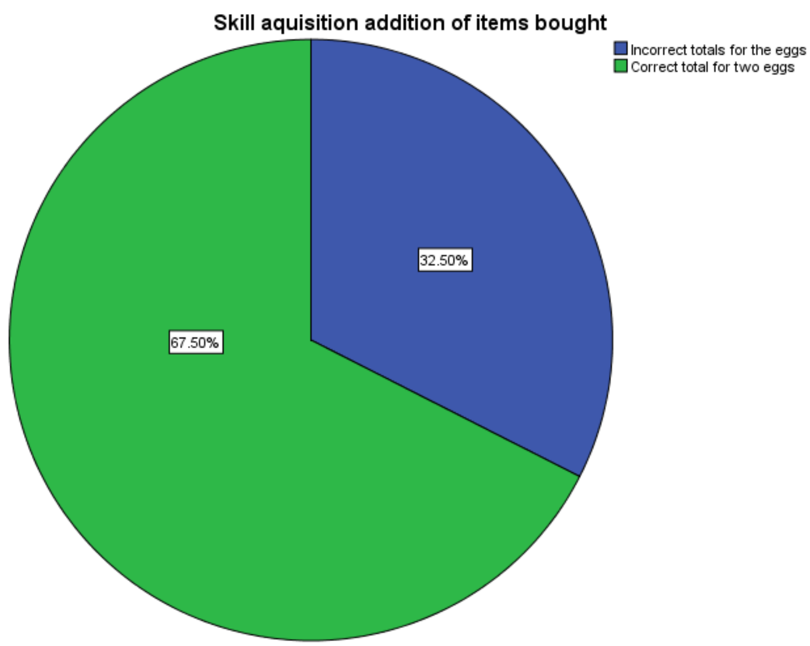


Figure 9: Skill acquisition, Addition of Items bought

Table 12: Cross tabulation of Gender, Skill acquisition addition of items bought and School

Name of School				Skill acquisition addition of items bought: Incorrect totals for the eggs	Skill acquisition addition of items bought: Correct total for two eggs	Total
Migosi SDA Primary School	Gender	Female	Count	3	13	16
			% within Gender	18.8%	81.2%	100.0%
		Male	Count	5	19	24
			% within Gender	20.8%	79.2%	100.0%
	Total		Count	8	32	40
			% within Gender	20.0%	80.0%	100.0%
Victoria Primary School	Gender	Female	Count	7	12	19
			% within Gender	36.8%	63.2%	100.0%
		Male	Count	2	19	21
			% within Gender	9.5%	90.5%	100.0%
	Total		Count	9	31	40
			% within Gender	22.5%	77.5%	100.0%
Highway Primary School	Gender	Female	Count	14	7	21
			% within Gender	66.7%	33.3%	100.0%
		Male	Count	8	11	19
			% within Gender	42.1%	57.9%	100.0%
	Total		Count	22	18	40
			% within Gender	55.0%	45.0%	100.0%
Total	Gender	Female	Count	24	32	56
			% within Gender	42.9%	57.1%	100.0%
		Male	Count	15	49	64
			% within Gender	23.4%	76.6%	100.0%
	Total		Count	39	81	120
			% within Gender	32.5%	67.5%	100.0%

The second part of the skill acquisition question asked the participants what the change would be from the twenty shillings they gave Kena. 52.50% of the participants were unable to correctly calculate the change, 45% were able to recall the arithmetic operation to calculate change (in this case subtraction) and the remaining 2.5% failed to answer this question.

56.2% of girls at Migosi SDA Primary applied the appropriate arithmetic operation and correctly calculated the change. 37.5% calculated incorrectly and the remaining 6.2% did not respond. Of the boys, 41.7% correctly calculated the change, 54.2% were incorrect and 4.2% did not respond. At Victoria Primary, 57.9% of the girls' responses were correct, 42.1% were incorrect and all participants responded. Of the boys' responses, 76.2% were correct, 23.8% were incorrect and all the participants responded. At Highway primary, 14.3% of the girls' responses were correct, 81.0% were incorrect and the remaining 4.3% did not respond. Of the boys' responses, 26.3% were correct, 73.7% were correct.

