Effects of a Paired Online First-Year Seminar with Developmental Mathematics on College Student Academic Achievement

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There is a growing demand in Texas for more individuals with degrees and certificates in order to remain globally competitive (THECB, 2015). Nearly half of the new jobs created since the 2008 recession went to workers who had some form of higher education (THEF, nd). In addition, those who receive a college degree earn on average a salary nearly 75% more than those without a college degree (Abel & Deitz, 2014). A major challenge to increasing degree attainment is that not all students are ready for college-level courses. The Center for the Analysis of Post-Secondary Readiness (CAPR) reported that 68% of students who began at a community college and 40% of students who began at a public 4-year college took one or more remedial courses (Hodara, 2013). Many of those students placed into remedial courses did not complete prescribed course sequences and persist to graduation (Bailey Jeong, & Cho, 2010).

A number of strategies have been suggested for addressing the issues of readiness for college-level coursework. For example, first-year seminars are courses intended to support the academic and social integration of students and are associated with increased retention and persistence rates (Permzadian & Crede, 2016; Robbins, Oh, Le, & Button, 2009). Although first-year seminars are commonly offered on most colleges and universities, they are not always required of remedial students or intentionally paired with remedial courses to support the specific needs of these students. The purpose of this study was to explore the effect of an intervention in which a first-year seminar was paired with developmental mathematics to improve the pass rates of these courses as well as the overall academic achievement of these students. The findings and implications from this study are discussed.

Literature Review

A significant challenge for college students is the lack of literary and mathematical skills required for college-level coursework. This is particularly true in mathematics where the percentage of students placed into remedial or developmental courses represents almost half of college students nationally (Bailey, Jeong, & Cho, 2010; Hodara, 2013). These students must often take multiple levels of developmental courses before they are ready for college-level coursework. Because developmental courses often do not count towards a degree, this can result in added time and cost to students. The number of noncredit bearing courses can also create additional exit points in a student's path towards graduation which can result in early departure from college. Bailey et al. (2010) found in a study among community college students that "fewer than one half of students complete their sequences, and only 20 percent of those referred to math and 40 percent of those referred to reading complete a gatekeeper course within three years of initial enrollment" (p. 267). Students who delay their enrollment in mathematics are also reported to have lower retention rates and are less likely to graduate within 6 years (Zientek & Lane, 2019). These statistics highlight the importance of needed interventions for underprepared students.

Concerns about the low completion rates of students in developmental education have led to increased efforts by practitioners, researchers, and policymakers to identify strategies for improving the success rates of students in these courses. Some of these efforts include reforms in areas of assessment, instruction (course structure, sequencing, content), and support services, including student success courses (Rutschow, Cormier, Dukes, & Cruz Zamora, 2019). Student success courses or first-year seminars are one of several high-impact practices associated with increased persistence, retention, and graduation rates of college students (Rutschow & Schneider, 2011). Barefoot (1992) identified five basic types first-year seminars including: a) extended

orientation seminars, b) academic seminars with generally uniform academic content, c) academic seminars on various topics, d) paraprofessional seminars, and e) basic study skills seminars. Although there are differences between the types of first-year seminars, these courses generally aim to support the successful transition of students to college. According to national data, first-year seminars are offered on more than 90% of college and university campuses (Young & Hopp, 2014).

Despite the availability of first-year seminars on college and university campuses and the success of these courses for students generally, they are not always targeted to developmental students or paired with developmental courses. Lane and Miller (2019) reported that only 29.7% of two-year colleges required students in developmental education to take a first-year seminar. This may be problematic given the potential benefits of these courses. When students in developmental courses are dually enrolled in a first-year seminar, they have been reported to persist at higher rates from fall to spring (Barnes, 2012). There is also evidence to suggest that students entering on probationary status who concurrently enrolled in a first-year seminar passed their courses and held a higher GPA at the end of the term than students who did not enroll in a first-year seminar. Despite this evidence, there remains a gap between the high number of students placed into developmental education and the low percentage of institutions pairing first-year seminars with developmental courses.

