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The Use of ICT Multimedia Tools to Enhance Literacy at the Elementary level

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Abstract

This paper investigates the impact of interactive gaming on improving literacy at the primary or elementary level of education. It builds on the works of Keller's ARCS Model of Motivation and Mayer's Cognitive Theory of Multimedia learning to test the positive effects of Information and Communication Technology Multimedia Tools in early childhood literacy in a developing country, Jamaica. A comparison between traditional instruction and the use of multimedia technology tools at the elementary level is given as well as the acceptance of and opposition to technology in the classroom. Post test results indicate a 43.7% improvement over pre-test scores for the experimental group versus 28.3% for the control group.

Keywords： ARCS Model; cognitive load; dual-channel; multimedia; motivation; ICT; Traditional instruction

I. INTRODUCTION

The traditional method of teaching is common among educators. Rather than being student-centred, it caters more to the methodology of the teacher, without the context of the subject, leading to a decrease in the mental interest of the students. However, rising trends are more focused on innovative activities and knowledge acquisition [1]. In other words, students need a creative way to acquire knowledge. Ref [2], agreed that traditional teaching methods have limitations as it related to providing practical insight for students.

As it pertains to the traditional teaching method, power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (in regards to curriculum content and specific outcomes). Students are regarded as having 'knowledge holes' that need to be filled with information. In short, the traditional teacher view is the that the teacher causes learning to occur [3].

Background

Jamaica is an English-speaking island country in the Caribbean region with a population is 2.7 million. There are approximately 2,600 early childhood schools in the island which have the responsibility to educate children between the ages of four to six years old. These include Primary (or Elementary) Schools, which are government funded, and Preparatory Schools which are funded by tuition fees. Primary education in Jamaica addresses the basic educational needs of students and prepares them for Secondary Education. It includes children between the ages of five to eleven years. This study took place at a Primary School located in the Kingston Metropolitan Transport Region.

Research in the field of education has suggested that pupil practice is a crucial factor in improving pupils' attainment in various content area [4][5]. One method of developing practical skills is using Information and Communication Technology (ICT). Ref [6] and [7] maintain that ICT has positively impacted practical skills from a wide range of studies including simple programs with a particular focus.

There is evidence in Jamaica to show that there have been many Ministry of Education (MOE), private sector and school community initiatives to introduce information technology in the education system over the last fifteen years.

Noteworthy, the Ministry of Education, Jamaican Foundation for Lifelong Learning introduced *Autoskills*, an online literacy improvement programme [9]. The programme was initiated in

Mona and Clan Carthy High Schools with the aim of improving literacy skills for students in the Career Advancement Programme. Private companies like GoGSAT and EduFocal offer online assistance for students at the primary and secondary level. Both programmes use ICT tools to aid pupils in practicing skills learned.

ICT in Education

In recent years there has been a groundswell of interest in how computers and the Internet can best be harnessed to improve the efficiency and effectiveness of education at all levels and in both formal and non-formal settings. Some of these settings include e-Learning, distance learning and blended learning.

Digital media is currently used in different ideas to involve entertainment (motivating factor) as a way of learning, also called edutainment. We are now in the era of digital natives, where most people are raised knowing and being surrounded by computers and electronic devices [8]. The widespread use of information technology (IT) and, in particular, the mass popularization of the World Wide Web (WWW) have meant that opportunities have been identified for developing distance learning activity into a more advanced online environment. Using technology in both classroom and distance learning will: improve the quality of learning, facilitate access to education and training as well as reduce the costs [10].

School observations within Jamaica's educational system show that schools were incorporating ICT tools in various aspects of teaching and learning. Facilitated by the E-Learning Jamaica Programme, schools are utilizing ICT to teach computer studies and information technology at the CXC level. At the primary level, there is some use of computer-assisted instructions for remediation, numeracy and literacy. These tools also promote computer literacy as well as enhance learning in different subject areas.

Despite the limited use, there has not been a concentrated drive to focus on the use of ICT tools to attack issues such as literacy deficiencies at the primary level in the education sector.

Research from the Ministry of Education, Youth and Information indicates that 78.7 percent of students who sat the Grade Four Literacy Test in 2016 had total mastery, with a total of 96.3 percent been deemed literate [11]. While, this is an improvement from 2015, when it was 86.5 percent [12], statistics still fell short of the Ministry of Education’s goal of 100 percent literacy in all primary schools by 2015. Therefore, there is room for improvement and the use of ICT tools can form a vital part of the improvement process. ICT tools such as interactive games, videos and software as suggested by Lynch, Fawcet and Nicolson, (2000), could ensure that

learners was given tasks at an appropriate level that can be matched with their prior attainment and their individual needs.

Problem Statement

Since 2013, the E-Learning Jamaica Programme has outfitted over 700 Jamaican primary schools with ICT equipment. This technological support could improve teaching methodologies, especially in numeracy, where urgent support is needed [13].

Despite the advancement of ICT tools as effective strategies for improving student educational output in numeracy, there has been a lack of wide scale implementation of ICT tools in enhancing literacy at the primary level. Low literacy rates among primary school is a cause for concern among educators in Jamaica as literacy plays a vital role in overall educational development which is directly linked to overall growth as a nation [14].

Since the launch of the Tablet in Schools Pilot Programme, the Government of Jamaica has spent $114 million for the provision of electronic content on the tablet computers. Content is available for the subject areas of Mathematics, English Language, and the Sciences from the lower primary to the secondary level [15].

Purpose of Study

This study will investigate the motivation factors of ICT tools, on young children's cognitive development and academic performance. It uses a hybrid of two conceptual frameworks to determine learning outcomes and compares the traditional method of teaching to that of an ICT aided method. It also receives feedback from both parents and teachers.

Furthermore, this knowledge can be used by key stakeholders that benefit from the early education sector by the integration of websites, games and mobile applications to augment literacy syllabi.

Conceptual Framework

Many theories have been proposed by proponents of Constructivism, Motivational and Humanist Theories, and even Media and Technology Theories, especially with regards to learning environments. In this study, researchers used a combination of Keller's ARCS Model and the Cognitive Theory of Multimedia (derived from the Cognitive Load Theory and developed by Mayer, Sweller and Moreno).

