FOCUS: Sustainable Mathematics Successes

By Selina V. Mireles, Taylor W. Acee, and Lindsey N. Gerber

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Abstract: ***The FOCUS (Fundamentals of Conceptual Understanding and Success) Co-Requisite Model Intervention (FOCUS Intervention) for College Algebra was developed as part of the Developmental Education Demonstration Projects (DEDP) in Texas. The program was designed to use multiple services, courses, and best practices to support student completion of a credit-bearing mathematics course. The curriculum design and instructional strategies of the College Algebra FOCUS band are described and examples are included to expand on the richness of the model. Using repeated measures of students' mathematics proficiency and baseline comparison group data of students' course grades, we present evidence linking the FOCUS Intervention with increased mathematics proficiency, fewer course withdrawals, and improved course grades.***

Researchers have shown that college students who place three levels below their first credit-bearing mathematics course have a 10% pass rate (Bailey, 2009). Myra Snell showed, at Los Medanos in California, only 18% of the students starting two levels below credit-bearing mathematics passed (Hern, 2010). Snell helped to redefine this attrition problem by identifying its cause as the length of the DE course sequence. Using the "multiplication principle," (Hern, 2010, p. 2) Snell reasoned that even if course success rates increased to 75% and of those who succeeded 75% enrolled in the next course there would still be an attrition problem for students needing to take three DE mathematics courses. This is because by the time students advanced through their first credit-bearing mathematics course only 13% of the original group would have passed the course. Designed to address this attrition problem, the FOCUS Intervention provides students with more opportunity to succeed by providing them with an alternative route to enrolling in developmental and credit-bearing mathematics courses.

The FOCUS Model

The FOCUS (Fundamentals of Conceptual Understanding and Success) model is best represented by a three-legged stool as a way to visualize the interdependent relationship of the program components (see Figure 1). The seat of the stool, the credit-bearing course, is supported equally by Developmental Mathematics, Learning Support, and Academic Support Services and the rim of the stool showcases the use of research-based best practices, such as the Concrete-Representational-Abstract (CRA; The Access Center, 2004) model, deconstruct/reconstruct (Mireles, 2010) and cooperative learning groups. The credit-bearing course has been developed via a backwards design utilizing state and local mandatory objectives. Subsequently, a developmental mathematics course comprised of just-in-time curriculum is offered in tandem with the credit-bearing course. Perhaps the most novel aspect of the FOCUS model is the introduction of learning support—a three-part approach (real-world problems, hot topics, and Q&A)—to contextualize mathematics concepts. Another essential component is the effective use of Academic Support Services, especially required tutoring.

FOCUS Intervention Curriculum Design and Instructional Strategies

FOCUS Intervention was a comprehensive program designed to support developmental mathematics students in completing their credit-bearing mathematics course. Students enrolled in the FOCUS Intervention program were registered in a developmental mathematics course and credit-bearing mathematics course concurrently; they engaged in learning support in addition to mandatory participation in Academic Support Services or "wrap-around services." Wrap-around services included weekly/monthly seminars, mentoring, and tutoring. To provide a holistic educational experience for the students, the curriculum and instruction were carefully coordinated and developed.

Curriculum Design

First, the credit-bearing mathematics' scope and sequence was designed. The organization of the concepts provided an organizational structure to the ideas for the students and was a critical aspect to students' understanding of the mathematics. Another noteworthy point is that some ideas such as that of continuity were discussed from an intuitive notion since those concepts are not normally in College Algebra. The logistic function also exceeded traditional expectations for College Algebra. However, when the students gained a deeper understanding of a function they were able to organize the functional ideas accordingly, including additional families of functions. More recent iterations of the program include sequences and series and the binomial distribution function.

Next, the developmental mathematics concepts and sequencing were chosen to support the content taught in the credit-bearing mathematics course. For example, prior to teaching solving systems of equations with matrices in College Algebra, the students were taught how to solve systems of equations using graphing, addition, and substitution methods in the developmental mathematics course. Complementing this Just-in-Time Teaching approach (Novak, 2011) is the idea that the developmental mathematics course is not exclusively algebraic. That is, the developmental mathematics course utilized an algebraic core extended to include geometry, measurement, probability, and statistics. The notion of "deconstructing" misunderstanding and "reconstructing" conceptual knowledge was prevalent in the developmental mathematics curriculum (Mireles, 2010). An example of deconstruct/reconstruct (D/R) was that students who used "FOIL" (first, outside, inside, last) for multiplying binomials confronted its limitations and were taught the distributive property. The D/R deconstructed their memorization of a limited and highly contextualized rule and built conceptual understanding that was more generalizable or reconstructed more powerful knowledge.

