Broadening Participation of Women and Underrepresented Minorities in STEM through a Hybrid Online Transfer Program

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ABSTRACT

The Microbiology and Cell Science (MCS) Department at the University of Florida (UF) developed a new model of a 2 + 2 program that uses a hybrid online approach to bring its science, technology, engineering, and mathematics (STEM) curriculum to students. In this paradigm, 2-year graduates transfer as online students into the Distance Education in MCS (DE MCS) bachelor of science program. The program has broadened access to STEM with a steadily increasing enrollment that does not draw students away from existing on-campus programs. Notably, half of the DE MCS students are from underrepresented minority (URM) backgrounds and two-thirds are women, which represents a greater level of diversity than the corresponding on-campus cohort and the entire university. Additionally, the DE MCS cohort has comparable retention and academic performance compared with the on-campus transfer cohort. Of those who have earned a BS through the DE MCS program, 71% are women and 61% are URM. Overall, these data demonstrate that the hybrid online approach is successful in increasing diversity and provides another viable route in the myriad of STEM pathways. As the first of its kind in a STEM field, the DE MCS program serves as a model for programs seeking to broaden their reach.

INTRODUCTION

Based on an influential report from the President's Council of Advisors on Science and Technology (2012), the president of the United States made science, technology, engineering, and mathematics (STEM) education a national priority when he announced the goal to increase the number of individuals who receive degrees in STEM by one million individuals in a decade. Institutions will need to increase the number of degrees awarded in STEM by more than 30% over current rates by 2020. Additional reports have called for an emphasis on STEM education to maintain the country's pre-eminence in science and technology (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2010; National Science and Technology Council, 2013).

Boosting the participation of women and minorities in STEM is one way to help close the STEM gap significantly, as women and minorities are disproportionately underrepresented in STEM degree attainment and in the STEM workforce (National Science and Technology Council, 2013). Individuals of racial and ethnic minority groups traditionally underrepresented in STEM account for only 13% of the science and engineering workforce (National Center for Science and Engineering Statistics, 2015). The proportion of underrepresented minority (URM) students who received 4-year college degrees in STEM disciplines in 2011 (18%) is far below their proportion in the U.S. college-age population (36%; National Science Board, 2014) and only 20% of URMs who intend to earn a STEM undergraduate degree have done so

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(National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011; National Research Council and National Academy of Engineering, 2012). In the biological sciences, URMs earn a combined 16% of bachelor's degrees, and this gap between the population demographics and the demographics within STEM fields is widening (National Science Board, 2014). According to the recent *Women, Minorities, and Persons with Disabilities in Science and Engineering* report, half of STEM undergraduate degrees are earned by women; however, this rate skews considerably toward psychology and biosciences, with women earning 70 and 58% of the degrees, respectively, in those fields (National Center for Science and Engineering Statistics, 2015). The proportion of women who earn degrees in engineering and physics is much lower, with only 20% of bachelor's degrees in those fields attained by women. Despite participation in STEM degree programs and despite accounting for half of the total workforce, women comprise only 29% of the science and engineering workforce overall (National Center for Science and Engineering Statistics, 2015).

Although there is a notable need to broaden the participation of women and URMs in STEM, there is not one clear formula for success (Maltese and Tai, 2011). Recommendations include partnerships between 2-year and 4-year institutions to provide more entry points and inclusive pathways to STEM degrees (Institute of Medicine, 2009; Labov, 2012; National Research Council and National Academy of Engineering, 2012). Recently, a report from the National Academy of Sciences described the complex array of pathways taken by today's undergraduates to earn a BS in STEM (National Academies of Sciences, Engineering, and Medicine, 2016). Community colleges play a significant role in the nation's higher education system, with almost one-half of all Americans with a bachelor's degree having attended a community college. Forty percent of STEM graduates have attended a community college at some point in their educational career (National Science Foundation [NSF], 2004). According to recent *Science and Engineering Indicators*, 20% of individuals who earned a PhD in STEM from 2007 to 2011 have attended a community college (National Science Board, 2014). Community colleges serve the most diverse student populations in the country with a higher proportion of women, older students, first-generation students, veterans, working parents, low-income students, and URMs than 4-year institutions (Labov, 2012; NSF, 2004; Provasnik and Planty, 2008; National Academies of Sciences, Engineering, and Medicine, 2016). Many community college students have a desire to pursue a 4-year degree, but, due to a myriad of factors, these students do not complete the 2 + 2 pathway, and this transfer gap is wider for URMs (Tinto, 2004; Packard *et al.*, 2011; Reyes, 2011). For example, while nearly half of Latino community college students express an interest in transferring and earning a 4-year degree, only 6% have earned a BS within 6 years (Nuñez *et al.*, 2011; Radford *et al.*, 2010). The barriers to transfer can include financial, social, and familial responsibilities (Nuñez and Elizondo, 2013). After transferring into a 4-year STEM program, the retention rate for URM remains low, and many factors have been cited as contributing to the attrition such as culture shock, isolation, lack of social networks, and balancing familial and outside employment obligations (Reyes, 2011; National Academies of Sciences, Engineering, and Medicine, 2016).

Increasing access to 4-year degrees in STEM when many public higher education institutions are at physical capacity with limited budgetary resources necessitates innovative approaches. One strategy to extend the reach of a curriculum is through online education. It is estimated that one-third of all college students are currently taking at least one course in an online format (Allen and Seaman, 2014). Although massive open online courses (MOOCs) have attracted great attention recently (Waldrop, 2013), students have been regularly taking online courses for credit for over a decade and are well versed in the online learning environment (Allen and Seaman, 2014). Perceptions of the quality of online education may vary, but many studies, including two large meta-analyses on learning outcomes, have shown that distance education can be as or more successful than the comparable classroom experience (Bernard *et al.*, 2004; Warren and Holloman, 2005; Weber and Lennon, 2007; Dell *et al.*, 2010; Means *et al.*, 2010). A "blended" or "hybrid" approach, one that integrates online education with face-to-face elements, demonstrates even higher learning outcomes, increased retention, and greater student satisfaction than traditional face-to-face formats (Means *et al.*, 2010; Sorden and Munene, 2013). Studies have also demonstrated success for online approaches in the life sciences (Jones, 2010; Drew *et al.*, 2015). Unlike MOOCs, which are known for their low retention (Reich, 2014), online education can have similar or even higher retention rates than comparable face-to-face courses (Meyer *et al.*, 2009; Moore *et al.*, 2009; Drew *et al.*, 2015). For students who are paying their own way through college, enrollment in distance education classes is associated with fewer enrollment gaps and increased completion rates (Pontes and Pontes, 2012). Despite the consensus that online education is as good as face-to-face instruction, there are data that suggest an achievement gap in online courses for Latino students (Kaupp, 2012).

