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Rethinking Academic Support: Improving the Academic Outcomes of Students in High-Risk STEM Courses with Synchronous Videoconferencing

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Abstract

This article presents findings of a study conducted to determine the impact of academic support provided through videoconferencing on the academic outcomes of Science, Technology, Engineering, and Mathematics (STEM) students enrolled in high-risk science courses in higher education. A quasi-experimental nonequivalent posttest only design was employed to determine if grade and retention outcomes of students receiving online academic support through videoconferencing were equivalent to outcomes received by students receiving face-to-face academic support and students not receiving academic support. Data from 1,276 students were analyzed and significant differences were found in rate of retention and final grades of "Cs or above" among the 3 groups. The untutored group had the lowest rate. There was no significant difference in retention or final grade proportions for online and face-to-face groups, providing evidence that synchronous academic support through videoconferencing is as effective as face-to-face academic support.

Introduction

Online academic support through videoconferencing provides students with a flexible, anytime, anywhere technological alternative to face-to-face instruction that enables the diverse interactions needed for effective academic support. According to meta-analyses by Jopling (2009, 2012) and other research studies (Shelley, White, Baumann, & Murphy, 2006; Whitney, 2007), however, research in the area of online academic support is relatively limited, underdeveloped, and/or often methodologically weak. Furthermore, existing research in the field has primarily focused on online tutor development and practice, and variability in program methodology or user interface. Literature discussing the use of videoconferencing for academic support (Jopling, 2012; K. C. Ng, 2007; Martinovic, 2009; Price, Richardson, & Jelfs, 2007) and the efficacy of online academic support (Kersaine et al., 2011) is lacking. The purpose of this paper is to present evidence that addresses these issues through two research questions:

1. Is there a significant difference among the proportions of students earning final grades of "Cs" and above, after receiving online academic support, face-to-face academic support, and no academic support?

2. Is there a significant difference among the retention rates of students receiving online academic support, students receiving face-to-face academic support, and students not receiving academic support?

Background

Distance education continues to grow as the capabilities of internet technology expand (Johnson, Smith, Willis, Levine, & Haywood, 2011) and the educational needs of our society change. In higher education, the proportion of academic leaders citing online learning as a critical strategy long term increased from 48.8% in 2002 to 63.3% in 2015 (Allen & Seaman, 2016). According to the National Center for Educational Statistics, the most common factors affecting the distance education decisions of post-secondary institutions were meeting student demand for flexible schedules, making more courses available, and providing students with greater access to college (Parsad & Lewis, 2008). Demand supports this direction. While the enrollment of students not enrolled in distance education courses decreased 5.5% from 2012 to 2014, the enrollment of students in distance education courses increased 7.4% in the same time period (Allen & Seaman, 2016).

Distance education adoption in the U.S. is also being influenced by globally inspired political pressures related to the impact of retention on institutional funding and accreditation. According to the President's Plan for a Strong Middle Class and a Strong America,

> The President will call upon Congress to consider value, affordability, and student outcomes in making determinations about which colleges and universities [should] receive access to federal student aid, either by incorporating measure of value and affordability into the existing accreditation system; or by establishing a new, alternative system of accreditation that would provide pathways for higher education models and colleges to receive federal student aid based on performance and results. (The White House, 2013, p. 5)

Retention concerns are particularly acute in the STEM disciplines. According to the Executive Office of the President, President's Council of Advisors on Science and Technology [PCAST], the number of students in the United States who receive undergraduate STEM degrees will need to increase approximately 34% annually over current rates between 2012 and 2022 in order for the US to maintain its prominence in science and technology and meet economic demand (2012).

In response to the need for an American STEM workforce to become "part of an increasingly global innovation system and workforce" (Carnevale, Smith, & Melton, 2011, p. 13), the PCAST (2012) recommended that institutions find more creative ways to accommodate students from divergent backgrounds by diversifying pathways to STEM degrees and find novel uses of information technology with interactive real-time feedback that can decrease the rising costs of higher education (PCAST, 2013). Some of the initiatives provided to guide the restructuring needed to increase effectiveness and raise graduation rates in the STEM domains are The American Graduate Initiative, which recommends the creation of new online learning opportunities by 2020 (The White House, 2009), and the National Education Technology Plan (NETP) (Office of Educational Technology [OET], 2010), which recommends using the flexibility and power of technology in order to enhance STEM learning by reaching learners anytime and anywhere. The strategic use of distance learning has the potential to meet these goals. However, it also has the potential to exacerbate the low retention rates currently reported for students in online courses in higher education (Herbert, 2006; Pierrakeas, Xeno, Panagiotakopoulos, & Vergidis, 2004; Sulčič & Sulčič, 2007; U.S. Senate Committee on Health, Education, Labor & Pensions [HELP], 2012).

