Journal for STEM Education Research (2020) 3:403–412
https://doi.org/10.1007/s41979-020-00043-x

RESEARCH BRIEF

Online and in-Person Delivery of Upper Division Lecture Courses in Undergraduate Life Sciences Degree Programs Leads to Equivalent Post-Graduate Degree Outcomes

Alexandria N. Ardissone[1] · Jennifer C. Drew[1] · Eric W. Triplett[1]

Published online: 27 July 2020

Abstract

Although many studies demonstrate that online education is as good as face-to-face education with regard to learning gains, course grades, and other near-term metrics, there is a major gap in exploring the long-term outcomes of online vs. face-to-face education, particularly in STEM programs. In this study, the effect of course delivery method on the long-term academic success of B.S. graduates was tested by comparing two similar life sciences undergraduate programs at the University of Florida. The Microbiology and Cell Science program teaches all upper division lecture courses online while the Biology program teaches nearly all of its upper division courses face-to-face. Graduate degree outcomes of 4978 students who completed their B.S. degree from either program (2011–2018) were determined using StudentTracker from the National Student Clearinghouse. The percentage of graduates with any doctoral degree (M.D., D.O., Ph.D., or other) did not differ. However, a significantly higher percentage of Microbiology and Cell Science graduates completed a Ph.D. or master's degree compared to Biology graduates. Thus, online delivery of upper division undergraduate courses had no adverse effect on the future academic success of these students.

Keywords STEM · Tracking · Graduate degrees · Academic success · Online education

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s41979-020-00043-x) contains supplementary material, which is available to authorized users.

✉ Eric W. Triplett
ewt@ufl.edu

[1] Microbiology and Cell Science Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611, USA

Introduction

Online courses in higher education have become commonplace in recent years (Seaman et al. 2018), and given the current global health pandemic, are likely to only grow more popular and, to some degree, mandated in the future. Institutions have received the growing presence of online education with mixed reaction; many still waiting to better understand the effectiveness and long-term implications of online education. Meta-analyses of literature on online education show that students learn as well or better from online teaching compared to in-class teaching (Bernard et al. 2004; Dell et al. 2010; Nguyen 2015; Vo et al. 2017; Warren and Holloman 2005). However, because online education in higher education is still in its infancy, or early adolescence at best, there is a gap in knowledge of how graduates from bachelor of science degree programs in which the majority of instruction is online fare in graduate degree attainment.

In 2011, the Microbiology and Cell Science Department of the University of Florida embarked on an ambitious plan to broaden participation and increase diversity in its undergraduate cohort by creating a distance education track and consequently moved all upper-division courses online (Drew et al. 2015). Many land-grant universities are often in small cities far from the urban centers of their states and are thus not easily accessible to all potential students and do not reflect their state's diversity. The Microbiology and Cell Science undergraduate degree program (MCS) was well-suited for the development of an online track. Nearly all of its courses are taught at the junior and senior level, which makes it ideal for someone to transfer in with an A.A. degree in the sciences and complete an B.S. online. The two required lab courses were condensed from a semester-long format to a week-long boot camp (Ardissone et al. 2019). Aside from two condensed lab courses at the main campus, a rising junior-level student can complete this B.S. degree program from anywhere in the world (Drew et al. 2015). Four years after launching the hybrid distance B.S. degree program, our online undergraduate cohort reached our goal of being more ethnically diverse than the state of Florida (Drew et al. 2016).

To make the transition to online education as easy for the faculty as possible, they were advised to offer their lecture courses exclusively online to all students, on-campus students as well as to students in the online track. Hence, nearly all of the MCS lecture courses were moved to an online mode of delivery (exceptions such as labs and some special topics courses remained). However, in the early phases of this transition, on-campus students were offered a choice of face-to-face or online delivery for some courses. In MCS courses where lectures were offered online or in-person, in-class attendance dropped by 80–90% among on-campus students. Thus, students seemed to appreciate the flexibility that the online format offered whether they were online or on-campus.

While the decision to transition all lecture courses online was motivated by increasing diversity and broadening participation of women and underrepresented minorities in STEM, it provided an opportunity to more generally compare long-term outcomes of B.S. graduates in the life sciences who received face-to-face versus online upper division course delivery from the university. Specific research questions to ask: were outcomes of graduates of MCS, which had embraced online teaching for all majors whether they be on-campus or in the distance education track, affected in the long-term? Did MCS graduates have the same opportunities and success as life science students taught in solely face-to-face programs? Of particular concern was whether

MCS graduates were successfully graduating from medical schools given the concern that students' education with online courses may not be competitive for admissions or graduation from medical school (Adams 2009; Cooper et al. 2019).

