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The Effect of Computer Mediated Instruction (CMI) on the Motivation and Achievement of Science Students in Mainstream Zone Education Prioritaire (ZEP) Schools

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Abstract

This study investigated the effects of computer-mediated instruction in an interactive multimedia learning environment on Standard V pupils from Zone d'Education Prioritaires (ZEP) schools in terms of achievement and motivation. The study measured the effectiveness of Computer Mediated Instruction (CMI) for science students. The theory was to provide a research framework to explain or predict effective learning by pupils using CMI. Two modes of instruction were used, computer-mediated instruction and the traditional book (control group); these modes were designed and developed to serve the purpose of this study. Both the CMI and the traditional book instruction were treated as independent variables, and the dependent variables were the students' achievement scores and motivation. A random sampling was taken from a total of 65 pupils from the ZEP schools participating in this study. The participants were randomly assigned to one of the modes of instruction. Descriptive and inferential statistics were performed to analyse the collected data. The results revealed that the pupils who used CMI performed significantly better than those who used traditional book instruction in terms of achievement and motivation.

Keywords: computer-mediated instruction, traditional instruction, Zone d'Education Prioritaires, motivation, achievement

Introduction

Early studies revealed that CMI focuses on drill and practice, which neither provides meaningful learning nor impacts students' achievement (Kulik and Kulik, 1991). However, CMI gained popularity and expanded to reach a wide spectrum of subjects, including mathematics, science, history, language arts, music and social studies (Chang, 2008). In a review of empirical studies on CMI, Cotton (1991) concluded that the use of CMI as an enhancement to traditional teaching produces improved achievement over the use of conventional methods alone; that research is inconclusive regarding the comparative effectiveness of conventional instruction alone and CMI alone; and that computer-based instruction yields higher achievement than conventional instruction alone. In addition, students learn the material faster with CMI than with conventional instruction alone, they retain what they have learned better with CMI than with conventional instruction alone and CMI activities appear to be at least as cost effective as other instructional methods. Based on a review of several studies comparing CMI with conventional instruction, CMI can be considered as effective as traditional instruction. Furthermore, how CMI is delivered can impact its effectiveness. New studies are needed to clarify the effect of CMI in the contemporary student environment (Jenkin and Springer, 2002). Although researchers agree that CMI has the potential to contribute immensely in education, they realise that the success of CMI is dependent on the way the technology is utilised, such as how teachers use the technology to design learning and how it influences their practices (Li and Ma, 2010; Lei, 2010; Raines and Clark 2011; Drijvers 2012; Cheung and Slavin, 2013). Researchers also noted that the transition to CMI should happen in an organic manner.

From a theoretical perspective, this study seeks to provide empirical evidence that supports and justifies the effective use of technology in boosting learners' motivation and improving achievement in science. From a practical standpoint, the results of this research could provide alternative guidelines for utilising technology appropriately in content design and the adaptation of teaching practices to help struggling learners through improving their motivation and their performance. Therefore, the purpose of this research is to examine the difference in achievement scores and motivation in science, if any, of primary Standard V pupils using computer assisted instruction and those utilising only conventional instruction.

To successfully attain the research objectives, appropriate technological tools were identified and the CMI pedagogical material was based on Gagne's nine events of instruction. An experimental study was conducted to measure the effects of CMI on students' motivation and achievement.

Review of Literature

Zones d'Education Prioritaires Concept in Mauritius

As part of educational reform, the Ministry of Education and Human Resource in Mauritius have sought to adopt a new strategy for upgrading the performance level of low achieving schools. For the last 10 years, these attempts have continued, under various names such as 'Project Schools', 'Special Support Schools' and the recent strategy is known as 'Zones d'Education Prioritaires' (ZEP). The ZEP concept is based on a desire to improve school infrastructure and environment and aims to mobilise all the resources within the Zone to raise the standard of achievement at the school. It is a new and ambitious strategy based on partnership and the premise that positive reinforcement is required to create favourable learning conditions for children living mostly in the less developed regions. This approach aims to reduce school inequality and in a broader perspective, to combat social inequality by providing equal opportunities to all primary school children in Mauritius. A school is classified as a ZEP-school when it has had a Certificate of Primary Education (CPE) pass rate of less than 40% over the last five years, or if it is a former Special Support School which had an average CPE pass rate between 40–45%.