Classroom Learning Structure

The learning support aided in teaching students the importance of the mathematics they were learning and how to apply that to real-world applications. The learning support time was divided into three sections: lessons on connections between mathematics and real-world using (a) technology, (b) hot topics, and (c) question and answer. The hot topic section was dedicated to discussing common misconceptions and/or misunderstandings of mathematical topics covered that week by using alternative approaches than those used in the classroom. Normally, 50% of the class time was dedicated to connections of mathematics topics and 30% of the time was spent on covering hot topics, leaving 20% dedicated to question and answer. In general, the Learning Support Class was offered weekly for 1 hour. An example topic used in learning support to connect science and mathematics was to simulate the Rutherford's Gold Foil Experiment (Purdue University, n.d.) with marbles to gather empirical data and use probability to determine the width of the marble, similar to Rutherford's experiment for measuring the nucleus of the atom in gold foil.

After the scope and sequence for the credit-bearing, developmental mathematics and learning support were developed, then lesson plans were created. The instructional strategies used in teaching these three areas included jigsaw (Aronson & Patnoe, 2011), discovery-based learning and the use of manipulatives—Concrete to Representational to Abstract (CRA; The Access Center, 2004)—and technology. Research has shown that these instructional strategies have been effective in the classroom (Cohen, 1995; Moore, 2009). An example activity in a developmental mathematics lesson plan was multiplying binomial expressions using the CRA model. First, the students learned how to multiply binomial expressions using algebra tiles (C = concrete), then the concrete representation was connected to the area model (R = Representational model). Then students practiced abstractly (A = Abstract) using the distributive property. An example of a jigsaw activity incorporated in the

The learning support model was a three-part approach generalizable to any mathematics course.

College Algebra curriculum dealing with rational equations. The students formed two groups: a home group and an expert group. Students began in their home group—in this example three people per home group—and each student was given one topic: (a) solving rational equation using proportions, (b) least common denominator, or (c) least common multiple. Then students from each home group grouped by topic to become experts. Once they mastered the topic they returned to their home groups to teach their home group what they learned.

Learning support has the role of mutually supporting the relationship between abstract mathematical concepts to the perceived relevancies of mathematics for this student population. The learning support model was a three-part approach generalizable to any mathematics course: (a) capstone problems that were contextualized, real-world problems with cultural relevance (Mireles, Rahrovi, & Vásquez, 2013), situational mathematics, and technology; (b) mini-instruction of "hot topics" through an expertise-based method (Bereiter & Scardamalia, 1993; Ericsson, 2006; Hatano & Inagaki, 1984); and (c) Socratic-style questioning targeting critical concept attainment especially using the algorithmic instructional technique (AIT; Vásquez, 2003). The Learning Support instructors built a set of lesson plans and activities that were used to engage students and meet the objectives of this program. In the classroom, the instructors of the Learning Support labs helped facilitate the labs and provided personal attention to students' needs. An example Learning Support activity used in the College Algebra course was using graphing calculators and Calculator Based Rangers (CBRs™) to understand continuous and discontinuous functions. The students were given graphs that represented time versus distance. Using the CBR, the students would walk toward or away from a wall to create the same graph on the calculator. One of the graphs was a step function, a popular yet difficult to comprehend discontinuous function. The students were provided a hands-on experience regarding the modeling of these functions thus allowing for a deeper understanding.

