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In this paper college science instruction via the Internet is examined from three perspectives: students' on-line learning experiences; a comparative examination of learning on-line versus traditional instruction; and instructors' experiences teaching on-line. The setting was a freshman-level human anatomy / physiology course. Three students participated in a collective case study to describe the learning environment created by the Internet course. Motivation, computer savvy, and self-confidence were important to their success. A quantitative study of the on-line course and the traditional course evaluated the comparative effectiveness of the learning environments. Achievement scores and survey results indicated content understanding and retention were not effected, while desirable student study habits were used more frequently in the Internet section. To better understand the instructional implications of on-line courses, a case study was conducted. Internet instructor's time commitment and level of teaching satisfaction were high. The instructor's role changed, causing some lessening of job satisfaction.

Disciplines

Curriculum and Instruction | Educational Assessment, Evaluation, and Research | Educational Methods | Educational Technology | Higher Education | Online and Distance Education

College Science via Internet: How effective is it?

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Abstract: In this paper college science instruction via the Internet is examined from three perspectives: students' on-line learning experiences; a comparative examination of learning on-line versus traditional instruction; and instructors' experiences teaching on-line. The setting was a freshman-level human anatomy / physiology course. Three students participated in a collective case study to describe the learning environment created by the Internet course. Motivation, computer savvy, and self-confidence were important to their success. A quantitative study of the on-line course and the traditional course evaluated the comparative effectiveness of the learning environments. Achievement scores and survey results indicated content understanding and retention were not effected, while desirable student study habits were used more frequently in the Internet section. To better understand the instructional implications of on-line courses, a case study was conducted. Internet instructor's time commitment and level of teaching satisfaction were high. The instructor's role changed, causing some lessening of job satisfaction.

Introduction

Higher education is increasingly using advanced technologies, such as the Internet, as a means of instruction. The asynchronous nature of advanced technologies is causing a cultural change in instruction. No longer is a college education confined to the traditional campus, where students and instructors meet at designated times; the dynamic nature of information technology is changing higher education (Connick 1997). Despite these changes, the responsibility of the instructor to maintain (and increase) the quality of instruction and create an appropriate learning experience remains. (Wagner 1997). The purpose of the research presented in this paper is to better understand the implications the Internet is having on higher education.

Distance education at the collegiate level is no longer novel, but the use of the Internet as a means of instruction is a relatively new phenomenon. Several studies have explored the supplemental instructional use of the Internet without delving into the effects of that use (Brooks 1997; Chute, Thompson & Hancock 1999). As a partial answer to this dearth of knowledge, this research was undertaken to examine Internet teaching effectiveness in a college science course. Three studies were conducted and comprise the research reported here. In the first study, on-line learning experiences were investigated using a case study approach. The second study was a comparison study in which student study habits and achievement in Internet-based instruction were compared with those in traditional instruction. In the third study, an investigation of teaching via the Internet was conducted. The intent of this case study was to better understand instructional factors of Internet-based instruction by gathering data from professors who teach via the Internet.

The Course

At Iowa State University, the freshman-level Human Anatomy and Physiology course (Zoology 155) was offered via Internet as well as via traditional format. A three-credit course, the traditional format for the Human Anatomy and Physiology class is taught in a single-section via lecture to more than 500 students who enroll each semester. There are no laboratory exercises associated with this class, although a companion laboratory class may be taken during the same semester. Course assessment is based on student performance on three or four exams, one comprehensive final exam, and 3 to 7 homework assignments and/or quizzes throughout the term. Typically, the class is taken by students from all colleges and majors in the university. It is required for a degree in Psychology and Food and Nutrition, and is used to fulfill requirements for coaching certifications and entry into the Veterinary Medicine program. Additionally, the course is taken by many students to complete their general science requirements prior to graduation.

An Internet offering of the same class was prepared in the Summer of 1997. The Internet version follows the protocol created through ProjectBIO (an externally funded project to create a protocol for internet-based college instruction). This protocol allows instructors to teach college courses entirely on-line. Each course in ProjectBIO, including Human Anatomy and Physiology, includes a series of lectures with pages of text and visuals as they appear in the traditional lecture. An audio stream accompanies the lectures, following as closely as possible to that given during traditional instruction. For the Human Anatomy and Physiology course, all lectures, exams, quizzes and homework assignments were created and made available to the student on the first week of the fall 1997 semester.