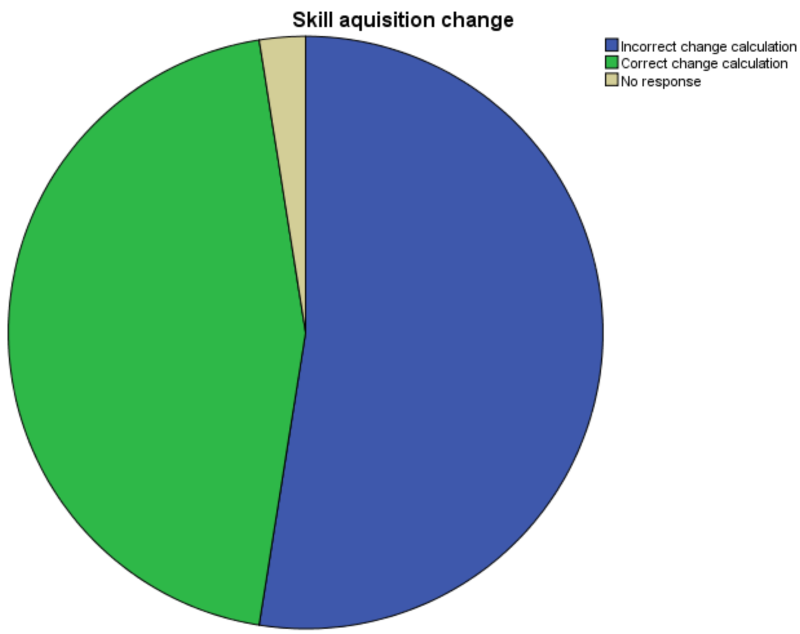


Figure 10: Skill acquisition, returning change

Table 13: Cross tabulation of Gender, Skill acquisition change and School

Name of School				Skill acquisition change			Total
				Incorrect change calculation	Correct change calculation	No response	
Migosi SDA Primary School	Gender	Female	Count	6	9	1	16
			% within Gender	37.5%	56.2%	6.2%	100.0%
		Male	Count	13	10	1	24
			% within Gender	54.2%	41.7%	4.2%	100.0%
	Total		Count	19	19	2	40
			% within Gender	47.5%	47.5%	5.0%	100.0%

Victoria Primary School	Gender	Female	Count	8	11		19
			% within Gender	42.1%	57.9%		100.0%
		Male	Count	5	16		21
			% within Gender	23.8%	76.2%		100.0%
	Total		Count	13	27		40
			% within Gender	32.5%	67.5%		100.0%
Highway Primary School	Gender	Female	Count	17	3	1	21
			% within Gender	81.0%	14.3%	4.8%	100.0%
		Male	Count	14	5	0	19
			% within Gender	73.7%	26.3%	0.0%	100.0%
	Total		Count	31	8	1	40
			% within Gender	77.5%	20.0%	2.5%	100.0%
Total	Gender	Female	Count	31	23	2	56
			% within Gender	55.4%	41.1%	3.6%	100.0%
		Male	Count	32	31	1	64
			% within Gender	50.0%	48.4%	1.6%	100.0%
	Total		Count	63	54	3	120
			% within Gender	52.5%	45.0%	2.5%	100.0%

The data obtained from the skills acquisition question was also used to test the hypothesis generated for this study. The hypothesis stated that:

> H_A: Pupils in the treatment group **will increase their effective use of math process skills** (after viewing animation that address curriculum based content, address learner characteristics, contain cultural determinants and story content derived from familiar real world experiences) at a significantly higher level than students in control group.

The table below shows the analysis of the pretest and posttest data using ANOVA.

Table 14: ANOVA (Skill acquisition: Addition of items bought)

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9.693	1	9.693	68.766	.000
Within Groups	16.632	118	.141		
Total	26.325	119			

Table 15: ANOVA (Skill acquisition: Calculation) of change

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.770	2	6.885	36.237	.000
Within Groups	22.230	117	.190		
Total	36.000	119			

The ANOVA tables above break down the variance of scores into two components: a between-group component and a within-group component. The F-ratio above, 68.766 and 36.237 refer to the ratio of the between-group estimate to the within-group estimate. Since the significance value of the F-tests are both less than 0.05, the data revealed that there is a statistically significant difference between the mean scores of the baseline and the post-test results at 95.0% confidence level.

Further analysis revealed that the baseline score have a significance difference in the mean scores when compared to the prêt test scores. This therefore implies that pupils were able to able to learn from the animation and that there was a statistical difference in the measure of the baseline/pre-treatment knowledge when compared to post treatment knowledge.

4.3. Enjoyment Assessment

Enjoyment was measured based on observation of expressions of laughter from the participants as well as responses circled on the five point face scale that was placed at the end of each questionnaire.

The children were very attentive during the entire viewing period and in one instance when the projector failed to work, all scramble to view the animation from the laptop. This situation was however quickly fixed to ensure validity as mentioned previously.

As indicated in table below, of the 120 participants, 102 (85%) circled the first scale which indicated that they like the animation very, very much. 12(10%) participants selectee the second scale that indicated the liked the show very much, 4(3.3%) participants indicated they were neutral by selecting the just ok scale while the remaining 2(1.7%) participants indicated that they thought the animation was very, very boring.

