MULTIMEDIA’S IMPACT ON STUDENT LEARNING OUTCOMES

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KATHRYN J POZNANSKI

DR. DARRELL BUTLER – ADVISOR

BALL STATE UNIVERSITY

MUNCIE, INDIANA

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LITERATURE REVIEW

Innovations in technology have been leading the way for educational learning materials to expand into more diverse options, providing students with several choices of educational mediums from which to extend their knowledge. Of course, from the very beginning of formal education, technology has been extremely influential in the classroom; there was once a time when having the opportunity to incorporate paper and pencil into the learning process was considered innovative (Wilson, Orellana, & Meek, 2010). At the present time, students are reconsidering technology’s role in their learning process with the overwhelming presence of the Internet. In an age when most individuals are an Internet connection away from accessing a wealth of global information, researchers must investigate how such technology is influencing students’ learning outcomes.

It is a common observation that students use modern technology like iPhones, laptops, and iPads now more than ever, whether in the classroom, at home studying, or even in online test centers on campus. In a study examining student attitudes towards electronic textbooks, Weisberg (2011) noted students are becoming increasingly receptive towards using electronic textbooks in higher education. Regarding student attitudes toward interactive multimedia as means for learning, Ring, Lemmon, Coffelt, & Butler (2011) found that students strongly prefer interactive multimedia learning platforms to outdated forms of technology like textbooks. Finally, Schacter (1999) concluded that incorporating innovative technology into students’ learning programs can not only enrich their educational experiences but can also increase test scores.

It is clear that to better serve our students’ learning progress, we need to encourage the use of emerging educational technology and understand the role such technology plays for
modern students. Universities were influential role models in the evolution of technology’s presence in educational institutions. Beginning in the early 1990s universities brought learning to the online environment (Harasim, 1996; Leiner et al., 1997). This transition into a new learning platform notwithstanding, it is evident from the overwhelming popularity of online classes today and available empirical research that educational institutions cannot ignore students’ technological needs.

While research concerning the relationship between technology and education reports positive findings, uncertainty about emerging educational technology’s pedagogical effectiveness remain. This is a valid hesitation because not all educational technology is created with the same pedagogical practices in mind. Mayer’s (2009) research has identified four key elements that tend to be found in effective educational technology, which include dual-coding, interactivity, feedback, and support for individual learning differences. When these key elements are incorporated into a learning medium, the result is often enhanced learning effectiveness.

**Dual-coding**

Paivio (1990, 2008) suggested humans’ make use of two basic cognitive systems; one specialized for processing information concerning objects best represented visually and another meant for language. In his discussion of dual-coding’s ability to facilitate memory for visual, auditory, and text-based information, Paivio noted that should one system fail, the other could be relied upon to retrieve the desired information. For example, if a student is having a difficult time retrieving the name of a famous scientist they may still be able to visualize the individual’s image, thus providing them with enough information to later recall the desired name.

Textbooks have the capacity to incorporate dual-coding principals into their material design, for example by overlaying text-based information over a picture representing related
information. However, while textbooks can show visual depictions of otherwise text-based information, interactive multimedia goes beyond static images to dual-code information into an experience. Interactive multimedia can not only use text and still images together; it surpasses this method by incorporating audio-based information over active video demonstrations of related concepts. Examples of advanced educational interactive materials with this capacity are mediums such as e-books, YouTube, and Rosetta Stone. These learning materials are increasingly being incorporated into study programs because they allow students to encode information in a superior way (Najjar, 1996; Plass, Chun, & Mayer, 1998; Moreno & Valdez, 2005; Hansen & Erdley, 2009).

This is an invaluable enhancement over textbooks when considering procedural learning tasks. For example, a student can read instructions from a manual to learn how to ride a bicycle or how to play golf, but they will excel in the procedure much more quickly if they are able to watch a video depiction coupled with audio explanations of that same information. This type of active learning is best supported by the type of clear and effective communication of information that interactive multimedia can provide (Schwan & Riempp, 2004; Karppinen, 2005; Arguel & Jamet, 2009).

