A Longitudinal Study of Student Persistence in Science, Technology, Engineering, and Mathematics (STEM) at a Regional Urban University

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Abstract

In 1995 the National Science Foundation (NSF) funded six minority-serving institutions in an effort to develop models for undergraduate science, technology, engineering, and mathematics (STEM) education that would increase the persistence, graduation, and success of all undergraduate STEM students; improve the quality of undergraduate STEM programs; and increase the diversity in STEM professions and graduate programs. The University of Texas at El Paso (UTEP), one of the six funded institutions, is located in the southwest corner of Texas bordering Juarez, Mexico and New Mexico. It primarily serves the predominantly Hispanic population of the region. Developed for all entering students in the College of Science and College of Engineering, the Circles of Learning for Entering Students (CircLES) program is a comprehensive institutional effort starting with a weeklong STEM summer orientation. CircLES also provides students with discipline-specific student advising and requires students to participate in one to two semesters of science or engineering-oriented learning communities, based on their pre-college preparation in Mathematics and English. This paper describes the design and findings of a five-year longitudinal study of student persistence in STEM since implementation of the program. Findings from the study indicate that students who participate in the program have higher retention rates in STEM, as well as at the University, and increased persistence toward graduation when compared to 1997 baseline rates. Similar results are

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observed when findings are disaggregated by gender, ethnicity, and level of entering mathematics course.

I. Introduction

Two themes re-occur in the literature and research on undergraduate education in science, technology, engineering, and mathematics. The themes are the need to improve the *quality* of undergraduate programs and student experiences in STEM and the need to increase the *quantity*, *diversity,* and *competence* of students interested in STEM disciplines and professions. In a recent review of the literature recounting national efforts in undergraduate education in STEM, Seymour describes a landscape of "shifting in the locus of concern" over the years. In the 1980s, attention was drawn toward the alarming decrease in the number of students who elected to major and graduate in science, technology, engineering, or mathematics. In the 1990s, this focus on the loss of potential and able STEM majors led to the "discovery of under-representation in the sciences" and engineering and a growing national awareness of students' and the public's limited understanding of mathematics and science.[1, 2 & 3] The increasing pressures to develop a scientific and technologically literate workforce advanced a call to "cultivate the scientific and technical talents of all … citizens."[4] The shift in focus from an emphasis on improving STEM student experiences and the quality of STEM courses for majors to improving STEM courses and teaching for all students at all educational levels highlighted the changing efforts in STEM during the past decade.[1] Research on student experience in STEM suggests that sufficient academic and personnel support to sustain motivation and morale is critical to persistence and graduation in a STEM major. Pace, load, and preparation for STEM majors are common student descriptions of 'hardness' and reasons for leaving a STEM major. There is a growing recognition that the transformation of STEM undergraduate education (i.e., courses, curriculum development, laboratories, and co-curricular activities in undergraduate STEM programs) is an institutional responsibility.[5] Current directions include efforts to develop strategies for transforming institutional practice – moving institutions and programs from a historical teaching centered environment to student-learning centered environments.[6, 7 & 8]

In response to the "shifting" landscape of concerns, the Model Institutions for Excellence (MIE) project at The University of Texas at El Paso, with support from the National Science Foundation, has developed and implemented a comprehensive model of undergraduate education in STEM.[9 & 10] The components of the model include an entering students program for all STEM students, a center for teaching and learning (faculty and student assistant professional development), an academic support center for STEM students, research and peer teaching experiences for STEM undergraduates, and support for evaluation and assessment of MIE project activities.

In this paper we describe the design of the model for entering students and the findings of the five-year longitudinal evaluation study of student retention in STEM and at the university. Student and institutional outcomes are linked to project activities through the use of an input-activities-output-outcomes program logic map of the entering students program. First, we briefly describe the entering students program. Secondly, we describe how the program logic map was developed and used to design the evaluation of the entering students program. Next, we present a description of the frequency of occurrence of selected program activities. Lastly, we present the findings from the longitudinal evaluation study of student retention and a description of the student evaluation of project activities. We conclude this paper with a discussion of the findings and their implications for the future of undergraduate STEM education.

II. Circles of Learning for Entering Students (CircLES)

The Circles of Learning for Entering Students (CircLES) program is a key component of the Model Institutions for Excellence (MIE) project at UTEP.[11, 12, 13, & 14] CircLES is dedicated to providing all pre-science and pre-engineering students with opportunities to develop the skills and knowledge associated with a successful college career, to enhance student leadership skills and self-awareness, to make connections with the university, the engineering and/or science colleges and programs, and to become acquainted with STEM faculty, staff, upper division students, and their peers. The goals of the CircLES program are to increase student persistence, improve their academic performance, and add value to their education.