Review of Computer Mediated Instruction (CMI)

20 years ago, CMI focused on drill and practice, movies, tutoring, testing, and fun activities (Kulik and Kulik, 1991). These methods did not provide meaningful learning nor did they impact on students' achievement, and they lacked research to substantiate their claims, which led to inconsistency in the study of CMI. Nevertheless, computer-mediated instruction has flourished and became more prevalent. In recent years, it has been used to enhance learning and influence educational practices in mathematics, science, history, language arts, music and social studies (Chang, 2008).

In 2009, Seo and Bryant conducted a meta-study of mathematics Computer Assisted Instruction (CAI) studies for students with learning disabilities over a period of 15 years to examine its effectiveness for improving student performance. The study revealed that the CAI studies were unable to demonstrate conclusive effectiveness for the mathematics performance of students with learning disabilities. Rana et al. (2011) further reported that more than 60 meta-analyses have been performed since 1980, each contributing significant information to the field but no single study has been capable of answering the overarching question of the overall impact of technology use on student achievement.

Larwin and Larwin (2011) conducted a meta-analysis on computer-assisted statistics instruction for postsecondary education evaluating 70 studies with 40,125 participants over a 40 year period. The results indicated the moderate effectiveness of computer-assisted instruction for statistics achievement in postsecondary education. Additionally, Li and Ma (2010) argued that despite increases in computer access and technology, technology's potential has not been harnessed in education. The researchers argued that change was needed within teachers in terms of teacher knowledge, self-efficacy, pedagogical beliefs and culture and concluded that teachers need to be training in the ways technology can be utilised to positively impact students' achievement.

Lei (2010) investigated the relationship between technology use and student outcomes by examining the quantity of technology used and the quality of technology used. In this study, no significant relationship between technology use and student achievement was reported. However, when the researcher studied how technology was utilised, he found that there was a positive correlation between technology use and most student outcomes. Lei concluded that technology does not have a significant effect on a student's marks but it does have a positive effect on student learning. His research indicated that technology can have an influence on a student's achievement. Nonetheless, this influence depended on how technology was used and analysed.

In 2011, Johnson and Rubin conducted a literature review on computer-mediated instruction and found several compelling results. Many of the studies (64.3%) showed significant gains in interactive CMI, while 31% of the studies showed no significant gains. Only 4.8% of the studies regarding traditional instruction were significantly better than CMI. Similarly, Drijvers' (2011) more recent research revealed that technology can improve skills and can trigger high order skills in math but it depends on the task and setting. This relationship between use and skills is subtle and is dependent on teachers, the students' skills, the tasks at hand and the opportunities for transfer of knowledge. In a recent research paper, Drijvers (2012) stated that three factors must be considered when studying technology. The first factor is design, including the design of the technology, the task, the lesson and the teaching. Second, the teacher factor has to be considered; how is he/she going to orchestrate learning. The third factor is the educational context. The use of technology has to be naturally intertwined into learning and has to make sense. Raines and Clark (2011) supported Lei's and Drijvers' research. They declared that technology is not the end of all solution for helping struggling students, but 'a tool for achieving instructional goals and can be used effectively or poorly' (Raines and Clark, 2011: 5).

Cheung and Slavin (2013), on the other hand, supports Lei's position. Cheung and Slavin asserted that technology is everywhere in society, including the classroom. To improve academic performance, it is no longer an issue whether to use technology, the question is how. Technology is more accessible and teachers are more technologically competent than in the past 20 years, therefore educators are in a better position to implement valuable educational technology into classrooms practices. Thus, Cheung and Slavin (2013) concluded that the use of technology in education has had only a small impact on math achievement when more is needed to improve math learning. Pedagogical methods, tools and practices that would fully optimise the potential of technology to improve student achievement need to be studied and developed.

Computer Mediated Instruction (CMI) in Teaching Science

In the digital age, current technologies have the potential to prepare learners with the competencies for success, including 'problem solving, critical thinking, creativity, self-learning strategies, meta-cognition, reflective thinking, social discussion skills, team work, and personal skills, such as persistence, curiosity and initiative' (Eyal, 2012: 40).