Earlier research (e.g., Castles, 2004; Pierrakeas et al., 2004) identified the absence or inconsistency in quality of learning support as a factor influencing this low retention of students in distance education. U.S. accrediting agencies (e.g., Middle States Commission on Higher Education, 2011; U.S. Department of Education, Office of Postsecondary

Education [OPE], 2010) and others (e.g., Angelino, Williams, & Natvig, 2007; Howell, Laws, & Lindsay, 2004; McCracken, 2004; W.-K. Ng & Kong, 2012) Simonson, Schlosser, & Orellana, 2011; Simonson, Smaldino, Albright, & Zvacek, 2012; Sulčič & Sulčič, 2007) have also recognized that support services can raise the retention rates and/or success of students in distance education programs. Consequently, in an effort to guide institutions in their development of quality, accredited distance education programs, the U.S. Department of Education and a number of regional and national organizations have developed policy guidelines that can be grouped into several operational areas, one of which is student support services that include academic support (Council of Regional Accrediting Commission [C-RAC], 2009; McCarthy & Samors, 2009; Simonson, 2009; Simonson et al., 2012; OPE, 2006). According to these policy guidelines, student support services must be "appropriate to the delivery of the online learning program" (Middle States Commission on Higher Education, 2011, p. 12); promote the stability and success of the online learning initiatives (McCarthy & Samors, 2009); and provide distance education students with the same access to student and academic services as on-campus students in order to insure equality and adhere to policy (C-RAC, 2009; McCracken, 2004; OPE, 2006). Consistent with these recommendations, the NETP (OPE, 2010) asked the U.S. Department of Education to encourage "states, districts, P-12 programs, and post-secondary institutions to experiment with such resources as online learning, online tutoring, and mentoring" (OET, 2010, p. 1) and HELP (2012) has recommended that higher education institutions "enforce minimum standards for student services that include tutoring [to help alleviate low retention]" (p. 10).

Academic Support

Academic support is particularly important for STEM and minority students. Students in the science and engineering majors have greater attrition out of these fields than those students who transfer into these fields from other majors, particularly if they are underprepared for postsecondary education (National Science Board ([NSB], 2012). Outcomes for minorities are less favorable. Far fewer African Americans actually receive a STEM degree compared to the other groups. Moreover, only half of these students who start with a bachelor's degree in a STEM major will graduate with that major. Consequently, minorities are underrepresented in a global STEM workforce and in a society recognizing the need for equitable representation (Carnevale et al., 2011).

Face-to-face academic support has been effective in positively influencing STEM major persistence related to academic performance at this institution (Potacco, 2015; Potacco, Chen, Desroches, Chisholm, & De Young, 2013; Potacco & Ramirez-Levine, 2006, 2007, 2008, 2009, 2011, 2012, 2013; Rask, 2010). However, coinciding with the diversity of this institution's student population, students with obligations related to work, family, and/or disability, are often unable to access face-to-face academic support. Online tutoring through synchronous videoconferencing provides these students with an innovative use of information technology that could conceivably meet their academic support needs and mitigate the academic unpreparedness that contributes to the low retention rates of students in STEM courses.

Theoretical Framework: The Equivalency Theory

The equivalency theory of Simonson and Schlosser (1995) posits that distance education students in various locations, at different times, and in a different context require a different mix of learning experiences to attain the learning outcomes. According to this theory, distance education systems that are being developed should strive to provide the distance learner with experiences that are equivalent to the experiences of face-to-face learners, therefore the objective of distance education should be to provide distance and face-to-face learners a collection of equivalent learning experiences appropriate to their different environments, which summatively have equal value for learners. Central to this theory is the comparison of outcomes, which are obvious, measurable, and significant changes, that occur as a result of learner participation in the educational experience (Simonson, Schlosser, & Hanson, 1999).

