Differences in Perceptions of Structure Dependence among Students in Online and Traditional Science and Engineering Courses at a Historically Black Institution

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ABSTRACT

Statistically controlling for differences in precollege characteristics, institutional characteristics, academic experiences, and nonacademic experiences, students in online science and engineering courses tended to prefer instructional environments that had more structure than students who took traditional courses at a historically Black institution. Recommendations for instructional strategies and future research, based on findings from the study, are discussed.

INTRODUCTION

Access to distance education courses has increased significantly in the last two decades. Thus, many institutions of higher learning now offer a wide variety of online courses and degrees. While the use of online and web-enhanced courses has become increasingly popular at colleges and universities, empirical research employed to evaluate how student learning preferences impact students’ academic experiences in online science and engineering courses is limited. In this regard, one question of interest pertains to how much guidance or structure students need in distance education settings versus traditional classroom environments. This concept has been examined in the research literature—in relation to general research on college students—to differentiate them in terms of how much guidance they need from instructors in college courses. According to Davidson and Beck (2006-2007), structure dependence is defined as “[a]n overly strong need for clear, detailed, external guidelines for academic assignments” (p. 298). In the teaching and learning environment, students who require higher levels of structure dependence may need additional clarification on assignments and guidance throughout the entire semester.

The higher education learning environment has changed considerably over the years (Roblyer, 1999; Schlosser & Anderson, 1994). At many colleges and universities around the country, technology has propelled this change. It has, in many ways, contributed to the investment of better university technological infrastructures and emerging technologies to improve faculty instruction, student-faculty interaction, and student learning. As a result, during the last ten years, distance education has increased in availability to students (Waits & Lewis, 2003). What once was an anomaly at postsecondary institutions is now a common instructional-delivery option for students at both public and private universities.
According to Lewis, Snow, Farris, and Levin (1999), there are several explanations on why American colleges and universities are increasing their distance education course offerings. Sherron and Boettcher (1997) suggest that the changing student demographics of those who pursue a postsecondary education, combined with the need to reduce costs associated with postsecondary education has contributed to this change. As a result, research literature on distance education has also increased. A considerable amount of this research has focused on the perspectives of course designers, administrators, and instructors (Harbeck, 2001). However, there is a dearth of research on the impact and effectiveness of online instruction in science, technology, engineering, and mathematics (STEM) disciplines, particularly at historically Black institutions. Further, there is a need for more student-centered investigations of distance education (Hara & Kling, 2000) that illustrate the appropriate use of technology in terms of how distance learning can be more advantageous to students pursuing science and engineering degrees. To this end, Miller and Husmann (1999) assert that educators and researchers need to learn more about the student learner to determine the quality and success of distance education courses. While this is a highly held contention, emerging social science research suggests that online students in STEM acquire similar or better educational gains, when compared to their on-campus student counterparts (Kirtman, 2009; Reuter, 2009).

Despite the increase in the number of distance education courses offered at American colleges and universities, there are still some institutions of higher learning that struggle with the implementation and sustainability of distance education programming. Poor technology, lack of training, professional issues, and student demographics are some of the factors that have been cited as inhibitors (Jacobsen, 1997; Nania, 1999). As stated previously, there is an increasing body of scientific literature on distance education. This research often indicates that the format of instruction has little effect on student learning outcomes if the delivery of technology is inappropriate to the course content and if the students do not have access to appropriate technology. However, Souder (1993) has found that learning outcomes on examinations administered by course instructors tend to be higher for distance education learners than for traditional classroom learners. Research also suggests that traditional classroom settings are perceived to be better organized and more clearly designed than distance education courses (Egan, Sebastian, & Welch, 1991). Studies also have concluded, over the years, that different factors determine successful learning outcomes, irrespective of whether the students are taught at a distance or in traditional classrooms.

Three comprehensive definitions of distance education inform the study. First, the study utilizes the definition of distance education from Moore and Kearsley (1996) who stated, "Distance education is planned learning that normally occurs in a different place from teaching and as a result requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements" (p. 2). Waits and Lewis (2003) define distance education "as education or training courses delivered to remote (off-campus) sites via audio, video (live or prerecorded), or computer technologies, including both synchronous (i.e., simultaneous) and asynchronous (i.e., not simultaneous) instruction" (p. iii). Given the interdependent perspectives on distance education, which informs the study's framework, an online distance education student was defined as a student who is enrolled in a postsecondary education institution and is currently taking at least 1 course for credit in a distance education format. For the purpose of the study, an online distance education student is currently enrolled in a STEM course that utilizes the Internet and other forms of technology to transmit instruction, encourage interactions with students and faculty, and enable students to demonstrate knowledge and skills in the form of discussions, presentations, essays, and examinations in a for-credit course.
METHODS

