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Open Educational Resource in Online Mathematics Learning

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***Abstract*—**Technology, multimedia in Open Educational Resources, can contribute positively to student performance in an online instructional environment. Student performance data of past four years were obtained from an online course entitled Applied Calculus (MA139). This paper examined the data to determine whether multimedia (independent variable) had any impact on student performance (dependent variable) in online math learning, and how students felt about the value of the technology. Two groups of student data were analyzed, group 1 (control) from the online applied calculus course that did not use multimedia instructional materials, and group 2 (treatment) of the same online applied calculus course that used multimedia instructional materials. For the MA139 class, results indicate a statistically significant difference (p = .001) between the two groups, where group 1 had a final score mean of 56.36 (out of 100), group 2 of 70.68. Additionally, student testimonials were discussed in which students shared their experience in learning applied calculus online with multimedia instructional materials.

***Keywords*—**Online learning, Open Educational Resources, Multimedia, Technology.

I. Introduction

THE online education continues to grow across disciplines at institutions of higher learning [3], [10], [16]. Accompanying the popularity of online education is the use of technology in teaching and learning that is believed to be redefining how learning takes place [2]. Along with the increasing use of iPads, tablet pcs, or smart phones, students are becoming familiar with and accustomed to listening to and watching materials which traditionally were simply read. Horizon Report [5], [6] identifies "digital media literacy continues its rise in importance as a key skill in every discipline and profession".

Striving to accommodate student needs and improve their performance in online learning, a multimedia component was introduced into MA139 Applied Calculus, an online math course for undergraduate students in fall, 2010. The multimedia component consisted of learning objects presented in the format of text, audio, video, and animation. This online applied calculus course had been taught by the same faculty for two years before the multimedia component was introduced. In 2012, the same instructor stated to incorporate the Open Educational Resources (OER) – that is, teaching, learning and research materials that their owners make free to others to use, revise and share. The OER material offers an effective education. This study analyzed student performance data in the online course. Specifically, the final course grades of the students enrolled in the MA139 without a multimedia component were compared with the final course grades of the students enrolled in the MA139 with the multimedia component. Student responses to an online survey were also discussed. The purpose of this study was twofold: First, it endeavored to determine whether technology, multimedia in this case, works to improve student performance in online instructional environment. Secondly, it attempted to reveal the value of OER multimedia in online learning as perceived by the students. Various factors may have contributed to the student performance of online instruction, including multimedia. Multimedia has been argued as an effective technology means to positively impact student performance, online, blended, or face-to-face [1], [7], [9], [13]. Multimedia is the combination of various digital media types, such as text, graphics, audio, video, and animation into an integrated multisensory interactive application or presentation. Owing to its attributes, i.e., visual, interactive, engaging, and animated, multimedia can present or represent action, objects, phenomena, or status that text alone can't or can't do as well. For example, multimedia are capable of demonstrating qualitative and quantitative relationships, showing changes over time and showing hidden concepts that enable students to see and hear many of the things that they can't through reading only. With visual display of the subject being studied, the students can process information quicker, which, consequently, may help foster their acquisition of sophisticated skills and understanding of complex concepts and procedures that may otherwise be unattainable, i.e., the skills, concepts and procedures illustrated with simply text. It is believed that learners can learn more deeply, including improved performance on tests of problem-solving transfer, from well-designed multimedia messages consisting of audio, visual, graphic, animation than from more traditional modes of communication involving verbal alone [9]. Such deeper learning is possible because of the way our brain processes information, as [9]-[11] articulate in dual-coding theory.

Dual-coding theory postulates that our brain has two distinct channels of auditory and visual that separate incoming information and then represent them in visual and verbal format [9]-[11]. For example, the video, animation, and graphics a person sees may be processed as visual representation in the visual channel whereas conversation and spoken words the person hears may be processed as verbal representation in the auditory channel. The combination of multiple media calls on the capabilities of both channels.

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Potentially, deeper understanding and better mental models occur now that the learners are actively engaged in processing incoming information and organizing them into visual and verbal models and integrate them with appropriate prior knowledge than processing information from individual channel alone [8]. Such meaningful learning process often results in problem-solving transfer [8]. While multimedia appears promising, its positive effect on student performance is far from a given as empirical studies offer diverse views on the relationship between student performance and use of technology [4], [12]-[15]. The literatures are limited on the impact of multimedia on student learning in online instructional environment.