Table 16: Preference levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Show was very boring	2	1.7	1.7	1.7
	Show was just ok	4	3.3	3.3	5.0
	Liked show very much	12	10.0	10.0	15.0
	Liked show very very much	102	85.0	85.0	100.0
	Total	120	100.0	100.0	

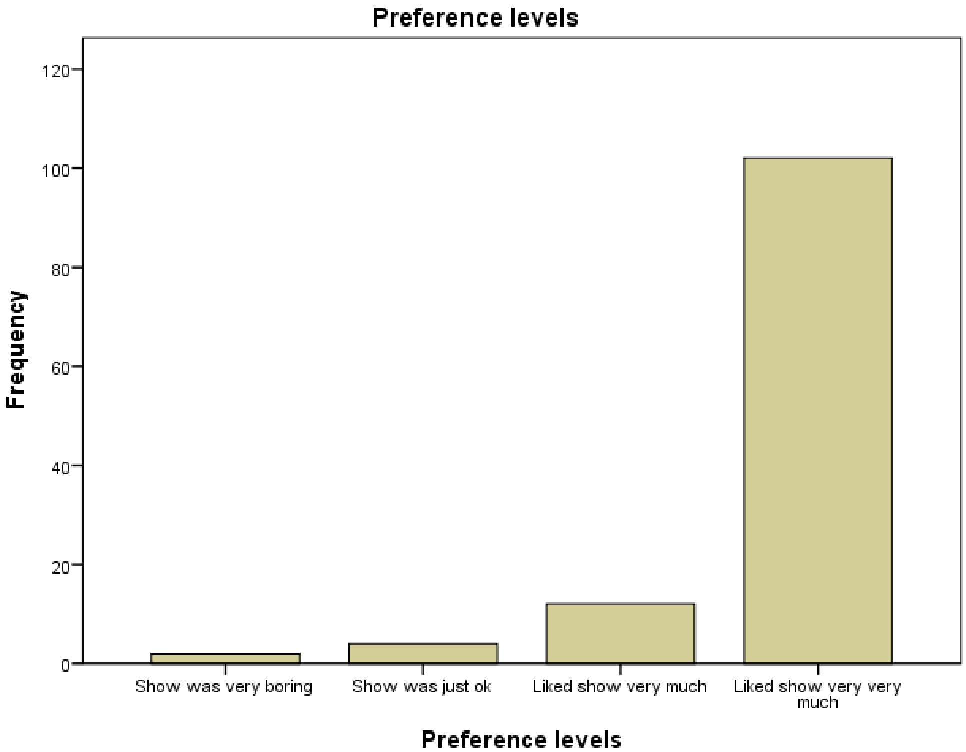


Figure 11: Preference levels

4.4. Socially Contingent behaviour

Socially contingent behaviour was measured in terms of the participant's verbal behaviour including; counting with the onscreen characters, verbal answers to the questions posed by characters and any other comment directed to the character. Specific segments were of the animation were designed to elicit such responses. It was observed that when the onscreen character first asked the viewers "How many eggs do you see", a few participants responded and counted along. However, when the character asked this question a second time, more participants responded and counted with the onscreen character. As the characters were adding up all the eggs, the participants seemed to have understood that they could also help in counting and joined in on the counting. In another scene where Kena asks the children add up the total cost of all the eggs, the children were seen to begin counting on paper by drawing sticks as well as using their finger to come up with the result. In the closing scene, the participants were by the character Bint

“So what did you learn from this story” after which she paused for a few seconds and looked at the viewers. It was noted that the children begun chuckling and shouting out the words “counting”, addition” and “money”. In the last question posed by Tosh “What else did you learn”, the children seemed to reflect on what else they learnt and a few responded by shouting “subtraction”.

CHAPTER FIVE: SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1. Introduction

The research questions for this study were:

1. What design factors are taken into consideration in the development of effective animated learning materials targeted at Kenyan primary school children?
2. What is the production process for development of a children's educational animation using digital cut-out techniques?
3. What are the cognitive implications of animated learning materials as used in a mathematics classroom setting?

5.2. Summary of Findings

The first research question sought to find out the design factors taken into consideration in the development of effective animated learning materials targeted at Kenyan primary school children. From a review of the relevant literature, it emerged that three key factors play a role on the design of culturally relevant animated content. They are; Language, Social relevance and Visual design.

Language encompasses both the dialect and accent as relayed in a vocal performance that is carefully styled to express purpose and meaning and has varying levels of perceptual salience. Vocal performance is also a key element in the formal features of production that are used to create animated materials for children.

Secondly the study sought to find out the production processes involved in the development of children educational animation. This included the technique of animation employed and the rational for its use as well as the formal features of production that and the animation principles that are essential to effective animation. It was established that although there exists several animation production techniques, cut-out animation has been used with great success in various children's production owing to its unique ability to use and simulate realistic textures and cut out shapes of real objects that create an overall visual design with a strong appeal of children. Additionally, the production costs of cut-out animation are relatively less than other production techniques and can do with a much smaller production team.