Information and Communication Technology (ICT) can play diverse roles in the learning and teaching processes. Several studies argue that the use of new technologies in the classroom is essential for providing opportunities for students to learn to operate in an information age. It is evident, as Bransford, Brown and Cocking (2000) indicate, that ICT has great potential to enhance pupil achievement as well as teacher learning. Similarly, Wong et al. (2006) reported that technology can play an important part in supporting face-to-face teaching and learning in the classroom. New technologies can help teachers promote their pedagogical practice but can also assist students in their learning process. However, it is useful to identify the factors influencing the likelihood that good ICT learning opportunities develop in schools. According to Grabe and Grabe (2007), technology can play a crucial role in student skills, motivation and knowledge. Moreover, Becta (2003) identified five major factors that influence the livelihood that good ICT learning opportunities develop in schools, such as ICT resources, ICT leadership, ICT teaching, school leadership and general teaching. According to Becta (2003), the success of the integration of technology into teaching and learning depends primarily on the ways it is applied. We have found that the integration of technology into science education has had a positive impact.

Gillespie (2006) reported that new technologies can be used in primary science education to enable pupils to collect science information, interact with resources and communicate and share. Kelleher (2000) explored effective ways of using ICT in science teaching and reported that ICTs could be positive forces in science teaching for a deeper understanding of the concepts and principles of science and could also be used to provide new, challenging and meaningful pedagogical activities.

Cognitive Theory of Multimedia

The Cognitive Theory of Multimedia (Mayer, 2001) provides theoretical evidence to support the idea that multimedia learning environments enhance cognitive processing and knowledge construction. Clark and Mayer (2008) identified three major metaphors of learning recognised by psychologists over the past century, which are response-strengthening, information-acquisition and knowledge-construction.

In the response-strengthening view of learning, learning is defined as a process of strengthening or weakening of associations where the learner is a passive recipient of rewards and punishments from an instructor who acts as the dispenser. Alternatively, the information-acquisition view of learning proposed that learning is a process of adding information to human memory. In this case, the learner is a recipient of information while the instructor is a dispenser of information. Nevertheless, these two metaphors of learning received numerous criticisms because they do not create meaningful learning.

Likewise, the knowledge-construction view of learning proposed that learning is a coherent mental representation construction and a sense-making process. In this view, the student is an active sense-maker trying to organise and integrate the presented instructional materials into mental representations. In this case, the instructor will act as a cognitive guide to facilitate the learner's cognitive processing. Based on this metaphor, the major goal of an effective multimedia instruction is to present information and to encourage and provide sufficient guidance for the learner to actively engage in meaningful cognitive processing.

Cognitive Processes in Multimedia Learning

Consistent with the knowledge-construction view of learning, the Cognitive Theory of Multimedia Learning explained that the human mind works to acquire and construct new knowledge from multimedia instructions by transforming information received by the eyes and ears through a visual-pictorial channel and an auditory-verbal channel, respectively.

The cognitive theory was formulated based on three theory-based assumptions about humans' learning through listening and seeing. The three assumptions include the Dual Channel Theory (Baddeley, 1999; Clark and Paivio, 1991; Paivio, 1986), which described humans' separate channels for processing visual and auditory information; the Limited Capacity Theory (Chandler and Sweller, 1991), which clarified that humans are restricted in the amount of information that they can process in each channel at a time; and the Active Processing Theory (Wittrock, 1989), which described active learning by humans as attending to pertinent incoming information, organising selected information into logical mental representations and blending the mental representations with other knowledge.

According to the cognitive theory, in order to comprehend the instructional messages from the multimedia learning environment, the learner will undergo several cognitive processes (Mayer, 2001, 2002), which include: (1) the selection of relevant information, (2) the organisation of patterns of information, and (3) the integration of prior knowledge with verbal and visual representations to construct new knowledge. Mayer (2001) presented the idea of the cognitive processes in the form of a diagram depicted in Figure 1.

