

Impact of Multimedia Instructional Materials on the Attainment of Higher Order Cognitive Skills: A Literature Review

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ABSTRACT

In the past decade studies have examined the role of multimedia instructional technologies in improving Higher Order Cognitive Skills (HOCS) (Bradley et al., 2007). Some studies show that it is difficult for learners to deal with decision-making situations that require HOCS. Undergraduate learning has been repeatedly criticized for failing to develop HOCS for Problem solving and Decision making in science education (Mbarika et al., 2003a). This suggests the need for new approaches to address this dilemma. The multimedia instruction is an IT tool developed to understand complex decision making that requires HOCS. There is insufficient research on the impact of multimedia technology on teaching, learning and assessment. This is proven by the paucity of research on the effectiveness and impact of Multimedia materials on HOCS development and on generation of creative instructional delivery. Furthermore, the impact of multimedia instructional materials on "actual" learning has received little research attention. Research (Bradley et al., 2007) shows that studies based on perceived learning prove that Multimedia materials improve the students' attainment of HOCS. Despite the attention this line of research has gained over past decade, there is no known study that has comprehensively compiled the knowledge base in this domain. In our study we present a comprehensive review of published studies that have examined the role of multimedia in improving HOCS of the learner. In all we find that these studies reveal four themes: (i) studies use only quantitative methods; (ii) studies are based on perceived learning; (iii) studies need to address actual learning; (iv) studies don't consider students' learning styles; (v) studies were carried out in one university. Our study aids researchers in this domain and those interested in doing work in this domain to have a sense of the direction needed to proceed.

Keywords: Higher Order Cognitive Skills, Multimedia, Learning, Teaching

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1. INTRODUCTION

Akdemir and Koszalka, (2007) state that 'Learning is a cognitive process of taking in information, processing, organizing, and storing it in rich connected schema in ways that knowledge formed is easily recalled when required'. Learning is the ability to acquire and retain new skills or knowledge. Learning is delivered using different methods including traditional, electronic or blended methods. Electronic learning approach is a method for propagating educational information, with the aid of internet and information communications Technology (ICT) (Rosenberg, 2001). E-learning is a learner-centered, flexible, convenient, collaborative learning approach that accommodates for learner difference. Therefore, e-learning aims at learner satisfaction by encouraging active self-paced learning, thereby enhancing learner responsibility for learning. Blended learning approach is a mixture of more than one learning method during teaching e.g. traditional learning and E-learning. Blended learning utilizes e-learning and maintains part of traditional learning. Traditional learning is a structured clear method that allows f2f interaction where the latter uses material from text books to aid learning. The traditional approach encourages passive learning since the students strongly depend on the teacher and therefore may lead to ineffective learning.

1.1 Higher Order Cognitive Skills Attainment using the Traditional Learning Approach

Traditional teaching and assessment strategies in science education are not compatible with promotion and development of students' HOCS (Zoller, 1993; Juwah, 2003), therefore do not favor development of problem solving and decision making skills needed by the employer (Mbarika, 2003; Ball & Garton, 2005). Therefore, the traditional approach may not be sufficient for gaining a good understanding of the concept. The complexity for people to deal with decision making situations that require HOCS has been identified (Mbarika et al., 2003b). It involves challenges such as selecting among alternatives that could have slight differences but with multi-million dollar implications. Therefore making a decision among the possible alternatives or a combination of alternatives requires that the decision makers apply HOCS during the selection process. It is a common complaint for educators that science students were not well prepared to take upper-level classes and that they often have to redo topics that

were supposed to be attempted in the introductory classes (Mbarika *et al.*, 2003a). This wastes the educators' time and resources thereby making the traditional approach ineffective.

The students' difficulty in comprehending technical issues is a concern in both academia and industry (Bradley *et al.*, 2007). There has been emphasis over time on preparing students to graduate as proficient problem solvers, decision makers, and team players with good analytical skills, reasoning, problem identification, so as to enhance their performance in the real world work environment (Rieley & Crossley, 2000). Employers expect students to sharpen their HOCS and make quick technical decisions that translate into business profits (England & Suits, 1998). These employers' aim at recruiting persons with average skills for problem solving, decision making and team playing that will profit the organization (Bargeron *et al.*, 2002). It is crucial to provide an education that encompasses HOCS to prepare students for today's workforce. There is a need for new teaching and learning methods, frameworks, tools or technologies, that impact on HOCS to prepare future university graduates and to address this dilemma.

