The Impact of Veterans and Curriculum Heterogeneity on Online Graduate Engineering Program Performance: An Empirical Study

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Abstract

Online educational programs have emerged as an innovative alternative to traditional off-line, face-to-face programs in "brick and mortar" classrooms on physical college campuses. Engineering programs are embracing these innovative online teaching programs to stay competitive by operating more efficiently and by attracting a variety of stakeholders. These stakeholders include student veterans enrolled in online graduate engineering programs attracted by a variety of engineering majors and courses. This study brings these developments together to answer the following research question:

How do student veterans and curriculum variety impact the performance of online master's degree engineering programs?

To answer this question, we develop a research model from hypotheses drawing from the literature. The model is then tested using secondary data from 65 online engineering master's degree granting programs throughout the United States. The statistical analysis technique used is linear regression. The independent variables represent veteran enrollment and curriculum variety, and the dependent variable represents online graduate engineering program performance. In sum, the heterogeneity of students and curriculum are found to positively impact on-line engineering program success. This study is important because it empirically identifies specific factors that can improve online graduate engineering program performance. The paper concludes with implications for engineering education and recommendations for future research.

Introduction

Online learning is changing the traditional ways of learning for students by attracting greater numbers of new types of students who live off campus and interact in virtual classes [1]. The online education phenomenon is immense with an overall year-to-year growth rate of 3.9%. Nearly 6 million students representing 28% of all students took at least one course online in 2016. 2.85 million students took all of their courses online, and another 2.97 million students took some of their courses online [2].

With the growing importance of online education, the goal of this research is to better understand online graduate engineering education programs by empirically identifying for the first time specific factors that have a significant impact on program performance. Drawing from the literature streams of heterogeneity and online learning, we examine the influence of online students who are veterans or active service members (Fig. 1). From the literature, heterogeneity has been defined from social structure theory as the "distribution of the population among many groups, defined by the probability that two randomly chosen persons do not belong to the same group," [3]. We focus on online student veterans as a heterogeneous factor for the overall online engineering student body. This research contributes new findings for engineering education as traditional brick-and-mortar universities increasingly embrace and, at the same time, compete against online education. While past research has examined factors for effective online education based on learning styles [4], there has been relatively little research focusing on the impact of heterogeneity on online educational program performance. Furthermore, no prior research empirically tests the impact of student veterans on online graduate engineering program success. This paper seeks to address these gaps.

The National Science Foundation (NSF) has promoted the assistance of veterans for attaining careers in engineering so they can participate to the Science, Technology, Engineering, and Mathematics (STEM) workforce for the benefit of society [5]. Most student veterans are supported by the Post-9/11 GI Bill for collegiate education as they work to help them transition into civilian careers. This is a large college student demographic in the United States receiving substantial educational assistance benefits from the federal government. In 2015, 790,507 veterans received almost $12 billion for their education [6]. We focus on veterans enrolled in online master's degree engineering programs. Traditional "brick and mortar" engineering schools are more likely to offer online master's engineering programs, compared to online bachelor's degree engineering programs.

We next present literature reviews on heterogeneity and online learning. We then develop our hypotheses for our research model for measuring online graduate engineering program performance. This is followed by analysis and results using data from 65 online graduate engineering programs [7]. The paper concludes with implications for engineering education and recommendations for future research.

Heterogeneity

Drawing from the heterogeneous stream of research, we argue that a variety students as well as online curriculum should yield greater performance benefits for online graduate engineering

programs. People tend to associate themselves and behave per the group norms in which they belong through self-categorization theory [3]. Heterogeneity or diversity on organizational outcomes have been examined in several different contexts [8-11]. From this research, cognitive heterogeneity is an important determinant of knowledge management. Differences in terms of mental models, attitudes, beliefs, and values among members of a heterogeneous group, whose members, in turn, belong to different social groups are key factors for organizational performance [12]. Employees in most of today's organizations need to contribute to heterogeneous networks of knowledge under greater distributed as opposed to centralized control [13]. Cognitive heterogeneous organizations have a greater variety of perspectives and ideas compared to more homogeneous organizations [14, 15].

In our study, we use the online enrollment of veterans as a proxy for adding cognitive heterogeneity to the student body of online graduate engineering programs. We argue that veterans should benefit student body cognitive heterogeneity by contributing different experiences and mental models through their interactions. We next present our literature review on online learning.