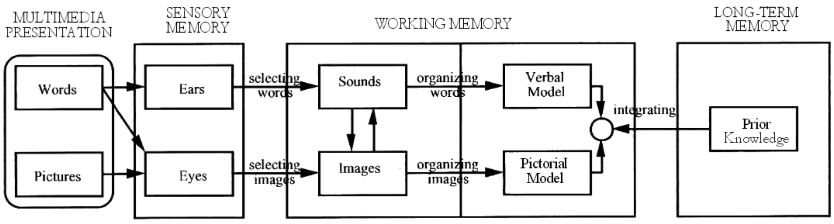

Figure 1 The cognitive processes in multimedia learning (Mayer, 2001).

The ability to complete the active-processing process affects learners' capability to transfer what was learned to related problem-solving endeavours. Mayer et al. (2004) stated that the two most important efforts in multimedia instructional design to foster meaningful learning are (1) to design the multimedia instructional materials to reduce cognitive load and to make more capacity available for active cognitive processing during instruction, and (2) to increase learners' interest and motivation toward the instruction so they will use the available capacity to engage in active cognitive processing.

ARCS Model of Motivational Design

Many instructors and instructional designers consider the motivation level of students the most important factor in successful instruction. When students have less motivation or are disinterested in the lesson, learning is almost impossible.

The ARCS model was developed in 1984 and consists of the different types of motivation necessary for successful learning (Keller, 1984). The ARCS model includes Attention, Relevance, Confidence and Satisfaction. Keller (1987a, 1987b) stated that in order to teach in a way that motivates learners, these four instructional attributes must be considered throughout the design of the instructional strategy.

The first aspect of motivation is to gain the learners' attention and sustain it throughout the instruction. The attention category includes human characteristics such as the orienting reflex, curiosity and sensation seeking. Educators believe that the avoidance of boredom is primarily the student's responsibility. There are specific kinds of activities that help avoid boredom and they tend to group into three general categories:

1. Perceptual arousal: The arousal of perceptual curiosity is a first step in the attention process but it is usually transitory because people adapt to the situation rather quickly. It needs to be followed by the next stage of curiosity arousal
2. Inquiry arousal: A deeper level of curiosity may be activated by producing a problem which can be resolved solely by knowledge-seeking behaviour. This could be conducted through the use of a warm-up activity that engages the learners in a problem-solving experiential situation or by the use of questioning techniques
3. Variability: To maintain attention it is beneficial to incorporate variability. YouTube video clips or peer activity are often a welcome change of pace

The second aspect of motivation is relevance. Relevance is a powerful factor in determining that a person is motivated to learn. A successful educator is able to build bridges between the subject matter and the learner's needs. Hence, setting goals and working to achieve them is a key component of relevance.

There are many different types of learning environments and students will differ in which environment they feel most comfortable in. If students feel positive about the interpersonal structure and working relationships in a learning environment they will be more likely to feel a sense of relevance. Understanding the students' personal motive structures can lead to the development of compatible learning environments.

At one level, familiarity can be as simple as including human interest language in textual information or human figures in graphics. At a higher level, instructional material that confirms the learner's prior knowledge and interests will be viewed as relevant.

The third aspect of motivation is confidence. Confidence is a complex concept that encompasses a number of motivational constructs varying from those that include perceptions of personal control and expectancy for success to feelings of complete helplessness (Keller, 1983). The learners must be confident that they can master the objectives of the instruction for them to be highly motivated. Therefore, building confidence in the learners throughout the instruction is important to trigger intrinsic motivation to complete the learning tasks.
There are several concepts and strategies that assist in building confidence:

1. Learning requirements: One of the simplest ways to instil confidence in learners is to let them know what is expected of them
2. Success opportunities: After creating an expectation for success, it is essential for the learners to be really successful at challenging activities that are meaningful. Frequent feedback helps learners succeed
3. Personal control: Confidence is frequently associated with perceptions of personal control over success at a task and the outcomes that follow success (Rotter, 1955). To enhance motivation, the controlling influence of the instructor should be focused in the areas of leading the experience and adhering to the standards that are expected. This provides a stable learning environment in which the learner should be allowed as much personal control over the actual learning experience as possible

The fourth aspect of motivation is satisfaction. The level of students' motivation correlates with the level of satisfaction from the learning experience. At times, satisfaction is sustained through the recognition of successful performance in the learning tasks.