Keller's ARCS model looks at ways of promoting and sustaining motivation in a learning environment which at its heart branches to Attention, Relevance, Confidence and Satisfaction. The Cognitive Theory of Multimedia Learning is based on three main assumptions: i)there are two separate channels (auditory and visual) for processing information; ii) there is limited channel capacity; and iii) that learning is an active process of filtering, selecting, organizing, and integrating information.

By using these models for a conceptual framework, the research was able to determine which environment best motivates students to learn and what are the most effective design principles to employ an easier way for students to learn.

The literature review in Section II outlines the following constructs of the ARCS model - Attention (A), Relevance (R), and Satisfaction (S), as well as aspects on the Cognitive Theory of Multimedia Learning as it relates to ICT Tools and literacy.

Significance of Study

Although multiple studies have been conducted on theories and models of motivation, little research has been done on applications of those models in different cultures and environments. In the same way, with the rapid development of technology, the methods of communication and speed of communication are rapidly changing.

Research Questions

The following research questions were used to guide the data collection and data analysis:

- What is the significant difference in levels of literacy attainment when the traditional teaching method is compared with computer/multimedia assisted learning?
- To what extent does interactive gaming impact students' literacy attainment?
- What is the correlation between motivation and exposure to computer/multimedia assisted learning?

Hypothesis

- The use of ICT Tools has a more positive impact on students' grades than the traditional method.

Variables

There was one dependent variable and one independent variable. The dependent variable was students' literacy performance, determined by the test results and interactive gaming application which was used with the experimental group to test the research questions stated above. The independent variable is test administered (gaming application and traditional test).

Limitations

Convenience sampling is also the preferred choice of sampling due to close proximity to the researcher, thus becoming cost effective. Another limitation of the quantitative approach is that other factors, such as a novelty effect involving increased enthusiasm of teachers and students, may be unconsciously introduced to confound the results of the experiment [16]. Also, if participants were to leave or quit the study while in progress, the outcome for those participants becomes unknown which can affect data quality and by extension the findings.

Since a pretest/post-test approach is being used, one limitation that is exposed is that participants may become familiar with the outcome measure and remember responses for the later testing.

II. LITERATURE REVIEW

Introduction

The literacy practices of young children and their parents are currently being characterized by their everyday use of digital technology. These technologies over the past decade have become cheaper, more portable and efficient [17]. These new and innovative tools that are now available have been what children have grown up with in the past generation, so it is no wonder why young children would be enthused to master their usage of these technologies [18]. However, research consistently show that though there are some who are eager to promote and embrace new technologies [19], there are others who believe that such technologies are developmentally inappropriate and risk exposing children to unsuitable content and uncritical engagement with information [20].

Typically in Jamaica, students are given traditional instruction whereby a teacher is in charge of the learning environment. Teachers use blackboards/whiteboards, various text books and handouts to instruct students through various exercises, which involve reading and writing.

According to Ref [21] the traditional classroom lacked any computer based technologies but the multimedia classroom was a computer based classroom where instructions are supplemented with multimedia applications (i.e. ICT is used to teach).

Unfortunately, many, but not all Jamaican schools have access to computer labs. However, in recent years, many schools have benefited from the Ministry of Education's Tablets in Schools Programme [22] as well donations from generous businesses [23].

Academic Views of ICT in Early Education

According to Ref [24], ICT "is used differently in education including benchmarks of digital literacy, economic sector definitions and regulations, information technology disciplines, socio-economic development, and governance" ([24], p 1).

Research suggests that the potential of new technologies for young children's literacy development remains largely untapped in educational settings, with a 'digital divide' such that some children develop considerable digital skills and knowledge by participating in supported activities at home, whilst others have little or no opportunity to engage with new media at home and even less so in education [25][26][27][.

Ref [17] agreed that there was a positive #impact of using technology in classrooms, particularly with mobile devices. In their research, iPads were integrated in a children's centre nursery (ages 3 – 4 years old), a primary school reception class (ages 4 – 5 years old), and a Special school (ages 7 – 13 years old) over a 2 month period. The usage of iPads stimulated children's motivation and concentration. They also offered a very rich opportunity for communication, collaborative interaction, independent learning and for children to achieve high levels of accomplishment. In some cases, this led teachers to favourably re-evaluate the competence of children's literacy and increased the children's self-esteem in terms of literacy. Practitioners particularly valued the opportunities iPads gave to deliver curriculum guidelines in new ways, and to familiarize all students with touch-screen technologies.

Ref [26], added that with computer interactions within the homes, young children acquire a wide range of skill set when using technology without direct instruction. Based on an investigation of children's technological learning at home [26] found that:

Although several research outline the benefits of ICT in children's early learning, due to the "digital divide", many childhood practitioners have their reservations about the use of technology aided learning. Some were wary of the addictive and 'over-stimulating' nature of

gaming and felt children were spending too much time sitting down and not enough time outside [17]. Others were afraid of the social deficiencies that may cause problems for development, such as patient perseverance due to the fast pace of digital gaming. As such there needs to be a balance in the use of these technologies to ensure proper development.

Motivation

Motivation is the process by which goal-directed activities are stimulated and sustained [28] and is seen by choice, persistence and effort.

Just as students deserve guidance as learners, professors are entitled to helpful direction in their teaching [29]. Seldin also noted that regardless of how good a teacher is, in a classroom or laboratory, there is always room for improvement. By bringing forward the point of why many question "what constitutes effective teaching?", Seldin then proclaims we have no reason to ignore hundreds of studies that are in general agreement on characteristics such as a deep knowledge of the subject, an ability to communicate with and motivate students, enthusiasm for the subject and for teaching, clarity of presentation, and fairness.

Infants and young children appear to be propelled by curiosity, driven by an intense need to explore, interact with, and make sense of their environment [30][31]. As one author puts it, "Rarely does one hear parents complain that their pre-schooler is 'unmotivated'" [32]. Ref [30] makes the observation that, as children grow, their passion for learning shrinks. She states that although students are physically present in a classroom, largely they are mentally absent. Consequently, an educator's awareness for students' attitudes and beliefs about learning will develop and whatever motivates learning can be used to reduce student apathy [30].