Case Study of Students' On-line Learning Experiences

To assess the learning environment perceived by the students enrolled in Internet-based science course, a case study was conducted. The research was guided by the question: What, specifically, does the student experience as he or she works through a semester-long science course taught entirely on-line?

Three students were chosen as subjects to be followed as they worked their way through the Internet offering of Zoology 155. As a basis for choosing these students, demographics on previous Zoology 155 enrollment was analyzed. The typical student in the traditional class, averaged over three semesters, was a female of sophomore standing with a GPA of 2.7. She was an Iowa native graduating from high school in the 68th percentile and currently enrolled in the College of Liberal Arts and Sciences. In choosing the three subjects for this study, one was chosen to match the traditional demographics as closely as possible. Her case was referred to as "Judy". A second student, "Mitch", was chosen as a representative of the "non-traditional student population" as defined by the University handbook. "Sara", the third student, was chosen from the University - defined at-risk population.

Data collection was carried out using the qualitative methods of interviews, informal chats, open-ended telephone conversations, participant journals and e-mail correspondence. These many avenues of data collection were employed to reduce the likelihood of misinterpretation, to include redundancy in the findings (Denzin 1989, Goetz & LeCompte 1984) and to provide triangulation of findings to ensure validity of the conclusions (Stake 1994). Additional information was gathered using the standard course assessment tools, including homework and exam scores as well as participation points for joining in discussions and chat sessions.

"Judy" was a native Iowan enrolled as a sophomore in the College of Liberal Arts and Sciences. At the start of the semester, she had a GPA of 2.8. She was a Psychology major; thus, Zoology 155 was required for completion of her degree. Her goals included becoming a Mental Health Therapist or a Counselor. In her first journal entry, she wrote "Today was a disaster! It took me an hour to figure out how to register on ClassNet. Talk about vague directions.". Judy had persistent difficulty with the technology, evident in her e-mail correspondences. "Did I really miss all the points or did I do something wrong? Please try to respond. Also, if I messed up when I entered them, is there any way I can go in and fix them?". "I tried to see lecture 6 - damn computer wouldn't let me - it's lucky I didn't break it! So I moved on to lectures 7, 8, and 9, which it allowed - You figure it out - I even tried 6 again later - but it still hated me - damn modern technology!!!". In her final course evaluation, Judy noted the class was interesting, the content was explained well, and the format was not a deterrent.

The second student, "Mitch", was selected as a representative of the adult student population. At the time of this study he was a 52 year old senior in the Bachelor of Liberal Science program, College of Liberal Arts and Sciences hoping to graduate in December. His grade point was high - 3.7 - but he graduated from high school in the lower half of his class. Mitch held a full-time job as a policeman, taking classes on nights and weekends to finish his degree. Mitch had a positive outlook on life. Each time we met, he was friendly and full of smiles. He is a realist, admitting his limitations and also his strengths without hesitation. This was evident in his e-mails: "I am looking forward to this course because not only will I find it challenging, but working my way around the web promises to prove challenging". Mitch felt that his grade was affected not by the computer technology, but rather by the "science technology - I just didn't know enough". During an interview, he emphatically noted that the medium did "not at all affect my grade. I could go back and repeat lectures and study before tests. This was a good thing". "This is a totally personal experience. I was hesitant at first - motivation? This was the first course where you got down and studied.". Although I did not sense his leaning on me as much as other students in the Internet section, Mitch admitted to being "quite reliant on the instructor. I re-listened to lectures, sent you lots of mail. I never felt out of touch". Mitch did note that motivation was a big factor in passing the class. He expressed concern for the average college student. "They can get lost easily. I got lost at first, then caught up. This is a benefit as well. You can get a week ahead if you want".