To broaden access and diversity to the life sciences at a public research university that was at maximum physical capacity, the Microbiology and Cell Science (MCS) department at the University of Florida (UF) designed a new type of 2 + 2 life sciences transfer program that uses online education as a way to increase access and diversity to STEM. The Distance Education in MCS bachelor of science (DE MCS) was established in 2011. In the DE MCS model, a 2-year student transfers into a 4-year institution as an online student. A BS in MCS, as for most life sciences, requires laboratory courses that must be completed in person in addition to the standard STEM discipline prerequisites such as biology, chemistry, and physics lab courses. Until rigorous testing of a virtual lab/field experience demonstrates equivalent learning and skills outcomes compared with face-to-face lab courses, it is important that lab and field courses remain as in-person experiences. Therefore, a hybrid, or blended, model of a transfer program works well, as the lecture courses that count toward the MCS major, generally taken in years three and four, are taken entirely in an online format, while the laboratory courses are taken face-to-face. A grant from the National Science Foundation (NSF) STEM Expansion Program has provided opportunities for some DE MCS students to participate in summer research experiences, work as peer tutors, and receive scholarships. A publication in early 2015 fully described the development and structure of the DE MCS program and analyzed initial results based on a small number of students. These early findings indicated that the model has potential in increasing the number and diversity in STEM (Drew *et al*., 2015). However, as enrollment in the DE MCS program accelerates, a more in-depth assessment of the educational paradigm is needed to determine whether the hybrid transfer program is successful in broadening access and participation in the life sciences without diminishing quality. The research presented here represents a more thorough analysis of the enrollment, demographics, retention, and academic performance of the DE MCS program after four full academic years. This online hybrid transfer program in STEM is an example of one unique approach among the complex array of pathways that are needed to broaden participation and enhance STEM opportunities for today's diverse students.

METHODS

This analysis is a component of a larger study that was reviewed and approved by UF's Institutional Review Board (2012-U-0518). The data are all deidentified. Archival data were provided by UF's Office of Institutional Planning and Research and department staff. The project evaluator collected focus group data.

The design and structure of the DE MCS program was described extensively in Drew *et al*. (2015).

Student enrollment and demographic data were obtained by request from the Office of Institutional Planning and Research at the UF. The enrollment data were reported as student head counts for MCS majors in the Fall semester from years 2010–2015 for students in the College of Agricultural and Life Sciences (CALS) and the College of Liberal Arts and Sciences (CLAS). The MCS program is in both colleges: CALS and CLAS. Although degree requirements for a BS in MCS are the same for all MCS majors, there are differences in requirements and expectations for students in the two colleges at the admissions level. First-time in college students (FTIC) entered the institution as degree-seeking undergraduates and did not transfer from another institution or attend another college previously. On-campus transfer students began their undergraduate degree at a different institution and then transferred into the UF as MCS majors. Typically, these students transfer from a 2-year institution in the state to complete their 4-year degree. Distance education transfers (DE MCS students) are students who transferred to the university as MCS majors, typically from a 2-year institution, but are not physically on campus as they complete their degree in the DE MCS program (Drew *et al*., 2015).

In addition to total head counts, the Office of Institutional Planning and Research provided the aggregate gender and race/ethnicity counts. Because the DE MCS program is only available through CALS, and since CLAS does not have a comparable distance education–based program, the demographics, retention, and quality of the DE MCS program is generally assessed by comparisons with the two most closely related cohorts: MCS on-campus (admitted as FTIC) and MCS on-campus transfers (admitted after attending another institution) from CALS. Comparisons of demographics and retention between the two cohorts were analyzed with 2×2 contingency tables, and significance was determined using Fisher's exact test. For the analysis of DE MCS cohort versus the university-wide enrollment data, a chi-squared with Yates correction was used because of the large sample size. The contingency tables were analyzed with the GraphPad software QuickCalc tool (graphpad.com). Underrepresented in STEM is defined as individuals with a racial/ethnic background of Hispanic, black, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander. The URM level was determined and compared as per the method in Garrison (2013). Briefly, all individuals reported as a single race/ethnicity are totaled. The proportion of URM per cohort is determined by summing the number of individuals reported as any of the URM backgrounds and dividing by the total number of individuals reported as a single race/ethnicity. Because the URM status of the remaining demographic categories (such as not reported, two or more races, permanent resident) is not provided, these counts were not included in the URM totals and contingency tables.

STEM retention was assessed in two transfer cohorts of CALS MCS majors who transferred into the university as juniors in the Fall of 2011 through the Summer of 2014: on-campus transfers (CALS TR) and distance education transfers (DE MCS). Retention was defined as students from the cohort who had completed a BS in MCS, completed a BS in another STEM field, or continue to persist in their programs toward earning a BS. The proportions of students from these categories were compared with Fisher's exact test using GraphPad. The time to degree was determined by comparing the average number of semesters per transfer cohort required to earn the BS. Twenty-four students in each of the CALS TR and DE MCS cohorts, who had started during Fall 2011–14, have earned a BS in MCS and were included in the time-to-degree analysis, the individual course grade analysis, and the degree demographics comparisons. Because the time-to-degree data did not fit a normal distribution, the data were compared with the Wilcoxon rank-sum test with a continuity correction and completed in R (R Core Team, 2013).

Two types of overall grade point averages (GPAs) were assessed for the three CALS MCS cohorts (on-campus FTIC, on-campus transfers, and DE transfers) current GPAs (as of Spring 2015) for all students and final GPAs at time of graduation for students who had graduated with a degree in MCS from Spring 2013 to Spring 2015. Owing to the GPA scale (upper limit cannot exceed 4), the GPA data were skewed and not normally distributed (Shapiro-Wilks test, $p < 0.05$). Therefore, Kruskal-Wallis analysis with the Tukey and Kramer (Nemenyi) test (for pairwise comparisons) was applied. The analysis was completed in R.