Methods

A quasi-experimental nonequivalent posttest only design (Gravetter & Forzano, 2011) was employed to determine whether there were significant differences in grade and retention outcomes among students receiving online academic support through videoconferencing, students receiving face-to-face academic support, and students not receiving academic support. According to Harris et al. (2006), "A quasi-experimental design is frequently used when it is not logistically feasible or ethical to conduct a randomized controlled trial" (p. 16). Since students' academic outcomes were positively impacted by face-to-face academic assistance (Potacco & Ramirez-Levine, 2006, 2007, 2008, 2009, 2011, 2012, 2013), it would have been unethical to potentially influence academic outcomes by randomly assigning students to groups. Furthermore, because the selection of participants was not done randomly, the groups could not be considered equivalent (Reichardt, 2005; U.S. Office of Justice, Bureau of Justice Assistance, Center for Program Evaluation and Performance Measurement, n.d.).

Context

The study was conducted at a 4-year public Hispanic-serving university in the Northeast area serving approximately 11,500 students (William Paterson University [WPUNJ], 2015). The site of this investigation is an academic support center located within the College of Science and Health. The site was chosen based on the demonstrated ability of its face-to-face academic support program to positively influence the grades and retention of students in high-risk science courses; the diverse demographic and socioeconomic profile of its student body (WPUNJ, 2015); and the accessibility of its students and staff to the researcher. The criterion for a course's designation as high-risk was a "D/F" grade rate greater than 25%.

All tutoring was by current or former STEM students at the institution who had previous experience tutoring students face-to-face in high-risk science courses and a GPA greater than 3.0. Most (83%) of these tutors were post baccalaureates and female (67%). One-third of the tutors were Hispanic and two-thirds Caucasian. Most face-to-face and online tutoring was provided through Study Groups provided 6 days per week. The online tutoring service was provided 7 days and evenings a week to accommodate students who were unable to attend face-to-face sessions.

Participants

Samples were drawn from approximately 2,488 students enrolled in a science course at the university during Spring 2014. The average age of these students was 22.5, and their average GPA was 2.84. Additional demographics of this population are provided in Table 1.

Table 1
Descriptive Statistics for Students Enrolled in a science course, Spring, 2014

Variable	*n*	%
Gender		
Male	1018	41
Female	1465	59
Ethnicity*		
Minority**	876	50
Non-minority	884	50
Class standing		
Freshman	515	21
Sophomore	553	22
Juniors	636	26
Seniors	691	28
Post Baccalaureate	93	4

Note. *Hispanic, Black, Asian, American Indian.

Purposeful, nonprobability, judgement sampling was used to select participants. Participants in the retention analysis were students enrolled in a high-risk STEM course during Spring 2014. Participants in the grade analysis were students enrolled in a high-risk STEM course during Spring 2014 who received a grade. Participants in the final grade and retention analysis were further divided into three groups: (a) students taking a science course who requested and received online tutoring; (b) students taking a science course who received face-to-face tutoring; and (c) students taking a science course who elected not to be tutored online or face-to-face.

Data Collection

A record of each student’s attendance in a face-to-face or online academic support session was documented on attendance sheets by the tutor and director, and then entered into the university’s database through the data entry screen of the support center’s tracking system. The criterion for entry into this database was between 1 and 1.25 hours of academic support. Students requesting online tutoring also completed an online tutoring application form that provided contact information needed for communication and the scheduling of tutoring sessions.

Procedures

The videoconferencing platform selected for this study was Blackboard Collaborate, which enabled audio and visual conferencing, instant messaging, an interactive whiteboard, application sharing, Internet access, and breakout rooms (Blackboard, 2013). In order to communicate through the platform, all tutors used a unidirectional headset and webcam. Some tutors also chose to use a graphics tablet. Additionally, online tutors were provided with instructional materials, an orientation in the use of this platform, and mentoring in online pedagogy during sessions.