Lastly, by way of creating an animation for this study, this research sought to find out the cognitive implication of using animated learning materials in mathematics classroom and it potential for cognitive enrichment. Analysis of the data obtained from the experimental design revealed that the participants levels of comprehension of the animated materials was significantly high since a large percentage were able to correctly respond to the recall questions. Additionally, a F-test revealed that there was a statistically significant difference between the mean scores of the baseline and post-test at the 95.0% confidence level. This can be attributed to the participants' knowledge gained from the animation and application of this knowledge in solving a similar problem.

5.3. Conclusions

This study has demonstrated that indeed animations can be used to enhance learning, particularly in helping children understand abstract concepts, but only so when the content is designed to reflect the learners' cultural reality using curriculum based content, socially meaningful characters and production features that facilitate learning. It has further demonstrated the use of a specific animation production technique, cut-out animation, can enable the creation of content with a strong appeal to children owing to its ability to simulate textures and use of cut out photographs. The findings also reveal that no major differences exist in the responses from girls and boys and also, no major differences existed amongst the participants from different schools. The animation served to both educate and entertain as shown the children's enjoyment behaviour as well as skill acquisition outcomes. It can therefore be concluded that educational animation, when primed to meet the target audience learning objectives, offers a great potential for cognitive enrichment.

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APPENDICES

Appendix A: Character Design Style sheet

Appendix B: Animation Storyboard

Page No. ______ Scene 1 ______ Production ______ Story Artist ______

Opening sequence.
Narrator: Toto's market day: returning change.
Toto: Giggles

Toto: Hello! On school holidays I help mother sell eggs at the market. First, I collect a tray full of eggs.
Chicken clucking in bg.

Toto: Then off I go to the market. Here I go!
Busy market sounds.
Bg panning to left.

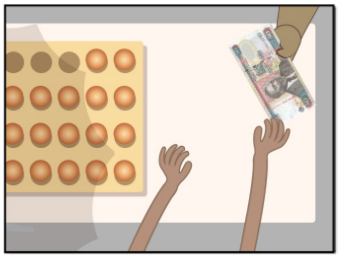
Page No. ______ Scene ______ Production ______ Story Artist ______

Toto: Humming as she sets up the stall.

Aha! A customer is here to buy the eggs!
Hello!
Customer 1: Hello Toto!

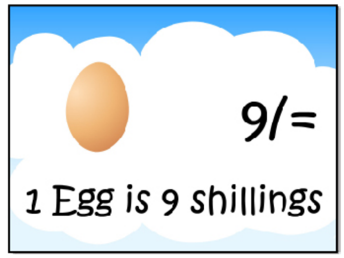
Customer: Four eggs please?
Toto(Counts four eggs) Here you are. Four eggs. Each egg is nine shillings.

Page No. ______ Scene 1 ______ Production ______ Story Artist ______



Customter: Hands over 50 shs.

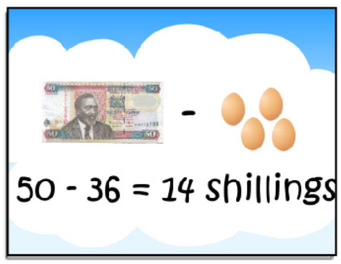
Hmm...I wonder what the change will be.



If one egg is 9 shs, four eggs will be....hmmm

Page No. ______ Scene ______ Production ______ Story Artist ______

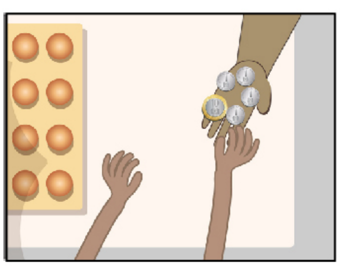
Four plus four plus four plus four. That will thirty six shillings.



Therefore fifty minus thirty six equals...hmmm....fourteen shillings! Yeah!

The change is fourteen shillings. Let us count together one, two three, four plus ten is fourteen.

Page No. ______ Scene ______ Production ______ Story Artist ______



Toto: Humming as she sets up the stall.

Yay! I gave back correct change.

Let's wait for the next customer. Will you wait with me?

Appendix C: Introductory Letter

UNIVERSITY OF NAIROBI
School of the Arts and Design

P.O. Box 30197
Nairobi, Kenya
Tel. 2724524/56
Telegram Varsity
E.mail:designdepte@uonbi.ac.ke

13th December, 2012

To Whom It May Concern:

Dear Sir/Madam

RE: ACHOKO MELISA ALLELA - B51/65020/2010

The above-named is a Master of Arts student at the School of the Arts and Design, University of Nairobi. She is carrying out some research as part of her project in the design studies in this School.

As part of the course work, the students are expected to conduct a research and collect sample materials to help them complete their research.