Math and science course grades were compared between the CALS TR and DE MCS cohorts in Table 1. Mean course grades were calculated by converting the individual letter grades according to the standard CALS scale: "A," 4.0; "A–," 3.67; "B+," 3.33; "B," 3.0; "B–," 2.67; "C+," 2.33; "C," 2.0; "C–," 1.67; "D+," 1.33; "D," 1.0; "D–," 0.67; "E," 0.0. If a course was taken more than once, the first recorded grade was included in the analysis. The means were analyzed with the Student's *t* test using StatPlus, which is a statistical analysis program for Mac OS, version 6 (AnalystSoft, www.analystsoft.com/en). The analysis represents the data provided to the researchers on math and science courses taken by a majority of the cohorts.

Individual and group interviews (Holstein and Gubrium, 2003; Kvale, 2007) with DE MCS students were used to further explore the quality of the program and its effectiveness in removing barriers for enrollment and retention and promoting positive learning outcomes. Each Fall semester since 2012, students participating in the different activities of the program

TABLE 1. Course grade averages for on-campus (CALS TR) and distance based (DE MCS) graduates who transferred into MCS between the 2011 and 2014 academic years

		CALS TR		DE MCS		
	Course type[a]	Mean grade[b]	SD	Mean grade[b]	SD	*p* Value (two-sided)[c]
Principles of Microbiology	R	3.26	0.66	3.03	0.75	0.256
Principles of Microbiology (Lab)	R	3.26	0.66	3.03	0.75	0.698
Advanced Microbiology (Lab)	R	3.51	0.42	3.70	0.43	0.249
Biochemistry	R	2.81	0.87	2.65	0.88	0.550
Molecular Genetics	C	3.38	0.95	2.76	0.78	0.007
Pathogens	C	3.43	0.66	2.91	0.69	0.008
Eukaryotic Cell Structure	E	3.55	0.57	3.08	0.82	0.110
Human Parasitology	E	3.41	0.74	3.26	0.78	0.540
General Virology	E	3.27	0.72	3.00	0.86	0.300

Each of the two transfer cohorts consists of 24 students who have earned a BS in MCS. Courses represent those taken by a majority of transfer students.
[a]The course type in the second column indicates the status of the course in the curriculum, in which R = required courses, C = core courses, and E = elective courses. The lab courses were taught in a face-to-face format for all students. All DE MCS students completed the R, C, and E courses in a strictly asynchronous online format.
[b]The mean course grades were compared with the Student's *t* test, and the standard deviation (SD) and two-sided *p* value are shown. Mean course grades were calculated by converting the individual letter grades according to the standard CALS scale: "A," 4.0; "A–," 3.67; "B+," 3.33; "B," 3.0; "B–," 2.67; "C+," 2.33; "C," 2.0; "C–," 1.67; "D+," 1.33; "D," 1.0; "D–," 0.67; "E," 0.0. If a course was taken more than once, the first recorded grade was included in the analysis.
[c]None of the comparisons between the cohorts' course mean grades met the experiment-wide adjusted *p* value threshold for significance of 0.005 or below.

have shared their experiences and perceptions through interview sessions. A total of 53 students have participated in interview sessions through either a focus group or an individual interview. There have been 10 focus group sessions and four individual interviews. All the DE MCS students in the Miami area were invited to participate in the interviews, and the sessions were scheduled around the availability of those individuals who expressed interest in participating. Semistructured interview guides (Kvale, 2007; Yin, 2011; Harding, 2013) were used for both group and individual sessions. Interview questions explored the perceptions of students resulting from their experiences with different processes and products of the DE MCS program; for example, participants were asked to identify the most challenging part of the experience, to identify aspects of the program in need of improvement and provide feasible solutions, to describe their participation and motivation, and so on. Students' feedback has been used to fine-tune program implementation. Interviews were audio-recorded and transcribed (Yin, 2011; Harding, 2013). Interview data were coded, summarized, and analyzed to identify the main themes and subthemes present in students' responses. A four-step thematic analysis process (Harding, 2013) was followed to identify the main themes emerging from interview data and find commonalities and differences in these themes across participants. A mixed "closed" (a priori) and "open" (empirical) approach to coding (Plowright, 2011; Harding, 2013) was used to identify relevant categories and codes in the data. Three main common themes (i.e., accessibility, institutional prestige, and personal growth), with both common and different subthemes within each, were identified through thematic analysis; as suggested by Harding (2013), a theme or subtheme was labeled as "common" if it was shared by at least three-fourths of the cases.

RESULTS

Enrollment

The DE MCS BS program is currently ending its fifth academic year and has therefore completed four full academic cycles. Students can matriculate into the program during the Fall, Spring, or Summer semesters. Students can major in MCS through either the CALS or the CLAS. However, the DE MCS major, the online hybrid transfer program, is only offered through CALS. The enrollment in MCS is carefully tracked to determine whether the establishment of DE MCS meets the objective of increasing the number of new life sciences majors without pulling students away from existing MCS programs. Since the launch of the DE MCS program in 2011, Fall head count has increased from 11 to 78 students (Figure 1A). The overall number of transfer students in MCS has more than doubled since 2011 from 83 to 190 total transfers. Although the on-campus transfer cohorts have increased enrollment in 5 years, the DE MCS cohort accounts for 75% of the increase in enrollment. During the same time period, enrollment of the on-campus FTIC cohorts, composed of nontransfer students who began their undergraduate degrees as freshmen at the UF, experienced a slight decrease of 2.4% total FTIC enrollment (Figure 1B). Despite the modest decrease in FTIC enrollment, overall total enrollment of all types of MCS majors, both FTIC and transfers, has climbed steadily with a net increase of 15% in enrollment since the establishment of the DE MCS program.

Qualitative analysis revealed that the reputation of the institution and its faculty, subthemes within the main theme of institutional prestige, and the format of the program, a subtheme within accessibility, were commonly identified by students as key factors connected with enrollment decisions. Respondents commonly cited the institution's prestige as a positive aspect of the program and reported that the flexible, online format of the program gave them the unique opportunity to earn their degree while maintaining jobs and family responsibilities. As stated by a participant, "UF is a very prestigious school, especially for the sciences. At that time, when I was learning about the program, it was practically impossible for me to travel to Gainesville because I had other financial responsibilities at home."