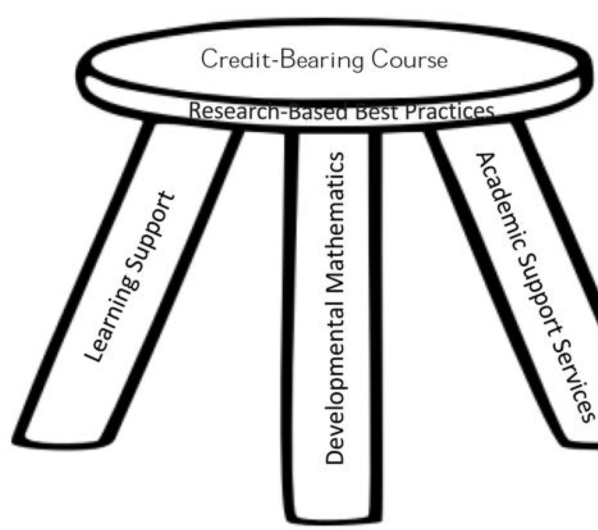

***Figure 1.* Visual representation of the FOCUS program modeled as a 3-legged stool.**

Research Questions

Two research questions were formulated for this study of the FOCUS Intervention:

> RQ1: How does the FOCUS Intervention influence student mathematics proficiency?
>
> RQ2: Do students who participate in the FOCUS Intervention experience differential markers of success as compared to a similar group who did not participate in the intervention?

Methods

Research Design

Two different research designs were used. A within-subjects pretest-posttest design was used in the testing of Research Question 1. Students' in the FOCUS Intervention were required to complete the Texas Higher Education Assessment (THEA; THECB & TEA, 2009), a measure of mathematics proficiency, at the beginning and end of the semester. A between-subjects quasi-experimental research design was used in the testing of Research Question 2. We created a baseline comparison group using data on students enrolled in College Algebra during the year before the implementation of the FOCUS Intervention so that we could compare course grades between students in the FOCUS Intervention and students in the baseline comparison group.

Participants

We obtained data for students who enrolled in the FOCUS Intervention ($N = 127$): Summer 2010 ($n = 20$), Summer 2011 ($n = 13$), Spring 2012 ($n = 37$), Summer 2012 ($n = 23$), and Fall 2012 ($n = 34$). We also created a baseline comparison group ($N = 1994$) using data from students who enrolled in traditional offerings of College Algebra during the year prior to the implementation of FOCUS, that is: Summer 2009 ($n = 451$), Fall 2009 ($n = 741$), and Spring 2010 ($n = 802$).

Table 1 describes the gender and ethnicity of students in the FOCUS Intervention and baseline comparison group. Students in the FOCUS Intervention had a mean age of 27.01 ($SD = 9.34$) and a median age of 23, whereas students in the baseline comparison group had a mean age of 21.69 ($SD = 4.80$) and a median age of 20.

Procedures

At this university, admissions data were used to identify a subset of entering students (e.g., students with low or no SAT or ACT scores) to take standardized tests for possible placement into DE (developmental education) coursework. Placement into DE coursework was then based on university-defined cut-scores, often higher than state standards (e.g., a cut-score of 270 on the THEA mathematics was used), for different placement tests that were available to students (e.g., ACCUPLACER and COMPASS).

Students who placed into developmental mathematics were eligible to apply for enrollment in the FOCUS Intervention. A panel of faculty selected candidates from this pool of applicants based on criteria such as repeated failure of developmental mathematics, first-generation college student, veteran, and enrolled in multiple developmental education courses. Students in the FOCUS Intervention, who placed into developmental mathematics, were given permission to bypass enrolling in the traditional developmental mathematics coursework sequence and instead enroll in the FOCUS offering of College Algebra, which provided additional content and support for students as described in detail in the previous sections. As part of the FOCUS Intervention, students were required to complete pretest and posttest THEA assessments, administered at the university's testing center, which were used to help evaluate the intervention.

Using data from the year prior to the implementation of the FOCUS program, we created a baseline comparison group of students who enrolled in traditional offerings of College Algebra that barred students who placed into developmental mathematics from enrolling until they completed their developmental mathematics coursework or retook and passed their placement test. Because students in the FOCUS Intervention placed into developmental mathematics, we only selected students to be in the baseline comparison group if they enrolled in developmental mathematics coursework, thus helping to establish a more comparable comparison group. Data on students' DE course enrollment from 2004-2009 was used for this selection. Placement test score data was not available for the baseline comparison group, only whether or not they completed their developmental mathematics coursework.

