TOP **HAT** MONOCLE

Case Study: How interactive learning using mobile devices enhanced students' comprehension 23%

ABSTRACT: University of Waterloo Professor Hamid Alemohammad used Top Hat Monocle's interactive simulations to teach a chapter on "assembly language programming." In his previous year teaching the course, students did not gain thorough knowledge of the materials in this chapter, as evinced by low final exam marks on this section of the test corresponding to this material. By having students complete a combination of in-class quizzes, questions and interactive simulations on their mobile devices, he observed a 23% increase in comprehension of concepts in the "assembly language programming" section of the final exam as compared to the previous years when the simulations were not used.

keywords: *active learning, mobile technology, classroom response systems, interactive simulations, interactive simulations, mechatronics, mechanical engineering, assembly language programming, digital logic, Top Hat Monocle*

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Introduction

Active learning, or learning by doing, is a student-centric method of learning where students are active participants in mastering a given concept. While it is difficult to formally define, this pedagogical technique emphasizes students "doing" and "thinking," focusing on critical thinking, synthesis and analysis through such techniques as writing, engaging in hands-on activities, utilizing case methods, engaging in simulations and collaborating with their peers (Turns, Pauley & Zappe, 2009). The active learning method is typically contrasted with the typical lecture format, whereby students are passive recipients of information (Bonwell & Eison, 1991).

One of the commonly cited reasons for the effectiveness of active learning surrounds the attention span during lecture, which studies suggest is roughly fifteen minutes (as cited in Wankat, 2002). Hartley and Davies (1978) found that after the lecture, students only remembered 20% of the information presented in the last ten minutes as compared to 70% retention of information presented in the first ten minutes of lecture. Active student engagement is also cited as one of the most influential predictors of success in college. In pre and post data collected from a physics course, Hake (1998) found that those who were taught using active learning techniques performed twice as well on exams than those taught in traditional lecture format. Furthermore, active learning techniques are linked to improved student outcomes and study habits, especially when multiple formats are utilized synergistically (Woods, 2003).

Active learning is particularly beneficial in engineering and the applied sciences, since these disciplines call for hands-on experience with real world problems (Duan & Ries, 2007). Turns et al. (2009), for example found that class averages increased 5% after incorporating in-class assignments, collaborative learning and interactive methods in a Fluid Mechanics course. Successes from incorporating active learning methods in other science courses where students are encouraged to engage in daily recall and interaction with the material with High Learning Opportunity (HLO) worksheets has also

Recently, computers and mobile devices have been leveraged in the classroom so as to encourage students to "develop higher order problem-solving skills," according to Holbert & Karady (2009). In their computer-based classroom environments, they encourage students to explore the theory of a physical phenomenon step-by-step, utilizing software such as MathCAD, PSpice and MATLAB. In a five-year longitudinal study, they cited increased student satisfaction as well as increased comprehension. Aziz (2008) also has implemented a variety of e-learning techniques in his "Machine Dynamics" course through problem-based learning, MathCAD-enhanced teaching and experiential learning. Having students design, model and simulate a real-world application (such as a car suspension system) with a web-based tool to understand the theory has been met with success.

This paper will focus on the use of a novel web-based learning strategy in the course of "Introduction to Microprocessor and Digital Logic" at the University of Waterloo in Canada and its impact on student learning outcomes, as evinced by performance on final exams and student surveys.

Teaching Context

The course in which the study took place was in "Introduction to Microprocessors and Digital Logic" (ME262). This is a second-year mandatory course in the Department of Mechanical and Mechatronics Engineering at the University of Waterloo, Canada. The number of students enrolled was 97, and the course met three times per week in 50-minute sessions. It was also accompanied by a 3-hour lab session once per week. According to Professor Hamid Alemohammad's previous year teaching the course, students consistently demonstrated low test scores on the section of the final exam pertaining to the chapter on "assembly language programming." The intended learning outcome for this section of the course were for students to be able to recognize the basic computer interfacing tasks and describe and identify simple assembly language programs.