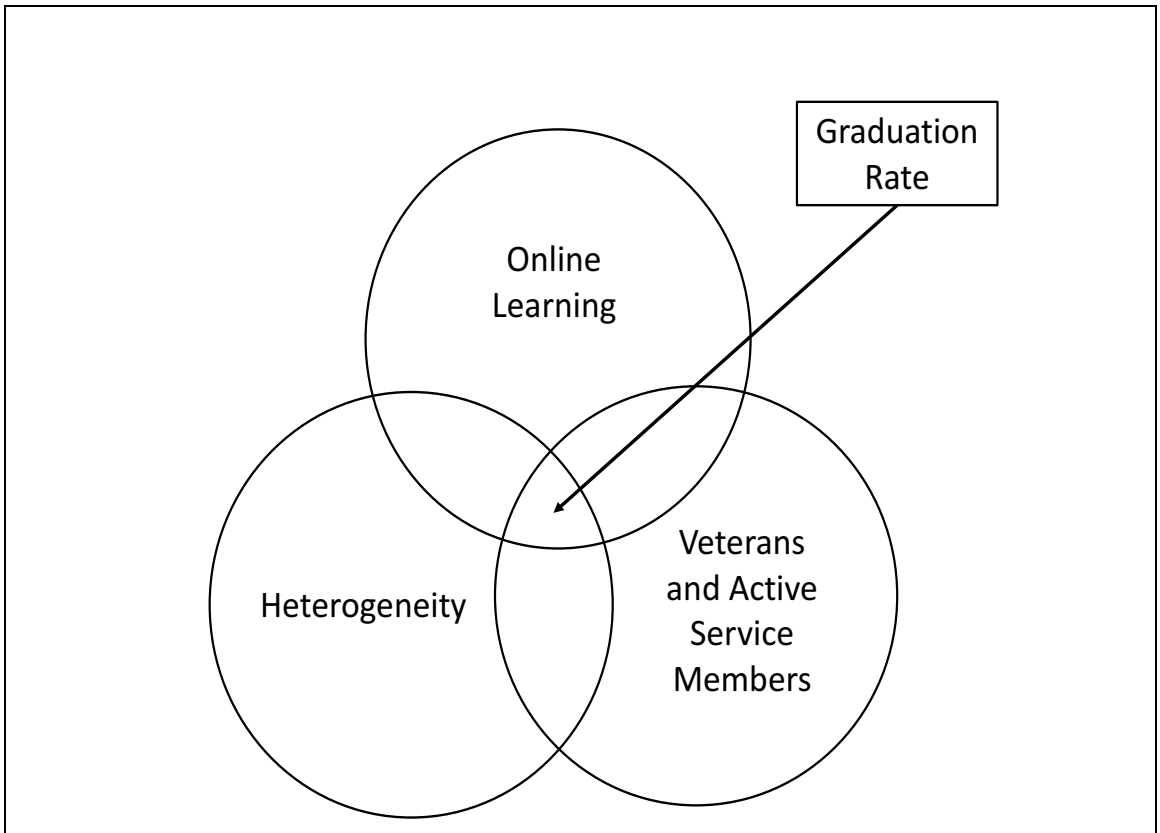

Figure 1. Online Graduate Engineering Performance

Online Learning

Engineering programs are now online offering a greater variety of majors and courses to complement and supplement traditional, physical college campus classrooms. Research shows that online learning can be as effective as offline learning for students [16]. In the past, however,

Web-based multimedia learning was less than seamless due to technical constraints including the unstructured nature of the Web. Often, there was too much emphasis on learning the technology and not the content of the course [17]. Online learning has since become more seamless as the enabling technologies have become more sophisticated and less expensive. Online students can now easily receive course information and share their knowledge 24x7. In the online learning literature, the determinants of course structure, interaction, and self-motivation have been among the factors determined significant for perceived student satisfaction [4]. Hence, in the context of online graduate engineering education, a greater variety of engineering majors and online courses should enhance course structure, interaction, and self-motivation leading to greater utility and satisfaction for online students.

Online educational programs support student-centered learning pedagogy where learning shifts from top-down to bottom-up. Many students, especially graduate students who work full or part-time in the military or as civilians, want more than traditional lectures at the same time and place. Traditional lectures are based primarily on one-way information flows from professor down to the students in the classroom. In the traditional classroom, it can be difficult to gauge if students are active or passive participants [1].