Students requesting online academic support were also required to attend an orientation in the use of Blackboard Collaborate. After the orientation, the researcher scheduled an online tutoring session for each student with a trained tutor proficient in the subject and sent an e-mail to the tutor and tutee, providing session details and contact information. After this introduction, tutors personally contacted each of their tutees with a welcome e-mail that provided additional contact information and content-related information needed for the online session. Whenever possible, applicants were scheduled to join an existing online Study Groups, provided the course and their schedules were compatible. The STEM courses in which students were tutored online and face-to-face were in the disciplines of chemistry, mathematics, biology, physics, anatomy, and physiology.

Data Analysis

Prior to the statistical analysis, data submitted into university's database were queried, aggregated with Excel, and analyzed with SPSS. Students who graduated in the spring were omitted from this sample.

A Chi-square test for homogeneity was used to determine whether there was a significant difference between the retention rates of students receiving online academic support, students receiving face-to-face academic support, and students not receiving academic support. A chi-square test for homogeneity was also used to determine whether there was a significant difference between the proportions of students receiving final grades of “C” and above, students receiving face-to-face academic support, and students not receiving academic support. Since the frequencies for the online group were small, a Fisher’s exact test was subsequently used to approximate the chi-square distribution.

Results

Approximately 26% (644) of students taking a science course were tutored. The average age of students who participated in online tutoring (25) was greater than the average age of the face-to-face group (22), $t(640) = -1.77$, $p = 0.0388$. There was no significant difference between the average GPA of students who came for tutoring face-to-face (2.96), compared to the average GPA of online students (2.85), $t(640) = -0.80$, $p = 0.4262$). Additionally, students seeking online academic support appear to be disproportionate in the categories of women, minority, and commuters, compared to the proportion of students tutored face-to-face, and not tutored (Table 2), further Chi-square analysis showed that the only significant difference was in the proportion of commuters, χ^2 (1, $N = 653$) = 5.07, $p = 0.0242$ (Table 3).

Table 2
Descriptive Statistics for Online, Face-to-Face, and Not Tutored

	Online		Face-to-face		Not tutored	
Variable	*n*	%	*n*	%	*n*	%
Gender						
Male	10	30	257	42	751	41
Female	23	70	362	58	1,080	59
Ethnicity						
Minority*	22	68	277	58	673	43
Non-minority	11	32	198	42	887	57

Level						
Undergraduate	32	97	609	98	1,753	96
Post Baccalaureate	1	3	11	2	80	4
Commuter status						
Commuter	29	88	431	70	1,370	75
Non-commuter	4	12	189	30	465	25
Class standing						
Freshman	3	9	76	12	188	11
Sophomore	5	15	204	33	361	21
Junior	9	27	158	25	463	26
Senior and post-baccalaureate	15	45	171	28	742	42

Note. *Hispanic, Black, Asian, American Indian.

Table 3
Differences in Proportions in Online versus Face-to-Face Demographics

Variable	Chi squared	*df*	*p*
Gender	1.63	1	0.2017
Class standing	7.14	4	0.1285
Commuter status	5.07	1	0.0242*
Ethnicity	1.07	2	0.5849

Note. * $p < .05$

Differences in Course Grades

There were significant differences in the proportions of students receiving final grades of "Cs" or above in the three groups, χ^2 (2, N = 1276) = 12.45, p = 0.002 (Table 4). Students tutored online had a significantly higher proportion of "Cs" and above than students not tutored. The sample proportions of students receiving good grades were 89.5% (tutored online), 79.2% (tutored face-to-face), and 70.8% (not tutored).

Table 4
Comparison of Final Grades of Students Tutored Online versus Face-to-Face versus Not Tutored (N=1,276)

		Final grades		
Method of tutoring	Count/%	DF	ABC	Total
Not tutored	Count	249	604	853
	% within condition	29.2	70.8	100.0
Tutored online	Count	2	17	19
	% within condition	10.5	89.5	100.0
Tutored face-to-face	Count	84	320	404
	% within condition	20.8	79.2	100.0
Total	Count	335	941	1,276

In order to determine whether there is a significant difference between students earning "Cs" and above between groups tutored online and face-to-face, a Fisher's exact test for homogeneity was used. There was no significant difference, p = 0.388.