Students also benefit from interactive educational multimedia for the built-in auditory components. Auditory material can be verbal or musical, catering to a range of individuals from the student listening to verbal accounts of information to learn about a historical event to the performing arts student learning from a particular clip of music. In some cases, auditory information may simply be more effective for communicating particular ideas than a textbook. Taking the visual and auditory components together, pedagogically savvy individuals can
understand the significance of this technological advancement to students’ learning outcomes. Essentially, this offers a whole new approach to dual-coding’s effectiveness in education.

**Interactivity**

Students tend to better remember information presented to them in interesting and attention-grabbing ways (Mitchell & Pelley, 2010). One means to accomplish this is to design educational multimedia to be highly interactive. To be considered interactive, an educational material must promote the activation of higher-order cognitive processes (Mayer, 2009). This type of interactivity goes beyond simply clicking around on a page to progress in the program as a means of learner control (Williams, 1996). Interactivity can be achieved by incorporating games, puzzles, and other cognitively complex activities that may increase the retention of knowledge.

To examine the importance of interactivity in a learning situation, Mayer, Dow, and Mayer (2003) tested participants’ short-term knowledge of electric motors by exposing them to relevant information in either an interactive or non-interactive manner, wherein they could either ask questions and be provided with answers during learning or not. Results indicated that participants in the interactive group were able to generate significantly more answers than the non-interactive group, demonstrating greater learning.

Other ways in which educational multimedia can adhere to the interactivity standard is through simulations of situations that would otherwise be difficult to personally experience. For example, Clark and Mayer (2011) discuss the usefulness of interactive simulations for medical students learning to perform surgical techniques. In an experiment investigating the diagnostic skills of students studying psychological disorders, students were better able to identify and diagnose disorders when the students were able to view and interact with a video depicting a
simulation of how individuals with disorders like depression might act (Poznanski, Butler, Ring, & Passay, 2012).

**Feedback**

Another criterion educational multimedia should meet to be pedagogically effective is that it provides immediate and elaborate feedback. As many students studying statistics can attest, receiving feedback during the problem solving process is immensely more useful than getting a correct/incorrect mark once the problem has been solved. In this sense, feedback facilitates decision-making. Given the choice between immediate versus delayed feedback, the literature suggests immediate is better because it is self-corrective and confidence boosting, which work together to increase retention of information (Dihoff, Brosvic, & Epstein, 2004). Furthermore, elaborate feedback tends to be preferable. Elaborate feedback provides a more detailed account of students’ learning progress, thus it gives them a better understanding of their skills and knowledge. In a study where feedback was either elaborate or simple, students receiving elaborate feedback for work they had done regarding reading comprehension as tested via writing pieces exhibited increased levels of reading comprehension over a four-month timespan (Meyer, Wijekumar, Middlemiss, Higle, & Lei, 2010).

**Support for Individual Learning Differences**

Finally, educational material that supports individual learning differences should be more effective for enhanced student learning outcomes, as it is flexible and can cater to unique cases. For example, students with disabilities can especially benefit from interactive educational multimedia because it can accommodate, to a certain degree, for blindness and deafness given the dual-coding nature of such learning materials. Additionally, learning material meeting this criteria should be able to accommodate for beginner through experienced students; in other
words, if a student is new to a particular type of information they should be able to pause, repeat, and re-test the material until they feel comfortable enough to move forward with the lesson, while experienced students should be able to fast forward until they reach novel material (Cairncross & Mannion, 2001).

**PRESENT STUDY**

The purpose of this study was to evaluate the differential impact of ViziSwap and traditional textbooks on student learning outcomes. Essentially, this research sought to answer the question, does student use of ViziSwap result in equal or better test scores, indicating superior learning outcomes? We felt it was necessary to conduct this research because although ViziSwap is currently being used as an educational supplement to classroom lectures, it is a fairly new educational tool, the true effectiveness of which has not yet been determined. Given what we knew about the four main pedagogical criteria summarized by Mayer (2009) and ViziSwap’s tendency to reflect these criteria, we hypothesized that students using ViziSwap as a learning tool should outperform students using textbooks as a learning tool.