Diversity

The demographic data indicate that the DE MCS cohort is more diverse than the corresponding on-campus cohorts, with a

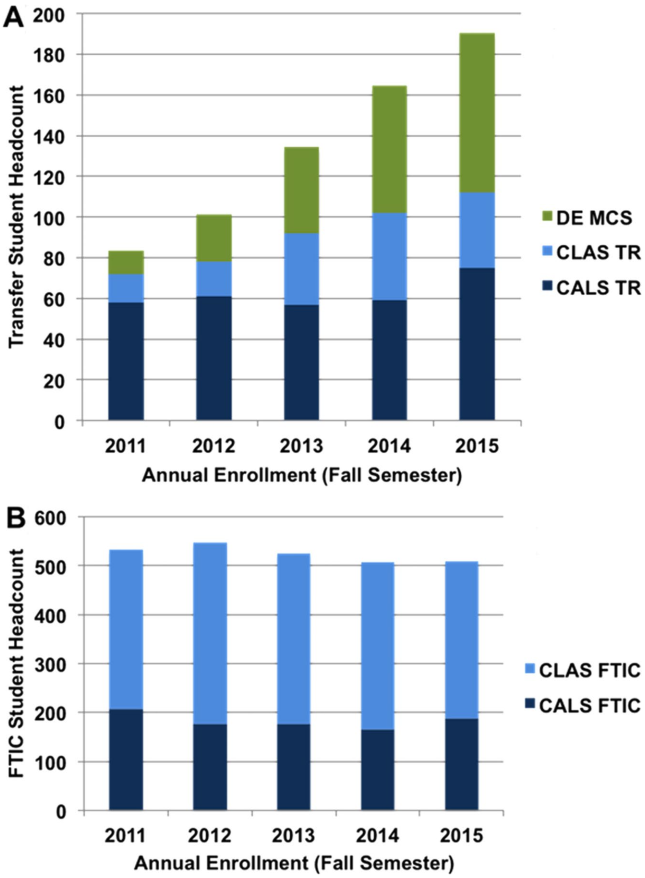

FIGURE 1. Annual fall enrollment of MCS students by college and transfer type. (A) Fall head counts of transfer students by year are depicted with the online transfer cohort (DE MCS) students in green and the two on-campus transfer cohorts in shades of blue. (B) The Fall head counts of the FTIC MCS majors enrolled in CALS (CALS FTIC) or CLAS (CLAS FTIC).

greater proportion of women and individuals of racial/ethnic backgrounds who are traditionally underrepresented in STEM. In the Fall 2015 head count, two-thirds of the DE MCS cohort (67%) is composed of women, which is a higher proportion of women than either the on-campus CALS TR cohort (44%) or the on-campus CALS FTIC cohort (56%; Figure 2A). The difference in the proportion of women between the online versus on-campus CALS transfer cohorts is statistically different (p value = 0.003, Fisher's exact test); however, the online cohort is not statistically different from the on-campus FTIC cohort (p value = 0.13, Fisher's exact test).

Half of the DE MCS students are from racial and ethnic backgrounds traditionally underrepresented in STEM fields. According to the NSF, individuals of Hispanic, black, American Indian, Alaska Native, Native Hawaiian, or Other Pacific Islander races or ethicities are URMs in STEM fields (National Science Board, 2014). The race/ethnicity demographics of five different cohorts from the most up-to-date enrollment data are depicted in Figure 2B. Fall 2015 represents the most current data set for the student cohorts shown: CALS FTIC, CALS TR, DE MCS, and all full-time degree-seeking undergraduates at the institution (undergraduates). The statewide demographics are based on 2014 census data (U.S. Census Bureau, 2015). The proportion of total URM enrollment in the DE MCS cohort (51%) is higher than any other comparison cohort, including the overall demographics for the state, which has a URM level of 42%. The proportion of URM participation to non-URM participation is statistically higher in the DE MCS cohort versus the CALS FTIC cohort (p value = 0.02, Fisher's exact test), and the DE MCS URM level is higher than the university-wide undergraduate URM level of 30% (p value = 0.0002, chi-squared test with Yates correction for a large sample size). The increase in the URM level of the DE MCS cohort versus the CALS TR cohort (44%) is not statistically different (p value = 0.40, Fisher's exact test). Because the population data for the state are based on 2014 data, and the state data were not collected in a similar manner and from the same source, the DE MCS URM level was not compared with the statewide URM level in a statistical analysis.

Retention

With a 2 + 2 program, the earliest time point at which most students are in the position to graduate with a BS is 2 years after they transfer to the 4-year institution. Because the DE MCS program began in 2011 and is therefore still relatively young, there are only 46 DE MCS students who have been in the program long enough to graduate (matriculated during the Fall 2011 through Summer 2014 window). For assessment of how the retention of the online transfers compares with the retention of on-campus transfer students in STEM, the graduation and persistence data from DE MCS and CALS TR students who matriculated during the same time frame were compared (Figure 3A). Because of the difficulty in comparing retention of nontransfer students who began as freshmen with transfer students, the retention of the DE MCS program is compared only with the retention of the on-campus CALS transfer cohort. Fifty-eight CALS TR students matriculated into MCS during the same time frame as the DE MCS students. Overall, the CALS TR program has a higher STEM retention rate of 78% (45/58) versus 69% (32/46) for the DE MCS cohort for all students who transferred into the CALS MCS majors from Fall 2011 until Summer 2014, but the difference in retention is not statistically different (p value = 0.38, Fisher's exact test). The overall STEM retention rate refers to students who have graduated with a BS in MCS or another STEM field or who are currenty still enrolled and therefore persisting toward their STEM degrees. In the DE MCS cohort, 24/46 (52%) have graduated with a BS in MCS, with an additional student graduating with a BS in another STEM field for a total STEM graduation rate of 54%. The MCS graduation rate of the corresponding on-campus cohort is 41% (24/58), with another 9/58 graduating with a BS in another STEM field for a STEM graduation rate of 57%, but these differences in graduation rates between the two types of transfer students are not statistically different (p values ≥ 0.3, Fisher's exact test). Fifteen percent (7/46) of the DE MCS cohort remain enrolled and persist toward their degrees, whereas 21% (12/58) of students in the on-campus CALS TR cohort persist.