Concerning student motivation, Lumsden says, it has to do with students' desire to take part in the learning process. However, it also concerns the reasons behind their involvement or non-involvement in academic activities. Although students may be motivated equally to do something, the sources of their motivation may differ. Student motivation is influenced by both internal and external factors that can start, sustain, intensify, or discourage behaviour [33].

Intrinsic and Extrinsic Motivation

Self determination theory provides a general understanding of motivation and how it applies to education [34]. For example, a student who is intrinsically motivated undertakes an activity "for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of

accomplishment it evokes" [35]. Internal factors include the individual characteristics or dispositions that students bring to their learning, such as their interests, responsibility for learning, effort, values and perceived ability [36].

However, an extrinsically motivated student performs "in order to obtain some reward or avoid some punishment external to the activity itself," such as grades, stickers, or teacher approval [35]. Depending on the activities done in class, they can either, promote or hinder motivation (Ainley, 2004). For example, challenging, relevant instruction helps to engage students. Another way to increase motivation was through positive connections to others, such as mentors and role models. When intrinsically motivated, students tend to employ strategies that demand more effort and that enable them to process information more deeply [30].

Ref [37] found that when students were confronted with complex intellectual tasks, those with an intrinsic orientation used more logical information gathering and decision-making strategies than did students who were extrinsically oriented. Schools can positively influence student motivation through varied and integrated instructional strategies and resources, an open and caring school environment, wide range of student supports and sharing information and responsibilities for student learning among the staff. These techniques all promote student motivation for educational success [38][39][40]..

Ref [41] queried the traditional distinction between intrinsic and extrinsic motivation and proposed an alternative view termed, "gradient knowledge" (p.4). Rather than viewing intrinsic and extrinsic as opposites, they looked at motivation as a part of a continuum where students "transitioned from lack of motivation, through a series of externally-driven regulations and incentives, to reach a self-determined level of intrinsic regulations which increased curiosity and determination to achieve a specific objective" [42].

In previous studies it was proven that high motivation in students was linked to reduced dropout rates and increased levels of student success [43][44][45][46]. Students were also more engaged in learning when they were active and had some choice and control over the learning process, and the curriculum was individualized, authentic, and related to their interests [47][48].

It was also observed that intrinsically motivated students retain information and concepts longer, are less likely to need remedial courses and review [43], and were more likely to be lifelong learners, continuing to educate themselves outside the formal school setting, long after external motivators such as grades and diplomas are removed [49].

Ref [47] suggest that to motivate students to learn, instructors need to engage students in setting learning goals, ensuring that goals are challenging, but achievable. Students also needed to take ownership for their learning, and to reflect on what they have learned and accomplished. In addition, by making real-world connections students can see how material learned can be applied outside the classroom. Ref [47], also recognize that not all students are motivated by the same thing so individual attention needed to be given, not only in motivation but also in feedback. Students need to be reminded that their success often requires persistence and a willingness to overcome obstacles.

When it came to rewarding students, caution must be taken as students who are only motivated to avoid failure or earn a certain grade rarely exert more than minimum effort to meet their goals. Giving early feedback and praising good work helps to build students' self-confidence.

Fostering collaboration rather than competition among students encourages them to master skills at their own rate, for their own benefit, rather than competing with classmates.

Lastly, developmental differences in educational level shows that student engagement in school tends to decline as students get older [47]. By middle school, peer influences have an increasing effect on motivation.

Conceptual Framework

The conceptual framework for this research was a hybrid model based on a combination of the Cognitive Theory of Multimedia Learning (CTML) and the ARCS Model for Motivation. One variable from the CTML, the Dual-Channel Assumption, was proposed to increase motivation to learn, thus resulting in an increased learning outcome as seen in Fig 1 below.

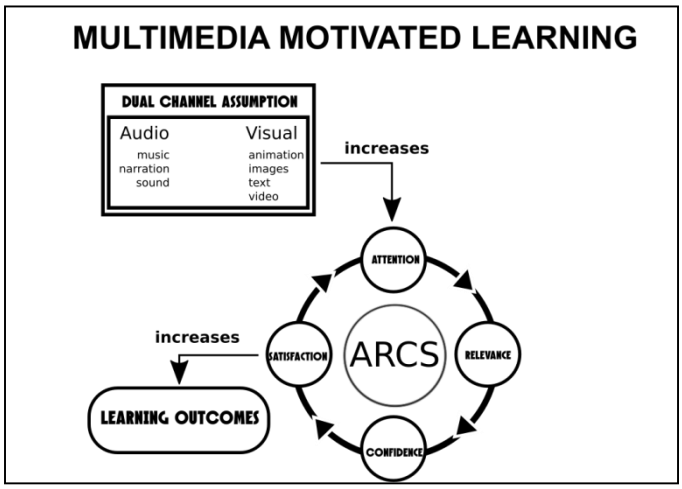

Fig. 1. **Hybrid Model "Multimedia Motivated Learning", of the Dual Channel Assumption and the ARCS Model**

Keller's ARCS Model

The ARCS Model of Motivation [50] was developed by John Keller, in response to a desire to find more effective ways of understanding the major influences on the motivation to learn, and for a systematic way to identify and solve problems with learning motivation [51]. Four key elements formed the acronym for the ARCS Model, namely, Attention, Relevance, Confidence and Satisfaction (ARCS).

From a theoretical perspective, ARCS model provides a framework for understanding how motivation works. The above mentioned key elements are four (4) steps to promoting and sustaining motivation in the learning process. Attention and relevance according to Keller's ARCS motivational theory are essential to learning. The first two of four key components for motivating learners, attention and relevance can be considered the backbone of the ARCS theory, the latter components relying upon the former [52]. Typically, motivation is viewed as "highly unpredictable and changeable", subject to many influences over which the teacher or designer has no control. Therefore, teachers and instructional designers see their responsibility as imparting good quality instruction and assume it is the students' responsibility to take advantage of the learning opportunity. Keller's ARCS Motivation Model also has been applied in web-based learning settings to create, stimulate and maintain motivating learning environments [53].

The model is based on the expectancy-value theory of [54] and [55] , which presumes that people are motivated to learn if there is value in the knowledge presented (i.e. it fulfills personal needs) and if there is an optimistic expectation for success [56]. Expectancy-value theory assumes that people are motivated to engage in an activity if it is perceived to be linked to the satisfaction of personal needs (value aspect), and if there is a positive expectancy for success (expectancy aspect) [53].