Experimental Design

To implement an interactive environment in the classroom, the course used Top Hat Monocle by incorporating students' handheld devices and portable computers. Students used any devices they happened to have in the classroom (WiFi/3G/3GS/SMS-enabled devices) to participate in in-class interactive activities. The instructor used Top Hat Monocle's front-end website to launch demonstrations and quizzes and receive students' responses. Each student was assigned an ID to log into the system, and all of their activities were logged on the server. This required no infrastructure aside from the university WiFi system.

A combination of traditional lecturing and experiential learning was used during 6 sessions (2 weeks) of teaching the "assembly language programming" section of the course. For each session, the instructor determined concepts to be learned through experiential learning and allocated time for it. During the interactive simulation slots, students were asked to do tutorials, answer questions or to do quizzes. Approximately 20-40% of the class time (10-20 minutes) in each session was devoted to the active and experiential learning activities. To ensure students were engaged, a 5% bonus mark was assigned to students participating in the activities. This was logged by Top Hat Monocle.

Based on Prof Alemohammad's experience in teaching this course, the topic of "assembly programming" consistently proved challenging for students to comprehend. These topics included:

- Memory address and memory values
- Memory segmentation and addressing
- Computer structure
- Assembly programming commands

For each topic, he designed one interactive demo and a series of questions. During the explanations, the students were asked to launch the demo on the browser of their respective devices. Most students had either smartphones or laptops/netbooks in the classroom. For the few who did not, the demos were kept open for the students to explore 24 hours after each lecture.

Results & Conclusions

To investigate the students' performance in the course, the final exam scores were used. Question #8 was the question assessing students' comprehension of "assembly language programming." To have an accurate comparison, the question was similar to the one in the previous term in Fall 2010 where Top Hat Monocle was not used. The same grading scheme was also used. While the students were not explicitly measured in terms of smartness, both classes were from the same program (Mechanical Engineering) with consistent admission requirements from year to year. As shown in Fig. 4, the results supported the hypothesis that utilizing active learning principles through the Top Hat Monocle platform bolstered student comprehension. It can be observed that the performance on the material that tested the content on assembly language programming when Top Hat Monocle was used resulted in students' scores increasing by 23% as compared to the term when Top Hat Monocle was not used.

Students were also surveyed on their perception of the new method. 93% of the students participated, and 100% of the students who participated on the interactive simulations and quizzes agreed that it helped the concepts "stick in their memory better," as indicated on a survey that was administered at the end of the term. The researchers recognized that this study involved a limited sample, but given the student satisfaction rate and the measurable increase in final exam performance, the researchers are eager to explore this platform across a variety of academic disciplines and with larger sample sizes. Ultimately, given the demonstrated improvement in comprehension, this study validates the potential of Top Hat Monocle as a tool to measurably enhance student performance.

