Comparison of Online and Onsite Bioinformatics Instruction for a Fully Online Bioinformatics Master’s Program

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The completely online Master of Science in Bioinformatics program differs from the onsite program only in the mode of content delivery. Analysis of student satisfaction indicates no statistically significant difference between most online and onsite student responses, however, online and onsite students do differ significantly in their responses to a few questions on the course evaluation queries. Analysis of student exam performance using three assessments indicates that there was no significant difference in grades earned by students in online and onsite courses. These results suggest that our model for online bioinformatics education provides students with a rigorous course of study that is comparable to onsite course instruction and possibly provides a more rigorous course load and more opportunities for participation.

Bioinformatics combines the disciplines of computer science, bioscience, and information technology for the purpose of storing and retrieving biological data and for discovery of novel biological relationships or associations. The Master of Science in Bioinformatics degree, a joint offering of Johns Hopkins University, Krieger School of Arts and Sciences, and Whiting School of Engineering, provides students pursuing a career in bioinformatics with a specialized course of study that emphasizes advanced topics in computational biology. This eleven course program, available online and onsite, includes science courses such as Molecular Biology and Gene Organization and Expression, and computer science courses such as Foundations of Algorithms and Databases and bioinformatics courses such as BioPerl and Protein Bioinformatics (Fig. 1). The Department of Education recently reported that 84% of students are nontraditional learners (9) and thus will require a more flexible classroom. The completely online format of the program is designed to allow working professionals access to the program and an opportunity to pursue a graduate degree in bioinformatics while maintaining rigorous academic standards. Bioinformatics, at the cross-roads of bioscience and computer science, is particularly suited to the online format as much of the analysis is completed in the digital environment (11).

The online program was designed in 2005 to reproduce in as many aspects as possible the onsite courses. In preparation for online delivery, the program’s online courses are first taught three times onsite by the instructor before the course content is converted and taught in the online format. Thus, the instructor has determined the content necessary for a comprehensive course and the appropriate assessments of student competence before proceeding with online instruction. The course management system WebCT is used for online instruction with a model of content delivery containing at least four main components: streaming video or web conferencing software (Elluminate, Inc.), narrated PowerPoint, asynchronous threaded discussions, and access to multiple online resources. Each content delivery component allows the students and instructor to become connected and engaged in the class by visual, auditory, or text-driven interactions.

Streaming video introductions and summaries are effective means to deliver content and provide context. In addition, video allows the student to see the instructor present material as if it were an onsite course and to replay the video for analysis and review. Elluminate, a delivery system that has voice and video capabilities, permits both real time and archived delivery of instructor-generated material, so students can access introductions and summaries at a later time. Narrated PowerPoint is a method whereby the instructor can explain the content of a PowerPoint slide set as the student reviews the material. The student learns through both auditory and visual modalities to better reinforce the concepts of the lesson. Several authors (7, 10, 12) have reported that interaction with faculty and other students online is one of the most important components for a successful class. Our model provides connection through the threaded discussion, e-mail, and chat rooms. The threaded discussion is the primary vehicle for class and instructor interaction. This asynchronous discussion occurs several times during a week of instruction and allows the class and instructor to discuss the week’s topics in detail. Students are required to post three to four substantial contributions to the threaded discussion in each unit. Many instructors use the informal meeting places in the courses’ online chat rooms, referred to as “coffee houses” or “the water cooler,” to continue networking outside of the threaded discussion without the pressure of assessment, which is essential to establishing a sense of community in the distance education environment. Collaboration is an important learning tool and critical in the online environment (3). All of our courses include group projects to foster interactive learning.