In the original model [57][58], the value aspect and the expectancy value were expanded to four (4). Value was subdivided to interest and relevance. Expectancy remained the same but another category, outcomes was added [53]. Interest and relevance were separated to make a distinction between constructs, which are primarily concerned with curiosity and arousal versus other motives, such as "need for achievement" and "perceived utility". All of these variables have an influence on what people think is important, however, interest refers more to "attentional" factors in the environment and relevance refers more to goal directed activity.

Expectancy refers to one's expectation for being successful. It includes several areas of research that are concerned with people's self-confidence and their feelings of control over their lives and environment. Therefore, is no doubt that a person's perception of the likelihood of success directly affects the actual success rate [59]. Outcomes refers to reinforcing value of instruction. The outcomes of goal-directed behaviour have an influence on subsequent levels of perceived value and expectancy for success, and consequently, form the final category of the motivational variables in the ARCS model [53].

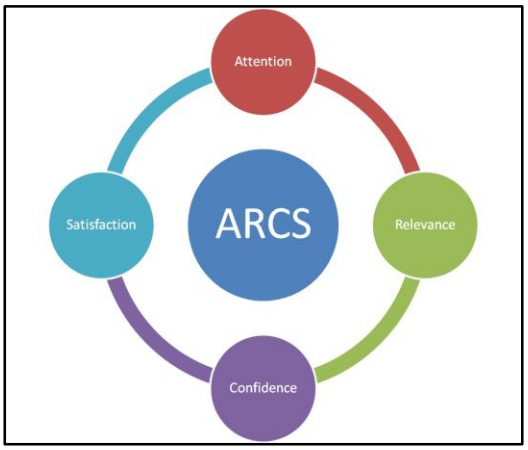

Fig. 2. **Diagram of Keller's ARCS Model**

Motivation is not only the learner's responsibility but is also the instructor or designer's responsibility. Each factor of the ARCS Model has three elements, which ref [60] delineates as seen in Table 1 below.

Attention

The attention mentioned in this theory refers to the interest displayed by learners in taking in the concepts/ideas being taught. This component is split into three categories: perceptual arousal, using surprise or uncertain situations; inquiry arousal, offering challenging questions and/or problems to answer/solve; and variability, using a variety of resources and methods of teaching. Within each of these categories, Keller has provided further sub-divisions of types of stimuli to grab attention, which include:

- Perceptual Arousal
- Inquiry Arousal
- Variability

TABLE I. **ARCS MODEL BREAKDOWN**

Attention	Relevance	Confidence	Satisfaction
Perceptual Arousal Provide novelty and surprise	***Goal Orientation*** Present objectives and useful purpose of instruction and specific methods for successful achievement	***Learning Requirements*** Inform students about learning and performance requirements and assessment criteria	***Intrinsic Reinforcement*** Encourage and support intrinsic enjoyment of the learning experience
Inquiry Arousal Stimulate curiosity by posing questions or problems to solve	***Motive Matching*** Match objectives to student needs and motives	***Successful Opportunities*** Provide challenging and meaningful opportunities for successful learning	***Extrinsic Rewards*** Provide positive reinforcement and motivational feedback
Variability Incorporate a range of methods and media to meet students' varying needs	***Familiarity*** Present content in ways that are understandable and that related to the learners' experiences and values	***Personal Responsibility*** Link learning success to students' personal effort and ability	***Equity*** Maintain consistent standards and consequences for success

Source: University of New England https://moodle.une.edu.au/mod/page/view.php?id=810955

Relevance

Relevance, according to ref [58], must be brought about by using language and examples that is familiar to the learners. Keller broke it down into three (3) major strategies [52]:

- Goal Orientation
- Motive Matching
- Familiarity

Confidence

The confidence aspect of the ARCS model focuses on building positive expectations for achieving success among learners. The confidence level of learners is often related to the motivation and the amount of effort put into reaching a performance goal. For this reason, it's important that learning design provides students with a method for estimating their probability of success. This can be achieved in the form of a syllabus and grading policy, rubrics, or a time estimate to complete tasks. Additionally, confidence is built when positive reinforcement for

personal achievements is given through timely, relevant feedback. Keller offers learning designers the following confidence building strategies: (1) Performance Requirements - Learners should be provided with learning standards and evaluative criteria upfront to establish positive expectations for achieving success. If learners can independently and accurately estimate the amount of effort and time required to achieve success, they are more likely to put forth the required effort. Conversely, if learners are unaware or feel that the learning requirements are out of reach, motivation normally decreases. (2) Success Opportunities – Being successful in one learning situation can help to build confidence in subsequent endeavors. Learners should be given the opportunity to achieve success through multiple, varied, and challenging experiences that build upon one another. (3) Personal Control- Confidence is increased if a learner attributes their success to personal ability or effort, rather than external factors such as lack of challenge or luck [52].

Satisfaction:

Learners must obtain some type of satisfaction or reward from a learning experience. This satisfaction can be from a sense of achievement, praise from a higher-up, or mere entertainment. Feedback and reinforcement are important elements and when learners appreciate the results, they was motivated to learn [52]. Satisfaction is based upon motivation, which can be intrinsic or extrinsic. Keller suggests three main strategies to promote satisfaction: (1) Intrinsic Reinforcement – encourage and support intrinsic enjoyment of the learning experience. Example: The teacher invites former students to provide testimonials on how learning these skills helped them with subsequent homework and class projects. (2) Extrinsic Rewards – provide positive reinforcement and motivational feedback. Example: The teacher awards certificates to students as they master the complete set of skills. (3) Equity – maintain consistent standards and consequences for success. Example: After the term project has been completed, the teacher provides evaluative feedback using the criteria described in class. To keep learners satisfied, instruction should be designed to allow them to use their newly-learned skills as soon as possible in as authentic a setting as possible.