Further complicating developmental education reforms are rapid changes in technology. There has been considerable growth in the use of computer-assisted delivery methods for developmental courses, making the use of online instructional practices relevant in other contexts. Yet support services have not necessarily adapted to changing technology at the same pace. Most first-year seminars continue to be offered in a traditional face-to-face format which may not meet

the needs of the developmental education population. For example, Hawley and Chiang (2017) reported that adult undergraduates accounted for more than half of all developmental education participants in Ohio. This is likely a function of the other obligations that non-traditional students or adult students have in comparison to their traditional student peers (work, family, etc.) and perhaps why this population comprises such a large percentage of online course enrollment (Johnson, 2015). Without a greater effort to blend technology across courses (developmental courses and first-year seminars), students may not receive the necessary support to be successful in developmental courses.

There is a need to better support students who are academically underprepared for college. First-year seminars can help to serve as an intervention for academic skill development and are associated with positive outcomes for students (Rutschow & Schneider, 2011). The problem is that first-year seminars are not always paired with developmental education courses or offered in formats conducive to the needs of this population. The purpose of this project was to create an online first-year seminar for student placed into developmental mathematics and explore the effects of this course on their academic achievement. The following research questions guided this study:

- What is the relationship between enrollment in a first-year seminar, performance in devel opmental mathematics, and student's overall GPA at the institution?
- What are the differences in performance outcomes between students who enrolled in any first-year seminar versus a first-year seminar specifically designed for students in devel opmental mathematics?

Method

A quasi-experimental design was used in this study to compare the effect of participation in an online first-year seminar (UNIV 1301) on the academic performance of students placed into developmental mathematics (MATH 0333). Because random assignment of participants was not possible in this study, inverse probability of treatment weighting (IPTW) was used to mitigate potential bias due to self-selection into a first-year seminar. Groups were then compared on their likelihood of passing a developmental mathematics course and their overall GPA at the institution. The data were obtained from the institution's Office of Institutional Research. The study was approved by the university's Institutional Review Board.

Participants

Data collection for this study began in fall 2018 and eligible participants included those students placed into a traditional developmental mathematics course. The state of Texas requires all entering students to be assessed for college readiness in mathematics, reading, and writing (TEC, Chapter 51, Subchapter F-1). Each student must meet the institution's respective TSI requirement or receive an exemption through scores on the ACT, SAT, or State of Texas Assessment of Academic Readiness (STAAR) prior to placement into a college-level English or Mathematics course. Students who do not meet this requirement are placed into developmental education. In addition to placement criteria, the state of Texas also requires that a certain percentage of students placed into developmental education at the institution to receive instruction through a corequisite model (HB 2223, 2017). Corequisite models allow students to enroll in a college-level English or mathematics course but also require that students concurrently receive academic support, usually in the form of developmental or remedial course. The institution in this

study placed students who earned a TSI score of 340 – 349 into the corequisite model while those who scored below 340 were placed into a traditional developmental mathematics course (MATH 0333). This study explored only those students who scored below 340 on the TSI and were placed into a traditional developmental mathematics course. Sam Houston State University provides only one level of remedial or developmental mathematics for students who are not TSI complete.

Table 1
Placement Criteria for Students in Developmental Mathematics

Course	TSI	Placement
Passing	350+	College-level Ready
Developmental Coursework	340–349	Co-Requisite Model Available
Required	340	Developmental mathematics Math 0333

A total of 692 students were placed into a traditional developmental mathematics course between the fall 2018 and fall 2019 semesters. This sample was then restricted to only those students who were first-time enrolled in college to reduced issues associated with individuals who transferred to the institution having previously taken a remedial course. This resulted in a final sample of 645 students, of which 39.2% were White, 32.1% African-American or Black, 22.0% Hispanic, 3.6% multi-racial, 0.6% Asian, and 0.8% Native Hawaiian or Native American. Approximately 54.6% of the sample was reported to be Pell-eligible, 13.3% STEM majors, and 32.2% were concurrently enrolled in a first-year seminar. The average age of students in the sample was 19 with an SAT score of 968 and an ACT of 18 (Table 2-3).

