ATTRITION IN ONLINE AND FACE-TO-FACE CALCULUS AND PRECALCULUS COURSES: A COMPARATIVE ANALYSIS

Sarah Ferguson, Old Dominion University

ABSTRACT

A multitude of online courses are available that provide opportunities for students to meet their higher education needs, goals, and desires in a nontraditional school setting. But, from a content specific perspective, how are students performing in online courses compared to their face-to-face counterparts? This study seeks to examine the attrition rates of online calculus and precalculus students relative to their face-to-face peers in an effort to expand the study of online mathematics pedagogy while providing course-specific data. Several studies have been conducted to explore attrition rates in relation to student demographics, STEM fields, and online course structure, but these studies do not take into consideration an acute content perspective. Focusing on calculus and precalculus while controlling compounding variables, this study seeks to answer the question: How do attrition rates in an online precalculus and an online calculus course compare to the attrition rates in a face-to-face precalculus and face-to-face calculus course?

Keywords: Attrition, Online Learning, and Synchronous Instruction

INTRODUCTION

Technology has brought about an education reform. Through online educational opportunities, learning experiences transcend the traditional classroom boundaries and are made accessible to previously under-represented learning populations (Smith & Ferguson, 2005). With the influx of technological capabilities and widespread accessibility, online learning techniques have gained considerable attention, but, as Garrison (2011) cautions, "surfing the Internet is not an educational experience, any more than wandering through a library is" (p. 4); merely being online does not constitute an online learning experience. Quality online learning opportunities combine rich learning experiences with convenient course and content accessibility, but they necessitate navigating unique learner characteristics (Patterson & McFaddon, 2009).

A multitude of online courses are available that provide opportunities for students to meet their higher education needs, goals, and desires in a nontraditional schooling setting. Allen and Seaman (2011) found that 31% of all higher education students take at least one online course and that online learning is deemed a critical component of long-term higher education strategies by 65% of chief academic officers. Online learning options make education available to all who desire to learn (Hrastinski, 2008).

While online courses make learning accessible, the accelerated growth of online learning opportunities also raises questions regarding the quality of online learning experiences and unique characteristics of online learners (Patterson & McFaddon, 2009). With the growth of online learning, there is a growing body of research regarding the background and development of online learning, the advantages and disadvantages of online learning, and online learning modalities, but content-focused research on specific attributes of online learning are lacking (Akdemir, 2010; Garrison, 2011; Hrastinski, 2007, 2008; Smith & Ferguson, 2005). While a significant body of research investigates student attrition rates relative to online learning experiences, reviewing attrition from a content-specific perspective is much less common because in other studies attrition is viewed relative to student gender, race, socio-economic status, and other demographical information (Carr, 2000; Morgan & Tam, 1999; Willging & Johnson, 2009). This study looks to review attrition from a content-specific perspective while comparing student attrition rates in online versus face-to-face calculus and precalculus courses.

Definitions of Terms

This study focuses on online learning attrition and, specifically, attrition rates in a group of online calculus and precalculus courses. This discussion will utilize key terms of attrition, online learning, and synchronous instruction. Attrition is defined as "the number of individuals or items that vacate or move out of a larger collective group over a specified time frame" (Galetto, 2015, p. 1). Online learning is defined as courses "in which at least 80 percent of the course content is delivered online" (Allen & Seaman, 2010, 2011). Synchronous learning refers to learning when interactions between teachers and students occurs in real time (Hrastinski, 2008).

Attrition data were reviewed to evaluate differences in attrition between online and face-to-face calculus and precalculus courses. For the purpose of this study, student attrition is regarded as the number of students who embarked on either the online or face-to-face precalculus or calculus course comprising this study but who withdrew from the course without completing it (Galetto, 2015). Students who failed the course or stopped coming to class but did not formally withdraw from the course are not considered as leaving the course for attrition calculations.