Table 1

Gender and Ethnicity of Participants

Demographic Characteristics	FOCUS Intervention ($N = 127$)		Baseline Comparison Group ($N = 1994$)	
	n	%	*n*	%
Gender				
Female	73	57.5	1291	64.7
Male	54	42.5	703	35.3
Ethnicity				
Black, non–Hispanic	14	11.0	176	8.8
Hispanic	40	31.5	633	31.7
White, non–Hispanic	53	41.7	1085	54.4
Other	20	15.7	100	5.0

Note. Students in the FOCUS Intervention reported Asian/Pacific Islander ($n = 2$), International ($n = 2$), and unknown or did not specify ($n = 16$) whereas, the baseline comparison group reported Asian/Pacific Islander ($n = 51$), American Indian/Alaskan Native ($n = 13$), International ($n = 8$), and unknown or did not specify ($n = 8$).

Measures

In this study we used two dependent variables, THEA mathematics test scores and course grades. The mathematics section of the THEA measures students' proficiency related to four general areas: fundamental mathematics, algebra, geometry, and problem solving (Pearson Education, 2013). Scores can range from 100-300. The minimum passing standard for the THEA is a score of 230. Students' course letter grades in College Algebra were obtained from institutional records along with their age, gender, and race/ethnicity. These data were obtained for students in the FOCUS Intervention and students in the baseline comparison group, whereas pretest and posttest THEA data were only available for students in the FOCUS Intervention.

Analyses and Results

Change in Mathematics Proficiency for the FOCUS Group

First, we examined participants' change in their THEA mathematics scores from the beginning to the end of the semester for students enrolled in the FOCUS Intervention. We ran a two-tailed paired t-test with time (pretest, posttest) as the within subjects factor. Of the 127 students, 12 did not complete the pretest or posttest THEA leaving 115 students for this analysis. We found that students made a statistically significant increase from pretest to posttest (M_{pre} = 210.43, SD_{pre} = 28.85, M_{post} = 227.61, SD_{post} = 28.49, M_{diff} = 17.17, t = -6.51 (114), p = .01, d = .61). In addition, we examined the percentage of students who met the THEA mathematics passing standard at pretest and posttest: At pretest, 27 students (23.5%) met the standard; at posttest, 60 students (52.2%) met the state standard.

We also wanted to determine if change in the THEA was related to the semester/year a student enrolled. It seemed possible that students could have benefited more or less during some administrations of the intervention compared with others. Therefore, we ran a repeated measures analysis of variance (ANOVA) and examined the interaction between the within-subjects factor time (pretest, posttest) and the semester/year the intervention was administered (Summer 2010, Summer, 2011, Spring 2012, Summer 2012, Fall 2012). We did not find a statistically significant interaction effect.

Course Grades Earned for FOCUS and Baseline Comparison Groups

FOCUS Intervention participants had a greater percentage of A-C grades than the comparison group. Table 2 shows the frequency and percentage of each letter grade earned by students in the FOCUS Intervention and baseline comparison group.

First, we examined the extent to which the FOCUS Intervention had a different percentage of students who withdrew from the course compared to the baseline comparison group. Using binary logistic regression we examined the FOCUS Intervention (1= received, 0 = not received) as a predictor of student course withdrawal (1 = withdrew, 0 = did not withdraw) after controlling for students' age (in years), gender (0 = female, 1 = male), and ethnicity (we dummy coded four categories: White, non-Hispanic (reference category); Black, non-Hispanic; Hispanic; and other ethnicity). We used a bootstrapping method with 2,000 samples stratified by intervention and comparison groups. The model was statistically significant (Chi-square = 55.64(6), $p < .01$). The regression coefficient for the FOCUS Intervention was statistically significant and suggested that students in the FOCUS Intervention were less likely to withdraw from their College Algebra course compared to students in the baseline comparison group (see Table 3). Odds ratio is a measure of effect size. Odds ratios greater than 1 indicate a greater odds when compared to the reference group. Odds ratios lower than one indicate a lower odds compared to the reference group. Because the intervention group was less likely to withdraw from the course, the odds ratio for the intervention effect (0.22) is less than 1. This odds ratio is also large; a rule of thumb for interpreting the size of odds ratios is: when less than one (small = .67, medium = .40, large = .23) and when greater than one (small = 1.5, medium = 2.5, large = 4.3). In regards to the statistical significance of covariates included in this regression model, male students were more likely to withdraw than female students, older students were more likely to withdraw than younger students, and there were no statistically significant effects of ethnicity on course withdrawal (see Table 3).