Online courses enable students to seamlessly interact virtually with professors, other students, and the course content synchronously as well as asynchronously. With the rise of online education programs, some engineering programs are moving towards "upside-down" classes emphasizing peer-led, student-centric, experiential learning [18]. Such active-learning approaches have helped increase confidence, intellectual curiosity, and teambuilding among students and should, therefore, contribute to successful graduation outcomes [19].

Student use of online education programs has become seamless because these online platforms are not only easy to use and useful, but they also enable students to interact with instructors as well as peers and the course content [1]. This transformation has made it easier to gauge active vs. passive students. From social learning theory, human behavior is described as an ongoing interaction among cognitive, behavioral, and environmental factors [20]. Online learning has reached a critical mass of adoption leading to greater diffusion. One learns how to execute new behaviors through the social influence from observing others [20]. Learning new ways to learn would take much more effort if it was limited to one's own autonomous actions [21]. Hence, through its own wide-spread acceptance and use, it has become easier for new students to adopt online learning as their means for graduate education. We next describe the design and data sample of our research.

Research Design and Data Sample.

This research takes a positivist, philosophical approach, developing hypotheses by extending previous heterogeneity and online learning research streams. This quantitative, empirical paper uses secondary data for testing a theoretical research model formed from the hypotheses. The impact of both the heterogeneity of students and curriculum on online graduate engineering program performance in the United States are examined.

The unit of analysis is online master's degree granting engineering programs in the United States. The number of student veterans (including active duty), engineering majors offered, and engineering courses offered were obtained by U.S. News and World Report by surveys sent directly to the engineering programs. In this research, we use data from the top 65 (top 75%) of 94 online programs with at least ten graduates (for the year group cohort of 2016-2017) as ranked by U.S. News and World Report [22]. A total of 94 schools (31%) of those surveyed, indicated they offered an online engineering master's degree program. To limit threats to internal validity, only online master's programs with at least one ABET-accredited engineering program at the bachelor's level or higher were included in the initial sample of 94 by U.S. News. The statistical analysis technique used to test the research model is linear regression via SPSS software. We next discuss our hypothesis and research model.

Hypotheses Development and Research Model

The hypotheses for the impact of veteran and curriculum heterogeneity on online graduate engineering program performance are next developed. Universities can no exclusively rely just on traditional physical classrooms on college campuses as their only platform for educating students. Universities do not have a monopoly of students in their own geography and must compete against other schools online for the same students globally. At the same time, many engineering schools recruit and retain new students who are veterans or who are still active members of the military. Former and current members of the military often receive education benefits for attending college to help them acquire skills for work in the civilian workforce. The American Society of Engineering Education (ASEE) has spearheaded guidance for assisting universities in helping smooth the transition for veterans for completing not only their bachelor's, but also their master's degrees, full and/or part-time while they are working and online courses are a key element [5].

Engineering students are likely to receive higher salaries through a more specialized graduate degree compared to just a bachelor's degree. Online engineering master's programs offer students several key advantages beyond anytime and anywhere convenience without transportation costs. Now most top online engineering master's programs enable students to receive their degrees 100% online [18]. Students often have the same professors online and on-campus, and they can choose to participate in classes or collaborate on projects in either format.

Heterogeneous groups with various expertise and experiences have a greater variety of perspectives and ideas for discussion, development, and integration compared to more homogeneous teams. The collisions of diverse ideas are essential in creating new understanding, knowledge, and innovation [14, 15]. Student veterans are often older and have more worldly experiences in a disciple and goal setting environment compared to many of their civilian counterparts. We argue that the heterogeneous impact of student veterans on graduate online engineering programs should have a positive influence for engineering schools.

Research shows that distance learners, like veterans, are more likely to be older with families and full-time jobs compared to traditional students living on campus. Online learning research also shows that these non-traditional students are likely to have the same or even greater determination in accomplishing their academic goals [16]. This leads us to our first hypothesis shown in Fig. 2:

Hypothesis 1: The number of online veterans or active service members will have a positive influence on online graduate engineering program performance.