Differences in Retention

There was a significant difference among the retention rates of students receiving online, face-to-face, and no academic support for high-risk science courses during the Spring 2014 semester, χ^2 (2, N = 1220) = 17.11, $p < 0.001$ (Table 5).

Table 5
Comparison of Retention Rates for Students Tutored Online versus Face-to-Face versus Not Tutored (N=1,220)

		Retained		
Method of tutoring	Count/%	No	Yes	Total
Not tutored	Count	163	602	765
	% within condition	21.3	78.7	100.0
Tutored online	Count	4	18	22
	% within condition	18.2	81.8	100.0
Tutored face-to-face	Count	51	382	433
	% within condition	11.8	88.2	100.0
Total	Count	218	1,002	1,220

Students tutored face-to-face had a significantly higher retention rate than students not tutored. The proportions of students retained were 88.2% (tutored face-to-face), 81.8% (tutored online), and 78.7% (not tutored), There was no significant difference between the retention rates of groups tutored online and face-to-face based on a separate test with p = 0.324.

Discussion

There was no significant difference in the gender, class standing, GPA, or ethnicity of students who received online tutoring, compared to students who received face-to-face tutoring. However, differences were found between the proportions of commuters who chose online tutoring versus face-to-face tutoring, suggesting that online tutoring may be particularly popular at schools with a larger commuter population. The demand for distance learning by commuters has been reported in the literature (P.-S. D. Chen et al., 2008; Dutton, Dutton, & Perry, 2002; Mattes, Nanney, & Coussons-Read, 2003).

In agreement with previous findings (Chen, Gonyea, & Kuh, 2008; Radford, 2011; Smith, Salaway, & Caruso, 2009), online adopters were older than face-to-face students. Radford (2011) also described the online learner as undergraduate students who are older, have dependents, are married, employed full-time, and/or have a mobile disability. It is possible that these populations are more motivated to adopt online academic support due to necessity influenced by situation. This position is supported by Howell et al. (2004) who report that older students are more likely to leave due to competing priorities that include the demands of family, work, and school.

More of the students who sought online academic support were also women and minorities. The minority student population is projected to increase in higher education. According to NCES projections, enrollment in postsecondary degree-granting institutions from 2009 to 2020 will increase 25% for Black, 46% for Hispanic, and 25% for Asian/Pacific Islander populations, compared to 1% White and American Indian/Alaska Native populations (Hussar & Bailey, 2011). The National Technology Plan (OET, 2010) highlighted the need to utilize the flexibility and “anytime-anywhere power” of technology to accommodate the post-secondary needs of these and other marginalized students, such as low-income, ESL, disabled, gifted, rural, and linguistically compromised students.

Research Question 1

There was no significant difference between the proportions of students receiving final grades of “Cs” or above for students receiving online and face-to-face academic support. This result provides evidence that online tutoring provided online participants with a learning experience that was at least equivalent to the learning experience provided to learners face-to-face. This result is in agreement with other studies and meta-analyses that have found that learners can be as successful in the online environment as in the face-to-face environment (Jahng, Krug, & Zhang, 2007; Lou, Bernard, & Abrami, 2006; Means, Toyama, Murphy, Bakia, & Jones, 2010; Summers, Waigandt, & Whittaker, 2005; Tallen-Runnels et al., 2006).

In contrast, several meta-analyses have reported that students enrolled in distance education courses had better learning outcomes than in face-to-face environments (Kersaint et al., 2011; Means et al., 2010; Shachar & Neumann, 2010). One feasible explanation for this discrepancy may be variations in infrastructure and strategies that have accompanied the evolution of technology. In corroboration of this possibility, Shachar and Neumann's (2010) meta-analysis of academic performance across a 20-year period reported that the experimental probability of attaining higher learning outcomes in the online environment, compared to the face-to-face environment, increased over time.

Research Question 2

There was no significant difference between the retention rates of students receiving online and face-to-face academic support. This result provides evidence that online academic support through synchronous videoconferencing was as effective as face-to-face academic support in improving student retention rates in high-risk STEM courses. Contrary to previous findings with the face-to-face program, however, no significant difference in retention was found between students receiving online academic support and those students not receiving tutoring.

A plausible explanation for this inconsistency is the sample size of the online tutoring group, which was relatively small for an analysis using categorical variables.