Here, the graduate outcomes of students in the Microbiology and Cell Science program are compared to the outcomes of graduates from the same university, during the same time period, in a closely related major, the B.S. in Biology degree program. Both degree programs are very similar except that the MCS program adopted the online format in 2011 for nearly all of its upper division courses while the Biology program teaches nearly all of its upper division courses in the traditional, face-to-face modality. Even with the widespread adoption of the online format in MCS, the vast majority (over 95%) of the MCS graduates were on-campus students, whereas 100% of the Biology students were on-campus students. So, this study explored whether the online delivery of upper-level courses could be associated with increased or decreased likelihood of attaining graduate degrees. The results of this study are relevant not only to one life sciences program, but they contribute to the body of knowledge about the long-term outcomes of online education, of which very little is known.

Methods

StudentTracker is a service from the National Student Clearinghouse (NSC) that contains enrollment and degree data from over 3600 colleges and universities (National Student Clearinghouse 2020). These institutions are members of the National Student Clearinghouse and enroll over 99% of college students in the United States (Dynarski et al. 2013). The member institutions provide their enrollment and graduation data for StudentTracker. StudentTracker was used to determine the post-baccalaureate academic achievements of students that graduated from the Microbiology and Cell Science and the Biology undergraduate programs from 2011 to 12 to 2018–19 academic years. Graduates from the in-person, Biology degree program were selected as a comparison to the online upper-division Microbiology and Cell Science program as it is the most similar degree program offered at the same university with the same admissions requirements and similar demographics (Supplemental Table 1). A batch query requesting the longitudinal cohort report provided by StudentTracker for a total of 4978 graduates from these two programs (1332 and 3646 for MCS and Biology, respectively) was submitted to NSC June 2019, with a begin search date of June 2003, according to instructions provided in their user manual (National Student Clearinghouse 2017). Enrollment records for all graduates queried were returned.

Post-baccalaureate degree completion was then identified and compared between the two degrees: 1) Biology and 2) Microbiology and Cell Science, with Fisher's Exact test using R v3.6.0 (R Core Team 2019). Graduates from the 2018–19 academic year were excluded due to insufficient time since graduation to obtain a post-graduate degree. Several advanced degree outcomes were tested, including: 1) all graduate degrees (includes doctoral, master's, subsequent bachelor's, and associate's or certificate programs); 2) all doctoral degrees (includes M.D., D.O. Ph.D. and others); 3) M.D. degrees; 4) all medical or health-related doctoral degrees excluding M.D. degrees (includes D.O., D.D.S/D.M.D., Pharm.D., D.V.M., D.P.T., etc.); 5) Ph.D. degrees; and 6) all Master's degrees (92% of which were a Master's of Science, Medicine or health-related field).

For each type of degree outcome, the percentage of MCS B.S. graduates who earned that degree type was compared to the percentage of Biology B.S. graduates who earned that degree type across all academic years. Analyses for a given degree type was performed on all years combined due to the low number of students receiving some degree types in more recent graduation years. However, data is presented by academic year in order to show the year-to-year variation. Because some degrees take longer than other types, recent graduate cohorts, in which neither major earned a degree, were excluded from the analysis. The data for the number and percentage of graduates in each degree category, as well as which academic years were included in each comparison is provided in Table 1. This study was approved as exempt by the University of Florida Institutional Review Board (IRB 201601296).