Figure 3B depicts the average number of academic semesters necessary for students to complete a BS in MCS upon transferring into the MCS program. The mean time to degree was compared between the on-campus transfer cohort (CALS TR)

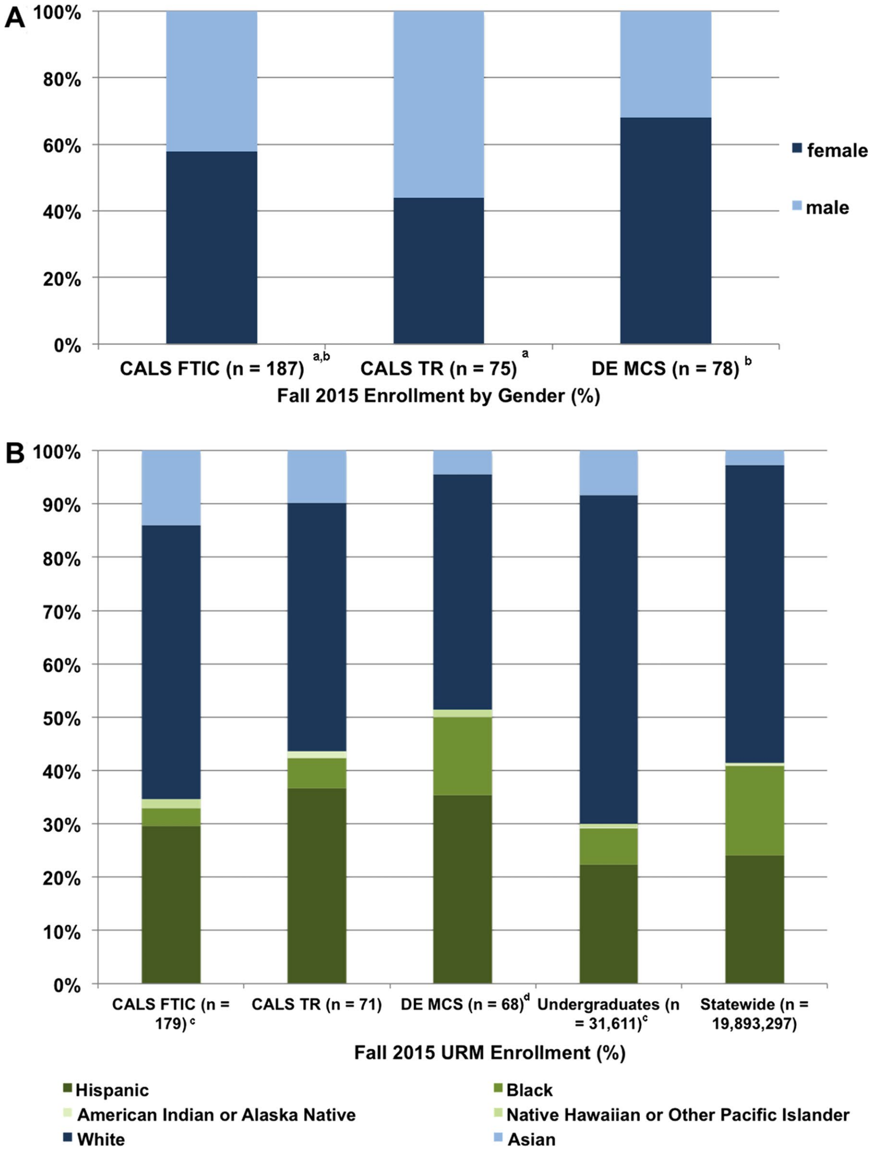

FIGURE 2. The proportion of women and underrepresented minorities in MCS varies among cohorts. (A) The proportion of females and males enrolled in the Fall 2015 CALS MCS FTIC cohort (CALS FTIC), on-campus transfer cohort (CALS TR), and online transfer cohort (DE MCS) is depicted. The number of students per cohort (*n*) is noted. As represented by superscripts, the proportion of women in the in the CALS TR cohort (44%) is significantly less than the proportion of women in the corresponding DE MCS cohort (67%; *p* value = 0.003, Fisher's exact test). There was no significant difference in the proportion of women in the CALS FTIC cohort vs. the CALS TR cohort or the CALS FTIC cohort vs. the DE MCS cohort. (B) The proportion of URM as a percent of all individuals reported as a single race/ethnicity per the methods described in Garrison (2013). The total number of individuals (*n*) reported as a single race/ethnicity per cohort is indicated in parentheses after the cohort name. The racial/ethnic backgrounds traditionally underrepresented in STEM are clustered in shades of green (Hispanic, black, Native Hawaiian, and American Indian) while the racial/ethnic backgrounds not underrepresented in STEM are shaded in blue (white and Asian). The student data in B represent the demographics from Fall 2015, but the statewide data are from 2014, which is the most recent data set available. The five cohorts are CALS MCS FTIC majors (CALS FTIC), CALS MCS on-campus transfers (CALS TR), online MCS transfers (DE MCS), all degree-seeking undergraduates at the UF (Undergraduates), and the overall state population (Statewide). As indicated by the superscripts, the level of URM participation of the DE MCS cohort (51%) is statistically higher than the URM levels of the CALS FTIC cohort (35%) and all degree-seeking undergraduates (30%) (*p* values = 0.02 and 0.0002, respectively). The comparison with the CALS FTIC cohort was performed with Fisher's exact test, and because of the large sample sizes, the comparisons with the undergraduate population were analyzed with chi-squared test with a Yates correction. The increase in the URM level of the DE MCS cohort vs. the CALS TR cohort (44%) was not statistically different (*p* value = 0.40, Fisher's exact test).

and the online transfer cohort (DE MCS). On average, the online cohort enrolls one semester more than the CALS TR cohort with the mean time to degree as 6.7 semesters for DE MCS and 5.9 for the CALS TR cohort (p value = 0.046, Wilcoxon rank-sum test with continuity correction). The distributions of the two cohorts are different in that most of the CALS TR cohort take five semesters to graduate while the DE MCS cohort ranges between five and seven semesters to complete the BS post-transfer (Figure 3C.)

