Evaluation in Online STEM Courses

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Abstract

Student enrollment in distance learning STEM programs is continually increasing. Recent developments of online instructional software and other electronic pedagogical tools have significantly improved the educational delivery of online programs. Quality online course evaluation provides the pathway to the future success of distance education. Typically, standard course evaluations only consist of summative assessment instruments. Online STEM faculty must develop and integrate both formative and summative course evaluation techniques to adequately measure the effectiveness of their online courses. Moreover, STEM faculty must employ rigorous statistical procedures when analyzing evaluation data. The study described herein utilized a quantitative survey instrument to evaluate online student perceptions. Results from 670 online and traditional student respondents were collected and analyzed for this study. Data were analyzed using regression analysis. Research findings suggested that students in traditional STEM courses reported a more favorable course experience than students enrolled in online STEM courses. This research article investigates the use of quantitative surveys and regression analysis to more effectively assess student performance and perceptions of the academic environment to improve pedagogy and student learning outcomes.

Keywords: online learning, distance education, quantitative survey, evaluation strategies, science education research

Introduction

According to national estimates, the number of students pursuing distance education in higher education is growing at a steady rate (Waits & Lewis, 2003). Given the increasing numbers of institutions and students involved in distance education and online courses, it is imperative that university administrators and faculty stay abreast of information regarding the strengths, benefits, and limitations of distance education. To adequately understand the positive attributes of online education, and areas where improvement is needed in distance education, science education researchers must explore and evaluate students' perspectives regarding the online environment and the quality of instruction in order to enhance student learning experiences. Assessing the impact of distance education is an important endeavor in today's technology-driven culture of higher education.

In response to this growing need, researchers have begun to develop instrumentation and special techniques designed to measure the effectiveness of online courses versus traditional courses (Roberts, Irani, Telg, & Lundy, 2005; Walker & Fraser, 2005). Viewed collectively, these instruments have the potential to be used in online courses as well as in traditional courses to support more accurate measurements to evaluate the degree to which the quality of instruction impacts the success of student learning.

The purpose of this study is to establish data on students' perceptions and experiences in STEM online courses. The data will be used to support the development and design of additional studies to glean information on the following research questions: a) How do students taking STEM online courses perceive their instructors ability to design and implement effective instruction?, b) How do students taking STEM online courses perceive the effectiveness of their courses?, and c) To what extent are students satisfied in STEM online courses?

Although it is one of the most discussed issues in science education, the topic of evaluation remains an important issue in the 21st century. Proper evaluation involves three cyclical phases: preparation, implementation, and evaluation of data (Murray & Murray, 1992). The first phase of proper evaluation, preparation, involves a variety of decisions concerning: a) What to evaluate?, b) How to evaluate it?, and c) What represents positive data? The first phase of proper evaluation requires a tremendous amount of planning. The second phase involves implementation of the evaluation process. This phase incorporates monitoring students' responses and managing the evaluation process. The third phase of proper evaluation involves the analysis of the evaluation data. This phase incorporates reviewing the data and deciding if the intended goal (phase 1) was met.

One type of student evaluation tool STEM online instructors can employ is to use short (e.g., 5-10 question) introductory questionnaires in the beginning of the course that investigate students' knowledge base and their prior experiences with online courses. This information will provide the online instructor with information regarding misconceptions, deficiencies, and potential barriers students may have. Based on student responses, online instructors can tailor their instruction and online academic support to specific students or groups of students to ensure their early success in the course (Dougherty, 1997). To tackle the problems associated with assessing problem solving skills and higher order thinking skills, online instructors are encouraged to employ modified objective examinations. Modified objective exams consist of standard multiple choice, true/false, short answer, and matching questions, but also require students to provide a rationale for their answers.

Online STEM instructors should employ an array of evaluation methods to accurately determine students' scientific aptitude levels and perceptions of the learning environment. One method to evaluate student learning is to use performance-based assignments such as STEM-based projects and individual portfolios that contain student work. Additionally, while traditional end-of-the semester course evaluations are comparable to online evaluations in terms of mean ratings and amount of student comments (Stowell, Addison, & Smith, 2012) special consideration must be given to designing effective end-of-the semester evaluations consistent with online instruction. The overarching purpose of the research study is to advocate the use of multiple online course and student evaluations coupled with appropriate statistical analytical procedures to improve current and future online courses.

Methodology

Conceptual Overview

The quantitative research component for this study includes the administration of an evaluation instrument designed to conceptualize students' dispositions regarding their academic experiences. The conceptual framework for the quantitative research component of the study is based on numerous research investigations on the effects of college on student development (Astin, 1993; Pascarella & Terenzini, 2005).

Participants

Institutional Review Board (IRB) approval was obtained prior to commencement of the quantitative study. The research study was conducted in a southeastern, four-year university. The study consisted of 670 undergraduate students majoring in a wide variety of academic disciplines (e.g., non-science majors and science majors). Of the sample, approximately 39% were men and 61% were women. Student participants were enrolled in online and traditional (e.g., face-to-face) courses in introductory STEM courses.