The purpose of this letter is to request you to facilitate the achievement of the student's goal.

Yours sincerely,

DIRECTOR
SCHOOL OF THE ARTS & DESIGN
COLLEGE OF ARCHITECTURE & ENGINEERING
UNIVERSITY OF NAIROBI

Dr. Walter H. Onyango
Director
School of the Arts & Design

Appendix D: Parental Consent Form

University of Nairobi
School of the Arts and DESIGN
P. O BOX, Nairobi

Title of Research: Using Animation to Enhance Learning: A Case Study of Primary School Mathematics
Name of Primary Researcher: Melisa Achoko Allela
Phone Number ofPrimary Researcher: 0736272798

A. Purpose and Background

Under the supervision of Mr. Muriithi Kinyua, Melisa AchokoAllela, a graduate student at the School of the Arts, University of Nairobi is conducting research on the use of animation to effectively enhance children's' mathematics knowledge. The purpose of this interview is to help the researcher study students' response patterns when presented with mathematics instruction in an animated format.

B. Procedures

If I agree for my child to participate in this research study, the following will occur:

1. My child will be asked to respond to a set of ten questions rating their understanding of the mathematics topic in question. They will provide narrative based answers and this should take about 30 minutes.
2. My child will be shown an educational animation on a mathematics topic about money and asked to respond to a set of questions.
3. The researcher will review your child's responses.
4. Participation in this study will take a total of 1 1/2hours over a period of 2 weeks in December 2012 and if need be, January and February 2013.
5. There will be no consequences if your child chooses to not participate.

C. Risks
Risks will include the possible loss of privacy, possible discomfort at answering some questions and inconvenience.
Confidentiality: The information gathered from this study will be kept as confidential as possible.

Your child's real name will not be used in the report and all files, transcripts and data will be stored in a locked cabinet in the researcher's home, and no one except the researcher will have access to them. Your child's name will not be used and any identifying personal information will be avoided.

D. Direct Benefits
There are no guaranteed benefits to your child.

E. Alternatives
Your child is free to choose not to participate in this research study.

F. Costs
There will be no costs to your child or you as a result of your child taking part in this research study.

H. Questions
I have spoken with Melisa Achoko Allela about this study and have had my questions answered. If I have any further questions about the study, I can contact Melisa Allela by calling 0736272798 or write to her at melisallela@gmail.com.

I. Consent
I have been given a copy of this consent form to keep.
PARTICIPATION IN RESEARCH STUDY IS VOLUNTARY. My child is free to decline to participate in this research study, or I may withdraw their participation at any point without penalty. Their decision whether or not to participate in this research study will have no influence on their present or future status at ______________________________Primary School.

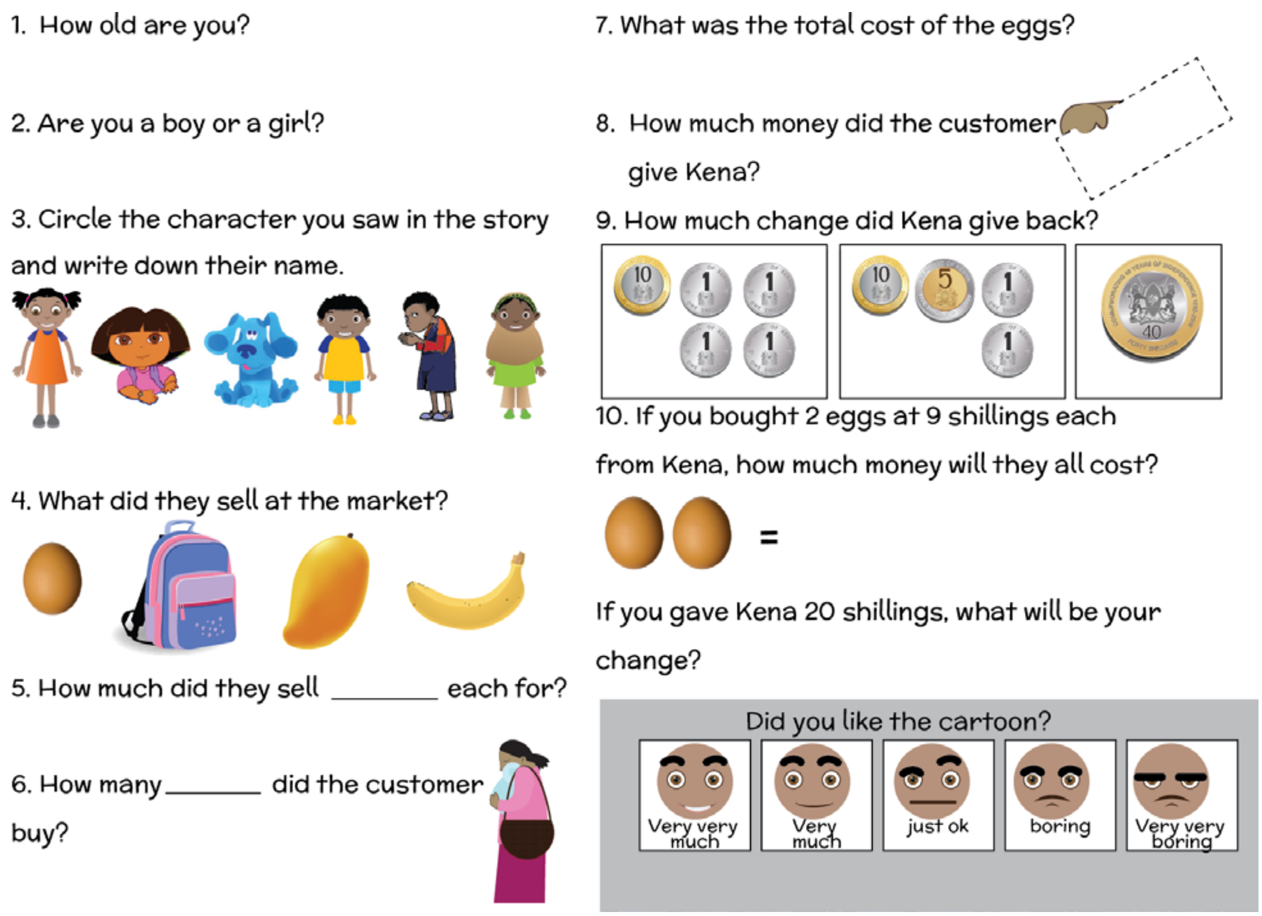
My child ___________________________________ has my consent to participate in the educational research study.