The diversity of the graduates of the hybrid online MCS program is greater than the diversity of the on-campus transfer cohort. Twenty-four students from each of the transfer MCS cohorts who began from Fall 2011 through Fall 2014 have graduated with a BS in MCS to date (Figure 3A). The demographics of these cohorts of students who completed the pathway to a BS in MCS are shown in Figure 4. The online cohort is 61% URM (14/23 reported as a single race/ethnicity), which is a statistically higher level of URM degree earners than on-campus transfer cohort of graduates, in which only 27% are URM (6/22 reported as a single race or ethnicity; p-value = 0.036, Fisher's exact test). The DE MCS graduate cohort also has more women, with 71% (17/24) compared with 42% women (10/24) in the CALS TR graduate cohort (p value = 0.0798, Fisher's exact test). These data indicate that the high levels of diversity in the DE MCS program (Figure 2) are retained and that there is not a retention gap among women and URM students in DE MCS.

The online format of the DE MCS program was identified through qualitative analysis as a common subtheme within the main theme of accessibility. Participants reported that the flexible, online format of the program allowed them to work and to maintain other family responsibilities while working on their degrees. As noted by one student, "I have personal responsibilities. I am a mother. I was working another job, two other jobs, the program

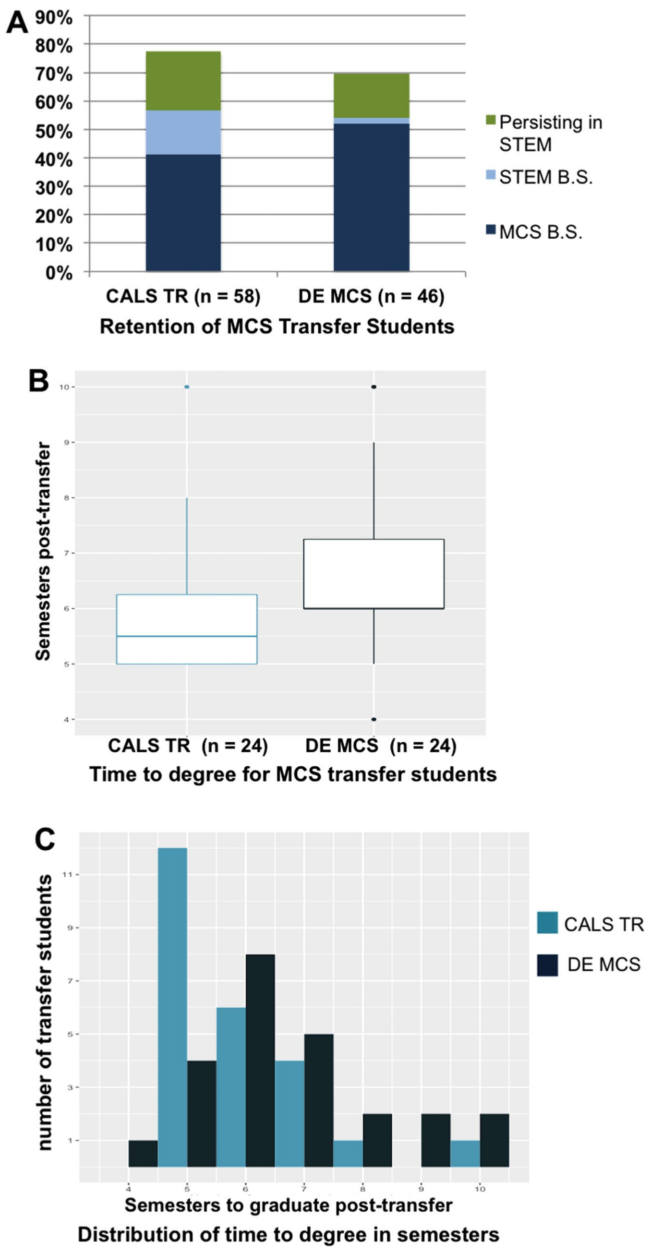

FIGURE 3. The STEM retention rate and time to degree differ by transfer type. (A) The percentages of students who transferred into the CALS on-campus transfer program (CALS TR) or the CALS hybrid online transfer program (DE MCS) from Fall 2011 through Spring 2014 and have graduated with a BS in MCS, graduated with a BS in another STEM degree, or have not yet graduated but are still pursuing a BS in MCS or another STEM field at UF (Persisting in STEM). The total number of students (*n*) in each cohort is indicated in parentheses. There is no statistical difference in STEM retention (graduated plus persisting) between CALS TR and DE MCS cohorts (p value = 0.38 per Fisher's exact test). The time to degree is depicted in B for the subset of students in A who completed a BS in MCS (24 in each cohort). The number of semesters needed by each student in the cohorts to graduate once they transferred into MCS is shown in the box plots. The CALS TR cohort had an average time to degree of 5.92 semesters, whereas the DE MCS cohort took an average of 6.7 semesters to graduate. The difference in time to degree is statistically significant, with a p value of 0.0457 by Wilcoxon rank-sum test with continuity correction. (C) The distribution of the time to degree in semesters for the two different cohorts: CALS TR and DE MCS.

really opened the door for me to get an education from a prestigious school, best education in the state, and then also be able to fulfill my obligations. Definitively was a life changer."

Academic Performance

To measure the quality of the online transfer program, we collected and compared the GPA of all CALS MCS majors in their junior year or higher enrolled in the Spring 2015 semester by program type (Figure 5). As described in Drew *et al*. (2015), the three cohorts take the same courses, taught by the same instructors, with the same exams and proctoring procedues. For some courses, the on-campus cohorts have the option to attend MCS courses in a face-to-face format, but it is not always required; however, the DE MCS cohort takes all lecture courses via asynchronous online learning. The Spring 2015 mean GPA of the online transfer cohort (3.34) was higher than the mean GPA of the on-campus transfer cohort (3.145), but the difference was not statistically significant (p value = 0.172, Kruskal-Wallis test). However, the Spring 2015 mean GPA of the on-campus CALS MCS nontransfer students (CALS FTIC) was 3.5 and was statistically higher than that of both transfer cohorts (p values < 0.02, respectively, Kruskal-Wallis test).