Gagne's Model of Instruction

The instructional events were formed based on the Information Processing Model (Gagne, 1985) with the concept of 'external supports for internal processes of learning'. The 'external supports' referred to the instructional events. The Information Processing Model (Gagne, 1985) indicated a number of internal structures in the human brain and some of the corresponding processes that they conduct.

Due to the importance of external supports for internal processes of learning, Gagne (1985) outlined nine instructional events which should be included in an instructional system: (1) gaining attention, (2) informing learners of the objectives, (3) stimulating recall of prior knowledge, (4) presenting the stimulus material, (5) providing learning guidance, (6) eliciting performance and practice, (7) providing feedback, (8) assessing performance, and (9) enhancing retention and transfer.

Development of CMI

The material entitled 'Air' from the 'Science – Standard V, Part 2' textbook by the Ministry of Education and Human Resources was developed to serve as instructional material for this study.

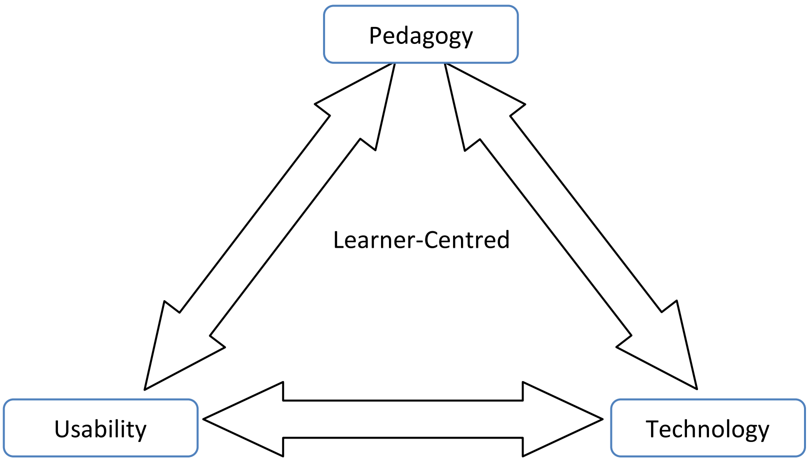

Figure 2 Proposed instructional model for CMI

The foundational principle of this proposed instructional model focuses on three key elements. The primary concern is identifying learners' needs and ensuring that the learners have access to the appropriate pedagogical resources and appropriate technology.

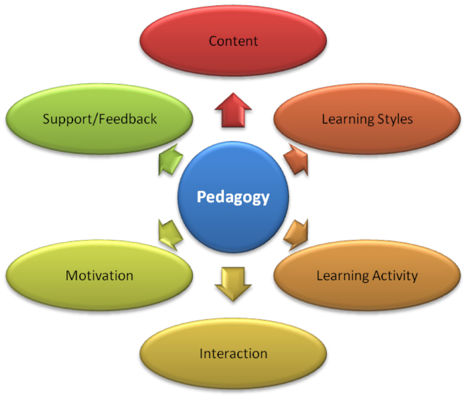

Figure 3 Factors influencing pedagogy

Based on the definition of pedagogy as a means to explore the nature of skills needed to learn effectively, this study applied these factors to the development of the CMI. As a result, the students' motivation and engagement in the learning process is enhanced and their achievement improves.

Students adopt different modes of learning depending on their own learning style. With this in mind, the use of graphics, animation, audio and videos are incorporated into the CMI content. This leads to the adoption of a learner-centred approach, which triggers the intrinsic motivation to engage more deeply in the learning process, while accommodating for learners' individual learning preferences.

Learning activity is the heart of learning process. In CMI, learning activity can be defined as the interaction between the learners and the learning environment based on defined learning outcomes. The development of activities is focused to ensure that essential content is individualised and includes students' prior experiences and goals so that the students will be motivated to value it.

Students' motivation, learning styles, prior knowledge, skills, needs and the set learning outcomes obtained from the analysis phase were carefully considered when the learning activity was designed. As a result, these activities accommodate one and all and aim to maximise the learning potential of all students.

Learning outcomes were clearly and explicitly stated at the beginning of the unit using simple language. The learning outcomes were measurable, which helps both the student and the classroom teacher.