The intent of the study is to identify components of online courses that students consider to be a positive influence on their academic performance. The research design was based on a cross-sectional study of students taking courses in science and engineering, and the sample for this study consisted of 337 African American students from 1 historically Black institution. Further, the total sample included approximately 60% females and 40% males. Thus, the total sample contained the following distribution of students: (a) 15% freshmen, (b) 22% sophomores, (c) 26% juniors, and (d) 37% seniors. The average age range of the sample was 19-21. Survey data were collected online and then transferred into SPSS® for analysis.

The conceptual underpinnings of this investigation were based on several studies, pertaining to the effects of college on student development and educational outcomes (Chickering & Reisser, 1993; Pascarella, 1985; Pascarella & Terenzini, 1991, 2005; Tinto, 1993). A substantial amount of research has considered the role of student characteristics on their academic orientations and achievements (Pascarella & Terenzini, 1991, 2005). This study is also based on accumulated research findings, highlighting the relevance of students’ experiences on- and off-campus (Astin, 1993; Pascarella & Terenzini, 1991, 2005; Terenzini, Pascarella, & Blimling, 1996; Terenzini, Springer, Pascarella, & Nora, 1995). Given the aforementioned research, an array of control variables were developed and coded for this study (i.e., age, gender, grade point average, year in school, residence status, hours spent studying per week, and hours worked on- and off-campus).

Variables

The dependent variable for this study consisted of the Structure Dependence scale from the Survey of Academic Orientations (Beck & Davidson, 2001; Davidson & Beck, 2006; Davidson, Beck, & Silver, 1999). The independent variable of interest was course enrollment, as measured by whether a student took an online STEM course or was enrolled in a traditional STEM course. The Survey of Academic Orientations is a 36-item, Likert-type scale (5 = strongly agree to 1 = strongly disagree). For each item, students were asked to rate the extent to which each statement described their attitudes, perceptions, and/or behaviors. Structure Dependence, a six-item scale, from the Survey of Academic Orientations measures the extent to which students prefer focused learning environments in college (Davidson, Bromfield, & Beck, 2007). More detailed information about the independent, dependent, and control variables is shown in Table 1.

Procedures

The Survey of Academic Orientations’ Structure Dependence scale was administered to students enrolled in both an online and traditional STEM course to determine students’ perspectives of structure dependence. Ordinary least squares regression was the principal data analytic tool used in the current study (Pedhazur, 1997). More specifically, the Structure Dependence scale from the Survey of Academic Orientations was regressed on the independent variable and the entire set of control variables to estimate the differences in structure dependence for students’ taking online STEM courses versus traditional STEM courses, while applying statistical controls. All statistical results were reported significant at $p < .05$. In the second stage of data analysis, effect sizes were computed by dividing the regression coefficient by the pooled standard deviation of the outcome measure to examine the practical significance of the significant regression coefficient (Cohen, 1988).
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<tr>
<th>Table 1: Operational Definition of Variables</th>
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<tr>
<td><strong>Part A: Independent Variable</strong></td>
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<td><strong>Course Enrollment</strong>: A categorical variable was coded: 1 = Enrolled in an online STEM course; 0 = Enrolled in a traditional STEM course.</td>
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<td><strong>Part B: Dependent Variable</strong></td>
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<td><strong>Structure Dependence</strong>: Six-item scale measuring the extent to which a student requires a clear and focused instructional environment.</td>
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<td><strong>Part C: Control Variables</strong></td>
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<td><strong>Age</strong>: A categorical variable based on a self-reported measure of the respondent’s age was coded: 1 = 18 or younger; 2 = 19-21; 3 = 22-25; 4 = 26-35; 5 = 36 or older.</td>
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<td><strong>Gender</strong>: A categorical variable was coded: 1 = female, 0 = male.</td>
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<td><strong>Grade Point Average</strong>: A categorical variable based on a respondent’s self-reported grade point average was coded: 1 = A; 2 = A, B+; 3 = B, 4 = B-, C+; 5 = C, C-, or lower.</td>
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<td><strong>Year in School</strong>: A categorical variable based on a student's year in school was coded: 1 = Freshman; 2 = Sophomore; 3 = Junior; 4 = Senior.</td>
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<td><strong>Residence Status</strong>: A categorical variable was coded: 1 = live on-campus; 0 = live off-campus.</td>
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<tr>
<td><strong>Hours Spent Studying Per Week</strong>: An interval-scaled variable based on a student’s self-report of the number of hours spent studying per week was coded: 1 = 0; 2 = 1-5; 3 = 6-10; 4 = 11-15; 5 = 16-20; 6 = 21-25; 7 = 26-30; 8 = more than 30.</td>
</tr>
<tr>
<td><strong>Hours Worked On- and Off-Campus</strong>: An interval-scaled variable based on a student’s self-report of the number of hours they worked on- and off-campus per week was coded: 1 = 0; 2 = 1-5; 3 = 6-10; 4 = 11-15; 5 = 16-20; 6 = 21-25; 7 = 26-30; 8 = more than 30.</td>
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**RESULTS**

