Eight Weeks of Chemistry: The Advantage of Accelerated Online Learning

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***Abstract*—Accelerated online learning opportunities have shown great promise in many disciplines, but little is known about student performance in laboratory science courses completed in an accelerated, online format. This study of 347 community college students enrolled in online laboratory science courses reveals significantly higher final exam scores for students completing accelerated, 8-week online courses compared to 15-week online courses. When examined by semester, final exam scores of summer students are significantly higher than final exam scores completed during the traditional fall/spring academic year. Implications for student self-efficacy, retention, and graduation are presented. The potential financial impact of accelerated online learning on higher education institutions is discussed.**

***Index Terms*—online learning, distance learning, accelerated learning, chemistry, laboratory science, general education requirements, community college**

I. Introduction

Online education is well established, having evolved from centuries-old correspondence education programs with the widespread availability of internet technology over twenty years ago [1], [2]. Curiously, even as the dominant delivery mode of distance education has evolved from paper-based correspondence to online learning, the dominant timeframe for course delivery has remained relatively static. The American higher education system in particular remains entrenched in the 15 week semester cycle upon which the Carnegie Foundation established the concept of a "student hour" over one hundred years ago [3]. In simple terms, a student hour was defined as 12 hours of student-instructor contact, or a single 50-minute class period once per week over a 14 – 16 week semester.

The student hour has become the standard measure for accredited degree programs, which require an average of 120 student hours or "credits" for completion. The student hour is also used as a measuring stick for faculty work load and compensation, as well as for Federal financial aid eligibility. In light of these connections, the credit hour is likely here to stay.

Many institutions of higher education now offer accelerated courses, compressing a standard semester's worth of student-instructor contact hours into a lesser number of weeks. Accelerated courses have become very popular with adult students, with approximately one-quarter of all returning adult college students over the age of 25 enrolled in some form of accelerated learning format [4].

As the number of adult learners in higher education programs grows, the importance of online learning programs also continues to grow. Over three-fifths of US institutions cite online course offerings as critical to their long-term strategic plans [5]. Internationally, online course offerings are even more significant. In Turkey for instance, over 40% of post-secondary students participate in online learning opportunities [6].

II. Accelerated Learning Research

From a student perspective, the advantages of accelerated learning opportunities outweigh the disadvantages. A study based upon a sample of students enrolled in one of eleven different courses (laboratory science excluded) concluded that the ability to control the pace of learning was not a significant variable in overall student satisfaction [7]. A variety of literature reviews and meta-analyses suggest that accelerated courses are superior to traditional, semester-long courses in promoting student self-efficacy, student-to-student interaction, and overall satisfaction [8], [9].

In terms of actual student learning, accelerated courses have shown great promise. A study of over 1,000 nursing students revealed statistically similar NCLEX pass rates regardless of whether students completed their BSN program in a traditional classroom format or an accelerated, online format [10]. An institutional study at The University of Puerto Rico in Mayaguez concluded that an accelerated, online developmental mathematics course was actually more beneficial for math-deficient students entering math-intensive fields of study than a traditional, semester-long developmental mathematics course [11]. In the field of psychology, an empirical study found that students enrolled in an accelerated, 8-week course outperformed students in both a traditional semester-long course and a 5-week course, suggesting that an 8-week course format may be ideal for student learning [12].

In addition to facilitating student learning, accelerated courses appear to promote the retention of knowledge as well as traditional, semester-long courses. A longitudinal study of 270 students enrolled in health science courses found no significant difference in either short-term or

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long-term knowledge retention between students who had completed accelerated courses and students who completed traditional courses [13].

Interestingly, faculty reticence remains a barrier to both online and accelerated course offerings. A recent survey of faculty opinions at a state flagship university revealed that while younger faculty were willing to teach select courses online, senior faculty viewed teaching online and teaching in an accelerated format unfavorably [14].