The learning environment was adapted to the needs of the students for successful learning. The technological tools used in the CMI are user-friendly and intuitive. Appropriate feedback and support were also embedded in the CMI to sustain the motivation of the students and ultimately make them independent learners.

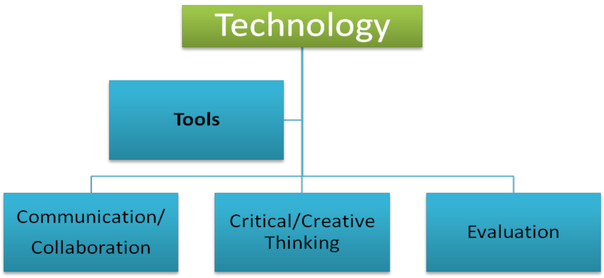

Figure 4 Expanded form of technology

The technological tools in the design and development of CMI were categorised into three broad groups (1) communication/collaboration, (2) critical/creative thinking, and (3) evaluation. Communication/collaboration tools were used to develop activities such as a puzzle, picture reading triggering peer-to-peer learning, social interaction and knowledge sharing. Usability aspects were applied to the CMI in the content and the learning environment to make it user-friendly, easy to navigate and intuitive. The major attributes associated with the content were currency, completeness, richness, clarity and the context. Figure 5 indicates the five aspects of usability for user interface which were considered.

Figure 5 Expanded form of usability

The term guidance refers to the means available to advise, familiarise, instruct and guide the students throughout their interactions with the CMI. The user-interface was adapted to the students' level and the navigation and interface elements were maintained in similar context for consistency.

Design of CMI Based on Gagne's Events of Instruction

Gagne's Events of Instruction (Gagne, 1985; Gagne, Briggs and Wager, 1992) were used as guidelines in designing the CMI. Gagne (1985) outlined nine instructional events which should be included in instruction.

The following are some of the brief descriptions of instructional events in the development of the CMI in this study.

1. Gaining attention

When students use the digital content (CMI), there is a welcome message (Figure 6) addressed to the students. In this section, the students are informed about the structure of the content and a timeline timer is used to indicate the sequencing of the content as well as its duration.

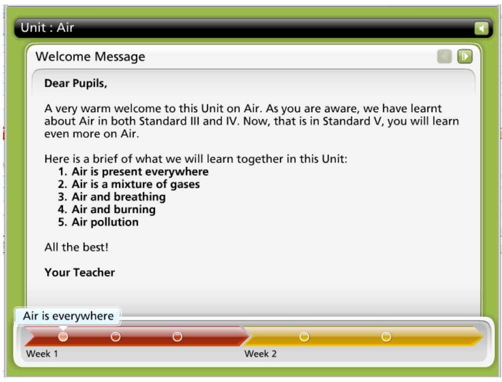

Figure 6 Welcome message

2. Informing learning of the objectives

The learning objectives (Figure 7) of the Unit on Air are clearly explained to the learners both in text and audio. Moreover, the learning objectives of the sub-units are also clarified.

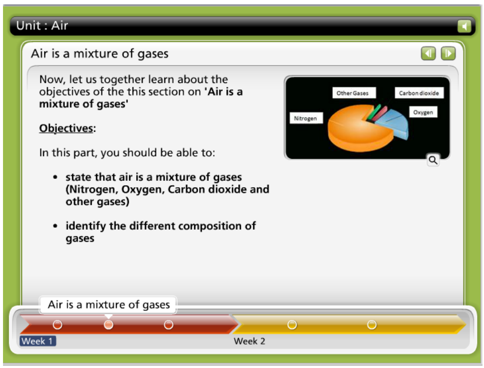

Figure 7 Learning objectives of a sub-unit

3. Stimulating recall of prior knowledge

The CMI contains some important concepts that the learners should know before proceeding to the main content.

4. Presenting the stimulus material

The existing content on 'Air' has been translated into interactive stimulus digital resources by using appropriate media. This translation makes the content more interesting, meaningful, clear and self-explicit to provide better guidance and encouragement for the students to be actively engage in the learning process. Thus, accommodating learners with different learning styles.