As mentioned before, ref [61] argues that designers often overlook motivational design components because they believe motivation is not a measurable aspect of learning and that motivation is too “unpredictable and changeable, subject to many influences” over which the teacher or designer has no control (p. 2). Keller maintains, however, that motivation is not as unpredictable as has been assumed. Motivation can, in fact, be approached systematically with

a model rooted in Instructional Systems Design [57][58][60][61][62]. Ref [63] demonstrate clearly how Keller's motivational design theory can be used successfully in concert with Dick and Carey instructional macro-design model and with Gagné's events of instruction.

Ref [64] added that Keller's ARCS Model of Motivation views learning as an "internal process." The ARCS Model and other micro-design models also indicate that learning is preceded by "sequenced instructional strategies that provide motivation, direction, guided practice, feedback, and reinforcement" [64].

Brief Overview of the Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia learning (CTML) concentrates on the idea that learners endeavor to build relationships between words and pictures and that they learn more deeply than they could have with words or pictures alone [65]. One of the principle aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material. The learner's job is to make sense of the presented material as an active participant, ultimately constructing new knowledge.

According to ref [66] and [67], CTML is based on three assumptions: the dual-channel assumption, the limited capacity assumption, and the active processing assumption.

The dual-channel assumption is that working memory has auditory and visual channels based on Baddeley's theory of working memory [68] and Paivio's dual coding theory[69].

Second, the limited capacity assumption is based on cognitive load theory [70][71] and states that each subsystem of working memory has a limited capacity.

The third assumption is the active processing assumption which suggests that people construct knowledge in meaningful ways when they pay attention to the relevant material, organize it into a coherent mental structure, and integrate it with their prior knowledge [72].

Cognitive Theory of Multimedia Learning (CTML)

People learn more deeply from words and pictures than from words alone. This assertion, which can be called the multimedia principle, underlies much of the interest in multimedia learning. For thousands of years, words have been the major format for instruction including spoken words, and within the last few hundred years, printed words [70].

Today, thanks to further technological advances, pictorial forms of instruction are becoming widely available, including dazzling computer-based graphics. A fundamental hypothesis

underlying research on multimedia learning is that multimedia instructional messages that are designed in light of how the human mind works are more likely to lead to meaningful learning than those that are not.

These multimedia instructional messages, according to Mayer [70], can be communicated through words and images aimed at fostering learning and can be delivered in book-based form (paper, etc) or computers. Words can be printed or narrated, and images can be static (still image) or dynamic (animation of video clips). Figure 2.2 below presents frames from a narrated animation on lightning formation, which Mayer [73] had studied in many experiments.

Learning, can be measured by how well information is retained (remembering the presented information) and how well it is is transferred (using the information to solve new problems). Therefore, multimedia instructional messages should be designed based what we know about how people process information.

Assumptions of the CTML

Mayer [74] stated that if a designer's concept of how people process information produces a multimedia presentation, overflowing with multi-coloured words and images, flashing and moving, etc., then the designer assumed and catered only to a single-channel of learning. Further assumptions, according to Mayer [74] was that the single-channel (visual) had an unlimited and passive processing system. The aforementioned designer would have failed to take advantage of the auditory senses in the presentation, assumed that humans can process an unlimited amount of material and need no guidance to make sense of the material presented.

Mayer disagrees with such assumptions by referring to the research in cognitive psychology in how the human mind works [75][76].

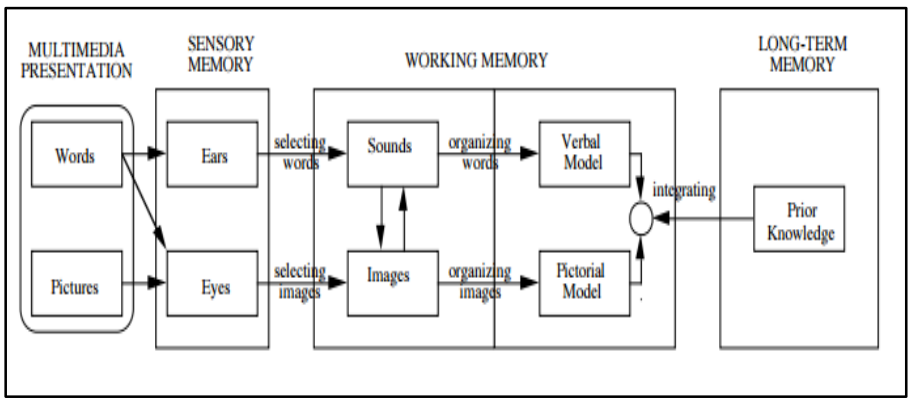

Fig. 3. **Mayer's Cognitive Theory of Multimedia Learning (Mayer 2010a)**

Dual-Channel Assumption

The dual channel assumption is that people possess separate information processing channels, one for visually represented material and another for auditory represented information. This proposed that the human information processing system has a verbal channel and a pictorial channel. When information is presented to the eyes (images, illustrations, videos, animation, text) humans process through the visual channel. Likewise when they information is heard (music, sounds, narration), it is processed through the auditory channel [74].

The concept has a long history in cognitive psychology, is closely related to Paivio's dual-coding theory [68] and Baddeley's model of working memory [67]. It is also possible for information to be converted from one channel to the next. For example, on-screen text may initially be processed in the visual channel but an experienced reader may be able to convert the seen text into sound (narration), which is processed in the auditory channel [74].

Limited Capacity Assumption

TABLE II. **COGNITIVE PROCESSES OF THE CTML**

Process	Description
Selecting words	Learner pays attention to relevant words in a multimedia message to create sounds in working memory.
Selecting images	Learner pays attention to relevant pictures in a multimedia message to create images in working memory
Organizing words	Learner builds connections among selected words to create a coherent verbal model in working memory.
Organizing images	Learner builds connections among selected images to create a coherent pictorial model in working memory
Integrating	Learner builds connections between verbal and pictorial models and with prior knowledge

The CTML in Education

Paivio [69] and Bradley [75][76] pointed out that "humans possess separate channels for processing visual and auditory information." Earlier research has shown that, between the traditional and the multimedia method, the multimedia method of instruction gave statistically significant improvements [78][79][80][81][82][83][66]. Multimedia was claimed to be one of

the best methods of instruction, because it addressed more than one of the senses, both sight and hearing.

Other research showed little to no difference in results between to two methods [84][85]. Mayer et al stated however that having too much stimuli in a presentation had negative impact on student retention which demonstrates the second assumption, limited capacity assumption [86].