Data Analysis Procedures

The quantitative instrument utilized in this study consisted of two major scales: the instructor scale and the learning experiences scale. The instructor scale is a 13-item, Likert-type scale (e.g., 1 = poor to 5 = excellent). The instructor scale measures students' perceptions of the instructor's ability to plan and teach the course. The learning experiences scale is a 7-item, Likert-type scale. The learning experiences scale measures students' perceptions of the technology and course learning experiences. Quantitative data collected from undergraduate students were transferred into SPSS®, coded, and analyzed using regression analysis. The use of regression analysis allowed researchers to control for the influence of other factors or eliminate confounding variables that may impact the dependent variable. In the present study we controlled for differences in precollege characteristics, institutional characteristics, academic experiences, and nonacademic experiences to more precisely determine the effects of online STEM courses on student perceptions. Each item from the quantitative instrument was analyzed to ensure it was suitable for statistical analysis (data not shown). All statistical results were reported significant at the $p < .01$ level. Effect sizes were also computed by dividing the regression coefficient by the pooled standard deviation of the outcome measure to examine the practical significance of the regression coefficient (Cohen, 1988).

Results

Research findings reveal informative information regarding students' perceptions of the online learning environment in a STEM course. The instructor scale and the learning experiences scale were used in the present study (Table 1). Statistically controlling for differences in precollege characteristics, institutional characteristics, academic experiences, and nonacademic experiences, students in traditional STEM courses reported a more favorable course experience than students who took online STEM courses.

Table 1
***Quantitative Survey*[a]**

Learning Experiences Scale

1. Relationship between examinations and learning activities.
2. Appropriateness of assigned materials (readings, video, etc.) to the nature and subject of the course.
3. Timeliness in delivering required materials.
4. Reliability of the technology(ies) used to deliver this course.
5. Technical support's ability to resolve technical difficulties.
6. Availability of necessary library resources.
7. Convenience of registration procedures.

Instructor Scale

1. Description of course objectives and assignments.
2. Communication of ideas and information.
3. Expression of expectations for performance in this class.
4. Availability to assist students in or out of class.
5. Respect and concern for students.
6. Stimulation of interest in course.
7. Enthusiasm for the subject.
8. Interaction opportunities with other students.
9. Timeliness in returning assignments.
10. Coordination of the learning activities with the technology.
11. Encouragement of ind ependent, creative, and critical thinking.
12. Facilitation of learning overall.
13. Overall rating of instructor.

[a]Likert-type scale (1 = poor, 2 = below average, 3 = average, 4 = above average, 5 = excellent)

Table 2 summarizes the direct effects of taking an online STEM course (versus a traditional STEM course) on students' perceptions of the academic environment. Multiple regression analyses demonstrated that taking an online STEM course had significant and negative direct effects on students' scores on the learning experiences scale (B = -1.473, $p < .01$).

Table 2

Effects of Online STEM Courses on Students' Perceptions[a,b]

Scale	Regression Coefficient	R^2
Learning Experiences Scale	-1.473*** (-.132)	.086

[a]Top number is the unstandardized regression coefficient, number in parentheses is the standardized regression coefficient.

[b]Statistically controlling for: age; gender; year in school, grade point average; residence status; hours spent studying per week; and hours spent working on-campus and off-campus per week

*** $p < .01$ ** $p < .05$ * $p < .10$

Table 3 summarizes the direct effects of taking an online STEM course (versus a traditional STEM course) on students' perceptions of the instructor. Regression analyses demonstrated that taking an online STEM course had significant and negative direct effects on students' scores on the instructor scale (B = -2.835, $p < .01$).

Table 3

Effects of Online STEM Courses on Students' Perceptions[a,b]

Scale	Regression Coefficient	R^2
Instructor Scale	-2.835*** (-.139)	.084

[a]Top number is the unstandardized regression coefficient, number in parentheses is the standardized regression coefficient.

[b]Statistically controlling for: age; gender; year in school, grade point average; residence status; hours spent studying per week; and hours spent working on-campus and off-campus per week

*** $p < .01$ ** $p < .05$ * $p < .10$

Discussion

Data presented in Table 2 indicates that online students perceive inadequacies with the online instructional environment in terms of the fundamental support systems that enhance student performance. Further, research findings presented in Table 3 suggests that online instructors may consider evaluating and modifying certain aspects of their courses, for example how they integrate technology in their courses and stimulate interest in online STEM courses. Most college faculty members are very familiar with the traditional evaluation surveys administered at the end of the semester. These summative assessment strategies occasionally provide useful feedback on how to improve the course. A more efficient evaluation strategy should involve the use of formative assessment approaches (e.g., midterm teaching and learning evaluation surveys). Following midterm evaluations, student response data could be used during the semester to improve instruction and may significantly result in higher student performance and retention rates in STEM online courses. As previously discussed, the use of e-mail to foster successful teaching and learning evaluations is an effective strategy to improve online instructor effectiveness and to improve adherence to student learning objectives (Flowers, Moore, & Flowers, 2011).

Implications for Future Research

Future studies will include the development of better evaluation tools to capture the perceptions, deficiencies, and barriers of students enrolled in online STEM education. Additionally, future research studies will also examine the extent to which online learning environments in STEM education improve student development and social interaction effects. Finally, multivariate research designs will be incorporated into the analytical research strategy to assist researchers in measuring the effectiveness of STEM online courses while controlling for the effects of student effort, student motivations, and student achievement. In summary, it is clear that student and course evaluations cannot be consolidated to one type of evaluation mechanism (Banta & Pike, 1989). Quality online evaluation procedures must involve comprehensive strategies that measure a variety of teaching and learning modalities.

Acknowledgements

This study was funded by a research grant from the National Science Foundation (HRD-0811728). The information reported in this article are those of the authors and do not represent the funding agency.

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