Sara, the third participant in the study, was a senior at the time of the class, with a 3.0 GPA. Her grade point had dipped slightly in the past semester from a 3.5 due to "senioritis". Sara was a native of Bombay India, and spoke both Hindi and English fluently. Sara fell under Iowa State University's "at-risk" student definition due to her low high school rank and her nationality. In her first interview she described herself as a "non-exceptional student who was on every school team she could". She did enjoy science in high school but did not take it in college. "I was afraid it would be too hard". She called me at the start of the semester to beg for help getting her computer to work. I felt badly for her, as she was almost in tears over the technology. "Initially I was really excited about this class - a little nervous but when I logged on that was really smooth. Did the first homework, that was easy! Next day - went to lecture - no sound. Why? I tried everything - frustrated". This frustration plagued Sara throughout the course. "I was excited to begin. The freedom excites me. I can do it at 3:00 am if I want. This is the height of customer service. The best thing college can do for you. I'm not trying to keep up with you. At the same time it is scary. Am I doing this right or wrong? There is a loss of the personal touch.. "I do one lecture over and over again. I am not confident. There is no immediate feedback. I feel like I am groping. Anxiety - am I really learning? This is not a factor in normal classes". Her reaction to the course was entirely technology-driven rather than a reaction to the content covered. "I have lost confidence doing [the class] this way".

Although case studies do not lend themselves to generalities, a list of the findings from these cases may help illuminate the students' experiences with on-line learning. These include:

1. The technology was problematic for some, particularly females. Confidence in the technology and in the user were important to a positive experience with the Web class.
2. Instructor availability was important to all students regardless of their level of comfort with the technology.
3. Attitude toward the subject did not seem to be affected by the Internet. In fact, students who scored low on exams still rated the class as "excellent" or "better than most".
4. Enthusiasm was high at the outset of the semester, and with nurturing can remain high throughout the term.
5. Motivation appeared to be the single most important factor affecting success in the Internet course.
Either internally or externally motivated students fared better.

Comparison of an Internet and Traditional College Science Course on Student Learning

With a rudimentary understanding of the learning environment created by Internet-based Human Anatomy and Physiology course, a quantitative comparison of the effectiveness of an Internet and traditional course was conducted. The following questions were used to guide this study: 1) How does Internet-based science instruction effect student achievement? 2) How does Internet-based science instruction effect student study habits? 3) Do the students perceive Internet-based science classes differently than traditionally taught classes? 4) Do students enrolled in an Internet-based science class perceive their education differently than do students enrolled in a traditional science class?

Five hundred seventeen students participated in the study; 457 and 60 in the traditional and Internet sections of Zoology 155, respectively. With the exception of the percentage of students enrolled as part-time students, the two sections were demographically similar. Student achievement in the traditional and Internet section of the class was assessed using grades earned on the four exams and assignments. Study habits were examined using a study habits survey adapted from Mohamed (1980). Also working with Zoology 155 students, Mohamed (1980) designed the original survey to assess the effect the availability of video presentations of class lectures had on student study habits. The modified survey was administered week 12 of the semester. In addition, the Attitude and Epistemology Survey was administered to examine students' attitudes and beliefs about science. This survey was administered in the second week of semester to determine students' attitudes when entering the course (not a change due to the course). T-tests were conducted on all survey and grade results to determine whether statistically significant differences existed between the two groups.

The results of the Attitude and Epistemology Survey revealed no significant differences between the two sections (alpha = 0.05). The survey results were grouped into four categories based on underlying concepts: attitudes toward science usefulness, interest in the field of science, problem solving abilities (use of the scientific process in problem solving), and understanding of the scientific process. These survey results were analyzed using gender, year in school, reason for enrollment Zoology 155, and choice of Zoology 155 section enrollment as parameters for comparison. Regardless of which parameter was isolated, no differences between the two self-selected populations could be ascertained from the survey.

When study habits were examined, differences appeared between the two sections. Tests were run comparing Internet section responses with traditional section responses. In addition, gender comparisons were made both within each section and between sections. Those enrolled in the Internet section reported missing fewer lectures, reading the text more often, reading a higher percentage of the required readings, and having more faith that the readings were an integral and helpful portion of the class than did those in the traditional section. The Internet students reported recognizing that their course allowed for different learning styles and self-paced learning; this was so for the traditionally taught section. The freedom to arrange study schedules around other classes was appreciated in the Internet section, while seen as indifferent in the traditional section. Responses to questions concerning the use of tutors, notes taken during the class, or outside resources such as experts or libraries did not significantly differ between the two sections. Males in the Internet section missed fewer lectures and relied more on the text than did the males in the traditional section. The males in the Internet section reported an increase in interest in the subject due to the class and an appreciation of the freedom allowed by the class. This same pattern also was evident when comparing mean responses in the two female populations. The females enrolled in the Internet section differed significantly from their traditionally-taught female peers in that they missed fewer lectures, relied more on the instructor-prepared notes and the textbook, found the lectures and readings more useful, and appreciated the freedom to schedule their studies.

