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# The impact of learning driven constructs on the perceived higher order cognitive skills improvement: Multimedia vs. text

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## ABSTRACT

The study aims at determining the impact of learning driven constructs on Perceived Higher Order Cognitive Skills (HOCS) improvement when using multimedia and text materials. Perceived HOCS improvement is the attainment of HOCS based on the students' perceptions. The research experiment undertaken using a case study was conducted on 223 students split into two groups who used multimedia and text book instructional methods respectively, to determine the impact of exposure to technology on HOCS improvement of such skills as: decision-making, problem-solving, critical thinking, analysis, synthesis, interpretation. The data collected was analyzed using the independent sample t-test to examine the effects of Learning Driven constructs of multimedia and textbook on students perceived HOCS. The findings from the study suggest that multimedia materials had no measurable effect on HOCS as compared to the traditional text book approach. The study therefore concludes that there was no significant difference in the students' attitudes, learning interest, learned from others, self reported learning, and HOCS of decision making, problem solving, critical thinking, and other skills when multimedia and text book materials were used.

***Keywords:*** *Perceived Higher Order Cognitive Skills, Learning Driven Constructs, Multimedia, Case study, Instructional methods.*

## 1. INTRODUCTION

Higher Order Cognitive Skills (HOCS) are skills that go beyond basic comprehension of a problem or concept, and relate to the perception that an individual has acquired skills to make a decision under various conditions of uncertainty and time limit (Mbarika *et al*., 2010; Lou *et al*., 2008; Bradley *et al*., 2007a, b; Zoller *et al*., 2002; Zoller, 1993; 1999). HOCS implies an improved learned ability to identify, integrate, evaluate, and inter-relate concepts within a given problem domain, thereby making the appropriate decisions to solve a problem. HOCS include skills of decision-making, problem-solving, critical thinking, analysis, synthesis, interpretation, among others. HOCS are essential if students are to apply knowledge acquired in class in novel and real life situations. Several authors imply that the traditional learning approach, a structured clear method that allows face to face interaction of students and their lecturers is not compatible with promotion and improvement of students' HOCS (Mbarika *et al*., 2010; Zoller & Pushkin, 2007; Bradley *et al*., 2007; Zoller, 1993; Juwah, 2003), therefore do not favor development of problem solving, critical thinking and decision making skills needed by the employer (Ball & Garton, 2005; Mbarika, 2003).

Undergraduate education is often criticized for failing to improve HOCS for problem solving and decision making in science courses like Computer Science, IT and Engineering (Mbarika *et al*., 2010; Bagarukayo *et al*., 2007; Bradley *et al.,* 2007a, b; Broussard *et al*., 2007; Zoller & Pushkin, 2007). For example, students taught theory without opening a computer to show them how computer parts are a installed, upgraded or repaired, may not give them good grounding of the concept. Students need exposure to troubleshooting in a simulated real work environment to obtain problem solving, critical thinking and decision making skills. Although educators typically understand the learning objectives of their courses, the reality is that these objectives are rarely fully attained (Mbarika *et al*., 2010; Bradley *et al*., 2007). Introductory courses have been taught using the traditional learning approach, during which the instructor lectures on these technical topics. It is a common complaint for educators that science students did not have HOCS to take upper-level classes and that they often have to redo topics that were supposed to be attempted in the introductory classes (Bagarukayo & Mbarika, 2008; Mbarika *et al.,* 2003a). This is reflected in many science graduates e.g. engineering, chemistry and IT, today. The complexity for people to deal with decision making situations that require HOCS has been identified (Mbarika *et al*., 2010; Bradley *et al.,* 2007). The decision making process 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.

As a result, there has been an 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 life work environment (Bradley *et al*., 2007). The relevance for graduates' HOCS for decision making, above average problem solvers, team players, in the industry to enable companies to make business profit has also been highlighted (Guzdial & Soloway, 2002; Rieley & Crossley, 2000; King, 2000). HOCS prepare students for today's workforce because graduates gain skills for problem identification, analysis, figuring out alternatives, evaluating alternatives, reasoning, synthesis, interpretation, question-asking problem solving, decision making, system and critical thinking, among others. Since research has shown that the current graduates lack these skills, there is a need for new teaching and learning methods, which impact on HOCS to prepare future graduates (Mbarika *et al*., 2010; Mbarika *et al*., 2003; Bagarukayo & Mbarika, 2008; Bradley *et al*., 2007a). It is therefore crucial to provide an education that encompasses HOCS to be successful in the work environment.