Furthermore, it is not uncommon for retention results to appear inconsistent. A meta-analysis of 232 studies by Bernard et al. (2004) reported a wide variability in retention outcomes and advocated that it is erroneous to state that either mode of instruction outperforms the other based on mean effect sizes and heterogeneity. This "W[w]ide variability means that a substantial number of distance education applications provide better achievement results, are viewed more positively, and have higher retention rates than their classroom counterparts. On the other hand, a substantial number of DE [distance education] applications are far worse than their classroom [face-to-face] instruction in regard to all three measures (p. 406)." That is, some distance education applications outperform face-to-face applications and vice versa. Causes identified for this variability in research findings included reduced internal validity due to the lack of control for media and/or method confounds and other sources of inequalities. According to Howell et al. (2004), "Numerous factors make comparisons between these two formats difficult, if not impossible due to limitation in research design itself, differences in student demographics, and inconsistent methods of calculating and reporting completion" (p. 244). When comparing synchronous distance education with face-to-face, Bernard et al. (2004) suggests simultaneous treatments in which the media is used for the same purpose in both conditions and distance is not the variable under investigation. According to this recommendation, this study simultaneously studied the synchronous distance education and face-to-face programs, replicating the successful face-to-face service as closely as possible and using the same staff. Additionally, in order to increase internal validity, this study focused on short term course completion rates, rather than long term program persistence rates in order to avoid confounding variables that can occur during long term degree persistence (Howell, et al., 2004). Based on these inconsistencies in the evidence, it is important to interpret these results in context with the grade outcomes of this investigation.

Conclusions

Synchronous learning incorporated into a LMS provided an educational resource capable of supporting the learning and academic success of students in high-risk STEM courses. Students supported in their academic efforts and experiencing academic success are more likely to be motivated to persevere in the STEM major.

Economically and politically, educational providers are being tasked with the responsibility of finding more creative ways to accommodate student needs in order to improve the retention of our STEM workforce, effectively appropriate government funding, and provide equal opportunity (American Association of State Colleges and Universities, State Relations and Policy Analysis Research Team [AASCU], 2013; PCAST, 2012). Ethically, institutions have the responsibility to provide students who are challenged by physical disability, work, family, and/or other responsibilities with an equal opportunity to obtain academic support. Equitably, it is an issue of equality and policy that students enrolled in online courses and programs have the same access to support services as on-campus students (McCracken, 2004; OPE, 2008). This online academic support initiative accommodated these needs by providing an effective, alternative mode of academic support that can be delivered to STEM and other students anytime, anywhere.

Recommendations

As previously noted by Jopling (2012), online tutoring is a fast-developing area that requires the identification of new pedagogies and approaches that differentiates between the needs of students and online tutors with different backgrounds and levels of education. Variations in design, expectations, assignments, activities, feedback, and other factors related to tutoring have the potential to affect the efficacy of a service. As emerging technologies continue to influence institutional direction and policy, it is also important that institutions strategically and responsibly select and fund distance education services that best serve their needs (Wilson, 2012; W.-K., Ng & Kong, 2012), empirically document learning gains to demonstrate that the program is a worthwhile and/or justified alternative (LaPointe & Linder-Vanberschot, 2012), and share best practices that have demonstrated the ability to positively influence student outcomes.

Limitations

The findings must be considered relative to a number of limitations that should be addressed in future research. First, although this study's external validity was expected to be high because it was performed in a real-world environment, it was confined to one higher education institution and program, which may differ contextually from other institutions and programs. Therefore, results may vary across higher education institutions differing in structure, settings, and geographical location, reducing external validity. Second, since it would have been unethical to potentially influence academic outcomes by randomly assigning students to groups, there is a threat of assignment bias. The problem of self-selection has complicated traditional and distance education comparison studies since subjects are rarely randomly divided (Bernard et al., 2004;

Howell et al, 2004). As a result, the determination of causation is more difficult since individuals choosing a particular group may have noticeably different characteristics that may influence the observed effects of the dependent variable. In addition to the user characteristics discussed in this paper, additional factors that have been found to influence student retention include socioeconomic status, prior academic preparation, delayed enrollment in college, family status, children, and work demands (Howell et al., 2004).

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