LITERATURE REVIEW

Several studies have been conducted to explore attrition rates in relation to student demographics, STEM fields, and online course structure. Willging and Johnson (2009) conducted a study that looked at the reasons students drop out of online courses. In their study, Willging and Johnson (2009) discussed issues such as "isolation, disconnectedness, and technical problems" as contributing factors leading towards attrition in online courses (p. 1). Willging and Johnson considered multiple content areas and did not segment their results based on course content areas. Chen and Soldner (2013) explored student attrition in STEM fields and found numerous attrition factors. Academic preparation, course selection, course performance, student demographics, student backgrounds, and postsecondary enrollment characteristics were reported by Chen and Soldner as factors influencing student attrition in STEM fields, but this was generalized to all STEM classes and did not include a specific content analysis comparison between face-to-face and online course attrition. While the above-mentioned research focused on attributes of attrition, research relative to content-specific attrition rates is lacking (Smith & Ferguson, 2005). With the prevalence of online learning opportunities continuing to grow, it is important to develop pedagogical best practices to enhance the learning of mathematics online.

Smith and Ferguson (2005) contend that mathematics courses, as a whole content discipline in general, have higher rates of attrition than other content area courses in a face-to-face setting. In a quantitative study, Smith and Ferguson (2005) looked at attrition rates as a measure of student's perception of the course difficulty level citing "higher attrition rates indicate problems from the student point of view" (p. 326). In a study of over 3,000 asynchronous online courses offered through the State University of New York (SUNY) system, the mean attrition rate in mathematics courses versus nonmathematics courses was found to be statistically significant at the 0.001 level with a mean attrition rate for math courses as 0.31 and nonmath course as 0.18 (Smith & Ferguson, 2005). This study focused broadly on all mathematics courses and did not consider a breakdown of attrition rates relative to different mathematics content, teacher, or course requirements. From this, Smith and Ferguson concluded that online math is more problematic than other online content areas as evident by its higher attrition rates. When expanding their study to the face-to-face course experience, no significant difference was found between math and nonmath course attrition rates (Smith & Ferguson, 2005). Smith and Ferguson speculated that higher attrition rates are due to more nontraditional students embarking in online courses after longer absences from mathematics study. A direct comparison of attrition rates between courses with similar content taught online or face-to-face was not included in the Smith and Ferguson study. Wadsworth, Husman, Duggan, and Pennington (2007) argued that appropriately implemented strategies to emphasize student self-efficacy will enhance student achievement in online developmental math courses. While mathematics specific, these studies do not consider a comparative analysis between online and face-to-face attrition rates while controlling for compounding factors such as course content, instructor, and course requirements. In these studies, the confounding variables could accentuate differences in attrition rates.

Sitzmann, Kraiger, Stewart, and Wisher (2006) conducted a meta-analysis study regarding the effectiveness of web-based and traditional classroom-based learning opportunities. In their analysis, they reviewed a meta-analysis by Zhao, Lei, Yan, Lai, and Tan (2005) that concluded that no difference was present in the effectiveness of the two delivery methods. The meta-analysis studies reviewed did not focus on specific content but rather included training, procedural knowledge transmission, and declarative teaching. After reviewing 96 studies regarding training courses, Sitzmann et al. found online teaching to be more effective than face-to-face instruction for declarative knowledge presented in training courses because individuals exhibited greater learning gains and knowledge retention through the online course. Johnson, Aragon, Shaik, and Palma-Rivas (2000) examined two groups of graduate students enrolled in an instructional design course at a large public university. The study found that students in the traditional face-to-face learning environment tended to be more satisfied with their learning experience, offered a slightly more positive rating for instructor quality, and exhibited stronger personal connections to their instructor, while face-to-face students reported more positive perspectives on their learning environments and higher levels of support from their instructors. The study also found that online students performed equally to their face-to-face peers regarding meeting learning outcomes. While acknowledging that online and face-to-face learning environments are distinct, Johnson et al. (2000) claimed that comparing online education to face-to-face education is like "comparing apples to oranges" and contended that the intent of their examination was not to prove "one fruit is better than the other" but rather that "different fruits can be equal in terms of taste and nutritional value" (p. 31). Upon concluding their study, Johnson et al. determined that optimizing online instructional design to maximize learning opportunities is instrumental in the propulsion of online learning to equivalence of face-to-face experiences.

Similar results were found by Larson and Sung (2009) when they studied student performance in three introductory Management Information Systems courses. No significant difference was found among student assessments or course grades among the three learning modalities: online, face-to-face, and blended. Students reported higher ratings for utilization of critical thinking and motivation to work at their highest level in online and blended course settings. Larson and Sung concluded that a significant difference in student performance could not be determined.

