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Can Computer-Based Instruction Improve Molecular Biology Comprehension Among General Education Students?

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Abstract

The study compared the efficacy of teaching key concepts of molecular biology using an online study environment with a more traditional, lecture-based approach. Two introductory biology classes were randomly divided and exposed to one of two instructional delivery systems. The traditional group attended class and heard lectures covering DNA structure and replication, RNA transcription and protein synthesis, and had live interaction with the instructor. The remaining students used computer-based instruction exclusively to cover the identical course content. These, so called, online learners had access to web pages with detailed lecture notes that were supplemented with graphics, animations and hyperlinks. They interacted with the instructor, and completed chapter quizzes, using electronic mail. Results of a multiple-choice final examination revealed significantly poorer performance by the online group (Mdns = 48% vs 60%, $p < .025$). Student feedback indicated that the online learning experience was perceived to be more solitary, require more time and personal responsibility. Implications for computer-based instruction were discussed.

Introduction

The study of molecular biology demands that students understand the abstract complexities of DNA structure and replication, RNA transcription and protein synthesis. The traditional lecture-based pedagogical practice may not be the best approach to support deep understanding of molecular biology among general education students. Fortunately, the explosion of computer technology in recent decades offers an opportunity to explore a very different, perhaps fuller and more engaging kind of, experience for students [1-4]. Not surprisingly, the effectiveness of web-based instruction on learning outcomes compared to a traditional classroom has been under intense scrutiny over the past several years [5-7]. The present study was designed to test the efficacy of computer-based instruction compared to a traditional delivery system when presenting molecular biology to general education students.

Creating the Computer-Based Molecular Biology Module

In an effort to mirror the traditional lecture experience in terms of content, web pages were created based on the class lectures covering DNA structure and replication, RNA transcription and protein synthesis. (For a detailed example of a web-page, please see figure 1A-C or link directly using http://www.firelands.bgsu.edu/fac/cgenovese/bio/online_104/eeis.html.)

Figure 1a

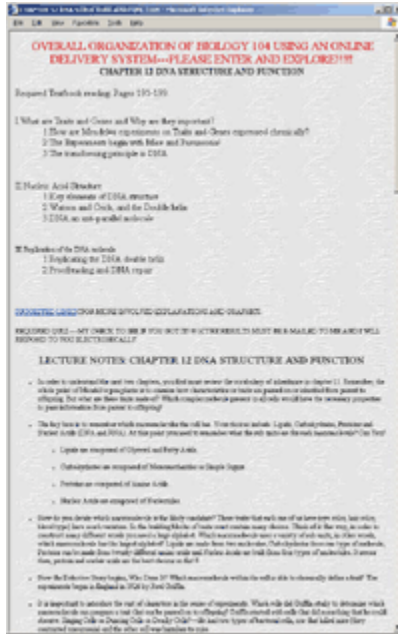


Figure 1b

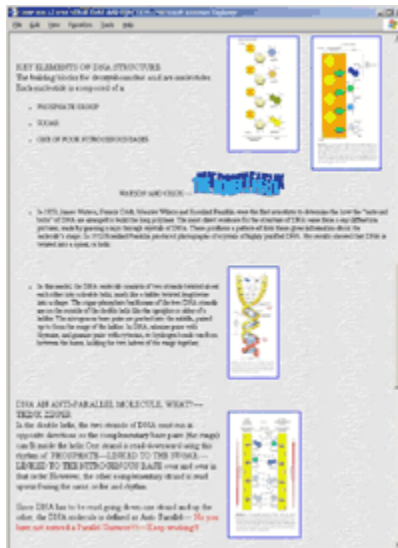
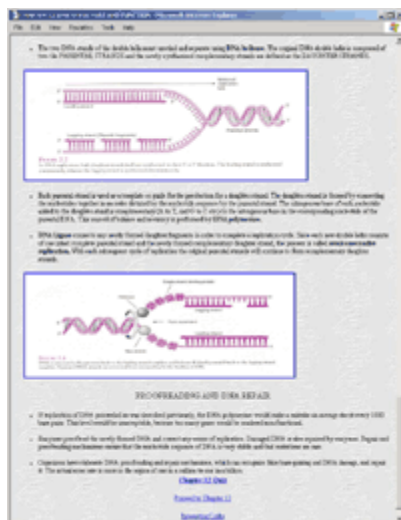


Figure 1c



Despite the standardization of content, the online format of instruction offered additional access to elaborate figures, graphics and hyperlinks, allowing students to explore the material in multiple formats. For example, students could link to short animations that detailed Griffith's experiments proving DNA's inheritability. Once the students finished a particular topic within the module, they were required to electronically submit a multiple-choice quiz that was graded by the instructor. The corrected quiz, returned via electronic mail, contained a detailed explanation of incorrect responses as well as equally supportive feedback for correct answers. Electronic mail was the only form of interaction between the online learners and the instructor.