There is a continuous search by educators for new approaches that can capture the students' attention and enhance students' attainment of HOCS. The need to create active customized learning environments for learner motivation and continuous learning desire, for different IT tools, is acknowledged. Therefore, IT tools such as Decision Support Systems and Expert Systems have been developed to help managers in decision making (Cole *et al.*, 2000; Tan & Thoen, 2000). Previous research (Mbarika, 2003; Mbarika *et al.*, 2003a; 2003b) shows that studies based on perceived learning have shown that Multimedia instructional materials improved the attainment of students' HOCS, but can hardly prove if actual learning occurred. However it is necessary to understand if HOCS were actually attained by the students. The current methods of evaluation are ineffective since they are based on the students' perceptions and do not measure actual learning (Mbarika, 2003). In addition the methods do not consider the students' personal needs; therefore there is need for an improved method that takes into consideration the students' needs. We propose a model for HOCS attainment that enhances the current MM instructional materials content strategy and assesses actual learning. The model will illustrate that by administering personalized MM instructional content to the students and the use of an observation instrument; actual learning is administered and can be tested.

1.2 Problem Statement

Studies show that it is difficult for students to deal with decision making situations that require HOCS (Mbarika *et al.*, 2003a). HOCS are significant for students to apply the knowledge acquired in class in real life situations. The emphasis of HOCS has also been stressed by employers who want to hire graduates that possess skills to solve real life problems and make decisions that will profit the organizations. Past research shows that the instructional method used is one of the causes for students' failure to develop HOCS. This research aims at assessing the impact of MM instructional materials for the development of HOCS and testing whether actual learning is attained by the students.

1.3 Theoretical Framework

Lower Order Cognitive Skills (LOCS) refer to the general knowledge attained by the students in class but cannot be used for problem solving. LOCS involve memorizing and reciting a series of facts (Zoller, 1993, 1999). The traditional learning methods emphasize LOCS teaching, where the learner needs to know one correct answer to one problem or question. LOCS teaching emphasizes exercise solving and not problem solving which is synonymous with HOCS learning. HOCS are purposeful, outcome-directed thinking that is based on a body of scientific knowledge derived from research and other sources of evidence (Bradley *et al.*, 2007). HOCS are related to critical thinking, problem solving, and are often manifested by question asking and decision making (Zoller & Pushkin, 2007). HOCS enable the students to put the knowledge acquired in learning into practice, and apply this knowledge in solving real life problems. Other researchers (Zoller & Pushkin, 2007; Guzdial & Soloway, 2002; King, 2000) have put emphasis on the need for students to demonstrate HOCS. This explains the need for an education that aims at improving analysis, problem identification, critical evaluative thinking, system thinking, reasoning, synthesis, making connections, applications, criteria content and problem solving skills for future learning.

The evident paradigm shift in educational goals requires new teaching and assessment methods, from LOCS teaching to teaching methods that promote 'HOCS learning' in science education (Lubezki *et al.*, 2004). The need for a shift in the students' learning methods in order to promote HOCS attainment is highly acknowledged. There is a need for new methods of learning to enable students achieve HOCS to satisfy the employer. Students need to grasp what they have learnt and use the knowledge acquired for problem solving and decision making. Through a blended approach, MM instructional materials content are argued to develop students' HOCS (Mbarika *et al.*, 2003a). Ball & Garton, (2005) show that the concept of HOCS is derived from the Bloom's Taxonomy. Bloom's taxonomy (Bloom *et al.*, 1956) identifies a hierarchical progression in which to categorize lower to higher order levels of cognitive processing. They further state that the six levels of Bloom's Taxonomy include knowledge, comprehension, application, analysis, synthesis and evaluation. The knowledge and comprehension levels form LOCS and application, analysis, synthesis and evaluation levels form HOCS. Educators are therefore faced with the challenge of emphasizing application, analysis, synthesis and evaluation of knowledge to promote students HOCS.

2. STATE OF THE ART IN HOCS ATTAINMENT The current practices of attaining HOCS include Problem Based Learning (PBL), HOCS Promoting Teaching & Assessment Strategies, and MM which are elaborated in the following subsections.