**METHODS**

**Participants**

Participants (N = 163; 37% female, 63% male) were recruited using non-random, convenience sampling through an online participant pool of students required to complete study hours to receive full credit for an introductory psychology course. Because the large majority of Ball State students take this course and the participant pool is well developed, recruiting this way facilitated obtaining a large, representative sample of students. Table 1 summarizes participant descriptive statistics.
TABLE 1

Descriptive Statistics of the Sample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
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</tr>
<tr>
<td>Mean</td>
<td>19</td>
</tr>
<tr>
<td>Standard Deviation</td>
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</tr>
<tr>
<td>Minimum</td>
<td>18</td>
</tr>
<tr>
<td>Maximum</td>
<td>22</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>53 (37%)</td>
</tr>
<tr>
<td>Male</td>
<td>89 (63%)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>120 (73%)</td>
</tr>
<tr>
<td>Black</td>
<td>13 (8%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>6 (4%)</td>
</tr>
<tr>
<td>Asian</td>
<td>2 (1%)</td>
</tr>
<tr>
<td><strong>Year in School</strong></td>
<td></td>
</tr>
<tr>
<td>High School</td>
<td></td>
</tr>
<tr>
<td>Senior</td>
<td>2 (1%)</td>
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<tr>
<td>Freshman</td>
<td>94 (58%)</td>
</tr>
<tr>
<td>Sophomore</td>
<td>33 (20%)</td>
</tr>
<tr>
<td>Junior</td>
<td>10 (6%)</td>
</tr>
<tr>
<td>Senior</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>Total N</td>
<td>163</td>
</tr>
</tbody>
</table>

Stimuli

**ViziSwap modules.** The research team explored the Psychology, Biology, and Mathematics ViziSwap educational materials to identify which would be appropriate for laboratory study based on three criteria: (a) participants should have been able to complete a module in less than one hour, (b) preferred modules should not be covered early in the course of the semester so as to minimize potential confounds, and (c) participants should be able to convey the knowledge they have gained from the ViziSwap modules or textbook through a multiple-choice test. Three total ViziSwap modules, one module from each discipline, were selected;
these included *Erikson’s Stages* (Psychology), *Population Outcomes* (Biology), and *Probabilities* (Mathematics).

**Textbook chapters.** Next, the research team explored popular Psychology, Biology, and Mathematics textbooks to choose the most appropriate materials for the study. Final textbooks were selected based on expert faculty recommendation. For Psychology, we chose David G. Myers’ *Psychology, 9th Edition*; for Biology, we chose Reece’s, Urry’s, Cain’s, Wasserman’s, Minorsky’s, and Jackson’s *Campbell Biology, 9th Edition*; for Mathematics we chose Parks’, Musser’s, Trimpe’s, Maurer’s, and Maurer’s *A Mathematical View of Our World*. We copied content from chapters or parts of chapters from the textbooks that covered material similar to that covered in the ViziSwap books.

**Assessment measure.** For assessing the knowledge participants gained from the learning material, we chose review questions located in the review section of each ViziSwap module. For each module we selected ten multiple-choice questions, which were all able to be answered whether participants were in the ViziSwap or the Text condition. We used the inQsit online testing platform to record participant responses which could later be securely downloaded as an Excel file.

**Procedure**

Participants were randomly assigned to a subject and a learning material. There were three subjects (Erikson’s Stages, Population Outcomes, and Probabilities) and two learning materials (ViziSwap and Textbook), which were completely crossed to create a total of six conditions. Participants were assigned to one of the six conditions.

**ViziSwap.** Participants assigned to the ViziSwap condition were run in groups of up to six at a time. They were instructed to meet the researcher in the laboratory and then seat
themselves at a computer station. Each computer was pre-loaded with a ViziSwap module and the inQsit website. Additionally, each computer station had a copy of the participation consent form and ViziSwap user instructions.

Once participants were settled, the researcher explained the study’s purpose and provided verbal instructions for ViziSwap navigation. Participants then began the learning task. Once participants had completed the assigned ViziSwap material, they were instructed to close the ViziSwap window and were asked to focus on the inQsit window consisting of the ten multiple-choice test items. The researcher was present for the entirety of the study to ensure a testing environment condition was met, as well as to answer any questions the participants might have had about the study.

**Textbook.** Participants assigned to the Textbook condition were run in large groups of up to 30 students in large campus lecture halls. As participants entered the lecture hall they were asked to seat themselves at desks with manila folders placed on the desktop surface. The folders contained the textbook material, study instructions, and participation consent forms.