The Student Population

The demographic data was compiled by the Office of Institutional Research and reflect the general education student norms within Bowling Green State University-Firelands College. The cohort:

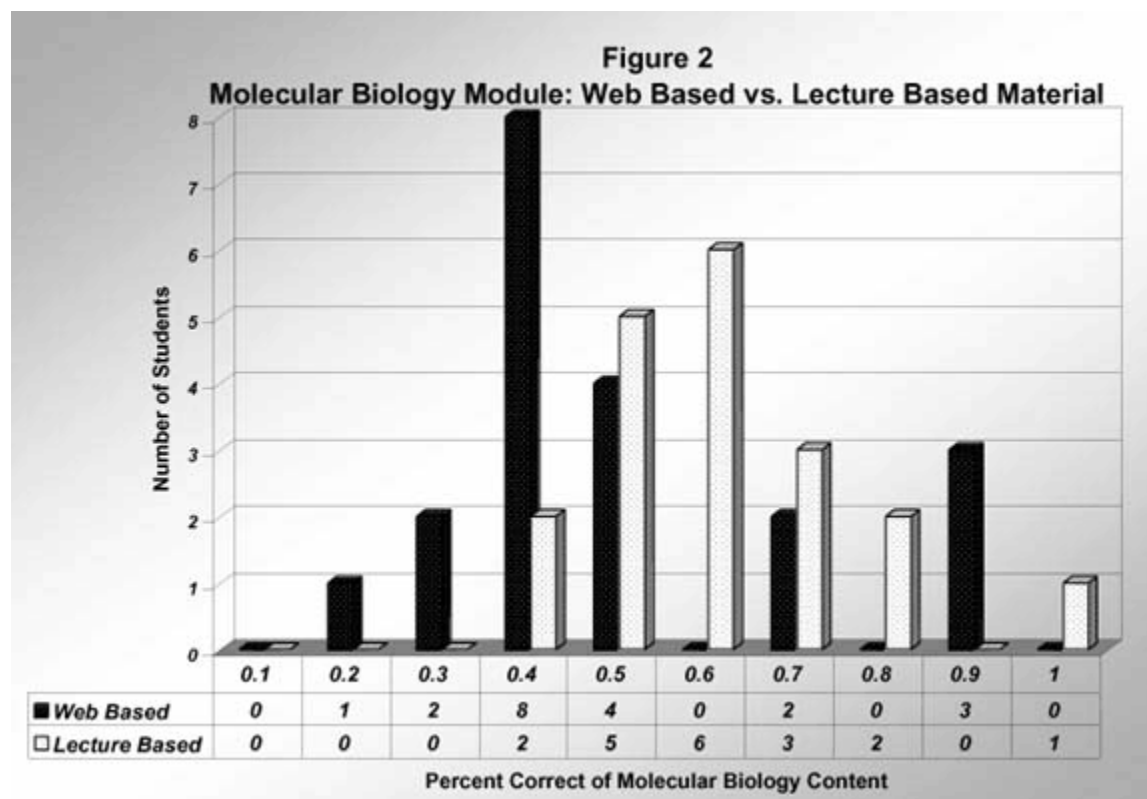
- was composed of pre-health professionals, teachers and/or social workers
- had an average GPA was 2.3
- was 70% female, 30% male
- was 50% non-traditional students
- was self-described as "computer-literate"

The Experimental Design

The students within this course were randomly divided by drawing numbers into two cohorts. One cohort stayed in the classroom to explore molecular biology, while the other cohort was required to experience the material wholly online. The molecular biology module was password protected so only the online learners students had access to that delivery system. Once the molecular biology course content were covered completely in lecture, the class was reunited, and the remainder of the course content was completed. The password-protected module remained active so that the online learners could review any of the material as needed. Both cohorts took the same multiple-choice comprehensive final examination, and the percent correct for the

molecular biology specific final questions were calculated separately for use in this study. Figure 2 illustrates the distribution of percent correct molecular biology specific final examination questions between the two groups, based on the standard 100% scale. The medians from the web-based cohort and the lecture-based cohort were 48% and 60% respectively. Since the data did not approach a normal distribution, the Mann-Whitney test was used to test statistical significance. The difference between the two groups was statistically significant, (p -value= 0.0246). Therefore, the data suggested that the online learners did not perform as well as the more traditional lecture-based cohort on a multiple-choice assessment tool.