Table 1 Degree outcomes by major and year

Outcome Category	Program	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	Total
Total BS Graduates	MCS	122	157	155	148	167	202	174	207	1332
	Biology	383	433	551	393	443	457	479	507	3646
1. Any type of Postgraduate degree/certificate/diploma (%)	MCS	85 (69.67)	117 (74.52)	81 (52.26)	48 (32.43)	40 (23.95)	35 (17.33)	*	*	416 (31.23)
	Biology	271 (70.76)	269 (62.12)	265 (48.09)	129 (32.82)	93 (20.99)	52 (11.38)	12 (2.51)	*	1092 (29.95)
2. Any doctorate-level degree (including MD, PhD) (%)	MCS	46 (38.00)	53 (34.00)	37 (24.00)	*	*	0	0	0	146 (10.96)
	Biology	169 (44.00)	147 (34.00)	121 (22.00)	24 (6.00)	*	0	0	0	465 (12.75)
3. Doctor of Medicine (MD) (%)	MCS	18 (15.00)	16 (10.00)	19 (12.00)	*	0	0	0	0	57 (4.28)
	Biology	84 (22.00)	48 (11.00)	44 (8.00)	20 (5.00)	0	0	0	0	196 (5.37)
4. Medically related doctoral degree (excluding MD) (%)	MCS	22 (18.03)	26 (16.56)	15 (9.68)	*	0	0	0	0	65 (4.88)
	Biology	75 (19.58)	88 (20.32)	73 (13.25)	*	*	0	0	0	244 (6.69)
5. Any type of PhD (%)	MCS	*	*	*	0	0	0	0	0	15 (1.16)
	Biology	*	*	*	0	0	0	0	0	12 (0.34)
6. Any Type of master's degree (%)	MCS	34 (28.00)	53 (34.00)	36 (23.00)	33 (22.00)	33 (20.00)	28 (14.00)	*	0	221 (16.58)
	Biology	80 (21.00)	91 (21.00)	94 (17.00)	83 (21.00)	58 (13.00)	37 (8.00)	*	0	447 (12.25)
a) Master's degree in science/medical/health-related field (%)	MCS	34 (28.00)	49 (31.00)	31 (20.00)	33 (22.00)	32 (19.00)	26 (13.00)	*	0	208 (15.61)
	Biology	73 (19.00)	78 (18.00)	83 (15.00)	75 (19.00)	53 (12.00)	32 (7.00)	*	0	398 (10.92)
b) Pre-medically focused masters (%)	MCS	12 (9.84)	16 (10.19)	10 (6.45)	10 (6.76)	*	*	0	0	58 4.35)
	Biology	30 (7.83)	27 (6.24)	25 (4.54)	36 (9.16)	22 (4.97)	12 (2.63)	0	0	152 (4.17)

The number of students who earned a type of degree corresponding to their academic year of graduation and the percentage (in parentheses ()) calculated from the total B.S. graduates per academic year are presented for MCS (Microbiology and Cell Science) and Biology majors. Cells in gray represent academic years that were excluded from analyses for a given degree type. An asterisks (*) denotes any subcategory that does not meet the minimal threshold of 10 students for aggregate reporting. Master's degree programs were counted as "pre-medically-focused" degree programs if the program promotes itself as one on its website. If a program didn't explicitly promote itself as one that prepares students for medical school or there wasn't enough information to determine, the program was not counted as a pre-medically focused one

Results

Thirty percent of all graduates from either the MCS or Biology program between Fall 2011- Spring 2018 completed a post-baccalaureate program (includes doctoral, master's, subsequent bachelor's, and associate's or certificate programs). The percentage of total post-baccalaureate degrees was not significantly different (p value = 0.384) between MCS (31%) and Biology (30%) as determined by Fisher's Exact Test. (Fig. 1).

There was no difference in the percentage of graduates of the two B.S. degree programs who went on to earn any type of doctoral degree including M.D. and Ph.D. (11% and 12.8% for MCS and Biology, respectively; p value = 0.320, Fisher's Exact test; Fig. 2A). Taking a closer look at this degree category, the number of students with an M.D. six years after graduation was 57 and 196 for the MCS and Biology programs, respectively. This number represents 4.28% and 5.37% of the graduates in the MCS and Biology programs, respectively and was not statistically different (p value = 0.440, Fig. 2B). Similarly, the percentage of medically-related doctorates (excluding M.D. but including D.O., D.D.S/D.M.D., Pharm.D., D.V.M., D.P.T., etc.) was also not different between the two degree programs (p value = 0.063; Fig. 2C). Very few Ph.D. degrees have been earned by the graduates of the two programs, 15 (1.2%) and 12 (0.9%) for MCS and Biology graduation cohorts from 2011 to 2014, respectively (p value <0.001; Fig. 2D).