Student is a minor ______________ (age)

Parent/Guardian: _____________________________ (signature)

Date: _______________

Appendix E: Children's Questionnaire



1. How old are you?

2. Are you a boy or a girl?

3. Circle the character you saw in the story and write down their name.

4. What did they sell at the market?

5. How much did they sell ________ each for?

6. How many _______ did the customer buy?

7. What was the total cost of the eggs?

8. How much money did the customer give Kena?

9. How much change did Kena give back?

10. If you bought 2 eggs at 9 shillings each from Kena, how much money will they all cost?

=

If you gave Kena 20 shillings, what will be your change?

Did you like the cartoon?

Very very much | Very much | just ok | boring | Very very boring

Figure 12: Children's Questionnaire

Appendix F: Chi Square Analysis of Cross tabulation data

Table 17: Chi-Square Tests for Gender *Recall of Characters name * School

Name of School		Value	df	Asymp. Sig. (2-sided)
Migosi SDA Primary School	Pearson Chi-Square	2.779[b]	2	.249
	Likelihood Ratio	3.097	2	.213
	N of Valid Cases	40		
Victoria Primary School	Pearson Chi-Square	1.469[c]	3	.689
	Likelihood Ratio	1.860	3	.602
	N of Valid Cases	40		
Highway Primary School	Pearson Chi-Square	3.852[d]	3	.278
	Likelihood Ratio	3.937	3	.268
	N of Valid Cases	40		
Total	Pearson Chi-Square	1.804[a]	4	.772
	Likelihood Ratio	2.188	4	.701
	N of Valid Cases	120		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .47.

b. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .40.

c. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .48.

d. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 1.90.

Table 18: Chi-Square Tests Gender * Recall the characters * Name of School

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	2.171[b]	2	.338		
	Likelihood Ratio	2.859	2	.239		
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	.261[c]	1	.609		
	Continuity Correction[d]	.000	1	1.000		
	Likelihood Ratio	.267	1	.605		
	Fisher's Exact Test				1.000	.538
	N of Valid Cases	40				
Highway Primary	Pearson Chi-Square	7.392[e]	3	.060		

School	Likelihood Ratio	9.341	3	.025		
	N of Valid Cases	40				
	Pearson Chi-Square	5.787[a]	3	.122		
Total	Likelihood Ratio	8.080	3	.044		
	N of Valid Cases	120				

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 2.80.

b. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .40.

c. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.43.

d. Computed only for a 2x2 table

e. 6 cells (75.0%) have expected count less than 5. The minimum expected count is 2.38.

Table 19: Chi-Square Tests Gender * Recall what was sold * Name of School

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	1.538[c]	1	.215		
	Continuity Correction[b]	.043	1	.836		
	Likelihood Ratio	1.871	1	.171		
	Fisher's Exact Test				.400	.400
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	1.134[d]	1	.287		
	Continuity Correction[b]	.003	1	.960		
	Likelihood Ratio	1.517	1	.218		
	Fisher's Exact Test				.475	.475
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	2.934[e]	1	.087		
	Continuity Correction[b]	1.236	1	.266		
	Likelihood Ratio	4.086	1	.043		
	Fisher's Exact Test				.233	.135
	N of Valid Cases	40				
Total	Pearson Chi-Square	5.963[a]	1	.015		
	Continuity Correction[b]	3.936	1	.047		
	Likelihood Ratio	7.870	1	.005		

		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
	Fisher's Exact Test				.020	.020
	N of Valid Cases	120				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.33.

b. Computed only for a 2x2 table

c. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

d. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .48.

e. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.43.