Figure 2



Representative Student Commentary On The Online Experience

All of the online learners completed a survey to gain some insight into how they perceived using computer-based instruction to explore molecular biology. The students' specific responses were, for the most part, positive and encouraging. Technical problems were at a minimum and instructor feedback was timely and helpful. Most students found the increased personal responsibility and the need to self-motivate the most difficult part of taking an online module. Therefore I feel some students still require one on one interaction, particularly for this topic, molecular biology. The students have to feel supported because the content is abstract. Presumably, when the study was initiated, I thought the computer could create three dimensional imagery more efficiently and vividly than a classroom chalkboard. Rather than experiencing this as enriching, some students became confused. This population clearly would benefit from one on

one interaction with the instructor. A cross-section of responses transcribed precisely from the survey is presented in Table 1.

Table 1 - Feedback from Online Students using Computer-Based Instruction

Questions	Comments
Did you receive feedback from your instructor in a timely manner?	"yes, she answered all my questions quickly" "my emails were responded to very quickly"
Did you ever experience problems with the graphics or the links?	"I never had any problems with the website. Every graphic worked all the animations worked and it was easy to access the website" "I had no problems with the graphics or the links" "The mouse graphics did not work for me"
Did you ever experience problems with emailing your quizzes to the instructor?	"Yes, I had some problems submitting the quizzes" "No, it came across clear"
Would you be more or less likely to take an online biology course after this limited experience?	"Less likely. I'm a hands on kind of guy" "I liked being online, but I would need just a little more time. I found I read the book more"
What was the most difficult part of taking the material online for you?	"The lacking of an instructor talking to me and personally reviewing the notes on the chalkboard was a big obstacle." "I think that I lack the responsibility to actually take the class completely on my own" "I'll have to put more study time since I was not in class having the information drilled in my head three days a week"
What was the most enjoyable and interesting part of taking the material online for you?	"The most enjoyable part was not having to come to class. It was also nice to work at my own pace" "I liked the fact that I could look at information when I had the most quiet time. I also enjoyed the links. They helped in understanding the material" "Interesting to see how it all worked"

Questions	Comments
Would formation of a chat-room be useful or tedious?	<p>"Probably tedious because I am not one to use a chat-room"</p> <p>"I think it would help. I think getting others point-of-view if you're having some confusion might make it clear"</p>
Compared to a lecture-based course, the online material required more or less study time?	<p>"I think more time was spent on the online material, but I did go into all the links and did the quizzes"</p> <p>"More because you don't have the instructor their to explain it different ways if you don't understand"</p>
Compared to a lecture-based course, the online material required more or less personal responsibility.	<p>"More you had to motivate yourself a lot more to get on the computer and figure out the material"</p> <p>"the online uses more personal responsibility since it is just you and the computer"</p> <p>"much more responsibility. I started to slack on my work"</p>
Compared to a lecture-based course, the online material provided for more or less instructor interaction and assistance?	<p>"The online material required more instructor interaction and assistance just because you don't have the classroom to the immediate feedback. The instructor can't see your expression (if you looked puzzled or confused)"</p>

Discussion

This pilot study provides what might be regarded as a preliminary attempt to evaluate the efficacy of delivering molecular biology content using computer-based instruction. There are many variables that cannot be easily controlled when comparing the two student groups. Self-motivation is a major determinative factor in having a successful outcome when working exclusively online. Computer-based materials require the student to navigate to pertinent materials instead of relying upon the instructor to find, present and explain the material. When the student does not immediately grasp computer-based course content, the student must be self-motivated to dig deeper or reread the material since he or she cannot simply raise a hand and expect an immediate explanation from the instructor. Because this is a survey course in which the students may lack the self-discipline to navigate through the more complex nature of molecular biology content completely on their own within a web-based, wholly online format, web-assisted instruction may be a more efficient presentation of the content and provide a more enriching environment for these students. In addition, pre-screening of students prior to taking any web-based or web assisted instruction may result in a more successful learning experience. However, I do believe that effective teaching practices should take into account the factors that are unique to the course content, teaching style of the instructor, and the characteristics and assumptions of the specific student learners. Consequently, I have begun using Blackboard® course management tools in all my courses to individualize a web-assisted format so my students can have the best of both worlds, continuous interaction with the instructor and their classmates

using asynchronous discussion groups and an easily accessible, ever-growing list of inventive and elaborate web-sites.

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