Table 2 summarizes the direct effects of taking an online STEM course (versus a traditional STEM course) on students’ perceptions of structure dependence. Multiple regression analysis demonstrated that taking an online STEM course had significant positive direct effects on students’ scores on the Structure Dependence scale ($B = .907$). This result suggested that students enrolled in online STEM courses were more likely to report a greater need for detail and structure as opposed to students in traditional courses who reported lower levels of structure dependence. The effect size indicates that this statistically significant difference is low to moderate (Cohen, 1988). Designing rigorous web-based STEM courses that support the academic needs of students and enhance their learning is a primary goal among course developers who teach STEM courses. The results obtained in this study indicate that online courses may need to incorporate elements that increase students’ perceptions of structure dependence.
DISCUSSION

Multiple regression analysis demonstrated that taking an online STEM course had significant positive direct effects on students’ scores on the six-item Structure Dependence scale. Further analysis of internal reliability coefficients, using Cronbach’s alpha, indicated that the instrument utilized in the study generated valid measurements for the construct of interest. Results suggest that online students prefer clear and specific assignment instructions. In contrast, another study (Diaz & Cartnal, 1999) examining students in a science course found that students in a distance learning environment preferred less structure and more independence than students in traditional courses. One explanation for the differences in this study and the Diaz and Cartnal study may be due to the lack of appropriate individual-level statistical controls for students’ precollege characteristics and students’ academic experiences.

The utilization of quality empirical research studies is a potent mechanism for improving distance education. Given the complexity of STEM courses and the inherent challenges faced by students to learn difficult concepts on a largely individual basis, academic performance may be directly linked to students' needs for structure integration in the framework of the online course design. The current quantitative study was conducted to assess the viewpoints of undergraduate students enrolled in online STEM courses at a historically Black institution. Based on the results presented in this study, online students in STEM courses expressed a greater need for comprehensible guidelines for academic assignments, when compared to students in traditional courses.

Recommendations for Online Course Development

Successful online courses involve a substantial amount of preparation, before the start of a new semester. Thus, structure dependence is an important concept to consider, when developing online courses. Because most online courses include asynchronous components, a clear and understandable assignment schedule may be paramount to student success. The utilization of a detailed syllabus, specific course announcements, and e-mails can be used to reinforce assignment instructions. Integrating synchronous elements in the online course will also allow students the opportunity to clarify course expectations in real-time.

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<th>Dependent Variable</th>
<th>Regression Coefficient</th>
<th>Effect Size</th>
<th>$R^2$</th>
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<td>Structure Dependence</td>
<td>.907*</td>
<td>.261</td>
<td>.127</td>
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</table>

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

*p < .05
The inclusion of comprehensive weekly assignment calendars in the syllabus or content management software may also enhance student learning. Moreover, assignment guidelines and grading rubrics should be posted at multiple locations on the course site to provide students with substantial access to course information. Further, employing explicitly labeled digital assignment folders in a course site, containing course documents and assignments, can aid in the creation of high-quality structured academic environments. Online course developers should also review research and scholarship on distance education (e.g., Clark-Ibanez & Scott, 2008; Puzziferro & Shelton, 2008; Silvers, O'Connell, & Fewell, 2007) and use this information to develop courses that meet the individualized needs of online students. Adopting the above recommendations may ultimately improve student retention (O'Brien, 2002), student persistence (Towles, Ellis, & Spencer, 1993), and enhance student achievement. Administering surveys to online students is an effective method to obtain student feedback, which may also be used to improve web-based distance education teaching and learning strategies.

**Future Research**

Future studies should be conducted on larger sample sizes and different institutional types to verify the conclusions drawn in this study. An investigation, comparing specific online student-centered structure integration approaches, would be beneficial for online course developers. Therefore, future research examining online and traditional students in STEM courses at community colleges may also be useful. Studies also should be conducted to explore other academic orientations to further delineate important student perceptions that are essential for improving online education in STEM courses.

**REFERENCES**


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