Overall course grades were slightly higher in the Internet section of the class. Scores on the cumulative final exam were significantly higher in the Internet section. Retention rates, analyzed by percentage enrollment dropping the course at midterm, were also different between the two sections. The Internet section lost a higher percentage of students than the traditional section . Achievement was not adversely effected by the use of the Internet as a means of course content delivery.

The Internet has not created a better way to teach, but appears to have facilitated the use of instructional design methods that move the student toward more interaction with the material. The benefits seen are not inherent in the medium, but rather they are due to the effective use of the properties of the medium. The learning environment created in the Internet-section of Zoology 155 did not appear to adversely affect learning. Students enrolled in the Internet section of this college science course demonstrated more efficient study habits (such as spending more time interacting with the material, using the text and ancillary materials, and attending the lectures) than those in the traditional course. Their content retention was better than those students taught in the traditional lecture, and their study habits more closely resembled those proven to lead to success (Piaget 1975, Pintrich 1994, Posner, Strike, Hewson, & Gertzog 1982).

Teaching On-line Courses: A Case Study of Instructors

The instructor experience while teaching on-line was investigated to complete this look at Internet-based science instruction. The guiding question for this study was "How does internet-based instruction impact the tasks of the instructor and the instruction itself? To examine this, two faculty members teaching on-line college science courses participated in this study. The time they spent on the class, as well as their comfort level with their workload, course product, and teaching effectiveness were investigated. Data were obtained through interviews and observations during the spring 1998 semester. The two participants had been teaching in the Zoology Department at Iowa State University for at least four semesters prior to their involvement with on-line courses through ProjectBIO. Both were full-time employees of the University, although neither held tenure-track professorial positions. Both participants held earned Doctoral degrees in science. At the time of the study, they were each approximately 40 years old, married and had children.

One instructor, Dr. Jenson, had been with ProjectBIO for more than two years, and was teaching an Internet science class for the fourth consecutive semester. The other instructor (Dr. Douglas) was new to on-line instruction and would teach his first Internet-based course during this study. Dr. Jenson had taught his biology course on the Internet using the ProjectBIO protocol three semesters including a summer session. Spring 1998 represented his fourth run of this course through ProjectBIO. He had an enrollment of 70 students in his Internet section during Spring 1998. While not particularly outspoken, he attended all ProjectBIO meetings and presented issues for group discussion many times. Dr. Jenson's input on teaching strategies and administrative routines was sought after and respected by the ProjectBIO staff.

Dr. Douglas was hired into the Zoology Department in 1995 as a spousal appointment. At the time of this study his position, like Dr. Jenson's, was defined as staff. His original duties included coordinating and instructing upper level laboratories, so few changes were necessary when Internet instruction was added to his responsibilities. The Internet course was viewed by the administration as equivalent to teaching one laboratory section. Dr. Douglas

was given a sophomore-level biology class to instruct via the Internet. Dr. Douglas was first and foremost a scientist, and he viewed teaching was a small part of his job. At the start of the semester, he had nothing prepared for Internet delivery, although he had previously taught the course (via traditional methods) and was confident in his knowledge of the content.

Dr. Douglas' lectures were not prepared until they were needed by the students, This did not allow students to work completely in an asynchronous manner. When asked about the time he spent on creating WWW lectures, Dr. Douglas responded "I spend much more time working on my WWW section. The preparation is very time-consuming. I spent 3 to 4 weeks working incredibly hard on getting my lectures done. It takes longer to do a lecture - it costs more to prepare". When talking with his spouse, Dr. Douglas' level of involvement with his Internet course was indicated. "He is demonstrating excessive signs of stress. He's not sleeping and staying up late several days a week. He writes out all his lectures, then reads them verbatim. He also does all his own graphics. He spends one hour per figure and has 5 to 6 per lecture. He wouldn't do that for live lectures". This high level of time commitment was indicated again when Dr. Douglas' spouse reported "I have hardly seen him for weeks. This definitely cuts into family time. He should have started in a more timely manner. Spring Break he began in earnest". In Dr. Douglas' opinion, he spent "longer on the WWW, and my time was not well spent. I had the entire lecture written out and tried to sound animated. I went back and edited mistakes - I fixed lectures because it's there and people hear it 3 or 4 times". He created his own lectures, but did have help with HTML cue points and other technical aspects of web delivery. Learning these skills again required more of his time then he anticipated "I spent more time piddling around with the Web resources".