Appendix

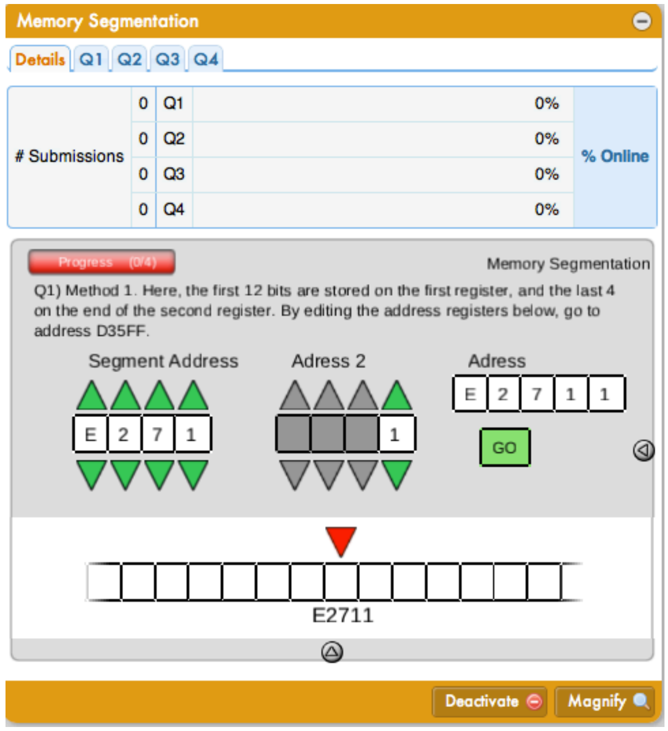

Fig. 1: Interactive Demo, Memory Segmentation

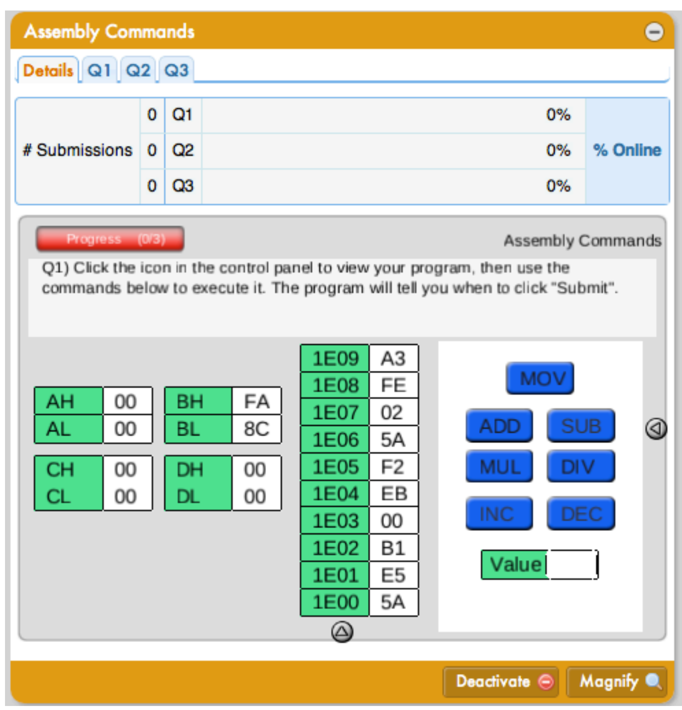

Fig. 2: Interactive Demo, Assembly Commands

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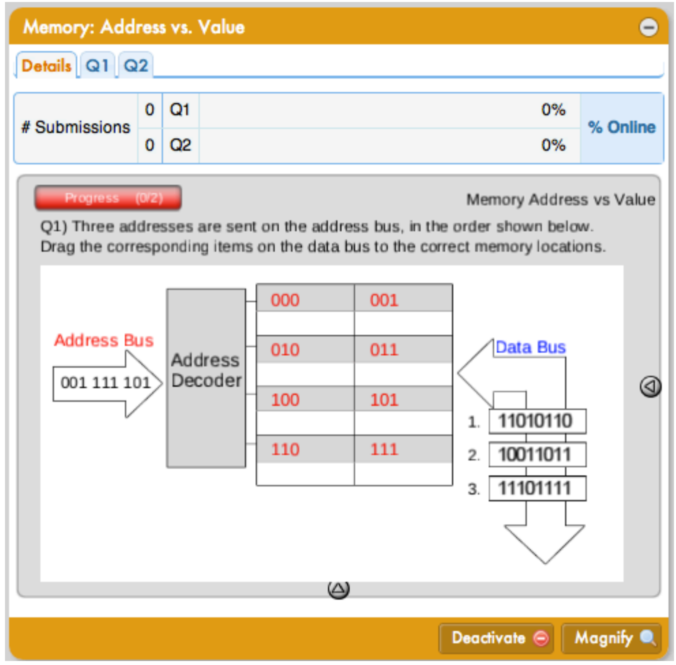