II. The Study

A. The Null Hypothesis

The researchers assumed that there would be no significant difference in student performance between the classes without a multimedia component and the classes with a multimedia.

B. Methodology

Data collected for this study was from MA 139 Applied Calculus, a three-credit hour online math course offered at Southeast Missouri State University each semester for the first year students of all disciplines, education, business, science, polytechnics, for example. The objectives of this course are to introduce basic concepts of differential and integral calculus, and to present applications of calculus to problems in business, life sciences and social sciences. During the spring and fall semester, the course is taught during 16 weeks with three hours per week. During the summer session, the course is completed in 6 weeks with 8 hours per week.

Since fall of 2010, the multimedia instructional materials were incorporated in this online class. In particular, different types of multimedia such as animation, audio, video, and YouTube were used to explain some difficult concepts.

Attempting to measure the impact of multimedia on student performance in an online instructional environment, this study analyzed student performance in a single online course, i.e., MA139 Applied Calculus, offered in multiple sections by the same instructor over four academic years. Specifically, group 1 data were collected from three sections without multimedia component, and group 2 from three sections with multimedia component. All the sections were taught by the same instructor. All course assignments and course exams were developed by the instructor using the same criteria and standards. As well, grading was done by the same instructor for all sections. Student final course grades were analyzed using an independent-samples *t* test to examine the impact of multimedia on student performance. Participants in the study (n=168) were from two groups – group 1 (n=83) from the class offerings in three semesters of 2008 spring, 2009 spring, and 2010 summer that did not have a multimedia component, and group 2 (n=85) from three semesters of 2010 fall, 2011 spring, and 2011 summer that had a multimedia component. Most students in the two groups were either freshman or sophomores majored in accounting, business administration, and management. Prior to taking MA139 Applied Calculus, all of the students had taken College Algebra, and completed the course with a minimal grade of “C” (70%-79%).

C. Results

A comparison of the descriptive statistics for the two groups for MA139 revealed that the mean, median and mode were all higher for the multimedia group. In addition the range of scores was smaller for the multimedia group (See Table I). For the final scores of Group 1, the range was 99.50%, the median was 71.90%, and the mode was F. For the final scores of Group 2, the range was 89.20%, the median was 75.30%, and the mode was B (89.5%-100%=A, 79.5%-89.4%=B, 69.5-79.4%=C, 59.5%-69.4%=D, 0-59.4%=F). Although there was not a big difference between Group 1 and Group 2 in terms of Median, the outliers in Group 1 greatly lowered the group’s mode because 29 students got F in Group 1 versus 13 students in Group 2. Had the outliers been excluded, C would be the mode for Group 1 and B for Group 2 An independent samples t-test was then conducted using SPSS (Statistical Package for the Social Sciences) to determine if there was a significant difference in final scores between the two groups of students participated in this study. The mean score for group 1 (without multimedia) was 56.36% (SD = 32.00 percentage points) whereas Group 2 was 70.68% (SD = 19.03 percentage points). The results of the t-test revealed a statistically significant difference between the two groups (t = 3.52, p = .001), indicating that group 2, where multimedia was used, had performed considerably better than group 1, where no multimedia was used. There was a mean difference of 14.32 percentage points between the two groups.