From the literature, online seekers of knowledge prefer content with greater variety [23]. Greater variety of information of more heterogeneous content for online students is more likely to be highly focused and useful content for their work [24, 25]. In business and industry today, changing organizational structures are creating greater demand for interdisciplinary engineering education to prepare students who are not only specialized, but are also able to interact with different types of engineers such as those who are electrical, computer, and mechanical. Engineers today need not only depth, but also depth to work with experts from multiple specialties for a multidisciplinary approach. Engineering students can save money by enrolling in online interdisciplinary, customizable master's degree programs [18]. Hence, engineering schools that offer greater varieties of educational content for students through the number of different online majors and courses offered should attract, retain, and yield greater numbers of students who successfully graduate. This leads us to our second and third hypotheses shown in Fig. 2:

Hypothesis 2: The number of online majors offered by engineering schools will have a positive impact on online graduate engineering program performance.
Hypothesis 3: The number of online credit-granting courses offered by engineering schools will have a positive impact on online graduate engineering program performance.

We next describe the variables and measures used in the research model of our paper.

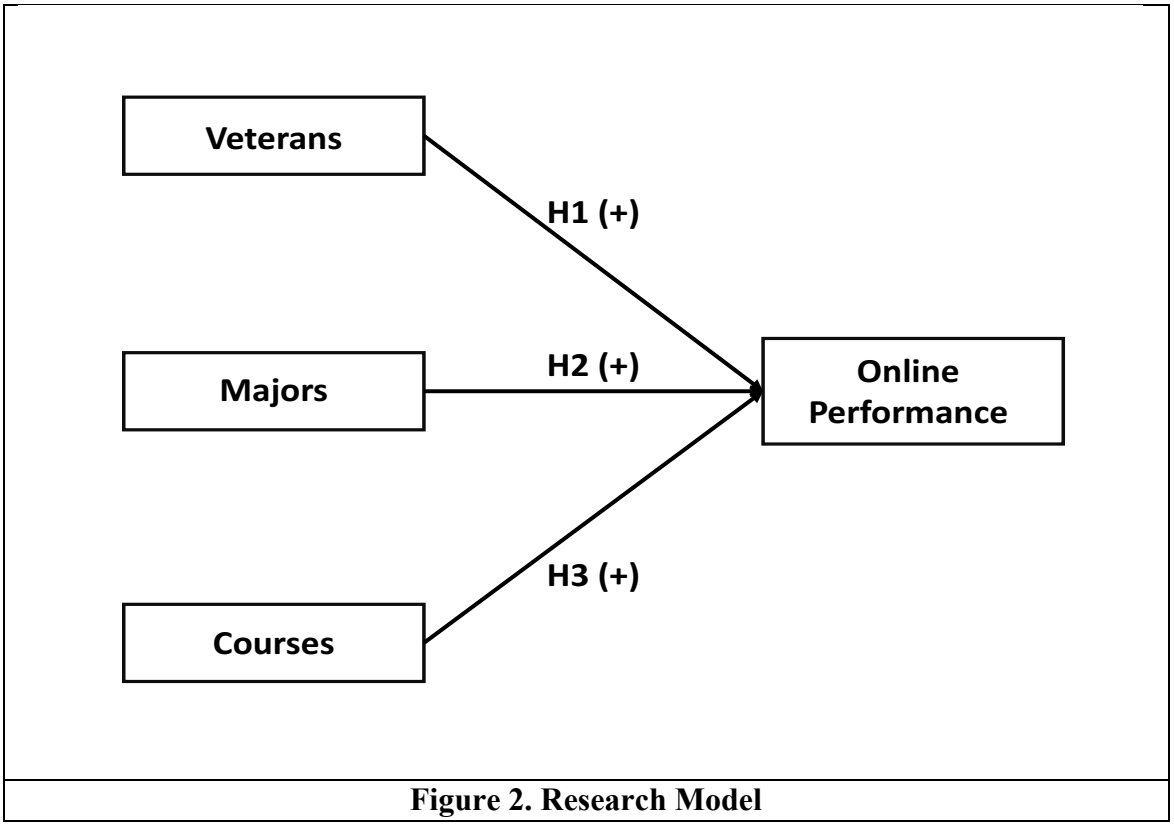

Figure 2. Research Model

Variables and Measures

The measures of the variables used in the hypotheses of the research model are defined in Table 1. Online performance is measured by the total number of online graduate engineering school students that graduated in the school year 2015-2016. The U.S. Department of Veterans Affairs recognizes that student veteran completion rate in terms of degree attainment is the best way to measure college success; enrollment rates are limited to measuring who enters but not graduates from college programs [26]. Hence, we use the number of online graduates as a proxy for measuring online graduate engineering program success.