III. Methodology

This study sought to answer two research questions for each of two undergraduate chemistry courses. First, "Is there a statistically significant difference in final exam scores between students enrolled in 15-week online laboratory chemistry courses and students enrolled in accelerated, 8-week online laboratory chemistry courses?" Second, "Is there a statistically significant difference in final exam scores between students enrolled in fall, spring, and summer semester courses?"

Final exam scores from 347 community college chemistry students were examined. Of the 347 students, 147 were enrolled in a four credit, freshman level Introductory Chemistry (GOB) survey course. The remaining 200 students were enrolled in a four credit, freshman level Introduction to Organic and Bio-Chemistry (BIO) course. These two courses are often but not always completed sequentially, with the GOB course completed first and the BIO course completed second. Traditionally, GOB is a fall-semester course and BIO is a spring-semester course. However, in the online environment, these courses consistently draw similar enrollment numbers in fall, spring, and summer semesters.

TABLE I. Final Exam Scores

	8 week GOB	15 week GOB	8 week BIO	15 week BIO
Students, *n*	86	61	96	104
Mean score	83.57	75.69	89.47	82.38
SD score	11.22	14.88	10.10	10.38

GOB = General, Organic, and Biological Chemistry
BIO = Introductory Biochemistry

TABLE II. Final Exam Scores (GOB)

	Summer	Fall	Spring
Students, *n*	55	49	42
Mean score	84.17	77.58	80.31
SD score	10.8	9.87	10.51

TABLE III. Final Exam Scores (BIO)

	Summer	Fall	Spring
Students, *n*	76	39	85
Mean score	89.86	79.66	84.95
SD score	10.93	10.10	9.70

The GOB and BIO courses together fulfill the laboratory science requirement within the state university system where the study was conducted for students majoring in in a wide range of disciplines other than chemistry or engineering. Traditionally, large numbers of nursing students enroll in this two course sequence. See Tables I - III for final exam data by timeframe and semester.

Null (H_0) and alternate (H_a) hypotheses for this study were as follows:

H_{01}: There is no statistically significant difference between final exam scores of students enrolled in the 15-week GOB course and the 8-week GOB course.

H_{a1}: There is a statistically significant difference between final exam scores of students enrolled in the 15-week GOB course and the 8-week GOB course.

H_{02}: There is no statistically significant difference between final exam scores of students enrolled in the 15-week BIO course and the 8-week BIO course.

H_{a2}: There is a statistically significant difference between final exam scores of students enrolled in the 15-week GOB course and the 8-week GOB course.

H_{03}: There is no statistically significant difference between final exam scores of students enrolled in the GOB course during the fall, spring, and summer semesters.

H_{a3}: There is a statistically significant difference between final exam scores of students enrolled in the GOB course during the fall, spring, and summer semesters.

H_{04}: There is no statistically significant difference between final exam scores of students enrolled in the BIO course during the fall, spring, and summer semesters.

H_{a4}: There is a statistically significant difference between final exam scores of students enrolled in the BIO course during the fall, spring, and summer semesters.

One-way analysis of variance (ANOVA) tests were conducted to test for statistically significant differences in final exam scores as described in each of the four null hypotheses. Because testing the third and fourth null hypotheses required ANOVA testing of three means, post-hoc testing was conducted. Tukey's honestly significant difference, or Tukey HSD, was selected for clean and conservative post-hoc analysis [15].

IV. Findings

Table IV and Table V reveal the results of the one-way ANOVA testing of final exam scores in both the 8-week and 15-week course timeframes for the GOB and BIO courses, respectively. In each case, the data reflects more variability between groups than within groups, by more than one order of magnitude. Also in each case, p-values are notably less than (α =)0.05, indicating that the group means are indeed different.