Xu and Jaggars (2014) conducted a study to examine the performance gap between online and face-to face courses with regard to multiple content areas and considering student demographics. Xu and Jaggars found a noticeable gap in final course grades between online and face-to-face students, and they considered multiple demographic distinctions and found "every student subgroup showed negative coefficients for online learning outcomes" (2014, p. 644). In addition to student demographics, Xu and Jaggars also explored performance gaps relative to course subject areas and found a significant difference in online versus face-to-face math scores with online mathematics course scores falling significantly (at a 1% significance level) below face-to-face mathematics course scores. To conclude their study, Xu and Jaggars reported that "overall, the online [course] format had a significantly negative relationship with both course persistence and standardized course grade, indicating that the typical student had more difficulty succeeding in online courses than in face-to-face courses" (2014, p. 651).

METHODOLOGY

As mentioned, Smith and Ferguson (2005)

found a statistically significant difference in attrition rates between online and face-to-face math courses in a large-scale study, but multiple compounding factors were present. The purpose of reviewing attrition in this study is to see if this study's findings replicate those of Smith and Ferguson relative to the selected focused calculus and precalculus student populations while also controlling for differences in instructors, course requirements, and course content. With 13 years passing since the Smith and Ferguson study, and the lack of content-rich, focused research, this study also aims to provide more current content specific attrition data. For this study, student attrition will be evaluated by reviewing instructor provided course rosters. Student names and other identifying information were removed from the course rosters prior to collection by the researcher and only final grades and withdraw notations remained.

For the purpose of this study, withdraws will be counted as such only if students formally completed the withdraw process and a grade of W appears on the course roster, signifying a withdrawal from the course. Students who elected not to take the final exam, who failed the course, or who stopped attending but did not withdraw are not included as withdrawals for the purposes outlined by this study.

To calculate student attrition rates, the attrition formula published by NG Data was utilized (Galetto, 2015). NG Data defines attrition as "the number of individuals or items that vacate or move out of a larger collective group over a specified time frame" (Galetto, 2015, p. 1). For this study, the "larger collective group" refers to the course and the time frame is the fall 2015 semester. The calculation formula used is attrition = (number of withdraws)/(initial number of enrollments). Galetto (2015) encourages all individuals evaluating customer satisfaction to review attrition rates because the calculation is quite basic, but the results reviewed over time can provide a great diagnostic tool regarding customer or, in the case of this study, student satisfaction.

The research question for this study is: How do attrition rates in an online precalculus and an online calculus course compare to the attrition rates in a face-to-face precalculus and a face-to-face calculus course?

Participants

This study is comprised of 195 students enrolled in an online or face-to-face precalculus or calculus course at a Southern Virginia community college during the 2015 fall semester. Student course rosters, void of student names and identifying information and indicating successful course completion or withdraw data for each student, were collected at the conclusion of the semester.

Data Collection

The students self-enrolled in the online or face-to-face sections of calculus or precalculus at the beginning of the semester. In an effort to compare differences in attrition rates, additional confounding variables were controlled to the greatest possible detail. Both the online and face-to-face sections of precalculus and calculus were taught by the same instructor, who used the same textbook, had the same course requirements, and had access to the same online supplemental resources. The online courses had access to video lectures of the face-to-face class sessions and both instructors made themselves available to students for both online and face-to-face office hours. Each course was conducted during the traditional fall semester and was 18 weeks in duration. Students in the online and face-to-face sections completed equivalent prerequisite requirements and were provided equivalent supporting resources relative to tutoring, assignment assistance, and grade explanations. The prerequisite requirement for each section could be achieved one of three ways: 1) successfully place into the course through a satisfactory score on the college's mathematics placement assessment, 2) successfully complete the preceding mathematics course in the college's course sequence outline, or 3) successfully complete an equivalent AP mathematics assessment at the high school level to satisfy a prerequisite requirement. Students who withdrew within the first week of classes due to incorrect course scheduling were omitted from the roster prior to data collection for this study.

At the conclusion of the semester, final course rosters showing grades and withdrawal status were collected for analysis. Excel tables were created to organize course grades and tally withdraw numbers. Online and face-to-face course information was kept separate for precalculus and calculus. After organizing the final grade data, the percentages of withdrawals for online and face-to-face courses was calculated and analyzed using a t-test to determine if a significant different was present.