Table 1. Variables & Measures	
Variables	**Measures**
ONLINE PERFORMANCE	Total Number of Online Graduate Engineering School Students that Graduated *(2015-2016)*
VETERANS	Number of Online Graduate Engineering School Students who are Veterans or Active Service Members
MAJORS	Number of Online Graduate Engineering Major Programs Offered by School
COURSES	Number of Credit-granting Online Graduate Courses Offered by School

The variables are next designated in Table 2 as dependent or independent variables for the research model. Online performance is the dependent variables and the rest of the variables are independent.

Table 2. Variable Designations	
Variables	**Designations**
ONLINE PERFORMANCE	Dependent
VETERANS	Independent
MAJORS	Independent
COURSES	Independent

Analysis and Results

Tables 3 shows the descriptive statistics. This paper focuses on online graduate engineering program performance in the United States from the top 65 programs[7]. From Table 3, the average total number of online graduate engineering school students that graduated (2015-2016) in these programs averages 70, ranging from 0 to 623. The average number of veterans in these programs is 22, ranging from 0 to 267. The number of online graduate engineering majors offered ranges from 1 to 41, averaging 6 majors. Finally, the number of credit-granting online graduate courses offered ranges from 1 to 365, averaging 76 courses.

Table 3. Descriptive Statistic				
	Mean	**Minimum**	**Maximum**	**Std. Deviation**
ONLINE PERFORMANCE	69.78	0	623	102.28
VETERANS	22.02	0	267	38.23
MAJORS	5.94	1	41	6.22
COURSES	75.92	1	365	68.14

The reliability and validity or the research model are tested using a correlation matrix as shown in the Table 4 [27]. There are no correlations between the independent variables below the 0.70 cutoff [28, 29].

Table 4. Correlation Matrix				
	VETERANS	***MAJORS***	***COURSES***	***ONLINE PERFORMANCE***
VETERANS	1			
MAJORS	0.23	1		
COURSES	0.18	0.61	1	
ONLINE PERFORMANCE	0.57	0.52	0.47	1

The research model analyzes the impact of the number of student *VETERANS* (and active service members), online graduate engineering *MAJORS* offered, and online credit-granting *COURSES* offered on *ONLINE PERFORMANCE* of the engineering school, measured by the number of online graduates. The model equation is as follows:

$$ONLINE\ PERFORMANCE = VETERANS + MAJORS + COURSES$$

The results of the regression analyses of the impact of veterans and curriculum heterogeneity on online performance summarized in Table 5. The overall results of the model show that online graduate engineering program performance, measured by number of graduates, is significantly influenced by the heterogeneity of students and the curriculum.

Table 5. Linear Regression Results	
	Research Model
VARIABLES	***ONLINE PERFORMANCE***
Constant	n.s.
VETERANS	1.273***
MAJORS	4.445*
COURSES	0.338*
Observations	65
*** p<0.001, ** p<0.01, * p<0.05, + p<0.10, n.s.= not significant	

All three coefficients of *VETERANS*, *MAJORS*, and *COURSES* are found to be positive and significant thereby providing evidence of significant support for the hypotheses H1, H2, and H3. This means that the greater the number of veterans and the greater the number of different majors

and courses offered, the more likely the online performance of graduate engineering schools will be successful in graduating online students. More specifically, the results show that the number of veterans (and active service members) enrolled online have the greatest significant impact ($p<0.001$) for online performance as hypothesized by H1. The number of different majors and courses offered also have significant impacts ($p<0.05$) in online performance as hypothesized by H2 and H3. These findings based on the testing of our research model can be applied by engineering schools for assessing their own online engineering program strategies. We next discuss implications and future research.

Implications and Future Research

In conclusion, we empirically prove that online graduate engineering programs that increase the numbers veterans, majors, and courses, yield greater graduation rate performance. These results imply that engineering schools should strive for a greater heterogeneity of students by making sure they include veterans and active service members which should, in turn, have a positive impact on online program graduation performance. Engineering schools should also work to provide a greater heterogeneity of curriculum options by offering greater numbers of online engineering majors and courses.

In sum, online engineering programs free students of temporal and geographic constraints by enabling them to take classes anytime and anywhere, thereby reducing opportunity costs, with little or no transportation costs. These programs can be particularly helpful for veterans with post-9/11 GI Bill collegiate education benefits as they transition from military to civilian employment. Through our model, we identify new opportunities for online engineering programs while capturing the positive impact of student veterans. Future research should extend this examination to directly compare the impact of off-line engineering programs. Hence it can then be determined whether veteran and curriculum heterogeneity have a greater impact to graduation rates online or off-line.

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