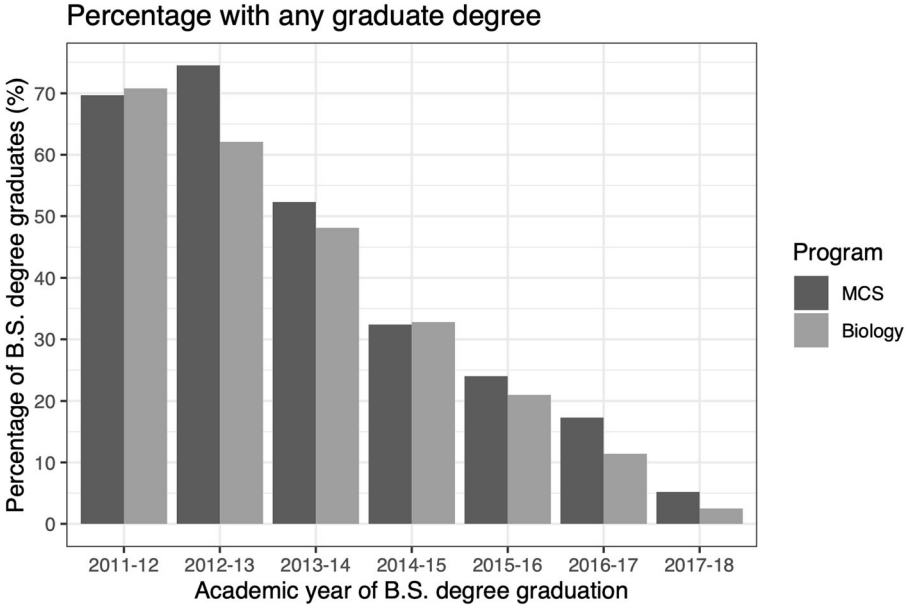

Fig. 1 Percentage of B.S. degree graduates who earned any graduate degree following completion of their undergraduate degrees from the 2011–2012 to the 2017–2018 academic years. B.S. graduates completed programs from the University of Florida from two very similar life science degree programs: Microbiology and Cell Science (MCS) offered all upper division lectures online; and Biology offered nearly all lectures via traditional, face-to-face format. There was no significant difference between the two programs in the percentage of B.S. degree graduates with graduate degrees from 2011 to 18 graduation years (p value = 0.380; Fisher's Exact Test)