TABLE I
Medians, Modes and Ranges for the Two Groups

	Mean	Mode	Range
1 Group	71.90%	F	0.5-100%
2 Group	75.3%	B	10.8-100%

The results support the theory of [8] that students value the multimedia component because of its visual capability of presenting or representing qualitative and quantitative relationships of the subject or topics being studied. A multimedia item used in MA139, for example, was able to first break the sophisticated and difficult concepts or formulas into smaller manageable pieces, then explain such pieces in detail, and finally connect the pieces together, present them as a whole concept or formula. The multimedia instructional materials would then present, illustrate, or explain the reference between the minimal pieces, and merge them into an integrated whole in a logical fashion such that it made sense now that each part of it had made sense. This value of multimedia was demonstrated through the students’ remarks about the multimedia component of the online course. The visual display and verbal explanation allowed the students to process information actively and in a meaningful way. In fact, the students’ testimonials in the open ended remarks area of the survey showed their preference to the visual display of reduction and induction process of math concepts and/or formulas. For example, many students expressed their appreciation for the step-by-step illustration of the problematic concept or formula through multimedia. They felt it (animation in this case) “a great teaching tool” because it “shows step-by-step what happening in the equations, …” “…it showed me visually why we use these and how to get the equation instead of just knowing it was the equation.” One student wrote: “…I am a visual learner. I understand more when I am able to see the process worked out than when it is left for me to just figure out on my own.” Owing to the multimedia item, another student remarked, “Everything seems to be very explanatory,” and that “… visual calculus program online for the product rule, quotient rule and the chain rule were exceptional. They really helped me to understand the problems better because they provided the step by step instructions…” Still another student explained why multimedia was very much appreciated for helping her/his understanding related content: “The greater the detail, the easier the concepts are to comprehend.” As student testimonials implied, this whole visual process demonstrated changes over time and revealed hidden concepts for the students [9]:“I like this animation a lot because it used words such as if, then, so, and to explain the progress of the problem and solution. The chain rule animation also highlighted the actual ‘rule’ part of the problem, so I was able to comprehend exactly how the chain rule impacted the problem. For instance, this animation showed when g(x) should be implemented into the problem and where it should be placed; this was a very nice tool to have for studying.” In spite of the mostly positive remarks, however, there were alternative perceptions of the multimedia and its instructional value in the online learning environment. For instance, some students felt that “it (multimedia) did not make up for not having an instructor teaching you the material face-to-face” while acknowledging that multimedia was “helpful in learning the material.” Some students felt that multimedia needed to do more and deeper on the content than they were now because right now “it doesn’t explain further than the book.” “It could go into a little more depth with the problem,” as one student suggested.

III. Conclusion

Technology, multimedia in this case, seems to have made a big difference on student performance in online instructional environment, as the quantitative data showed. Various factors may have contributed to the positive difference multimedia made, for example, its visuality and animation can make the learning engaging and active, its 24/7 accessibility affords student autonomy and control over pacing and sequencing of the learning content, its motion capability and revealing process of deduction and reduction enable student the retention and application of knowledge. Multimedia, therefore, can extend and augment student learning experience as it capitalizes on the characteristics of each individual medium [8], [9]. There was abundant qualitative evidence from student testimonials why technology in general, multimedia in particular made a difference. One student, for example, wrote in open remarks area that “the technology helped me through this course.” Benefiting from the multimedia component, many students suggested that more technology be used in online courses, for instance, “animation along with video should be used,” and that “multimedia be used in all aspects of the class.”

While both qualitative and quantitative data demonstrate that in the same online instructional environment, using multimedia will effectively improve student performance than not using multimedia, further studies may reveal whether the demographics of student also contribute to student performance, for example, their gender, age, marital status, and employment status. As well, it will be interesting to see whether the students’ improved technology skills is another contributing factor to different student performance. In this study, for example, group 2 students were enrolled in most recent semesters, i.e., 2010 and 2011 semesters when more people were exposed to the use of technology while group 1 students were enrolled earlier, i.e., in 2008, 2009, and 2010 semesters when fewer people were exposed to technology. Our hope is that with the passage of time, as students became more proficient in the use of technology, the demand for all online offerings will keep on growing.

One weakness in this study was the skewed student data that have resulted in unusually large ranges for the two groups and the odd mode for Group 1. The student data was likely skewed because: Some students, although performed poorly, stayed in the course through the semester because they had to pass the course. So, they kept trying, failing, trying again, failing again, and trying again until they passed it eventually. Some students had jobs, and could not concentrate on their school work, so performances were quite low on each exam. Some students could not drop even if they wanted because they wanted to keep their full time students status. A few, such as a student who had less than 10%, were those who quit in the middle but didn't drop the course.

Future efforts may be made to identify and exclude those outliers such that the data will more accurately reveal the impact of multimedia on the performance of students taking online math course than they did in this study. As well, efforts may also be made to improve the quality of multimedia presentation such that it will do more, and deeper on the content, i.e., development of more multimedia instructional materials for teaching and learning, and more in-depth into content analysis, illustration, and/or demonstration, than they were now and that it replicates the dynamics in a face-to-face learning environment.

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