Therefore there are several recommendations for revising the curriculum to emphasize on preparation of students to graduate with HOCS to enhance graduates' performance at the work place. New approaches to increase students' attention, interest, motivation, continuous learning desire and HOCS are continuously being sought. The multimedia (MM)-based form of instruction is one of the IT tools that have been developed to understand complex decision making and problem solving situations that require HOCS. Incorporating simulation or MM content into instructional materials has been argued to enhance student attention capturing, understanding, retention, engaging to use, and enhancing learning interest (Liu & Yuan, 2005; Jonassen, 1989). Studies based on student perceptions show that MM instructional materials improve HOCS (Mbarika *et al.,* 2010; Bradley *et al*., 2007). However, there is insufficient research on the impact of MM technology on teaching, learning and assessment.

In this paper we measure the impact that MM instructional materials have on 223 undergraduate students perceptions of HOCS improvement compared to traditional text book materials by investigating: -

1] The existing effectiveness and impact of MM case studies on creative teaching strategies and perceived HOCS improvement.

2] The effectiveness of MM case studies as teaching / learning tools to enhance the emergence of best practices to guide successful implementation and foster perceived HOCS improvement.

3] The study aims to evaluate the merits of MM to encourage HOCS development over traditional text book approaches.

## 2. METHODOLOGY

### 2.1 Participants

A total of 497 second year Computer Science undergraduate students from a Ugandan university were contacted for the experiment. 223 students comprising of 70 females and 153 Males were selected to participate in the experiment because they were undertaking the operating systems course that semester, on which the case study is based. The selection for the control and experimental groups was random using the simple random sampling. 154 students in the experimental group accessed MM case study content online and 69 students of control group accessed the case using a text book for a period of one semester. Unfortunately the number of the students in MM and textbook groups is not the same because half of the students did not show up for the experiment.

### 2.2 Data Collection

#### 2.2.1 Case study Content

The chick-fil-A case study brings real-world problems from company into the classroom. The case study was developed with the objective of providing material so that theory, practice and design could be brought together to solve real life problems and provide material that improves HOCS (Mbarika *et al*., 2010; Sankar & Raju, 2000; Raju & Sankar, 2002; Mbarika, 2003). It illustrates the management decisions Chick-fil-A faced as the organization prepared to move from its current Point-of-sale (POS) system to a choice between two operating systems. The two POS systems are based on Windows NT and Windows CE technology. Students assumed the role of a MIS executive who had to choose between two operating systems for use as the company's POS system. The students worked in teams and each team had to determine which operating system is a better choice. The concepts to be covered included operating systems, business-technology alignment, joint application development process, and user interface issues. Since the Chick-fil-A chain operates over 700 corporately owned stores this changeover has an impact of approximately $3.29 million investment. Each team had to take the following into consideration as part of the decision making process (a) the mission of Chick-fil-A; (b) depreciation of existing systems; (c) projected return on investment of new systems; (d) total cost of ownership of existing and new systems; (e) employee retention, training, and education; (f) alignment of Chick-fil-A's IT Strategy and Business Strategy; (g) competitive advantage; and (h) Chick-fil-A's critical success factors. In addition to this, a tutorial provided background information on Windows CE and NT. The team wrote a report and gave an oral presentation explaining their decision and recommendations. After the students completed the case study, they completed a questionnaire that measured perceived HOCS improvement.

The openly available multimedia instructional materials used in the experiment were aligned to selecting between two POS Operating Systems for the simulation company Chick-fil-A's (Sankar & Raju, 2000). The MM content was available online for students to access freely using the usernames and passwords. The MM content had videos, images, audio and text and the text book content only features text and graphics. The text book was developed using the same case study content. The text book was printed and given to the students in the control group. Both the

text book and MM content is available online, so the students had access to it the entire semester. The experimental and control group were students from different classes doing the same course and hence there was no known interaction. The day students used MM and the evening students used the text book content. The students accessed the content during the class practical hours each week. The students were introduced to the case study during one lecture session.

### 2.2.2 Experiment procedure

Data was collected from students of both the control and experimental groups with the same case study content in text book and MM format respectively. The control group used the text book content of the same case, as explained in a text book, hence the traditional approach. The experimental group used the MM content of the Chick fil-A case study to evaluate HOCS improvement (Raju & Sankar, 2002; Mbarika, 2003). Both groups of students filled in online questionnaires which were analyzed to determine which of the instructional methods was better for perceived HOCS improvement.