Secondly, we examined the course grades of students who did not withdraw from their College Algebra course (N = 1787). We transformed students' course letter grade in College Algebra into the number of course grade points earned where a grade of A = 4, B = 3, C = 2, D = 1, F = 0. Students in the FOCUS Intervention (n = 119) scored a mean of 2.62 grade points (SD = .95), whereas students in the baseline comparison group (n = 1668) scored a mean of 2.11 grade points (SD = 1.22). Using multiple regression, we examined intervention effects on course grade points earned after controlling for students' age, gender, and race/ethnicity. We used a bootstrapping method with 2,000 samples stratified by intervention and comparison groups. The model was statistically significant (F = 7.28(6), $p < .01$, R^2 = .02). There were statistically significant effects for ethnicity and intervention but not for age or gender (see Table 4, p. 30).

The results suggested that students in the FOCUS Intervention earned significantly more grade points towards their GPA from College Algebra as compared to students in the baseline comparison group. However, the effect size was small; it only accounted for one percent of the variation in course grade points earned. In regards to the statistical significance of covariates, Hispanic students and Black, non-Hispanic students earned fewer grade points compared to White, non-Hispanic students. The effect sizes for these two

Table 2

Course Letter Grades by FOCUS Intervention and baseline comparison group

Course Grade	FOCUS Intervention (N = 127)		Baseline Comparison Group (N = 1994)	
	n	%	n	%
A	24	18.9	215	10.8
B	39	30.7	473	23.7
C	45	35.4	494	24.8
D	9	7.1	257	12.9
F	2	1.6	228	11.4
Withdrawal	8	6.3	327	16.4

Table 3

Binary Logistic Regression Analysis Predicting Course Withdrawal

Variable	b	SE^a	95% CI[a]	Odds Ratio
Age	.05**	.01	[.03, .08]	1.05
Male	.48**	.12	[.25, .72]	1.61
Black, non–Hispanic	–.20	.25	[–.73, .23]	.82
Hispanic	–.01	.14	[–.28, .27]	.99
Other ethnicity	.06	.28	[–.49, .55]	1.06
FOCUS Intervention	–1.50**	.39	[–2.33, –.98]	.22

Note. *$p < .05$, **$p < .01$. Age is in years. Reference category for male is female. Reference category for race/ethnicity is White, non–Hispanic. [a] Bootstrapping results.

effects were also small; together they accounted for 1.2% of the variation in course grades.

Discussion

Students who placed into developmental mathematics courses at the university were traditionally barred from taking College Algebra and required to first complete their developmental education courses. As part of the FOCUS Intervention, students were permitted to enroll in College Algebra while simultaneously completing developmental mathematics coursework and participating in required learning support and academic support. The concurrent enrollment in developmental mathematics and college algebra course with the Just-In-Time Teaching (JIT) approach aided students in building the foundation they needed prior to learning a more complex concept in the College Algebra course. Students in the FOCUS Intervention made statistically significant improvements in their mathematics proficiency as measured by THEA mathematics scores.

Despite increases in THEA scores, 55 (47.8%) of students still did not meet the state standard score. The FOCUS Intervention courses were of similar difficulty as the regularly offered College Algebra as these courses were aligned to the departmental syllabus. Because we did not have a comparison group that used pretest and posttest THEA assessments we do not know whether the observed increase in THEA mathematics scores was an improvement relative to the status quo. For Research Question 2, we compared students in the FOCUS Intervention with students from the previous year who did not have the FOCUS Intervention available to them and who, like students in the FOCUS Intervention, placed into developmental mathematics courses. These results suggested that students in the FOCUS Intervention were significantly less likely to withdraw from their College Algebra course compared to students in the baseline comparison condition: 6.3% of students withdrew in the FOCUS Intervention compared to 16.4% in the baseline comparison group, and the effect size for this result was large (odds ratio = .22). Furthermore, students in the FOCUS Intervention were significantly more likely to earn higher grades. The students in the FOCUS Intervention earned an average of 2.61 grade points, whereas students in the baseline comparison group earned on average 2.12 grade points. However, the effect size for this result was small ($\eta^2_p = .01$) and explained only 1% of the variation in students' grade points earned. Limitations of this research include but are not limited to: pretest-posttest THEA mathematics scores only being available for students in the FOCUS intervention, lack of random assignment to groups, differences in instructors for students in the intervention and comparison group, and generalizability of results to students in community colleges.