Baddeley [87][88], along with Chandler and Sweller's [89][90] recognized that humans had a limited capacity to process information for each of the individual channels. Test can typically be done by using a memory span test. Chandler and Sweller [89] demonstrated that one method for reducing extraneous cognitive load is to eliminate redundant text. Mousavi, Low, and Sweller [91] and Sweller et al. [91] reasoned that cognitive load is reduced by the use of dual-mode (visual-auditory) instructional techniques and that the limited capacity of working memory is increased if information is processed using both the visual and auditory channels, based on Baddeley's model of working memory. In one study, the recall performance of 60 undergraduate students was tested using multimedia learning environment where the results indicated that multimedia instructional design were effective in recall performance [93].

Gaps in the Literature

From the literature review, some gaps were found. Firstly, as it pertains to determining how to measure the cognitive load during learning [74]. Also, a range of measures are needed to assess the effects of different uses of ICT on pupils' attainment, and also to assess the effects of other non-ICT-based learning experiences on attainment [94] Recommendations were made to have research done with both qualitative and quantitative approach to the effectiveness of multimedia learners [21].

With majority of research being done in the formal education sector, not much research seemed to focus on the effects of using ICT Tools in the home, whether on its own or to supplement the established educational curriculum of a child [17]

Though research exist on the effective use of ICT worldwide in various levels of education, it has been noted that not much implementation has been forthcoming for ICT in Jamaican Primary level education [95]. Hence, this research seeks to address that gap.

III. METHODOLOGY

Research Design

The research design of choice was the experimental design. This systematic approach to the research allowed the researcher to manipulate one or more variables and controls, to measure any change in other variables. Therefore, a literacy pretest and post-test control group design was used for the study. The experiment was a one (1) by two (2) independent groups design and measured one (1) level of the independent against two (2) levels of the dependent variable respectively. An interactive gaming application was developed and used so as to measure against two levels of literacy performance. There was a control and an experimental group. The control group was given the traditional method of instruction while the experiment group was facilitated by a teacher with the Interactive Gaming Application during a three weeks period.

A case study was used to to determine the impact of an interactive gaming application on students' literacy attainment in primary schools. The dependent variable was students' literacy performance, determined by the test results. The independent variable was the interactive gaming application which was used with the experimental group to test the research questions stated above. In judging students' performance the total pass was compared with the total failure. A comparison of average percentage improvement of the pretest versus and the post test results.

Population and Sample

The selected primary school was located in an inner-city area in the Kingston Metropolitan Transport Region. The school's population was one hundred and twenty students, most of whom are from inner-city communities. The school on average receives students who seemed to have behavioural problems, literacy and numeracy deficiencies and were financially challenged. The school consists of 11 teachers. The teaching staff generally consists of trained teachers, most of whom are not computer literate and/or adequately educated about the functions of information and communication technologies. There is an average of two teachers per grade. There was only one grade four class at the institution.

The study consisted of two teachers from the fourth grade, 11 males and 11 female students. All student participants were within the age group range of eight and ten years old. Twenty-two (22) grade four students were selected from a grade population of 120 students using a

simple random sampling technique. Student participants were divided into two (2) groups. The students in the first group were given a series a phonic and vocabulary building activities using the conventional method and the second group used an ICT interactive gaming application. There was a preliminary training activity for the teachers on how to use the gaming application and how to instruct students to use the said tool.

TABLE III. **SAMPLE OF PARTICIPANTS IN CASE STUDY**

SAMPLE			
Participant	Population	Size	Percentage %
Students	120	22	18.3
Teachers	11	2	18.2
Total	133	24	18.05

Sampling Technique and Instrumentation

A sample of 22 participants from a population of 120 students was chosen from the city primary school in Jamaica. They were observed using cross sectional surveys of gathering data when the participants take the pretest until they take the post test. The participants were stratified into male and female to observe their learning progression. In order to fulfill the above objectives, participants were tested weekly by the interactive gaming application to record their scores for statistical analysis. The main statistical techniques i.e. Frequency, Mean, and Variance testing was used for the data analysis.

The test instrument administered to the students consisted of 20 multiple choice question items created based on the selected subject topics which were used as pretest and post-test.These were then used to measure both the lower and higher cognitive skills of the students in reading comprehension and reading skills and vocabulary acquisition. Both the experimental and control group were exposed to word and syllable pronunciation and vocabulary testing hence both groups took the achievement test.

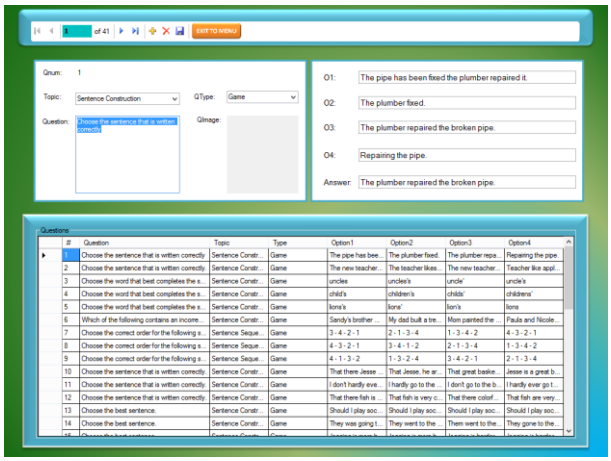

Fig. 4. **Buzz Bee application allowed instructors to create questions.**

Fig. 5. **Quizzes are timed with multiple choice questions.**

The treatment instrument was an interactive ICT gaming application. The two subject topics from the subject content of the grade four reading syllabus was used as an aid in developing this instrument. The gaming application allowed for students to partake in fun but constructive activities such various interactive gaming accompanied by the use of multimedia materials. It also allows for teachers to set quizzes (Fig 4 and 5 above) that was administered weekly to students during the research at the end of each week. Important to note is that the pop quiz administered by the teacher could be used as a tool in the researcher's analysis as method of determining a test subject's weekly progress. The application also had an auto test marking feature that grades and tabulates the students' performance on the given test or pop quiz.