RESULTS

Data for this study consists of final grades from 195 students. A breakdown of students by course and platform are show in Table 1. This data represents the number of students who were enrolled in the courses at the conclusion of the semester drop/add period, meaning these students embarked on the course experience and either completed the course and received a grade or withdrew from the course.

Table 1. Breakdown of Students by Course and Platform

Course	Platform	Total
Calculus	Face-to-face	28
Calculus	Online	23
Precalculus	Face-to-face	59
Precalculus	Online	85

Table 2 shows a final course grade breakdown, as calculated by the course instructor, for each group of students. Table 3 shows the percentage of students in each group who withdrew from the course. Of the 28 students who enrolled in the face-to-face calculus course, five students withdrew, correlating to a 17.9% attrition rate. Comparatively, of the 23 students enrolled in the online calculus course, four students withdrew, correlating to a 17.4% attrition rate. Looking at the precalculus courses, eight of the 59 students enrolled in the face-to-face precalculus course withdrew, correlating to a 13.6% attrition rate. Of the 85 online precalculus students, 24 withdrew, resulting in a 28.2% attrition rate.

Table 2. Breakdown of Student Grades by Course and Platform

Course	Platform	A	B	C	D	F	W
Calculus	Face-to-face	7	9	5	0	2	5
Calculus	Online	7	2	4	1	5	4
Precalculus	Face-to-face	25	11	8	3	4	8
Precalculus	Online	17	10	11	3	20	24

Table 3. Withdrawal Percentages

Course	Platform	% Withdrew
Calculus	Face-to-face	17.86
Calculus	Online	17.39
Precalculus	Face-to-face	13.56
Precalculus	Online	28.24

ANALYSIS OF FINDINGS

Table 4 shows the t-test results for the attrition rate comparisons for the calculus courses: $-2.01 < -0.04 < 2.01$, which signifies that there is no significant difference between the percentage of students who withdrew from the online and face-to-face calculus courses.

Table 4. *t*-Test: Two-Sample Assuming Equal Variances

	Variable 1	Variable 2
Mean	0.17	0.18
Variance	0.15	0.15
Observations	23	28
Pooled Variance	0.15	
Hypothesized Mean Difference	0	
df	49	
t Stat	-0.04	
P(T<=t) one-tail	0.48	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.97	
t Critical two-tail	2.01	

Calculus is an upper-level course and typically not a first experience with online learning or an introductory mathematics course. The calculus courses are smaller in size and this could impact students' comfort in both the online and face-to-face course. Additionally, the teacher who taught the calculus course commented they had many of the calculus students the previous semester in precalculus, which could further lead to student comfort with both content, background knowledge expectations by the teacher, and familiarity with the teaching style presented throughout the course.

Table 5 shows the t-test results for the attrition rate comparisons for the precalculus courses: $-1.98 < 2.47 > 1.98$, which signifies that there is a significant difference between the percentage of students who withdrew from the online and face-to-face precalculus courses.

Table 5. *t*-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	0.28	0.12
Variance	0.21	0.11
Observations	85	58
Hypothesized Mean Difference	0	
df	140	
t Stat	2.47	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.66	
P(T<=t) two-tail	0.01	
t Critical two-tail	1.98	

There were almost three times as many enrollments in precalculus as calculus with 51 total students enrolled in calculus and 144 total students enrolled in precalculus. Precalculus is an intermediate level course and often a first experience in a college-level math course and/or an online course. It is expected that there would be more precalculus enrollments than calculus enrollments because precalculus is a prerequisite requirement for many courses and programs, whereas calculus is not required by as many programs or as a prerequisite for as many courses.

While not the main focus of this research, it is interesting to note that the comparative differences in course grades between the online and face-to-face students in both the calculus and precalculus courses. Table 2 shows the breakdown of student grades by course and platform in a categorical sense. Table 6 shows this same breakdown of student grades by course and platform in a qualitative sense, depicting the percentage of students who earned each letter grade. This representation of grades is intriguing as it shows face-to-face students in both calculus and precalculus earning the higher percentages of A and B grades while the prevalence of F's is much higher in the online calculus and precalculus courses. Looking at calculus, approximately 33% more F's were earned in the online course than the face-to-face course. Similarly, in precalculus, approximately 29% more online students earned an F than their face-to-face peers. This grade variation coupled with the attrition statistics justifies the continued need for investigating student struggles in online mathematics courses.