Optimally, online education differs from traditional classroom education only in its delivery, not in the content.
or interactions among students and with faculty. The challenge for online education is to ensure that course content and student interactions online are comparable to the onsite environment. Master’s degree programs are second only to associates degree programs in online offerings (2). Few fully online graduate programs have been evaluated for student success and satisfaction and no fully online bioinformatics program has been analyzed. Kearsley reported on the Masters of Engineering in Professional Practice program, a fully online program at the University of Wisconsin (5). Analysis of student satisfaction indices revealed that students found the fully online experience academically rewarding and that it contributed to professional development. Analysis of the S-Star bioinformatics course, a fully online bioinformatics course established by the S-Star group, indicated that students were satisfied with their online experience and would take another online course (6). Stansfield, McClellan, and Connolly reported on two Master’s degree programs, Management of eBusiness and IT with Web Technology (8). Their analysis of student performance on exams in courses taught face-to-face and online showed that students in online sections did better than their counterparts in the face-to-face classes. Ali and Elfessi (2) undertook a study to examine graduate and undergraduate student attitudes and performance in an educational media and technology class. They reported no significant difference in attitude or performance whether the class was online or face-to-face. The data indicates that in most cases online education is at least comparable and may be better than face-to-face training.

Each online program uses different elements for delivery of content and interaction, which will affect the outcome of these studies. To evaluate the success of the Johns Hopkins University online program and its model for online education, we have compared student course evaluations and exam performance for courses in the online and onsite bioinformatics program. Analysis of one course, Gene Organization and Expression, taught online and onsite during the spring semester 2005 indicated that students’ performance on the midterm exam was not statistically different. Thirteen students in the online course and 23 students in the onsite course completed the exam. The average grade for the online course was 86% (range: 67 to 98.5%). The average grade for the onsite course was 88% (range: 67 to 99.5%). In this study we examined student satisfaction with bioinformatics courses online and onsite and analyzed student success in a course taught online and onsite.

**METHODS**

Student satisfaction was assessed online and onsite using a standard questionnaire administered at the end of the course. The evaluation instrument measures 17 areas that assess student responses to both the course structure and instructor performance. In this study, only six questions were evaluated. The evaluation instrument asks students to respond to statements with any of the following responses: strongly agree, agree, neutral, disagree, or strongly disagree (Fig. 2). Students complete the evaluation instrument on the last night of class onsite or when the last unit opens online. The data pertaining to course structure for three online (n = 79) and four onsite courses (n = 261) was collected, combined,
and analyzed. Biochemistry and Molecular Biology, prerequisite and core courses in our bioinformatics program were analyzed. To determine if there was a significant difference, student responses were subjected to a chi-square analysis. We assigned the responses to two categories, “agree” which included “strongly agree” and “agree,” and “other,” which included “neutral,” “disagree,” and “strongly disagree” responses. A two-by-two chi-square analysis was performed for each of the following statements: “The course was taught at a level I expected,” “I learned a great deal from this course,” “Assignments were an effective way to learn the material,” “Instructor encouraged participation,” “The work load was rigorous,” and “I would recommend this course.” Student responses to these six questions were evaluated because they would provide information on interactivity, content delivery, and overall satisfaction. The same survey instrument was used in the onsite and online classes to eliminate any bias that might be introduced using separate surveys.

Student performance was analyzed by comparing the assessment grades for a quiz, midterm exam, and final exam for students enrolled in Gene Organization and Expression (spring 2006) either online or onsite from the same instruc-
tor with exactly the same content and assessment tools. This course is representative of the type of courses offered in the bioinformatics program as the content delivery mode of this online course is similar, incorporating the elements of asynchronous discussion, group work, and both timed and take-home assessments. In addition, as the same instructor taught both online and onsite sections at the same time, we were able to eliminate variability due to different instructors or to the semester the course was offered. The students self-selected whether they took the course online or onsite. The quiz assessment was a timed quiz; the midterm and final exams were “take-home” essay exams. The course grades were analyzed by two-way t test using Origin75 software (Origin Corp).