Fig. 3: Interactive Demo, Memory: Address vs. Value

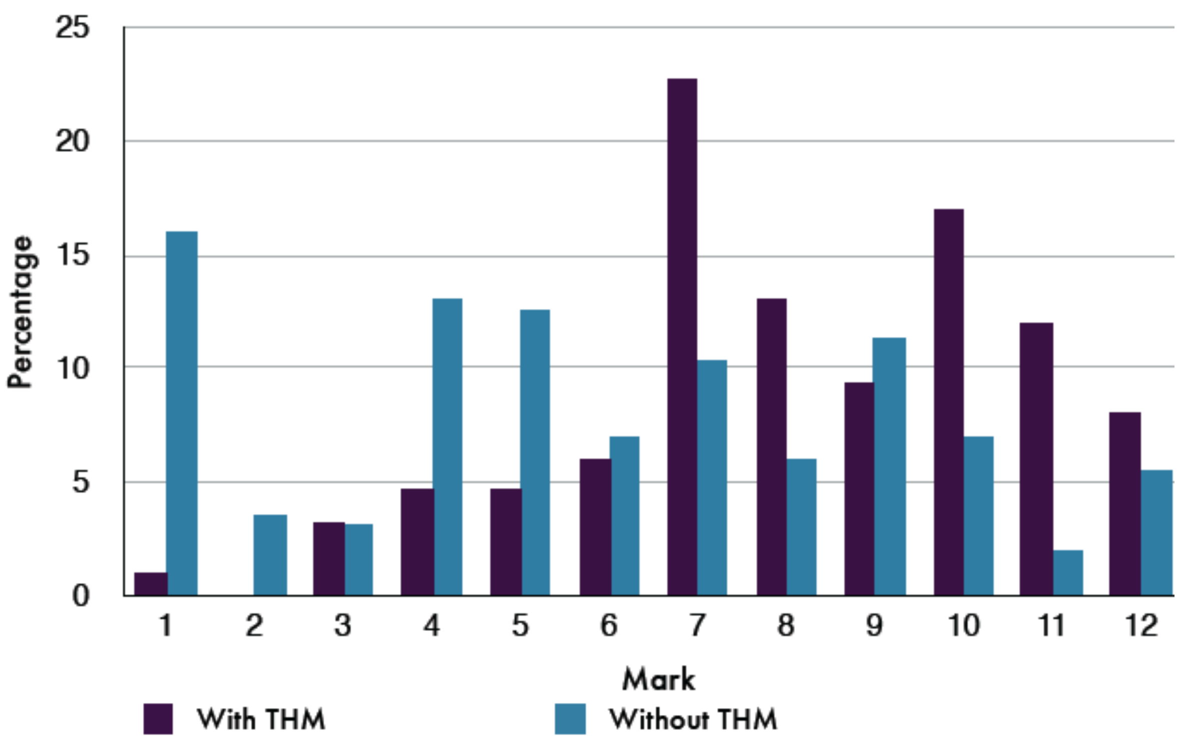

Fig. 4: Student Exam Scores, With and Without Top Hat Monocle

References

[1] Bonwell, C.C. and J.A. (1991). Eison. Active learning: creating excitement in the classroom. *ASHEERIC Higher Education Report, 1*. George Washington University: Washington, DC.

[2] Ruhl et al. (1987). Using the pause procedure to enhance lecture recall. *Teacher Education and Special Education, 1, 10*: 14-18.

[3] Wankat, P. (2002). *The Effective Efficient Professor: Teaching and Service*. Allyn and Bacon: Boston, MA.

[4] Woods, Donald R. <http://www.chemeng.mcmaster.ca/pbl/pbl.htm> 12/03/03.

[5] Turns, Pauley and Zappe (2009). Active and collaborative learning exercises for a first course in fluid mechanics. *International Journal of Engineering Education, 25*, 5: 979-997.

[6] Holbert, K.E. and G.G. Karady. (2009). Strategies, challenges and prospects for active learning in the computer-based classroom. *IEEE, 1*: 31-38.

[7] Duan, Shanzhong and Andrew Ries. (2007). Promoting active learning in teaching the course of design of machine elements. *ASME Conf. Proceedings*,

[8] Turns, Stephen, L.P. Pauley and S.E. Zappe. (2009). Active and collaborative learning exercises in a first course in fluid mechanics: Implementatoin and transfer. *International Journal of Engineering Education, 25, 5*: 979-997.

[9] Hake, R. (1998). Interactive-engagement vs. traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 6*, 1: 64.