Table 6. Breakdown of Grades as Percentages of Full Enrollments

Course	Platform	A	B	C	D	F	W
Calculus	Face-to-face	25.00	32.14	17.86	0.00	7.14	17.86
Calculus	Online	30.43	8.70	17.39	4.35	21.74	17.39
Precalculus	Face-to-face	42.37	18.64	13.56	5.08	6.78	13.56
Precalculus	Online	20.00	11.76	12.94	3.53	23.53	28.24

SUMMARY

It is hypothesized that attrition in online mathematics courses is accentuated because "the current models of e-learning and the common online course management systems do not effectively address the challenges of [teaching and learning] mathematics online" (Smith & Ferguson, 2005, p. 332). Text-oriented learning management systems do not appropriately support the graphical depictions, intricate formulas, and advanced notations required of mathematics study (Smith and Ferguson, 2005). Issues such as technology trouble, feelings of isolation and disconnectedness from teacher and peers, and potentially delayed communication are compounding factors contributing to attrition in online courses (Willging & Johnson, 2009). With threaded discussions and email being key components of communication in asynchronous online courses, limited notation ability compounds student struggles with notation and notation interpretation. Due to lacking the ability or having difficulties with accurately typing mathematics notation, online math instructors and students are often forced to communicate in code or through scanned and emailed free writing, rather than by using precisely typed mathematical notation. Higher attrition rates are a contributing factor to the diminishing perception of online learning quality for mathematics courses (Smith & Ferguson, 2005).

Willging and Johnson (2009) found that "the highest number of dropouts left after completing the first course" (p. 126). In this study, online precalculus had a 28.24% attrition rate whereas online calculus had a 17.39% attrition rate. Based on Willging and Johnson's (2009) findings, the decline of attrition from online precalculus to online calculus is expected. As students move from precalculus into calculus, they have expanded their mathematics knowledge and, if they took both precalculus and calculus online, their comfort with navigating online learning experiences. Students who move into the calculus course are comfortable navigating the online resources as both the face-to-face and online courses used in this study had access to identical online course resources.

CONCLUSION

The purpose of this study was to explore student attrition for online precalculus and calculus courses. To accomplish this, course rosters were collected and student final grades were analyzed. Of the 195 students listed on the precalculus and calculus rosters, 144 students enrolled in precalculus and 51 students enrolled in calculus. Online precalculus had a 28.24% attrition rate, which was more than double the 13.56% attrition rate from the face-to-face precalculus course. Online calculus had a 17.39% attrition rate, which was just slightly less than the face-to-face calculus attrition rate of 17.86%.

It is not argued that attrition impacts students' success in online courses and degree programs. Mathematics can be difficult to navigate in online learning environments, and learning mathematics can prove challenging for students, whether online or face-to-face. But, as online learning opportunities expand and increase in both availability and popularity, it is important to continuously review data relative to online learning endeavors and outcomes to enhance online learning opportunities for students.

This study is not without limitation. Limitations include:

1. The study population is limited to undergraduate students enrolled in selected online or face-to-face precalculus or calculus courses and one institution and the results may not be indicative of other programs or institutions.
2. Students self-enrolled in online or face-to-face precalculus or calculus courses, which prohibited an opportunity for treatment and control groups for a true experimental study.
3. Only students who withdrew from the courses through the formal institutional withdrawal protocol were considered in the attrition calculations, which potentially overlooked students who mentally withdrew but possibly, for other reasons (e.g., financial aid), elected to fail the class rather than formally withdraw.

Despite its limitations, this study provides a glimpse into a much-needed reinvestigation of attrition rates in online and face-to-face mathematics courses. Smith and Ferguson (2005) found a statistically significant difference in attrition rates between online and face-to-face math courses, but this study found a statistically significant difference in attrition rates in precalculus but not in calculus, solidifying the need for additional content specific research to determine trends across mathematics as a whole content area, as well as among each mathematics course. Questions for future research include:

1. How do the attrition rates of lower-level mathematics courses compare to the attrition rates of upper-level mathematics courses?
2. What factors influence attrition in an online mathematics course that differ from a face-to-face mathematics course?
3. What levels of support and interventions could be implemented to decrease the likeliness of online mathematics students withdrawing from online mathematics courses?

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