RESULTS

We compared student satisfaction with online and onsite instruction using the standardized survey instrument in Fig. 2. Holcom, King, and Brown reported that the student population they surveyed believed that the traditional course evaluation used by the University was appropriate for Web-based courses (4). As seen in Fig. 3, students were at least as satisfied with the online courses as their counterparts were with onsite courses. In general, students were highly satisfied with their academic experience whether they took the course online or onsite. Over 75% of students reported that the course was taught at the expected level, they learned a great deal, assignments were an effective way to learn the material, the instructor encouraged participation, the work load was rigorous, and they would recommend this course. Further investigation of the data by chi-square analysis indicated that there was no significant difference in the responses given by online and onsite students to “The course was taught at a level I expected,” “I learned a great deal from the course,” and “I would recommend this course.” However, there was a significant difference for the student responses to the questions, “Instructor encouraged participation” ($P \leq 0.001$) and “The workload was rigorous” ($P < 0.05$). More online students tended to agreed with the statement “assignments were an effective way to learn the material” than onsite students, but the difference was not significant.

We investigated whether online and onsite students achieve

FIG. 3. Comparison of online and onsite student responses. The data represent the percentage of students who agreed with the statements, “The course was taught at a level I expected,” “I learned a great deal from the course,” “Assignments were an effective way to learn the material,” “Instructor encouraged participation,” “The work load was rigorous,” and “I would recommend this course.”
or learn at the same level by analyzing exam data from the course Gene Organization and Expression taught onsite and online. The course was taught by the same instructor with the same content in the same semester (spring 2006). The data from assessments—quiz 1, midterm examination, and final exam—were compared by a two-tailed t test. Quiz 1 was a timed test; the midterm and final were take-home exams for both online and onsite courses. Analysis of the data (Table 1) showed that for all three assessments, there was no significant difference between the grades received by the onsite and online students.

**DISCUSSION**

The completely online Master of Science in Bioinformatics program differs from the onsite program only in the delivery of content. Several mechanisms are required to assure comparable quality between onsite and online courses, such as the courses are taught by the instructor onsite three times prior to online development, the use of standard assessments for courses online and onsite, and collection of student satisfaction data. The online courses are designed for interaction between faculty and students through the threaded discussion and include streaming video and narrated PowerPoint so that students may learn through both visual and auditory modalities.

Analysis of the results indicated a statistically significant difference for the metrics “the course load was rigorous” and “the instructor encouraged participation.” While our hypothesis was that there is no difference in student satisfaction with online or onsite courses, we found online students were more likely to find the course rigorous and to report that the instructor encouraged participation. The data indicate that the online environment is challenging and highly interactive. In addition, online students tended to respond more positively as compared to onsite students to the statement, “Assignments are an effective way to learn the course material.” Collection of additional data may elucidate whether this result has true significance. Analysis of student performance in the online and onsite sections of Gene Organization and Expression, a representative bioinformatics class, using three assessments indicated that there was no significant difference in grades earned by students in online and onsite courses. This result agrees with preliminary data collected in spring 2005 from the same course for the midterm exam. These results suggest that our model for online bioinformatics education provides students with a rigorous course of study that is comparable to onsite course instruction, and that online course assignments may be more beneficial to student learning; however, a longitudinal study assessing long-term recall and employer satisfaction with graduates of the program would be informative. One can surmise from this result that students are engaged with the course material in novel ways using technology to enhance the learning process. To better understand the factors which affect this outcome, we plan to track and analyze student work across course management functions and in other classes to better assess how students engage with course content in the online environment.

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| Exam     | n   | Mean  | SD    | SE   | P value |
|----------|-----|-------|-------|------|---------|
| Online   |     |       |       |      |         |
| Onsite   |     |       |       |      |         |
| Quiz 1   | 26  | 8     | 22.336| 1.688| -0.13237| 0.26589|
| Midterm  | 25  | 8     | 106.92| 11.285| 11.551  | 0.19899|
| Final    | 24  | 8     | 244.75| 11.7112| 2.025   | 4.083   |

*For all values, at the 0.05 level, the difference of the population means is not significantly different than the test difference (0).
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