Table 2
Demographic Characteristics of Students Enrolled in MATH 0333 Developmental Mathematics (N = 645)

Demographics	N	%
African American	207	32.1
Native American	5	0.8
Asian	4	0.6
Hispanic	142	22.0
International	6	0.9
Multiple Races	23	3.6
Native Hawaiian	1	0.2
Unknown	4	0.6
White	253	39.2
Pell Eligibility	352	54.6
STEM Major	86	13.3
Conditional Admission	165	25.6
First-Year Seminar	208	32.2
Math Frameworks Learning Community	18	2.8

Table 3
Descriptive Statistics for Students Enrolled in MATH 0333 Developmental Mathematics

	M	SD
High School GPA	3.33	0.38
SAT	968.74	82.01
ACT	18.43	2.02
Age	19.61	4.97

Math Frameworks Learning Community

All students placed into the traditional developmental mathematics course (MATH 0333) were then invited to participate in an online first-year seminar to support their academic skill development. The course was offered as a special section of UNIV 1301 that was paired with developmental mathematics. All first-year seminars at the institution are delivered under the prefix UNIV 1301 (Introduction to Collegiate Studies) and operate as a three-credit-hour elective that is not included

as part of the institution's core curriculum. There are approximately 20 sections of UNIV 1301 offered each fall to students and some sections are grouped around themes and experiences of select academic programs. Several sections of UNIV 1301 are also offered as learning communities in which students take two or more courses together. All UNIV 1301 sections have common course objectives and complete some of the same course activities. For example, all sections focus on core competencies of critical thinking, communication skills, and social responsibility. All sections also participate in the university's common reader program. However, specific course assignments and curriculum may vary across sections, depending on whether the course is stand-alone, paired with another academic course, or part of a learning community. Students in the Math Frameworks Learning Community concurrently enrolled in both UNIV 1301 and developmental mathematics (MATH 0333).

The purpose of the first-year seminar associated with the Math Frameworks Learning Community was to help students develop the strategies necessary to succeed in mathematics, in other college coursework, and in their careers. Curriculum for this first-year seminar was adapted from the Frameworks for Mathematics and Collegiate Learning course developed by the Dana Center at the University of Texas at Austin (Charles A. Dana Center, 2014). Frameworks was field tested in partnership with community colleges across Texas and focused on four primary content areas: A) building community and connecting to campus resources, B) motivation, C) strategies and skills, and D) finding direction in college. Frameworks was also designed to be paired with a quantitative literacy-based course (Foundations of Mathematical Reasoning) as part of the Dana Center Mathematics Pathways project (DCMP). As a result, lessons and course activities directly connect back to mathematical concepts or attitudes and behaviors shown to positively impact mathematics performance among students. Rutschow and Diamond (2015)

reported that the DCMP resulted in a higher percentage of students who had completed a college-level statistics course by the end of the following spring semester.

Although similarities existed between the Frameworks course and the first-year seminar in the Math Frameworks Learning Community in this study, Frameworks was not developed for delivery in an online format and required modification. The first-year seminar in this study was offered online for several reasons. The demand for online courses has increased in recent years and there is a need to explore how first-year seminars can be successfully delivered using this instructional modality. Developmental education serves a higher number of adult learners and online courses provide needed flexibility for students navigating work or other obligations. There has also been growth in the use of computer-assisted delivery methods for developmental mathematics courses making the use online instructional modalities relevant in other courses.

To redesign the first-year seminar for an online context, the original Frameworks lessons were thematically grouped into 15 units with approximately equal levels of course content and activities. Some lessons were also expanded to help students better acclimate to a digital learning environment. The course was then reviewed by instructional designers and evaluated in the following areas: general course information, presentation of course content, collaboration and communication, assessment strategies, course technology, learner support, and accessibility and ADA Compliance. Information about the development and evaluation of this online first-year seminar are detailed further in Lane (2019).

Data

Grouping Variable. Students in the sample were grouped into one of three categories for comparison. The categories included (a) participation in a first-year seminar, (b) participation in

first-year seminar associated with the MFLC, or (c) no participation in a first-year seminar. There were 208 students (32.2%) in the sample who self-selected into a first-year seminar while taking their developmental mathematics course. Twenty of these students were associated with the MFLC. The number of students who did not participate in any first-year seminar was 437.

Covariates. Several covariates were included in the study to control for bias due to self-selection into a first-year seminar. The covariates included the student's age, ethnicity, and Pell eligibility given their relevance to remedial course placement in the literature (Crisp & Nora, 2010; Kolajo, 2004; Melguizo et al., 2008; Wolfle & Williams, 2014). Race and ethnicity were collapsed into four categories (White, Black/African American, Hispanic, and other) to ensure the groups were large enough for meaningful comparison. The study also considered the students' prior performance on standardized assessments (SAT and ACT) as well as their admission status into the institution (conditional admission vs. regular admission).