2.1.1 Problem-Based Learning

PBL is a method of learning where the problems act as the circumstance and driving force for learning. PBL encourages acquiring knowledge to solve a given problem and hence the problem students are solving determines the skills attained. PBL involves teaching students to apply knowledge acquired within their disciplines to solve the authentic and practical situations (Barrows & Tamblyn

1980; Hmelo, 1998). PBL increases student motivation, deeper understanding of subject area, encourages collaborative learning, and develops HOCS (Bradley *et al.*, 2007, Bradley *et al.*, 2005). There are hardly any direct solutions to problems from the materials in text books.

2.1.2 HOCS Promoting Teaching and Assessment Strategies

The paradigm shift from LOCS teaching to 'HOCS learning' is aimed at improving the quality of teaching and learning (Lubezki *et al.*, 2004). There is a need for a change in students' assessment to HOCS promoting assessment. This approach develops and implements HOCS promoting environmental exam questions in traditional exams, teaching methods and environmental education courses. These environmental issues are integrated to bring real life problems into the classroom and interest students in the subject area. This approach cultivates students' HOCS by promoting teaching strategies (Zoller, 1993, 1999, 2001; Zoller *et al.*, 2002). The approach aims at using appropriately designed HOCS-oriented exams in science teaching in order to cultivate the students' HOCS capabilities targeting at 'HOCS learning' (Tsaparlis & Zoller, 2003).

2.1.3 Multimedia and Hypermedia

Studies highlight the importance of MM tools to communicate complex technical and engineering problems to non-technical managers (Bradley *et al.*, 2007). Deeper learning is identical with HOCS because it leads to problem solving transfer, and is promoted by the use of MM in learning (Mayer, 1999, 2003; Mayer & Anderson, 1992). The author notes that assessment of MM learning is carried out through situations in which the learner uses the MM material to solve a problem. The impact of MM on learner performance has received different views by researchers. Positive and negative findings on the perceived impact of MM on student learning have been documented.

The use of MM instructional materials has confirmed the enhancement in students' perceived HOCS (Mbarika, 2003). Students' HOCS improved after MM instructional materials were administered. Past research (Bradley *et al.*, 2007) recommends incorporating learning-driven factors in MM instructional materials because they account for HOCS improvement. It is critical for MM instructional materials to include the constructs and items corresponding to learning-driven factors i.e. challenging, produce learning interest, provide self-reported learning, and provide opportunities to learn from others. Assessment of experiments using MM technologies showed a significant improvement in students' perceived HOCS development with an intervening variable. The research questions included intervening variables, because past research (Mbarika *et al.*, 2003a) indicates that intervening variables like content-driven and learning-driven factors might explain why perceived HOCS improved. The main categories for each of these tools include learning-driven factors, content-driven factors, and HOCS factors. Specific items in each category were developed based on identified learning questionnaire and assessment instruments which tap into these three constructs (Mbarika *et al.*, 2003a; 2003b).

In summary, it seems clear that the majority of published research in the field of instructional technology that purported to have found no significant difference in learning effectiveness between technology-based and conventional delivery modes were largely flawed due to the biased research questions that guided the

investigations and the inadequacy of the research methodologies (Joy & Garcia, 2000). As other authors, we argue that learning effectiveness is a function of effective pedagogical practices and that the guiding research question in integrating MM ought to be: "What combination of instructional strategies and delivery media will best produce the desired learning outcome for the intended audience?"

2.2 Learning Theories

Learning theories control how learning occurs in human beings, they determine how knowledge is acquired, constructed, processed and stored for future reference. They include situated learning, Gagne's Theory of instruction, constructivism, cognitive, behaviorism. Mayer, (1996) describes the learning theories as:

- Constructivism: the ability for students to construct their own knowledge,
- Behaviorism: the acquisition of knowledge through a stimulus – response pairs,
- Cognitive: the processing of information in order to interpret and understand it.

The learning theories have greatly impacted on the educational learning methods used today. Fosnot, (1996); Steffe & Gale, (1995) argue that learner's own knowledge is constructed individually and actively basing on their experience. The constructivist theory allows students to create knowledge from what they see, hear, read and perceive. Bruner, (1960) states that constructivism is a process in which students construct new ideas or concepts based upon their current and past knowledge. Students should construct their own meaning out of the knowledge acquired from the learning situation and interpret it based upon their experiences, to construct their own knowledge.