The idea of transforming traditional courses and pathways into a dynamic program is fundamental to the successful academic trajectory.

Implications

The first implication is the clear impact of the transformation of the traditional offering of College Algebra. This study focused on the curriculum and instruction aspects of the intervention that were one critical piece to the FOCUS Intervention. In the spirit of addressing college readiness, the FOCUS Intervention utilizes a programmatic approach as opposed to that of a single classroom. The second implication is that of a more efficient educational system. The FOCUS Intervention provided a construct for reducing student time to degree and costs. Many colleges and universities are incentivized through funding to assist students to enroll and complete first-year credit-bearing courses. The FOCUS Intervention provides a model to meet these goals in mathematics, an important gateway course/content area.

Conclusion

The primary strength of the FOCUS Intervention lies in the manner in which the curriculum and instruction was designed. The College Algebra and developmental mathematics courses use Backward Design and an algebraic core with extensions to geometry, measurement, probability, and statistics to yield a holistic curriculum. And it is delivered using instructional methods that are based on research and best practices such as the AIT (Vásquez, 2003), technology incorporation, and manipulatives. Moreover, the idea of transforming traditional courses and pathways into a dynamic program is fundamental to the successful academic trajectory that the students experience, embrace, and extend.

Table 4

Multiple Regression Analysis Predicting Course Grade Points Earned

Variable	b	*SE*[a]	95% CI[a]	η^2_p
Age	.00	.01	[−.01, .01]	.000
Male	−.04	.06	[−.17, .08]	.000
Black, non–Hispanic	−.35**	.10	[−.55, −.14]	.007
Hispanic	−.19**	.07	[−.32, −.07]	.005
Other ethnicity	.21	.13	[−.06, .45]	.001
FOCUS Intervention	.49**	.09	[.33, .67]	.010

Note. *$p < .05$, **$p < .01$. Age is in years. Reference category for male is female. Reference category for race/ethnicity is White, non–Hispanic. [a] Bootstrapping results.

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The Path Forward

Texas is taking a multipronged approach to improving developmental education delivery and increasing student success rates by aggressively pursuing programmatic, research, and instructional strategies that will boost college completion and help reach labor market goals. To that end, the following two recommendations have been offered to the Texas Legislature to ensure that the state is able to accomplish its vision of significantly improving the success of underprepared students.

- Through statewide professional development programs and grant funding, continue to support and further promote the scaling of acceleration models that are nontraditional, integrated, contextualized, and technology-enhanced to better support the persistence and completions of underprepared students.
- Provide the necessary resources to identify and build a statewide online referral system for use by advisors, counselors, agency, and organizational staff to make appropriate and efficient referrals for students who require adult education and literacy (AEL) and other support services and for students who are receiving AEL services but who are ready for and need postsecondary education, with the goal of identifying the most effective program and intervention for meeting their needs.

Texas higher education has committed itself to providing improved and more efficient avenues to success for academically underprepared students through the Texas Success Initiative system, which is more nuanced in its advising, placement, and curricular interventions than previous models. Similarly, Texas has also taken on the considerable challenge of addressing reform efforts that promote the transition of students assessed at basic skill levels from high school completions through postsecondary training and education, with an emphasis on programs that support academic and workforce success.

During the next few years, the Texas postsecondary system will continue to undergo significant changes and face additional challenges resulting from reform efforts. Those challenges will be informed and mitigated by studies exploring and confirming best practices in regard to the use of the Texas Success Initiative Assessment and the full implementation of the diagnostics that inform student profiles. Challenges include developing a comprehensive, statewide professional development and referral system and the continued, full-scale implementation of nontraditional interventions for underprepared students seeking postsecondary training and education. However, the state of Texas and its stakeholders are committed to the ongoing improvement of the programs and services for underprepared students. Through continued collaboration, Texas will strive to identify and coordinate systems and initiatives that support the educational and economic goals of its residents.

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