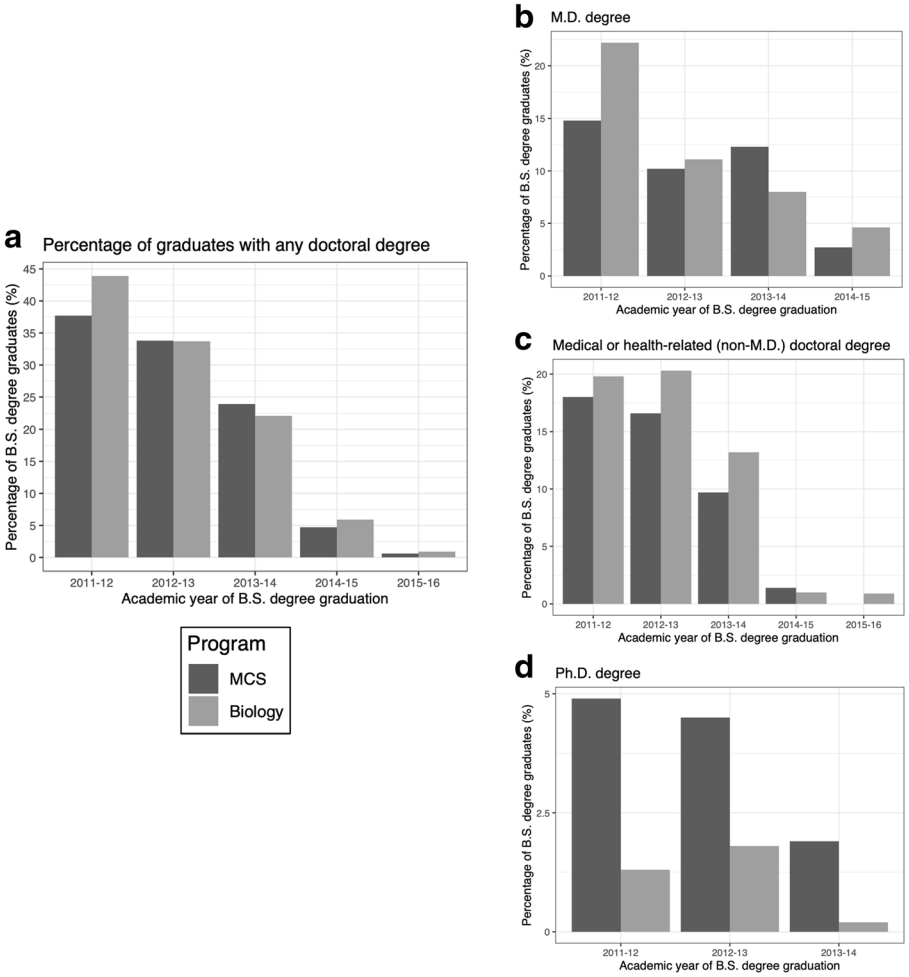

Fig. 2 Percentage of B.S. degree graduates who earned any doctoral degree following completion of their undergraduate degrees from the 2011–2012 to the 2015–2016 academic year (A). There was no significant difference between the two programs in the percentage of B.S. degree graduates with doctoral degrees from 2011 to 16 graduation years (p value = 0.320; Fisher's Exact Test). The percentage of doctoral degrees awarded to MCS and Biology graduates was divided by type of doctoral degree: B.S. graduates from 2011 to 2012 to 2014–2015 academic years earning an M.D. (B); B.S. graduates from 2011 to 2012 to 2015–2016 academic years earning a medical or health-related doctorate (excluding M.D.) (C); and B.S. graduates from 2011 to 2012 to 2013–2014 academic years earning a Ph.D. (D). The MCS degree program offered all upper division lectures online, while the Biology degree program offered nearly all lectures via the traditional, face-to-face format. There was no difference in the percent of graduates between 2011 and 15 who obtained MDs between MCS and Biology (p value = 0.440; Fisher's Exact Test) or in the percent of graduates between 2011 and 16 who obtained medically- related doctorates (p value = 0.060; Fisher's Exact Test). A greater percent of MCS graduates than Biology graduates obtained their Ph.D. for cohorts who graduated between 2011 and 14 (p value <0.001; Fisher's Exact Test)

The percentage of graduates later receiving a master's level degree do differ significantly between the two programs. For the 2011 to 2017 graduation cohort, 16.6% of Microbiology and Cell Science graduates completed a master's degree compared to 12.3% of their Biology B.S. counterparts (p value <0.001, Fig. 3). This

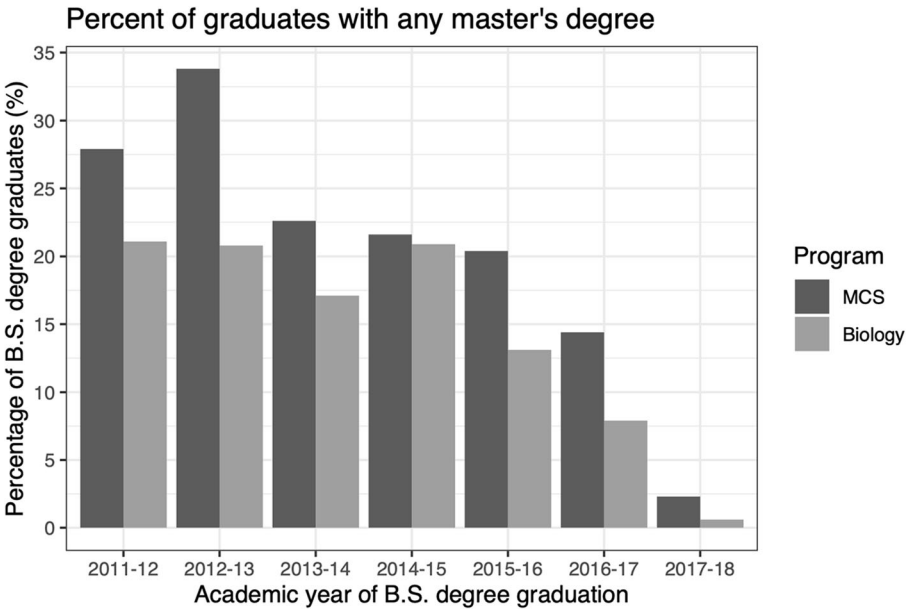

Fig. 3 Percentage of B.S. degree graduates who earned any master's degree following completion of their undergraduate degrees from the 2011–2012 to the 2017–2018 academic year. B.S. graduates completed programs from the University of Florida from two very similar life science degree programs: Microbiology and Cell Science (MCS) offered all upper division lectures online; and Biology offered nearly all lectures via traditional, face-to-face format. For graduates between 2011 and 2018, a greater percentage of MCS graduates obtained their master's degree vs. Biology graduates (p- value <0.00002; Fisher's Exact Test)