Table 20: CHI-SQUARE TESTS: GENDER * RECALL COST OF EACH ITEM * NAME OF SCHOOL

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	1.172[c]	1	.279		
	Continuity Correction[b]	.554	1	.457		
	Likelihood Ratio	1.200	1	.273		
	Fisher's Exact Test				.329	.230
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	2.327[d]	1	.127		
	Continuity Correction[b]	.638	1	.424		
	Likelihood Ratio	3.094	1	.079		
	Fisher's Exact Test				.219	.219
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	.043[e]	1	.836		
	Continuity Correction[b]	.000	1	1.000		
	Likelihood Ratio	.043	1	.836		
	Fisher's Exact Test				1.000	.554
	N of Valid Cases	40				
Total	Pearson Chi-Square	.213[a]	1	.644		
	Continuity Correction[b]	.060	1	.806		
	Likelihood Ratio	.214	1	.644		
	Fisher's Exact Test				.672	.404
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.07.

b. Computed only for a 2x2 table

c. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.60.

d. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .95.

e. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.70.

Table 21: Chi-Square tests Gender * Recall number of items sold * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	.556[c]	1	.456		
	Continuity Correction[b]	.139	1	.709		
	Likelihood Ratio	.570	1	.450		
	Fisher's Exact Test				.711	.360
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	.[d]				
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	2.162[e]	1	.141		
	Continuity Correction[b]	1.282	1	.258		
	Likelihood Ratio	2.208	1	.137		
	Fisher's Exact Test				.186	.129
	N of Valid Cases	40				
Total	Pearson Chi-Square	.347[a]	1	.556		
	Continuity Correction[b]	.127	1	.722		
	Likelihood Ratio	.346	1	.556		
	Fisher's Exact Test				.644	.360
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.73.

b. Computed only for a 2x2 table

c. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.00.

d. No statistics are computed because Recall number of items sold is a constant.

e. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.18.

Table 22: Chi-Square Tests Gender * Recall total cost of all the items * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	2.298[c]	1	.130		
	Continuity Correction[b]	1.372	1	.241		
	Likelihood Ratio	2.403	1	.121		
	Fisher's Exact Test				.177	.120
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	.[d]				
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	1.069[e]	1	.301		
	Continuity Correction[b]	.505	1	.477		
	Likelihood Ratio	1.078	1	.299		
	Fisher's Exact Test				.349	.239
	N of Valid Cases	40				
Total	Pearson Chi-Square	1.675[a]	1	.196		
	Continuity Correction[b]	1.202	1	.273		
	Likelihood Ratio	1.690	1	.194		
	Fisher's Exact Test				.236	.136
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.27.

b. Computed only for a 2x2 table

c. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.20.

d. No statistics are computed because Recall total cost of all the items is a constant.

e. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.60.

Table 23: Chi-Square Tests Gender * Recall the amount of money the customer gave * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	.060[c]	1	.806		
	Continuity Correction[b]	.000	1	1.000		
	Likelihood Ratio	.061	1	.804		
	Fisher's Exact Test				1.000	.652
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	.005[d]	1	.942		
	Continuity Correction[b]	.000	1	1.000		
	Likelihood Ratio	.005	1	.942		
	Fisher's Exact Test				1.000	.731
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	.935[e]	1	.334		
	Continuity Correction[b]	.345	1	.557		
	Likelihood Ratio	.952	1	.329		
	Fisher's Exact Test				.457	.280
	N of Valid Cases	40				
Total	Pearson Chi-Square	.699[a]	1	.403		
	Continuity Correction[b]	.304	1	.582		
	Likelihood Ratio	.698	1	.404		
	Fisher's Exact Test				.570	.290
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.53.

b. Computed only for a 2x2 table

c. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.20.

d. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .95.

e. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.28.

Table 24: Chi Square Tests Gender * Recall the amount of change returned * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	6.155[c]	1	.013		
	Continuity Correction[b]	4.642	1	.031		
	Likelihood Ratio	6.505	1	.011		
	Fisher's Exact Test				.022	.014
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	1.134[d]	1	.287		
	Continuity Correction[b]	.003	1	.960		
	Likelihood Ratio	1.517	1	.218		
	Fisher's Exact Test				.475	.475
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	.401[e]	1	.527		
	Continuity Correction[b]	.056	1	.812		
	Likelihood Ratio	.405	1	.524		
	Fisher's Exact Test				.698	.408
	N of Valid Cases	40				
Total	Pearson Chi-Square	1.937[a]	1	.164		
	Continuity Correction[b]	1.368	1	.242		
	Likelihood Ratio	1.968	1	.161		
	Fisher's Exact Test				.188	.121
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.13.

b. Computed only for a 2x2 table

c. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.80.

d. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .48.

e. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 3.80.