**a) Attitude Pre-test and post-test questionnaire**
The researcher uses a modified multi-item questionnaire to measure the impact of the learning driven factors on the perceived HOCS construct. The multi-item questionnaire was developed to evaluate whether the case study (a) successfully brought real life problems to the classroom, b) was helpful in learning difficult management and computing topics, and c) was helpful in transferring theory to practice. The students filled in a pretest to determine their prior knowledge, perceptions and attitudes before the case study content was administered. The pre-test questionnaire was administered prior to intervention to collect background information related to knowledge of the topic under study, gender distribution, overall Grade Point Average (GPA), and related demographics. The questionnaire also deals with attitudes in several areas like general attitude toward subject matter, relevance to life and society, impact on cognitive domain of learning, impact on positive and negative aspects of affective domain, impact on teamwork, and communication skills. The pretest determined the students' attitudes to the subject by being administered to all subjects prior to the treatment to determine their prior knowledge.

After the pretest questionnaire, the case study was administered by text book to the control group and MM online content to the experimental group for a period of one semester. They accessed the content in form of MM and text respectively, based on the group they belonged to. After the students had accessed the content, the post test questionnaire was administered to measure the change in HOCS and prior knowledge. The post-test questionnaires indicated how their learning improved in terms of the HOCS, and Learning-Driven constructs. It tested for attained knowledge after administering the instructional materials to measure treatment effects and the attitudes towards the material. It measured perceived HOCS improvement and the perceptions on the improvements achieved on the different items after the case study was administered.

In the post-test phase, the questionnaire will test for the attained knowledge after administering the MM instructional materials to measure treatment effects and the attitudes towards the material.

The items of the questionnaire are a result of progressive refinements and by their inclusion in multiple studies, possess a high degree of construct validity (Mbarika, 2003; Mbarika *et al*., 2010; Bradley *et al*., 2007a). The research used a modified multi-item questionnaire to measure the main constructs and items corresponding to learning-driven factors and HOCS factors and criteria to assess students' perceived learning. The questionnaire items measured the three Learning-driven constructs of learning interest, self reported learning, learned from others and one construct of HOCS improvement with items of problem solving, critical thinking, decision making,

and other skills to reinforce construct validity(Mbarika *et al*., 2001; Mbarika *et al*., 2010; Hingorani *et al*., 1998).

The learning-driven factor and HOCS factor (Mbarika *et al.,* 2001) are elaborated below and their items in table 1:-

a) The **Learning-driven factor** explains how the instructional materials will be used as a tool to challenge the end-user in learning difficult IT and CS topics, in connecting theories and practice, in improving students' understanding of basic concepts, and in providing the students a platform on which to learn from one another.

b) The **HOCS factor** represents how an individual has acquired an adequate portfolio of skills that can be used to make decisions within a specified period of time. HOCS improvement was measured by a set of items that were validated in earlier research studies.

***Table 1:*** *Constructs and items that are used to measure the factors in the research model (Mbarika et al., 2001).*

| Construct | Definition | Items |
|---|---|---|
| **Learning-Driven factors** | **Composed of constructs that show the intrinsic value of the instructional materials to the end user.** | **Constructs include self reported learning, learning interest, learned from others, and challenging** |
| Self Reported Learning (3 items) | Measure of student's improvement of basic concepts and of identification of central management and technical issues through use of case study | Improved my understanding of basic concepts, learned new concepts, learned to identify central management and technical issues. (Hingorani *et al*., 1998) |
| Learning Interest (3 items) | Measure of the level of student interest generated during and after the case study | Discussed technical and managerial issues outside of class, did additional reading on technical and managerial issues, did some thinking for myself about technical and managerial issues. (Hingorani *et al*., 1998) |
| Learned from Others (2 items) | Measure of how much the students learned from each other by valuing other student's point of view or interrelating important topics and ideas | Learned to value other students' point of view, learned to inter- relate important topics and ideas. (Hingorani *et al*., 1998) |
| **HOCS-factors** | Improved ability to Identify, integrate, evaluate, interrelate concepts within the case study and make decision in a given problem solving situation | Identify, integrate, evaluate, interrelate, problem solving, critical thinking, decision making |

Students were asked to indicate the extent of their agreement with the six evaluator statements in the questionnaire that measured the constructs on a 5-point Likert scale ranging from 1, *strongly disagree*, to 5, *strongly agree*. The items used to measure the perceived improvement of HOCS construct for the Chick-fil-A case include:

- I improved my ability to identify operating system issues.
- I improved my ability to integrate operating system issues.
- I improved my ability to evaluate critically operating system issues.
- I became more confident in expressing my ideas.
- I learned to interrelate important topics and ideas.
- I learned to solve problems based on business theories.