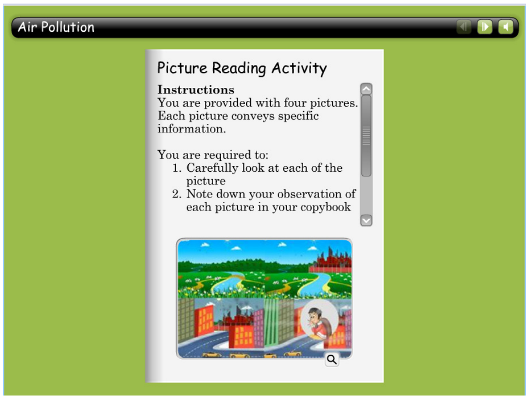

Figure 8 Stimulus activity

5. Providing learning guidance

Along with the main content, additional guidance in terms of picture reading, puzzle, mnemonics and analogies in learning activities and examples are provided. The variety of learning resources used in the CMI guides the learners to a better understanding of complex concepts.

6. Eliciting performance and practice

The practice and learning activities are embedded in the instruction in the CMI. This provides an opportunity for the students to check their understanding, monitor their learning progress and confirm their correct answer.

7. Providing feedback

The practice and learning activities provide immediate corrective feedback to the students' responses. Figure 9 depicts a screenshot of the corrective feedback during practice.

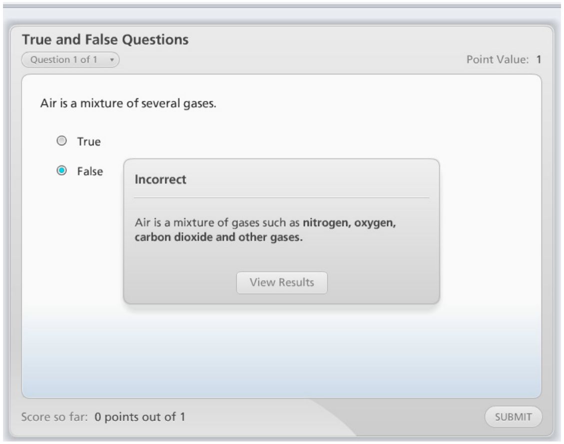

Figure 9 Corrective feedback during practice

8. Assessing performance

Upon completion of each content section and its activities, the students were given the opportunity to assess their own learning in a formative and summative manner. These assessments were conducted by the students themselves. Appropriate feedback was provided to the students to channel them in the proper direction. An overall performance score was also given to the students.

9. Enhancing retention and transfer

Upon completion of specific sub-units, a summary of each is presented in bullet points and a mind map to enhance retention and the transfer of knowledge and skills from one sub-unit to another.

Methodology

A mixed research method (quantitative and qualitative) was used to gather information. There were two types of variables present in this study. The independent variables were the traditional method and the CMI and the two dependent variables were the pupils' motivation and their achievement scores.

This study targeted upper primary level pupils from mainstream ZEP schools for the experiment. Random sampling was employed in this study to eliminate any potential of bias. The participants consisted of 65 pupils

(35 female and 30 male) from Standard V. Their age ranged from nine to 10 years, with the mean of nine years.

The Intrinsic Motivation Inventory (IMI) is a multidimensional instrument designed by Ryan (1982); it consists of 45 items categorised into seven sub-scales that assess individuals' intrinsic motivation and subjective experience related to a specific activity or learning task (McAuley, Duncan and Tammen, 1989). In this study, 15 items were carefully selected and modified to construct the questions used during the focus group discussion to measure students' motivation. The focus group discussion was led by the researcher and each group consisted of six participants.

The performance tests (pre-test and post-test) were systematically developed to measure student achievement regarding the instructional material before (pre-test) and after (post-test) the learning activity in the CMI. The performance tests items were based on Bloom's Taxonomy Revised version. Each test consisted of 20 multiple choice questions and three open-ended structural questions. Both pre-test and post-test items were similar in content but the structure and sequence of the items and the correct answers were modified slightly and randomised to reduce the probability of item memorisation. Moreover, the time interval between the pre-test and post-test was purposely arranged to be completed in four weeks to minimise the threat of possible interaction between the pre-test and post-test.

Findings and Discussion

To test the hypotheses a paired *t* test and an independent *t* test were performed. Prior to conducting the analyses, the assumption of normally distributed difference scores and the equality of variance in the samples were examined.