Because he had taught the course previously, Dr. Jenson was involved not in creating lectures, but with "maintenance and fixing to make it better". Dr. Jenson mentioned that "editing took an incredible amount of time. I had to do lectures all over again. You have to be more efficient and careful about what you are saying. I want the product to be good quality - this takes a fair amount of time. Just the audio took a lot of time". After the initial creation, Dr. Jenson planned to go back and fix up the lectures. "I haven't yet. I would like to add new stories and change the information that's in there. The development phase is long. Once its developed there's maintenance - well, more than that. It requires attention. New exam made up. I type all the exams in myself. I now know HTML - this is a nuisance that takes a while. Far longer than regular lectures. I should be tweaking the course, but I have no time".

Both instructors talked about their feelings of job satisfaction while teaching on-line. They reported similar experiences. In an interview, Dr. Jenson noted "I do get frustrated doing all this. I feel I'm not using my time most effectively. With my experience and knowledge I don't need to be doing this [administrative work]. I'm not teaching [repeated twice]. In traditional classrooms, you feel like you are teaching. You have tried to communicate and some may have gotten it. With the Web, there's no immediate feedback. The e-mail has nothing to do with content at all. I'm not really teaching. The sense of personal satisfaction is a problem". Dr. Douglas' interview comments mirrored this. "I generally dealt with only two things - all procedural questions. No course information, almost no content questions. I had only one or two questions on each assignment - was the paper available or is the content relevant? Student feedback is not enriching". There was a bright spot for the experienced Web instructor. Dr. Jenson was surprised by the level of interaction between student and instructor that this format provided. "The students e-mail me constantly, telling me things that I don't usually hear in traditional lectures". "I feel like I know these students personally, much more so than I do with traditional students." Even his spouse was able to see the relationship that developed between Dr. Jenson and his Web students. "He talks more about his Web students. He has more contact with those students. It's weird - especially the off-campus students". Dr. Douglas was not far enough along in his Web teaching experience to notice many differences in the student attitude, but he did notice there were fewer "no hope-ers" in his WWW class than he'd been seeing in his traditional classes.

Despite the acknowledged increase in administrative work the instructors experiences in teaching via the Internet, their overall impression of teaching on-line was positive. Dr. Jenson's spouse noted "He has been excited about the possibilities of teaching in this way all along. He sees a lot of potential in on-line teaching". Dr. Douglas noted that "the on-line experience could be positive - it has the potential to be positive. I would like to do it again and do a better job".

Conclusions

The dynamic nature of the Internet makes it viable tool for instruction. As more and more colleges and universities offer on-line courses, it is important to understand the potential and limitations of the Internet as a means of instruction. The research reported in this paper suggests that the Internet can be an effective means of

college science instruction. The case study about students' on-line learning experiences indicated that students enjoy learning on-line, and although students do not meet with instructors regularly, instructor availability was important to the students. Also, motivation is a key factor impacting student success in on-line instruction.

When compared with traditional instruction, Internet instruction appears to be an effective method for teaching college science, as student achievement was not adversely effected. Students in an Internet course were less likely to miss lectures and used lecture notes and textbooks more frequently than those in the traditional course.

Internet instruction changes the role of the university professor. The results of the instructor case study suggest that teaching on-line courses consumes more time than traditional courses. In addition to understanding the course content, instructors who teach via the Internet must possess technical skills to design and maintain course materials. Although the instructors spent a great deal of time designing and maintaining their web-based courses, they possessed positive attitudes about teaching on-line.

To better understand the implications of Internet teaching and learning, additional research needs to be done. Future studies should examine instructional design and on-line instruction; policy issues with on-line instruction in higher education; and student self-efficacy in on-line courses.

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