## 3. DATA ANALYSIS

The researchers uploaded the instruments to a website for easy access, to ease the data collection and analysis process. The data was analyzed to determine the difference in the attitudes, perceptions and whether there was an improvement in perceived HOCS of problem solving, critical thinking, decision making and other skills. During the analysis phase the data collected was cleaned. Statistical Package for the Social Sciences (SPSS) was used to analyze data. The research questions were developed and investigated using the t-test since we were comparing two groups. The procedure solicited the perceptions of two groups of students, on the impact of learning driven constructs on perceived HOCS improvement when using different instruction methods.

### 3.1 Measures

The experiment explored the association between the instruction method and HOCS improvement while examining 4 dependent variables. The experimental design subjects were measured in terms of the dependent variables (pretesting), exposed to stimulus representing an independent variable (multimedia), and then remeasured in terms of the dependent variables (post testing). The attitudes attribute refers to the measure of the students change in attitudes after accessing MM and Textual content. Blooms Taxonomy highlights that the students learn when there is a change in attitudes (Bloom, 1956). We measure the change in the students' attitudes after accessing MM content as compared to the text book content by comparing the pre-test and post test questionnaires. The learning interest is the measure of the level of student interest generated during and after the case study (Mbarika *et al*., 2001; Hingorani *et al*., 1998). Self Reported Learning is the measure of student's perceived improvement of basic concepts of the course (Mbarika *et al*., 2001; Hingorani *et al*., 1998). It is the perceived ability to improve students understanding of basic concepts, new concepts, and identify central management and technical issues from the case study. The learned from others attribute is the measure of whether the students perceived they learned from each other by valuing other student's point of view or interrelating important topics and ideas (Mbarika *et al*., 2001; Hingorani *et al*., 1998). The attribute identifies the perception of students to learn from each other.

As previously noted, perceived HOCS improvement in this study is the perception that an individual has acquired the required skills for decision making, problem solving and critical thinking, analysis, interpretation, among others (Mbarika *et al*., 2001). Decision making is the perceived ability for the student to make a selection and justify the choice. Problem solving is the perceived ability of a student to correctly find a correct solution to a problem. Critical Thinking is the perceived art of analyzing, synthesizing and evaluating thinking with a view of improving it (Paul & Elder 2009). It is the perceived ability to interpret, analyse, reason, analytically and reflectively think, draw conclusions and find solutions to problems, among others. We therefore measure whether there is a significant difference in the students' perception of their ability to think critically when they use MM and text book materials.

The 'skills attribute' deals with the ability of students to attain general skills from the content. The skills in this case include writing, presentation skills among others. It is important to create a wholistic learner, who has attained knowledge, skills and attitudes (Bloom, 1956).

## 4. RESULTS

Demographic characteristics of all 223 students who participated are described in Table 2, stratified by the instrument.

***Table 2.*** *Characteristics of the Sample (N=223)*

| Variable | Multimedia (N=154) | Text (N=69) |
|---|---|---|
| **Gender** | | |
| **Male** | 66% (101) | 75% (52) |
| **Female** | 34% (53) | 25% (17) |
| **GPA** | | |
| **2.0-2.5** | 7% (11) | 13% (9) |
| **2.51-3.0** | 14% (21) | 19% (13) |
| **3.01-3.5** | 20% (31) | 22% (15) |
| **3.51-4.0** | 59% (91) | 46% (32) |
| **Experience** | | |
| **Less than 1 year** | 83% (127) | 74% (51) |
| **1-2 years** | 10% (15) | 16% (11) |
| **2-3 years** | 6% (9) | 6% (4) |
| **More than 3 years** | 2% (3) | 4% (3) |

***Table 3.*** *Descriptive Statistics of Factors*

| Factors | Group | Obs. | Mean | Std. Dev. |
|---|---|---|---|---|
| **Attitude** | M | 154 | 43.82 | 9.77 |
| | T | 69 | 42.83 | 11.18 |
| **Learning Interest** | M | 154 | 11.24 | 4.26 |
| | T | 69 | 10.75 | 3.76 |
| **Self Reported Learning** | M | 154 | 3.90 | 1.63 |
| | T | 69 | 3.83 | 1.58 |
| **HOCS** | M | 154 | 6.84 | 2.74 |
| | T | 69 | 6.81 | 2.45 |
| **Critical Thinking** | M | 154 | 11.04 | 4.33 |
| | T | 69 | 10.68 | 3.77 |
| **Decision Making** | M | 154 | 8.92 | 3.61 |
| | T | 69 | 9.04 | 3.45 |
| **Problem Solving** | M | 154 | 1.68 | 1.46 |
| | T | 69 | 1.84 | 1.39 |
| **Learning from Others** | M | 154 | 3.21 | 1.38 |
| | T | 69 | 3.14 | 1.30 |
| **Skills** | M | 154 | 12.91 | 5.31 |
| | T | 69 | 12.44 | 5.02 |