Procedure for Data Collection

For the purpose of this research and in order to achieve the objectives, data collected and was used for both primary and secondary data. The secondary data contributed toward the formation of background information, needed by both the researcher in order to build

constructively the project and the reader to comprehend more thoroughly the intervention outcome.

Primary data was collected in two ways. Firstly, the test (Pretest and Post-test) constructed was conducted with students before and after participating in the study. Secondly, the gaming application will maintain statistical records of students' performance while using the application.

Secondary Data was collected via online questionnaire to participants who have passed through primary education. The data collected from them were not limited to the school where the gaming application was used.

Pretest and Post Test

Before the sample participants are divided into two groups of 11, a pretest was conducted. The test will consist of 20 multiple choice questions. The test was graded and tabulated by the teacher for later use. The scores generated from the pretest was used to compare with the score obtained after the respective tools have been applied to the control group and the experimental group.

The post test is the same test that was conducted in the pretest right before the teaching methods are applied to the two groups. The scores obtained in the post test was used to compare with the scores recorded in the pretest to determine any change in performance of the students and their group.

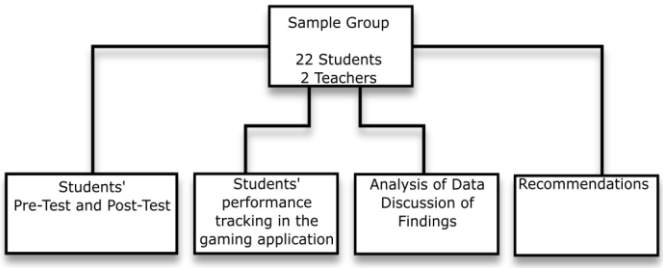

Fig. 6. **Model of Research Design and Data Collection Procedure**

Questionnaire

A questionnaire was also designed and sent to public participants over the age of 18 years, including caretakers of children. The aim of the questionnaire was to identify variables within the theories presented and how they affect the learning of children, the exposure of ICT Tools

in the classroom as well as in the home unit. It was also used to ascertain whether students were exposed tools and which tools were used to supplement learning (if used at all) within the school system as well as to determine by observation (through either parents or teachers) whether children within the Primary Education system are motivated to learn , through the use of ICT Tools.

At total of 35 questionnaires were completed through online medium Google Forms, sharing a link on email as well as social media platforms such as Facebook and LinkedIn. The data was then interpreted and translated to PSPP for data analysis. Questions five (5) to twenty-one (21) and thirty-four (34) to thirty-seven (37) correspond to the ARCS Model while twenty-two (22) to thirty-three (33) correspond to the Dual-Channel Assumption as seen in Table IV below.

TABLE IV. **SUMMARY OF QUESTIONNAIRE ITEMS**

ITEMS	RELATES TO	ITEM LABELS
1 – 4	Demographic Information	
5 – 16	Attention	ATT01,ATT02,ATT03,ATT04,ATT05, ATT06,ATT07,ATT08, ATT09,ATT10, ATT11, ATT12
17 – 21	Relevance	REL01, REL02, REL03, REL04, REL05
22 – 33	Dual Channel	DC01, DC02, DC03, DC04, DC05, DC06, DC07, DC08, DC09, DC10, DC11, DC12
34 – 35	Confidence	CON01, CON02
36 – 37	Satisfaction	SAT01, SAT02

Validity and Reliability

Reliability is an indicator of the consistency of a measure. A measure is reliable when different attempts of measuring converges on the same result [96]. Reliability is comprised of three categories, namely: equivalence, stability and internal consistency. Equivalence has to do with the ability of the instrument to use consistent measurement for an entity with two or more researchers. Stability, however, refers to the degree in which the instrument performs

consistently whenever it is utilized to measure an entity multiple times and internal consistency refers to the degree in which the items on the instrument used are measuring the same construct [97].

Coefficient alpha is the most popular method used to assess reliability [98]. A Cronbach's Alpha is a measure of internal consistency [99] consistency and reliability of questionnaire items. The coefficient obtained for the questionnaire was between 0.61 and 0.84 for each variable in the questionnaire. PSPP (open source alternative to SPSS; program for the analysis of sampled data) was used for variable calculations. Cronbach Alpha values ≥ 0.7 are considered to be desirable however if the value exceeds < 0.9 is tremendously unlikely to be desirable [100]. However rated coefficient alpha values between 0.60 and 0.70 as having fair reliability [96].

IV. FINDINGS AND RESULTS

Descriptive Statistics

The sample size for the experiment was comprised of 22 participants (11 males and 11 females). The participants were Grade 4 students with an age range from 8 to 10 years old. Each student did a pretest and post test having both basic and challenging literacy skill levels as seen in Table V below.

TABLE V. **AVERAGE OF PRETEST AND POST TEST RESULTS**

	PRETEST	POST TEST	+VE/-VE %
	BASIC/ADVANCE AVERAGE	BASIC/ADVANCE AVERAGE	
CTRL	45.00	57.7	28.3% INCREASE
EXP	46.80	67.3	47.7% INCREASE

[a.] The average results above were derived form twenty-two students who participated in basic and advance literacy exercises. The last column shows the percentage increase or decrease between the pretest and post test.

Summary of Findings

It should be noted that for the control group, participants had an average score of 45 for the pretest and 57.73 for the post test. This shows a 28.29% increase between the average pretest and post test scores. As for the experimental group, participants had an average of 46.82 for the

pretest and 67.27 for the post test. This shows a 43.69% increase between the average pretest and post test scores.

Hypothesis Testing

A hypothesis is a testable statement which proposes a relationship between two or more concepts. The hypothesis posited is based on a theory [101]. The levels of significance for hypothesis tests are normally set at 5% or 1%. If the probability is less than or equal to the level of significance (α), the null hypothesis should be rejected, otherwise it should be accepted [102]. The value 0.05 (5%) is normally used as the level of significance to determine if the result obtained from the hypothesis test is credible (Trochim, 2000).

- Research Question 1:

What is the significant difference in levels of literacy attainment when the traditional teaching method is compared with computer assisted learning?

- Hypothesis 1: The use of ICT Tools has a more positive impact on students' grades than the traditional method.
- Null Hypothesis: The use of ICT Tools has no positive impact on students' grades than the traditional method.