A Shapiro-Wilk's test ($p > 0.05$) (Shapiro and Wilk, 1965; Nornadiah and Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the test scores both before and after the use of CMI for the males and female participants were approximately normally distributed, with a skewness of .343 (SE = .512) and a kurtosis of –1.178 (SE = .992) for the males while the females with a skewness of .024

(SE = .597) and a kurtosis of –.769 (SE = .1)154 for the pre-test score. By contrast, the post-test scores depicted a skewness of .429 (SE = .512) and a kurtosis of –1.050 (SE = .992) for males but a skewness of –.065 (SE = .597) and a kurtosis of –.738 (SE = 1.154) for the females. A Levene's test verified the equality of variances in the samples (homogeneity of variance) ($p > .05$) (Martin and Bridgmon, 2012). Additionally, a one-tailed paired t test revealed that the participants using the CMI performed significantly better in the post-test.

Additionally, the CMI group ($N = 34$) was associated with a numerically higher achievement score compared to the traditional group ($N = 31$). To test the hypothesis that the CMI group performed significantly better than the traditional method group in terms of achievement scores, an independent t-test was performed. The statistical values obtained indicated that the CMI and the traditional group distributions were sufficiently normal for the purpose of conducting a t-test (i.e., a skewness of .432 (SE = .427) and a kurtosis of –.721 (SE = .833) for the traditional group whereas a skewness of .116 (SE = .403) and a kurtosis of –1.068 (SE = .788) for the CMI group. Moreover, the assumption of homogeneity of variances was tested and satisfied via Levene's F test, F (62) = 1.30, $p = .258$. The independent samples t-test was associated with a statistically significant effect, t (34) = –1.78, $p = .080$. Thus, the CMI group was associated with statistically significantly higher achievement scores than the traditional group. Cohen's d was estimated at .58, which is a moderate effect size based on Cohen's (1992) guidelines.

Additionally, the qualitative analyses were conformed to the results obtained from quantitative analysis. The pupils were as interested and enthusiastic to use the computers as they were good at using the technological tool. It was further reported that the pupils appreciated the break from the monotony of traditional science instruction. The results also indicated that the students adapted easily to this technological innovation. Students' motivation was enhanced as they enjoyed interacting with the CMI and the increased confidence associated with such interaction. Because less effort was expended in interacting with the CMI, the students felt more relaxed and willing to learn. This resulted in deeper engagement with the learning material and more independent learning. It was also reported that students were socially engaged through peer learning thereby becoming autonomous in the development of interpersonal skills. As the students were interacting with their preferred method of learning, their confidence level was enhanced and they valued the experience. This result indicates that the use of CMI in teaching science would facilitate learning by priming the learner's attention, showing the relevance of the learning material, promoting learners' confidence levels and providing extrinsic as well as intrinsic motivation for learning. The motivational strategies, as proposed by Keller (1987a, 1987b), were the determining elements in enhancing the learners' motivation to be actively engaged in learning. Moreover, these findings are supported in previous studies conducted by Bransford, Brown and Cocking (2000), Grabe and Grabe (2007) and Wong et al. (2006). The findings of this study also indicate that the achievement and motivation gap between students using the traditional method and those using CMI could be bridged by making effective use of technological tools in the design and development of learning resources. This reveals that the idea of cognitive apprenticeship (Collins, Brown and Newman, 1989) in the multimedia learning setting is an option for optimising and enhancing the motivation and achievement of learners.

Conclusion and Recommendations

This study successfully supports the idea that CMI plays a fundamental role in student skills, motivation and knowledge enhancement. This research found that infusing the right blend of technological innovation and creativity into existing instructional content reinforced pupils' achievement and motivation. The outcome of this research is consistent with the findings of many recent studies that technology can positively influence motivation and achievement when utilised appropriately. To conclude, this study offers empirical evidence that supports and justifies the effectiveness of CMI in teaching and learning science to boost student achievement and motivation. However, the sample population in this study were Standard V pupils of ZEP school. This could be a limitation because the experimental effects of CMI may differ for participants of different ages. Future research on the use of CMI should extend to the effects of CMI on individual differences such as intelligence level, psychological traits, gender, age group, cultural differences and cognitive development.

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