3.1 DATA COLLECTION

The literature was established by the use of journal papers and conference papers of ten years worth. The papers were accessed from online databases like EBSCO, IEEE, and Springer among others. The contradictory results suggest that we use MM instructional technology to supplement a written case study to bring a complex technology problem to the classroom. Research (Mbarika, 2003; Bradley *et al.*, 2007) shows that perceived learning using MM case studies confirmed enhancement in students' HOCS.

3.2 Proposed Approach

We will use MM instructional materials to bring real world technology issues in the classroom. We will assess the effectiveness of MM instructional materials for the development of students' HOCS, literature review on HOCS attainment, evaluate whether MM materials can develop students' HOCS and assess their impact on perceived and actual learning. We intend to use both the quantitative and qualitative methods to supplement each other. The research hypotheses will be tested by conducting field experiments in several classes at two universities.

Students will engage in small group collaborative learning activities while using the MM materials in the computer labs. We will assess the students' actual learning in terms of HOCS development using the student grades and two assessment tools i.e. Lab observation instrument and performance evaluation. We will observe and analyze the lab activities for evidence of HOCS

development. We will develop a lab observation instrument based on a small group observation instrument (Kouros et al., 1993; Kouros & Abrami 2003) to examine the learner collaboration and group dynamics. We will develop a project performance evaluation rubric to assess the quality of learner performance in analyzing and developing their solution for the MM case study.

We will administer a learning style questionnaire to measure the learner's preferred modes of learning, learning experience and learning strategies. We intend to carry out a thorough literature review of the existing learning style inventories to decide on the one to adapt for the study. The items from this questionnaire will be used to measure the learning-style factor.

3.3 Recommendations

Mbarika et al., (2003b) ascertain MM methodology has been validated to demonstrate the improvement of students' perceived HOCS. The authors (p. 226) further state that "the impact of MM materials on a students' HOCS improvement is not well established." The authors note that the major limitations of the previous research is that the results of the experiments, based on "perceived" learning could not be used to infer whether actual learning had been attained, and data collection was carried out using one method in the studies. They recommend measures such as learner grades, an observation instrument, pre and post-tests as a measure of actual learning. They recommend replication of the study with a larger sample size to improve validity and a longitudinal multi method study that involves a variety of data collection approaches to confirm that students' HOCS improve with MM in analyzing and solving a problem. It is against this background that we will use a large sample size and develop a model that will measure actual learning to supplement the perceived learning matrix. The model will be used to test for HOCS attainment and whether actual learning occurred. The research will address the following issues fill the research gap, increase employer satisfaction, and Teaching and Curriculum Improvement.

3.4 Conclusion

The existing literature on the methods of HOCS attainment was examined to find the gaps in the existing models and methods used. Unlike MM case studies, these methods have not been validated to reveal whether they lead to perceived improvement of HOCS. Previous research focuses on "perceived" learning where as it is necessary to understand if HOCS were actually attained by the students since they are necessary for successful learning. The existing methods of promoting HOCS do not consider initially the learner's learning profile and do not monitor how students are realistically carrying out problem solving and decision making. The content presented to the learner does not suit them; hence testing for actual attainment of HOCS is hard. The students profile is needed during the learning process. The research will illustrate whether by administering personalized MM content and an observation instrument; actual learning is administered and can be tested. The post-test that is incorporated within the study assesses in reality how students can analyze, evaluate, synthesize and problem solve within a given environment. The model will be evaluated by piloting it on several groups of students undertaking science courses.

The standardized series of assessment matrices and MM materials will be re-visited to effect any necessary revisions. This will maintain the

quality of the assessment tools and instructional materials, a process, which is especially important for the rapid changes and developments in the CS and IT field. This process will contribute in developing a distinctive teaching competence and facilitate major direct curriculum improvement. Professionals, colleges and universities will disseminate all the materials through the WWW to facilitate the dissemination and curriculum adoption. The faculty members will be trained through dissemination initiatives and access the tools online. The research focuses on developing a multimedia model that will be tested on students. Students from varied backgrounds and academic abilities will participate in this research. The model will be validated through the administering of a case study to the students to test whether HOCS have been attained and actual learning has occurred.

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