The GPAs at the time of graduation were also compared for all CALS MCS students who graduated during the Spring 2013–Spring 2015 time frame (Figure 5). The three cohorts also have the same graduation requirements. The mean graduating GPAs for the CALS FTIC majors, CALS on-campus transfer majors, and the online DE MCS majors were 3.45, 3.19, and 3.28, respectively. The mean GPA of the DE MCS cohort was comparable to that of the CALS on-campus FTIC cohort and the on-campus transfer cohort (p values = 0.27 and 0.9, respectively, Kruskal-Wallis). The mean GPA of the on-campus CALS FTIC cohort was statistically higher than the mean GPA of the on-campus transfer cohort (p value < 0.0005, Kruskal-Wallis test).

To further explore academic differences between the on-campus and online transfer students, we compared mean course grades of nine life science courses between the BS graduates of the on-campus MCS transfer program and the hybrid online DE MCS transfer program (Table 1). Table 1 is a set of common courses taken by a majority of the MCS students who transferred into the on-campus or online program from Fall 2011 through Spring 2014 and who have since graduated with a BS in MCS. Four of the listed courses (R) in Table 1 are required of all MCS students and are designated as such. Two of the listed courses fulfill core course requirements in which students select a subset of core courses from a small list (C). The remaining courses are electives (E). Except for the lab courses, the DE MCS students completed the required, core, and elective courses in a strictly asynchronous online format. The two microbiology lab courses were taken face-to-face by all transfer students regardless of location. The required, core, and elective courses taken by the on-campus transfer students were delivered in a variety of modalities ranging from entirely face-to-face formats to flipped classrooms to asynchronously delivered

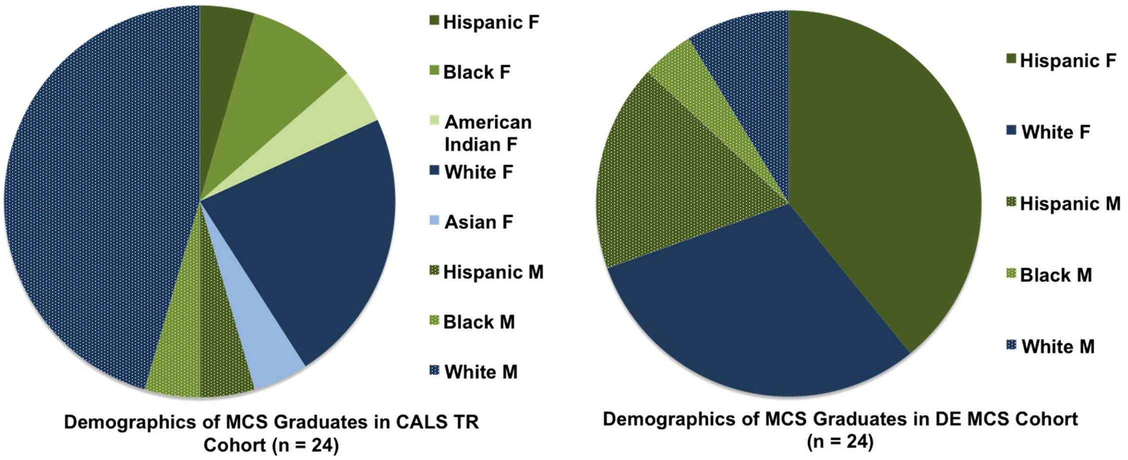

FIGURE 4. Diversity of transfer students who graduated with a BS in MCS. The demographics are shown for individuals who transferred into either the on-campus CALS program (CALS TR) or the online program (DE MCS) between the Fall of 2011 to Summer 2014 and who have completed a BS in MCS. The circle graphs represent the percentages of males and females of different races and ethnicities in the two different cohorts. Individuals of backgrounds that are traditionally underrepresented in STEM are depicted in shades of green, and nonminority backgrounds are depicted in shades of blue. Slices of the chart indicating females are shaded in a solid color, whereas the slices representing male participation are patterned. The total number of individuals per cohort is indicated in parentheses after the cohort name. The DE MCS graduate cohort is 61% URM, which is a statistically higher level of URM graduates than the CALS TR graduate cohort (27%; p value = 0.036, Fisher's exact test). The DE MCS graduate cohort also has more women, with 71% compared with 42% women in the CALS TR graduate cohort (p value = 0.0798, Fisher's exact test).

lectures. The approaches vary widely according to instructor preference. The mean course grades were compared with Student's t test and the two-sided p value (Table 1). Although the on-campus transfer cohort had a higher mean grade for most of these courses, the differences between the two cohorts are not statistically significant (p values > 0.005, adjusted for multiple comparisons).

The mean course grades of 12 prerequisite courses do not differ between the two cohorts before transfer (Supplemental Material). These include the math and science prerequisite courses taken at the students' respective community colleges before transfer.

Professional development opportunities and skills, such as research and critical thinking, emerged as subthemes within the main theme of personal growth associated with the academic performance of the students. Students in the DE MCS program reflected on the impact of undergraduate research with experts in the field as a positive experience, with one student saying, "I never thought I would participate in research and now I'm writing a thesis. It pushes you and I'm graduating with honors." Another respondent reflected on his/her maturation as a student: "I came out as a better student and person. It taught me a lot. I've definitively grown a lot in this experience."