Students in MM group were of similar gender, GPA, and experience distribution to students in text group. In the MM group, a total of 154 students completed and returned the survey (Table 2). Over the half of these respondents (66%) were male, 59% of the sample had a higher than 3.5 GPA. In both MM and text group, over half of these students had less than one year experience.

A comparison of individuals with and without MM instruction by factors is presented in Table 3. An independent sample t-test was performed to examine the impact of exposure to technology on HOCS improvement.

Results of an independent sample t-test presented in Table 4 indicate that students instructed with MM had higher means for all factors, except for "decision making" and "problem solving" than those with textbook instruction. However, these differences are statistically insignificant.

Unexpectedly, both decision making and problem solving factors in MM group had lower mean scores (M=.92 and M=1.68, respectively) than those with textbook instruction (M=9.04 and M=1.84, respectively). However, these difference are statistically insignificant (t=.248 and t=.761, df=221, p>.05, respectively).

***Table 4.*** *Results from Independent Sample t-test*

| Factors | Mean Difference | t-statistic | P-value |
|---|---|---|---|
| **Attitude** | .999 | .674 | .501 |
| **Learning Interest** | .486 | .816 | .415 |
| **Self Reported Learning** | .083 | .354 | .724 |
| **HOCS** | .032 | .085 | .933 |
| **Critical Thinking** | .357 | .593 | .554 |
| **Decision Making** | -.127 | -.248 | .804 |
| **Problem Solving** | -.158 | -.761 | .448 |
| **Learning from Others** | .069 | .353 | .724 |
| **Skills** | .466 | .617 | .538 |

## 5. CONCLUSIONS AND FUTURE RESEARCH

This study evaluates the impact of learning driven constructs on Perceived HOCS improvement when MM and text book materials are used by students from different backgrounds with different GPA, gender and work experience. We carried out an experiment on undergraduate students to determine the impact of learning driven constructs on the perceived HOCS improvement, when a case study was administered to two groups of students using the MM and text book content.

We performed the independent t-test for comparing means between the two groups; MM and textbook. From the results we presented, there was insignificant difference between the treatment groups on students' perceptions on HOCS improvement and the learning-driven factors. The results indicate insignificant differences were observed between students who used the MM and text book case study.

The negative results from this study agree with the findings of *(*Orr et al., 2001) who claim that MM-based information technology does not positively impact on learning. The similar attributes in MM and in textbook are the possible reason of the non significant differences findings. The non significant difference may be attributed to the fact that the materials were not appropriate to the

Ugandan context, since the case was based on a scenario from the United States. In future we will develop materials that represent the context they are familiar with.

Therefore we conclude that the exposure to MM did not impact on all the constructs as compared to the textbook materials. The results also indicate that there was no difference in the students' attitudes, learning interest, learned from others; self reported learning, decision making, problem solving, and critical thinking. In conclusion therefore, based on the above results, exposure to MM during the learning process was not different form the text book materials significantly. Therefore there was no advantage (advancing their HOCS improvement) of using MM materials over traditional text materials.

Our study dealt with only perceptual measures of HOCS improvement were measured, therefore, the researchers restricted the study to measuring students' perceived HOCS improvement. There is difficulty in measuring actual HOCS improvement and a limited number of instruments available to measure actual HOCS improvement. Therefore the ability to measure actual HOCS improvement using multimedia instructional materials remains a challenge for future research. In future the experiment will be undertaken to measure whether actual HOCS improvement occurs when MM materials are used for instruction as compared to text. The researchers intend to measure whether actual HOCS improvement occurs by comparing students performance and GPA. The researchers will develop an instrument that will ask exam-like questions to determine whether the students actual HOCS improved after using MM materials.

In future, we intend to find the specific technologies that can improve HOCS improvement, by testing different technologies that may impact on the different HOCS attributes of decision making, problem solving, critical thinking, analysis, interpretation etc.

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