Table 25: Chi Sqaure Test Gender * Skill aquisition addition of items bought * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	.026[c]	1	.872		
	Continuity Correction[b]	.000	1	1.000		
	Likelihood Ratio	.026	1	.871		
	Fisher's Exact Test				1.000	.601
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	4.269[d]	1	.039		
	Continuity Correction[b]	2.846	1	.092		
	Likelihood Ratio	4.436	1	.035		
	Fisher's Exact Test				.060	.045
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	2.431[e]	1	.119		
	Continuity Correction[b]	1.540	1	.215		
	Likelihood Ratio	2.454	1	.117		
	Fisher's Exact Test				.203	.107
	N of Valid Cases	40				
Total	Pearson Chi-Square	5.134[a]	1	.023		
	Continuity Correction[b]	4.287	1	.038		
	Likelihood Ratio	5.157	1	.023		
	Fisher's Exact Test				.032	.019
	N of Valid Cases	120				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.20.

b. Computed only for a 2x2 table

c. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 3.20.

d. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.28.

e. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.55.

Table 26: Chi Square Tests Gender * Skill acquisition change * Name of School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	1.075[b]	2	.584		
	Likelihood Ratio	1.083	2	.582		
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	1.522[c]	1	.217		
	Continuity Correction[d]	.802	1	.370		
	Likelihood Ratio	1.530	1	.216		
	Fisher's Exact Test				.314	.185
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	1.695[e]	2	.429		
	Likelihood Ratio	2.082	2	.353		
	N of Valid Cases	40				
Total	Pearson Chi-Square	1.006[a]	2	.605		
	Likelihood Ratio	1.012	2	.603		
	N of Valid Cases	120				

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.40.

b. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .80.

c. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.18.

d. Computed only for a 2x2 table

e. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .48.

Table 27: Chi Square Test Gender * Preference levels * School

Chi-Square Tests

Name of School		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Migosi SDA Primary School	Pearson Chi-Square	.684[b]	1	.408		
	Continuity Correction[c]	.000	1	1.000		
	Likelihood Ratio	1.039	1	.308		
	Fisher's Exact Test				1.000	.600
	N of Valid Cases	40				
Victoria Primary School	Pearson Chi-Square	2.439[d]	2	.295		
	Likelihood Ratio	2.841	2	.242		
	N of Valid Cases	40				
Highway Primary School	Pearson Chi-Square	1.844[e]	3	.605		
	Likelihood Ratio	2.239	3	.524		
	N of Valid Cases	40				
Total	Pearson Chi-Square	4.447[a]	3	.217		
	Likelihood Ratio	5.273	3	.153		
	N of Valid Cases	120				

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .93.

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .40.

c. Computed only for a 2x2 table

d. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .48.

e. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .48.

Appendix G: Pretest Experimenter Script

Before beginning the viewing procedure on the first day, the experimenter will sit down with the child and follows this script to determine what, if anything, the child has learned. If the child does not respond, or responds incorrectly, the experimenter may improvise so that the script can be followed, however only in a manner that does not influence the child's knowledge or confidence.

1.1st Experimenter: Hi! My name is _________. What is your name?
(Child responds)

2. **How old are you?**

(Child responds)

3. **1st Experimenter: Do you know how to buy eggs at the market or shops?**

(Child responds)

1st Experimenter: (Place an image showing four eggs on the table) If you are sent to the market to buy two eggs that each cost nine shillings, how much money will you pay?

(Child responds)

This question tests the child's ability to work out a basic arithmetic operation (addition and multiplication)

4. **1st Experimenter: And if you gave the shop keeper 20 shillings for the eggs, how much change should she give you back?**

(Child responds)

This question tests the child's ability to work out a basic arithmetic operation (subtraction)

Appendix H: Pretest Correct Responses

1. **1st Experimenter: Hi! My name is _________. What is your name?**

(Child says name)

2. **How old are you?**

(Child says age)

3. **1st Experimenter: Do you know how to buy eggs at the market or shops?**

(Child responds)

1st Experimenter: (Place an image showing two eggs on the table) If you are sent to the market to buy two eggs that each cost nine shillings, how much money will you pay?

Correct Responses: 18 shillings.

A correct response is worth 5 points.

4. **1st Experimenter: And if you gave the shop keeper 20 shillings for the eggs, how much change should she give you back?**

Correct Responses: Two shillings.

A correct response is worth 5 points.