TABLE VI. GOB Final Exam Scores ANOVA (8 Week Vs 15 Week)

Variation	SS	df	MS	F	P
Between Groups	2216	1	2216	13.4	0.0004
Within Groups	23985	145	165		
Total	26201	146			

Null hypotheses H_{01} and H_{02} are therefore rejected. Alternate hypotheses H_{a1} and H_{a2} are accepted. There is a

statistically significant difference between the final exam scores of students enrolled in the 15-week GOB course and the 8-week GOB course, with students in the accelerated, 8-week course outperforming students in the traditional, 15-week course (see Table I). There is also a statistically significant difference between the final exam scores of students enrolled in the 15-week BIO course and the 8-week BIO course, with students in the accelerated, 8-week course again outperforming students enrolled in the traditional, 15-week course (see Table I).

TABLE V. BIO FINAL EXAM SCORES ANOVA (8 WEEK VS 15 WEEK)

Variation	SS	Df	MS	F	P
Between Groups	2509	1	2509	23.9	0.0001
Within Groups	20788	198	105		
Total	23298	199			

Table VI and Table VII reveal the results of the one-way ANOVA testing of final exam scores in fall, spring, and summer semesters for the GOB and BIO courses, respectively. For each course, the data reflects more variability between groups than within groups, by more than one order of magnitude. Also in each case, p-values are notably less than (α =)0.05, indicating the existence of statistically significant differences between some group means.

Tukey HSD post-hoc testing was conducted to determine which specific group means were significantly different. Only significant post-hoc findings, i.e., situations where the Tukey HSD post-hoc confidence interval included zero and the p-value was less than (α =)-.05 are shown in the tables below.

TABLE VI. GOB FINAL EXAM SCORES ANOVA AND POST-HOC (SUMMER, FALL, SPRING)

Variation	SS	df	MS	F	P
Between Groups	1142	2	571	5.27	0.0062
Within Groups	15503	143	108		
Total	16646	145			

Tukey HSD Post-Hoc (Summer Vs Fall)
Diff = -6.59, 95% CI = -11.43 to -1.75, p = 0.0045

Null hypotheses H_{03} and H_{04} are therefore rejected. Alternate hypotheses H_{a3} and H_{a4} are accepted. There is a statistically significant difference between the final exam scores of students enrolled GOB course based upon semester, with students in the summer course outperforming students in the fall semester course (see Tables II and VI). There is also a statistically significant difference between the final exam scores of students enrolled in the BIO course based upon semester, with students enrolled in the summer course outperforming students enrolled in both the fall and spring semesters (see Tables III and VII).

TABLE VII. BIO FINAL EXAM SCORES ANOVA AND POST-HOC (SUMMER, FALL, SPRING)

Variation	SS	Df	MS	F	P
Between Groups	2784	2	1392	13.22	0.0001
Within Groups	20740	197	105		
Total	23524	199			

Tukey HSD Post-Hoc (Summer Vs Fall)
Diff = -10.20, 95% CI = -14.97 to -5.43, p = 0.0001

Tukey HSD Post-Hoc (Summer Vs Spring)
Diff = -4.91, 95% CI = -8.73 to -1.09, p = 0.0077

V. CONCLUSIONS

Overwhelmingly, the data in this study suggest that accelerated, online learning formats are viable options for undergraduate students seeking to fulfill their laboratory science general education requirements. Not only is student learning entirely possible in an accelerated, online environment, the accelerated students in this study clearly outperformed their peers in semester-long sections of the same courses.

Studies increasingly show that for community college students, time is a critical factor in overall success. Student self-efficacy wanes as the time required to complete degree programs lengthens, whether the reasons are within or beyond the students' control [16]. In contrast, allowing students the opportunity to pursue accelerated learning opportunities has a positive impact on both first-year retention and overall graduation rates [17], [18].

In addition to fostering student success, accelerated learning formats yield significant cost savings to higher education institutions themselves [19]. From local community colleges to elite, flagship universities, budget cuts are forcing higher education institutions across the United States to look for more cost-effective course delivery methods [20]. In this era of ever-tightening budget constraints, implementing course format strategies that both foster student success and conserve financial resources is a win-win scenario for all stakeholders.

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