Once participants were settled, the researcher explained the study’s purpose and the study task. Participants read photocopied textbook material and then took the same ten question, multiple-choice test as those in the ViziSwap condition; however, participants in the Textbook condition took their test using paper and pencil.

**RESULTS**

**Analysis overview**

We have broken analysis down into results for each module. First, to test the assumption that the items themselves were not driving the results, we performed an item analysis on the 10 multiple-choice questions for each test. Upon reviewing the results the research team determined the items were, overall, not unfairly biased toward any particular test or learning material. There
were no meaningfully significant interactions using this approach to analysis; therefore, we only report the between-subjects ANOVA results with learning material as the primary variable.

**Population Outcomes.** Results indicated a significant difference between ViziSwap and Textbook scores: $F(1, 49) = 36.537, p < .001, \eta^2 = .432$). Participants using ViziSwap scored higher than those in the Textbook condition (ViziSwap, $\bar{x} = 8.31$; Textbook, $\bar{x} = 5.21$). This effect size is equivalent to comparing a B grade (83%) to an F grade (52%).

**Probabilities.** Results indicated a significant difference between ViziSwap and Textbook scores: $F(1, 51) = 4.389, p = .041, \eta^2 = .081$). Participants using ViziSwap scored higher than those in the Textbook condition (ViziSwap, $\bar{x} = 6.76$; Textbook, $\bar{x} = 5.85$). This effect size is equivalent to comparing a D grade (67.6%) to an F grade (58%).

**Erikson’s Stages.** Results indicated a significant difference between ViziSwap and Textbook scores: $F(1, 60) = 5.109, p = .028, \eta^2 = .08)$. Participants using ViziSwap scored higher than those in the Textbook condition (ViziSwap, $\bar{x} = 8.08$; Textbook, $\bar{x} = 6.92$). This effect size is equivalent to comparing a B- grade (80.8%) to a D+ grade (69.2%).

*Figure 1: Mean test scores for the ViziSwap-Textbook comparison.*
DISCUSSION

This research indicates that, in some cases, students’ learning outcomes are enhanced through the use of the interactive multimedia educational tool ViziSwap. For the ViziSwap modules studied in this research, the Biology, Mathematics, and Psychology modules, students’ learning outcomes (i.e. test scores) were superior to that of students in the textbook condition.

That being said, it is important to note that for any circumstance in which a significant difference was observed, the primary factor for the difference was the learning material. ViziSwap generally outperformed textbooks, which was reflected by students’ enhanced learning outcomes. Practically speaking, even a small, yet statistically significant difference in this research area translates into real-world significance when considering that in terms of grades, a 5% difference may mean passing or failing a course. Additionally, given the sample size of the data, we were able to clearly see the effect of multimedia on learning outcomes.

However, while we observed enhanced learning outcomes for participants using ViziSwap in this study, it is possible that some of the ViziSwap modules in general are more effective than others. At this time, ViziSwap has been created for Psychology, Criminal Justice, Arts & Journalism, Biology, and Mathematics, and each subject has a different number of available modules; we have not studied all available modules, so we cannot claim ViziSwap will always be superior in comparison to textbooks. This may be due to the nature of material. For example, when time binding processes (e.g.: the process of a volcanic eruption; the binding of DNA and protein) are involved multimedia may be more important than when time binding is not fundamental. It is also possible that some of the ViziSwap modules used pedagogy more effectively, in terms of the principals suggested by Mayer (2009). Future researchers should
consider measuring the quality of pedagogy of educational media in order to determine if that is important in determining the differences obtained when comparing media.

**CONCLUSION**

Interactive multimedia like ViziSwap exposes students to a wide variety of educational information, offers dual-coding, is interactive, provides fast feedback, and supports individual differences in learning. Students who have access to such materials and the knowledge of how to use them have the opportunity to learn in exciting new ways. Because traditional textbook-based learning materials cannot offer students the technologically-advanced interactive multimedia educational tools can, it is reasonable to assume students’ learning outcomes would benefit from the latter learning material. Our research shows that in some cases this is true; however, more evaluation research specific to the creation of this type of learning material is required to be sure students are receiving the highest quality education available.
References


Ring, Lemmon, Coffelt, & Butler (2011). Evaluation of multimedia use in university classes. Poster presentation at the 23rd annual meeting for the Association for Psychological Science.