difference is statistically significant across the entire time period. The majority (90.8%) of master's degrees were master of science degrees (M.S.) or master's in medical or health-related fields, such as M.P.H. degrees. This observation remained significant when master's degree in other fields were excluded, such as M.A. degrees. Master's degrees were further distinguished as "medically focused" if they explicitly promote themselves as one that prepares students for medical school. Although a higher percentage of MCS students earned an M.S. degree compared to Biology students, the two programs had equivalent outcomes regarding students who obtained a medically-focused master's (4% and 4%, respectively; Table 1).

Discussion

In this research brief, we show that the online vs. face-to-face lecture formats in upper division undergraduate courses for life sciences students at the same university lead to remarkably similar outcomes in graduate degrees. While there are many factors that contribute to the motivations and success of students' pursuit of post-baccalaureate education, this study represents a pilot effort for long-term tracking studies that are necessary to assess the long-term effectiveness of online STEM undergraduate education.

This work is part of a series of papers that shows the efficacy of the online lecture format for STEM degree programs. First, we described our approach to designing an

online program, which proved encouraging as no adverse effects on student retention or GPAs were observed (Drew et al. 2015). Second, we showed that offering the Microbiology and Cell Science B.S. degree to students off-campus can significantly increase the diversity in STEM (Drew et al. 2016). Third, we focused on the development and success of a bootcamp model for providing an essential face-to-face lab course in an otherwise online program (Ardissone et al. 2019). Teaching microbiology students hands-on lab skills is crucial to their education, and we now provide it in a manner that is complimentary to the many demands on the lives of our off-campus, non-traditional students (Drew et al. 2015; Drew et al. 2016). While the initial motivations of delivering lecture courses online and creating a distance education track were to increase accessibility and diversity, it has consequently resulted in online course delivery for all MCS majors, on-campus and distance education students alike. This study is the fourth report in the series and addresses long-term outcomes of graduates who received upper division course work online, indicating that they are just as successful in graduate degree attainment as students receiving traditional, face-to-face course delivery. With thoughtful design and implementation, online course delivery can prove to be just as effective for a student's future outcome for any type of master's level or doctoral degree compared to traditional face-to-face delivery. Hence, graduate degree programs should consider that graduates from programs with online lecture courses are likely to have similar graduation rates as students with lectures provided through a solely face-to-face program from the same university.

MCS graduates' success at the M.D. level is equal to those students who were taught in the traditional classroom format at the same university in a very similar degree program. Medical schools often require that all lab courses remain as in-person experiences (Adams 2009; Cooper et al. 2019). First, our lab courses were designed to be in-person, but with sufficient flexibility to allow our online students to attend without major disruption of their career goals or family needs (Ardissone et al. 2019). Second, medical schools often require core requirements and that these requirements be taught in-person (Adams 2009; Cooper et al. 2019). The Microbiology and Cell Science Department teaches primarily upper division undergraduate courses; none of which are core requirements for medical schools. MCS students take those requirements from other departments (Biology, Chemistry, and Mathematics) and those courses are all taught in-person from the University of Florida or from a community college. And third, our courses are taught by the same high-quality, full-time faculty that would traditionally be teaching these courses in an in-person format on campus. Hence, our program was designed with medical school requirements in mind.

A significantly greater percentage of MCS students have earned their Ph.D. or a master's degree than the percentage of students from the primarily face-to-face program. Master's degrees are sometimes seen as a compensatory program for admission to professional or graduate degree programs. However, the percentage of graduates that received a medically-focused master's degree were equivalent between the MCS and Biology programs. This result suggests that graduates receiving primarily online upper division education were no more likely to seek additional preparedness for professional or graduate programs than graduates receiving face-to-face course delivery. Although a very small percentage of graduates in either program earned a Ph.D., very few earned a master's degree prior to Ph.D. This result is not unexpected since an M.S. degree is no longer considered a steppingstone to a Ph.D. in the life sciences. Data for this result was

not reported since it does not meet the minimum reporting threshold of ten students necessary to protect deidentified student data.