TABLE VI. **ANALYSIS OF VARIANCE FOR CONTROL GROUP RESULTS**

ANOVA - Single Factor						
Alpha	0.05					
Groups	Count	Sum	Mean	Variance	Std Dev	
Pretest	11	495	45	215	14.663	
Post Test	11	635	57.727	221.818	14.894	
Source of Variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**P-value**	**F critical**
Between Groups	890.909	1	890.909	4.0791	0.0570	4.3512
Within Groups	4368.182	20	218.409			
Total	5259.091	21				

[b.] ANOVA analysis showing the differences between the average scores obtained by pretest and post test of the control group.

TABLE VII. **ANALYSIS OF VARIANCE FOR CONTROL GROUP RESULTS**

ANOVA - Single Factor						
Alpha	0.05					
Groups	Count	Sum	Mean	Variance	Std Dev	
Pretest	11	515	46.818	271.364	16.473	
Post Test	11	740	67.273	236.818	15.389	
Source of Variation	**Sum of Squares**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	2301.136	1	2301.136	9.056	0.007	4.351
Within Groups	5081.818	20	254.091			
Total	7382.955	21				

c. ANOVA analysis showing the differences between the average scores obtained by pretest and post test of the experimental group.

Single factor between groups ANOVA was used to assess the effect of teaching method on the average scores obtained. Table VI shows the statistical analysis for the control group (those exposed to traditional method). There was a statistically insignificant difference ($p > 0.05$) between the pretest and the post test of the control group.

However, Table VII showed the statistical analysis for the experimental group (those exposed to ICT gaming application after the traditional pretest). These was a statistically significant difference ($p < 0.01$) between the pretest and post test of the experimental group, proving hypothesis one that ICT Tools had a more positive impact on students' grades than the traditional level.

- Research Question 2

To what extent does interactive gaming impact students' literacy attainment?

According to the Table 4.1 both the control group and the experimental group experienced an increase in the average grade for both pretest and post test. For the control group the pretest and post test showed an average score of 45.00 and 57.73 respectively showing a difference of 12.73 in score. For the experimental group the pretest and post test showed an average score of 46.82 and 67.27 respectively showing a difference of 20.45. The control group showed a score increase of 28.29% while the experimental group showed an increase of 43.68%. This shows a 15.39% more significant improvement in grades with the use of the ICT gaming application.

- Research Question 3

What is the correlation between motivation and exposure to computer/multimedia assisted learning?

Pearson's Correlation

The Pearson correlation coefficient, also known as the product moment correlation coefficient, is represented in a sample by r, while in the population from which the sample was drawn it is

represented by ρ. The coefficient is measured on a scale with no units and can take a value from −1 through 0 to +1. If the sign of the correlation coefficient was positive then there was a positive correlation between variables, however if the sign was negative there was a negative or inverse correlation between variables.

Pearson's Correlation was done on the results of the questionnaire to analyze the opinions of participants on the relationship between each variable for motivation (Attention, Relevance, Confidence, Satisfaction) and the use of ICT multimedia tools (Dual-Channel) as seen in Tables IX to XII below. As stated before, the results of the questionnaire are not limited to the participants of the experiment, but the questionnaire was issued to persons who have already passed through primary education.

TABLE VIII. **PEARSON'S CORRELATON FOR KELLER'S ARCS MODEL AND THE DUAL-CHANNEL ASSUMPTION**

Correlations

		Attention	Relevance	Confidence	Satisfaction	Dual_Channel
Attention	Pearson Correlation	1.00	.73	.63	1.00	.91
	Sig. (2-tailed)		.000	.000	.000	.000
	N	35	35	35	35	35
Relevance	Pearson Correlation	.73	1.00	.60	.73	.85
	Sig. (2-tailed)	.000		.000	.000	.000
	N	35	35	35	35	35
Confidence	Pearson Correlation	.63	.60	1.00	.63	.83
	Sig. (2-tailed)	.000	.000		.000	.000
	N	35	35	35	35	35
Satisfaction	Pearson Correlation	1.00	.73	.63	1.00	.91
	Sig. (2-tailed)	.000	.000	.000		.000
	N	35	35	35	35	35
Dual_Channel	Pearson Correlation	.91	.85	.83	.91	1.00
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	35	35	35	35	35

[d.] Pearson's Correlation between Keller's ARCS and the Dual-Channel Assumption

Analysis of Questionnaire Data

A Pearson's Correlation was done to determine the correlation between 35 correspondents (N=35) view on child attention and dual channel values.

There was very strong positive correlation between Attention and Dual Channel ($r=0.91$, $p<0.01$). This implies that when Dual Channel levels increase so does the Attention of students.

There was also a very strong positive correlation between Relevance and Dual Channel ($r=0.8$, $p<0.01$). This implies that when Dual Channel increases, so does the Relevance of students.

Correlation between CO and DC was another strong and positive one ($r=0.83$, $p<0.01$). This implies that when the DC increases, so does the CO. Finally, the correlation between Satisfaction and Dual Channel was another strong and positive one ($r=0.91$, $p<0.01$), show that as Dual Channel increases so does the Confidence of the students.

It could then be assumed that most persons believe that a multimedia approach to teaching directly affects the motivation to learning. However for each of the correlations, there were no significance ($p=0.00$), indicating no statistical significance. This may be due to a small sample size. Another possibility may come from calculating the average for each of the variables.

v. CONCLUSION

The results showed that there was a very strong linear correlation between the use of ICT Multimedia tools in the classroom and the increase of students' grades in Primary education. In the experiment performed showed that by comparison, students who were exposed to an interactive gaming software performed on average did better than those expose to only tradition method of learning. At the end of the experiment the post test of experimental showed an increase 43.7% improvement over pretest scores while the control group only showed an increase of 28.3%. These results contribute to the body of knowledge within the scope of ICT in early childhood education. It also adds to the works of motivational model of Keller and the Dual-Channel Assumption found in the Cognitive Theory of Multimedia Learning, by Mayer and Moreno. Whereas many previous research look to these models separately, this paper sought to investigate the correlation between increased stimulus in learning and motivation to increase the outcomes of students. The hypothesis proposed, that using ICT Tools has a more positive impact on students' grades than the traditional method and that students are more motivated to use ICT Tools in learning, was proven to be true.

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