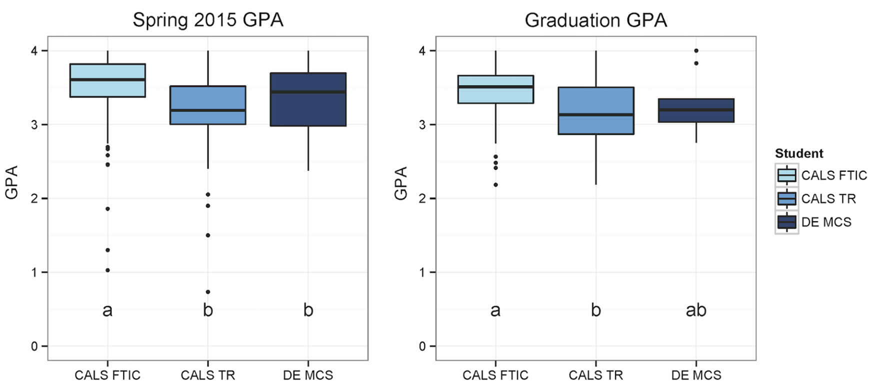

FIGURE 5. Box plots representing the GPAs of CALS MCS majors. The horizontal lines represent the median. The boxes represent the interquartile range (IQR). The IQR includes the 50% of samples closest to the median. The lines above and below the IQR represent either 1.5 times the IQR or the maximum range of the samples if that range is below 1.5 times the IQR. The dots above or below these lines represent outliers that are above or below 1.5 times the IQRs. As determined by the Kruskal-Wallis test, the on-campus nontransfer cohort (CALS FTIC) had a statistically higher mean GPA than the on-campus transfer cohort and the DE MCS cohort in the Spring 2015 semester (left). The mean GPAs of the two transfer cohorts were not statistically different. At the time of graduation, the on-campus transfer cohort (CALS TR) had a statistically lower mean GPA than the on-campus cohort ($p < 0.0005$), but there was no statistical difference between the graduating GPAs of the on-campus FTIC students (CALS FTIC) and DE MCS students or the on-campus transfer (CALS TR) and DE MCS cohort as determined by the Kruskal-Wallis test.

DISCUSSION

Broadening the participation of underrepresented groups is an important goal for STEM, and from this aspect, the DE MCS represents a model with notable success in increasing diversity. Given the higher levels of URMs at 2-year institutions, it is not surprising that the DE MCS program, a transfer program that draws from 2-year programs, is more diverse than the on-campus MCS cohort members who began as freshmen. However, results demonstrate that the diversity of the DE MCS is higher than all undergraduate programs (STEM and non-STEM) and is even higher than the diversity of the state's population. To date, we are not aware of any other STEM undergraduate program at an Association of American Universities institution whose diversity is higher than its overall student population and the state or regional general population.

The DE MCS program is designed to be affordable and does not require any student to live on or near the main campus. Thus, the DE MCS program may appeal to a less affluent student population that simply cannot afford the residential college experience. Lower cost and geographic accessibility are cited as critical factors in increasing the STEM degree attainment of less economically advantaged URM students (Pérez and McDonough, 2008). Interestingly, the proportion of URM students who completed a BS in MCS through either transfer pathway—on-campus or online—was greater than the proportion of URMs who are enrolled in either program.

Another important result is the significant proportion of women (67%) in the DE MCS cohort. This proportion is in stark contrast to the on-campus transfer cohort, which has a statistically lower proportion of women and is majority male (56%). The reasons for this gender difference are not clear but it suggests that women may encounter more barriers than men in transfering to an on-campus program. Minority women encounter barriers in STEM as a result of the interaction of their gender and race, described as a "double bind" (Malcom *et al.*, 1976; Malcom and Malcom, 2011). Many factors, such as culture shock, isolation, lack of social networks, and balancing familial and outside employment obligations, have been identified as contributing to lower retention of minority women in STEM transfer pathways (Reyes, 2011). The format of the DE MCS program may circumvent many of these barriers to success in STEM. In fact, as depicted in Figure 4, Hispanic women have earned 39% of the bachelor's degrees awarded through the DE MCS program, which represents the largest individual demographic sector of the DE MCS graduate cohort and is more than twice the proportion of biological sciences degrees (15%) earned by minority women as reported by the NSF's National Center for Science and Engineering Statistics (2013). The qualitative findings support the notion that the hybrid online format contributes to retention in the program by offering women the flexibility to enroll in a STEM degree program, work, and raise a family.

Not surprisingly, the STEM graduation rate of the hybrid online program has increased substantially to 54% since the initial analysis reported a 21% graduation rate (Drew *et al.*, 2015). One reason for the increase is that the program is maturing and more time has passed to capture retention data of more students. Although the on-campus transfer cohort has a higher retention rate, the difference is not statistically significant. An analysis of time to degree has revelaed that the online students do require more time, one additional semester on average, to complete the BS as compared with the on-campus students. A more thorough analysis of the characteristics, including the identification of predictors of success of the different student cohorts, may identify factors such as employment and dependent status that likely contribute to a longer graduation time for the distance-based cohort. A recent report from the National Student Clearinghouse states that 4 years after transferring to a 4-year institution, 72% of transfer students (originating at a 2-year institution) have either graduated or are persisting in degree attainment (National Student Clearinghouse Center, 2012). This statistic is for all degrees, not just for STEM, but indicates that the DE MCS program is on par with published retention rates for transfer students.

The academic performance data indicate that the hybrid online program provides an education that is comparable to its on-campus counterpart, with similar retention levels and similar GPAs. Cumulative GPAs are not different between the transfer cohorts. To explore academic metrics beyond overall GPA, we compared the performance of the transfer cohorts for several individual STEM courses. Although the on-campus transfer cohort has a higher mean course grade than the DE MCS cohort for most of the courses analyzed, these grade differences are not statistically significant. A focused analysis on the framework and results of the face-to-face microbiology lab experience for DE MCS students is in preparation.

Because it was structured to be as similar to the on-campus programs as possible, online transfer students receive essentially the same education and have the same postbaccalaureate opportunities, which is supported by the retention and academic data and qualitative findings. To date, graduates in the DE MCS BS program have been accepted into STEM graduate programs; medical, veterinary, and dental schools; and some are STEM teachers and research technicians. Despite previous evidence of an achievement gap for Latino students in online classes, there is not an apparent achievement gap in the online hybrid program (Kaupp, 2012). As the DE MCS program continues to grow, future studies will capture additional data, including student perceptions, long-term outcomes, and the role of scholarships, research experiences, and tutoring on student performance and as determinants of success. As identified by Wood *et al.* (2012), environmental factors such as familial responsibilities and social integration activities like clubs are important determinants of transfer of community college student, and these factors will be included in future analyses as the program grows. In summary, the educational outcomes of the on-campus and online programs do not differ, but the hybrid online program significantly broadens participation in STEM pathways. Given these results, we propose a hybrid online degree transfer program as a means to increase participation of women and URMs in STEM.

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