As online education will likely continue to expand in STEM, the efficacy of this format will continue to be questioned. Studies such as this one are important because they demonstrate the value of long-term tracking and address key gaps in the literature surrounding online education. There is still a general skepticism that perceives online education to be inferior to face-to-face education among stakeholders, employers, policy makers, etc. (Fain 2019). However, to our knowledge, this is the first study that compares post-baccalaureate outcomes of online education using tracking tools such as StudentTracker from the National Student Clearinghouse. Studies like this are essential in assessing the future academic success of the B.S. degree graduates in any STEM program.

Conclusions

Eight years after the introduction of the online delivery of upper undergraduate division lecture courses, B.S. degree graduates from the two programs, MCS and Biology, do not differ in the percentage of graduates who have earned a doctoral degree, including M.D., Ph.D. or other doctoral degree. Thus, graduate degree academic outcomes do not appear to differ by the mode of delivery of lecture courses during an undergraduate program in the life sciences. Graduates of a primarily online format, the MCS major, complete master's or Ph.D. degrees at a significantly higher rate than B.S. graduates from a similar program with a traditional format. Hence, these results indicate that graduate schools and professional schools should not be concerned with the modality alone of upper division course delivery during their admissions process.

Compliance with Ethical Standards

Conflict of Interest The authors have no financial or personal relationship with a third party whose interests could be positively or negatively influence' by the article's content.

References

Adams, J. (2009). The acceptability of online courses as criteria for admission to medical school. *Ochsner Journal, 9*(1), 7.

Ardissone, A. N., Oli, M. W., Rice, K. C., Galindo, S., Urrets-Zavalia, M., Wysocki, A. F., Triplett, E. W., & Drew, J. C. (2019). Successful integration face-to-face bootcamp lab courses in a hybrid online STEM program. *Journal of Microbiology and Biology Education, 20*(3), 20.3.49.

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozny, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439.

Cooper, K. M., Gin, L. E., & Brownell, S. E. (2019). Diagnosing differences in what introductory biology students in a fully online and an in-person biology degree program know and do regarding medical school admission. *Advances in Physiology Education, 43*, 221–232.

Dell, C. A., Low, C., & Wilker, J. F. (2010). Comparing student achievement in online and face-to-face class formats. *MERLOT Journal of Online Learning and Teaching, 6*(1), 30–42.

Drew, J. C., Oli, M. W., Rice, K. C., Ardissone, A. N., Galindo-Gonzalez, S., Sacasa, P. R., Belmont, H. J., Wysocki, A. J., Rieger, M., & Triplett, E. W. (2015). Development of a distance education program by a land-Grant University augments the 2-year to 4-year STEM pipeline and increases diversity in STEM. *PLoS One, 10*, e0119548.

Drew, J. C., Galindo-Gonzalez, S., Ardissone, A. N., & Triplett, E. W. (2016). Broadening participation of women and underrepresented minorities in stem through a hybrid online transfer program. *CBE—Life Sciences Education, 15*(3), ar50.

Dynarski, S. M., Hemelt, S. W., & Hyman, J. M. (2013). The missing manual: Using national student clearinghouse data to track postsecondary outcomes. *Working Paper No. 19552.* National Bureau of economic research.

Fain, P. (2019) Takedown of online education. *Inside Higher Ed*, https://www.insidehighered.com/digital-learning/article/2019/01/16/online-learning-fails-deliver-finds-report-aimed-discouraging.

National Student Clearinghouse. (2020). StudentTracker. Retrieved June, 2019, from https://www.studentclearinghouse.org/colleges/studenttracker/.

National Student Clearinghouse. (2017). *StudentTracker for Colleges & Universities User Manual.* Retrieved June 2019 from https://studentclearinghouse.info/onestop/wp-content/uploads/STCU_User_Manual.pdf.

Nguyen, T. (2015). The effectiveness of online learning: Beyond no significant difference and future horizons. *MERLOT Journal of Online Learning and Teaching, 11*(2), 11.

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for statistical computing, Vienna, Austria. URL https://www.R-project.org/.

Seaman, J. E., Allen I. E., & Seaman, J. (2018). Grade increase: Tracking distance education in the United States. Babson Survey Research Group https://files.eric.ed.gov/fulltext/ED580852.pdf.

Vo, H. M., Zhu, C., & Diep, N. A. (2017). The effect of blended learning on student performance at course-level in higher education: A meta-analysis. *Studies in Educational Evaluation, 53*, 17–28.

Warren, L. L., & Holloman, H. L. (2005). On-line instruction: Are the outcomes the same? *Journal of Instructional Psychology, 32*(2), 148–151.