Outcome Measures. The outcome measures in this study included the student's performance in their developmental mathematics course and overall GPA at the institution (4.0 scale). Mathematics course performance was recoded into a dichotomous variable separated by students who (a) passed by earning a grade of C or above or (b) did not pass by earning a grade of D, F, or withdrew from the course.

Propensity Score Analysis

Propensity score analysis (PSA) was used as a quasi-experimental method to explore the impact of participation in a first-year seminar on the outcomes in this study. The use of propensity scores to minimize bias in non-randomized studies can be traced back to the seminal work of Rosenbaum and Rubin (1983). Propensity scores are an estimation of a participant's likelihood to

be assigned to a specific group and can be used in four ways: covariate adjustment, stratification, matching, and inverse probability of treatment weighting (IPTW). Inverse probability of treatment weighting (IPTW) was used over other available PSA methods to maximize sample retention. Inverse probability of treatment weighting (IPTW) uses propensity scores as weights in a manner similar to survey sample weighting. Propensity score matching and IPTW have been reported to comparably remove systematics differences between group in some studies (Austin, 2011).

Propensity scores were estimated through logistic regression to predict participation in a first-year seminar. The covariates used in score estimation included the student's age, race, ethnicity, Pell eligibility, SAT score, ACT score, and admission status (conditional vs. non-conditional) as covariates in the model. The estimation of the effects from participation in a first-year seminar were then computed using the approach discussed in Lunceford and Davidian (2004). The average treatment effect (ATE) was estimated as

$$\frac{1}{n}\sum_{i=1}^{n}\frac{Z_i Y_i}{e_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{(1-Z_i)Y_i}{1-e_i}$$

where Z denotes treatment assignment, e is the propensity score, and Y is the outcome variable. The effect of the weighting on sample size was adjusted through generalized estimation equation approach.

Results

The groups were compared for differences in the passing rates of students' developmental mathematics course (MATH 0333). The percentage of students who earned a grade of C or better was 78.8% in the first-year seminar group. This was approximately 12 percentage points higher than the passing rate of non-participants (students who did not participate in any first-year seminar).

Students in the first-year seminar associated with the Math Frameworks Learning Community also performed better than non-participants (72.0%), although this increase was not as large as what was observed from students in other first-year seminar sections.

Logistic regression was then used to evaluate statistical differences in passing rates for developmental mathematics (MATH 0333). A generalized estimation equation was used to adjust the statistical power of the analysis based on IPTW. Despite differences in the passing rates between the groups, the observed differences were not statistically significant (Table 4). To aid in the interpretation of the data, odds ratios were also computed to evaluate the magnitude of the observed differences. Statistical significance testing evaluates only the probability of obtaining a result given certain conditions (e.g., sample size) and not necessarily the importance of it. Much has been written on the value of interpreting effect sizes in conjunction with statistical tests (Hanel & Mehler, 2019; Thompson, 2001; Vacha-Haase & Thompson, 2004). Those who participated in a first-year seminar were 1.9 times more likely to earn a passing grade (C or better) in their developmental mathematics course.

Table 4
Summary of Statistical Tests and Odds Ratios

	Passed	%	B	SE	x^2	df	p	Odds
No FYS	283	66.00						
FYS	135	77.80	0.63	0.33	3.56	1	.06	1.87
MFLC – FYS	14	72.20	0.26	0.89	0.09	1	.77	1.30

The students' overall GPA at the institution was also compared between the groups using regression analysis. A categorical coding scheme was used for the grouping variable. Students

who did not participate in a first-year seminar (non-participants) were used as the reference group. Non-participants had a weighted mean GPA of 2.06 (SD = 1.04). This overall GPA was notably lower than the GPA of students who enrolled in a first-year seminar ($\bar{x}$_gpa = 2.33, SD = 1.05) and students enrolled in the Math Frameworks Learning Community first-year seminar ($\bar{x}$_gpa = 2.43, SD = 0.76). Despite these observed differences, the regression did not yield any statistical differences between the groups (F[2,496]= 2.262, p = .105). The effect size between the first-year seminar groups and non-first-year seminar groups ranged between d = 0.26 – 0.41.

Table 5
Summary of Regression Weights

	B	SE	β	t	p	d
No FYS	2.06	0.12		17.28	<.01	
FYS	0.27	0.13	.10	2.10	.04	0.26
MFLC – FYS	0.37	0.48	.04	.78	.44	0.41

Discussion

The purpose of this study was to evaluate the effect of an online first-year seminar for students placed into developmental mathematics. Given the number of students who come to college academically underprepared and who are not ready for college-level mathematics (Bailey et al., 2010; Hodara, 2013), interventions are needed to help support the success of these students. The purpose of the Math Frameworks Learning Community was to provide an intervention (online first-year seminar) to support the skill development of those students placed into developmental courses. Such interventions can help to further our understanding of which reforms may be more effective in supporting these students.

The findings from this study did not show any statistical differences in academic performance based on participation in a first-year seminar. The sample size of the MFLC was small and likely affected statistical power in this study. As a result, it is also possible that the observed differences may be normal random fluctuations due to sampling error. However, the potential value of these seminars should not be dismissed either. Students who enrolled in a first-year seminar had both notably higher odds of passing their developmental mathematics course (1.9 times) as well as a GPA 0.25 points higher than their peers. These results, if replicable, would have practical implications for students underprepared for college-level coursework. It is also important to highlight that the findings in this study yielded patterns that were consistent with prior research, even if not statistically significant. For example, Barnes (2012) reported that participation in a first-year seminar was associated with higher pass rates for students dually enrolled in developmental courses as well as higher end of term GPAs for probationary students. The similarities between these findings offer some level of convergent validity, but continued collection of data is necessary to better inform whether this approach may be effective for developmental education students.

Unlike Barnes (2012), the first-year seminar in the Math Frameworks Learning Community was delivered online. It is possible that the modality of instruction affected student performance in the course. Some studies have suggested students taking online courses perform substantially worse (Bettinger, Fox, Loeb, & Taylor, 2017), but other studies have suggested students perform similarly in online and face-to-face classes (Jaggars & Bailey, 2010) when the "lectures, materials, learning modules, quizzes, and tests presented in the online and face-to-face classrooms were reasonably equivalent" (p. 4). The activities and learning assessments varied between the Math Frameworks Learning Community and other UNIV 1301 sections in this study, but it also possible

that both equally met the same learning objectives. Regardless, there was no evidence in this study to indicate that participation in the online first-year seminar lowered student's academic performance, at least relative to non-participants.

Online courses are not a panacea for developmental education, but the unique challenges of this population cannot be ignored. Students enrolled in developmental education are more likely to be non-traditional students (Hawley & Chiang, 2017), a population typically in need of the flexibility that online courses provide (Johnson, 2015). For online courses to be successful, Dixon (2010) suggested that faculty create opportunities for students to interact with one another (e.g. group projects, peer review, discussion forums). The purpose of first-year seminars naturally lend themselves to these types of activities, but faculty should be prepared to engage with students in multiple ways. "For instance, instructors need to use several channels: announcements on the homepage of the course delivery system, e-mails to students, discussion forums in which the instructor interacts, and online lectures or connect sessions and chats, to enhance engagement (Dixon, 2010, p. 8). This may be particularly important in a course intended to support both academic and social integration onto campus.

It has also been suggested that colleges provide readiness activities for students considering online courses (Jaggars et al., 2013). It is not clear from this literature what these readiness activities might look like or include, but one suggestion may be to provide students with access to a sample course unit or assignments. One of the benefits of an online course is that course content and assignments are already curated for faculty and students. This project may provide those interested in delivering an online first-year seminar with sample lesson plans and activities to familiarize students with online course instruction and to prepare them for expectations when taking courses through this modality.

Conclusion

A significant proportion of college and university students take one or more remedial courses while enrolled in college (Hodara, 2013). Many of these students do not complete prescribed course sequences and persist to graduation (Bailey Jeong, & Cho, 2010). The purpose of the Math Frameworks Learning Community was to provide an online first-year seminar to support the academic skill development of these students. Online course options may provide needed flexibility given the non-traditional characteristics of many of developmental students. Online courses options also align with the growth of computer-assisted delivery methods for developmental mathematics. The findings from this study did not show statistical differences in academic performance based on participation in the online first-year seminar, but the trends associated with this data were in the hypothesized direction and may reflect a viable option for developmental students if results can be further replicated.

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