To accomplish these goals, the CircLES program creates a smooth transition from high school to the university and provides academic and student support environments that foster student success and increase student persistence toward graduation. In the past, a majority of entering students who had an interest in the STEM disciplines had little or no association with STEM faculty or upper level students at the beginning of their college experience. To accelerate the integration of new students into STEM and the university community, CircLES provides an academic and support "home" for these students. A summer orientation begins the process of introducing new students to the academic and social communities of the university. Students then enroll in a one or two-semester science or engineering-oriented learning community. The engineering or science-oriented learning communities are the hallmark of the CircLES program. All entering STEM students are required to participate in a three or four-course cluster consisting of a Mathematics course, an English course, a science or engineering oriented Freshman Seminar, and –for the majority of students– an introductory course in their chosen major. Unique features of the learning communities are student assignment to cluster courses based on their scores on Mathematics and English placement examinations and their interest in engineering or science. Once in a learning community, entering students interact with engineering and science faculty and staff, as well as upper division STEM students and their peers in the clustered courses. The learning communities in STEM provide students with the necessary knowledge and skills for success at the university and facilitate students' progress into their major. Throughout the first year, students participate in advising activities conducted by student development professionals whose areas of expertise are in the advising of STEM students. The intentional linking of student orientation, student advising, and learning communities is based on the research on student departure and persistence in higher education, curricular transformation in post-secondary education, and student persistence in STEM.[15, 16, 17, 18, 19, & 20] The literature on departure and persistence in higher education suggests that a student's decision to depart or persist is a function of the interaction between the academic and social context of campus and the student's background and experiences within these contexts. The

CircLES program is an integrated approach that intentionally combines the academic context with the social context and proves to be highly effective in enhancing the one-year retention and persistence of entering STEM students.

III. The relationships among inputs, activities, outputs and outcomes

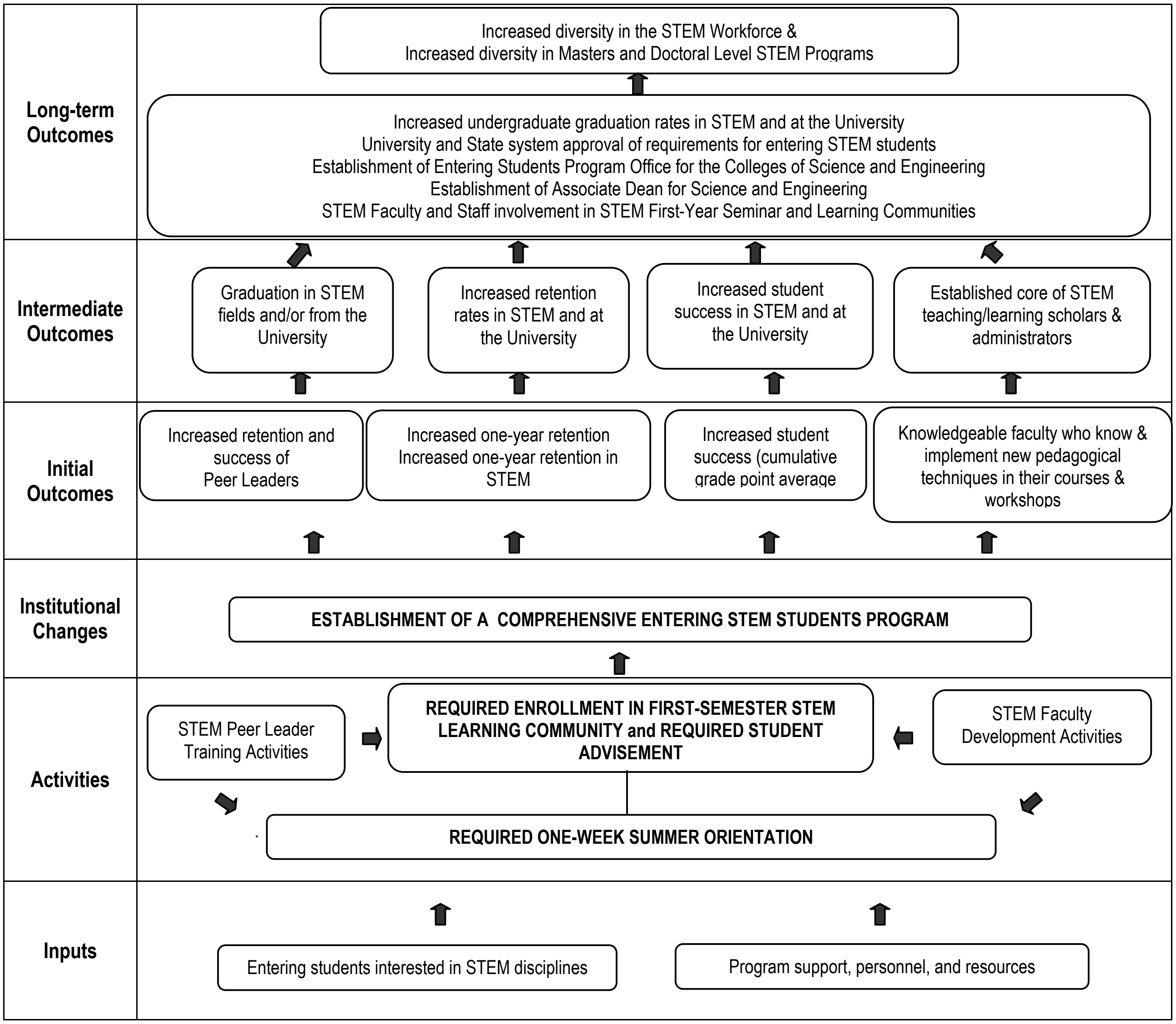
A program logic map is a tool that makes explicit the theory of action underlying an innovation or intervention through the creation of a "map" that graphically represents inputs, activities, outputs and outcomes.[21] In describing a program logic map and the use of evaluation, Weiss suggests that this type of map provides a representation of the logical framework and the theoretical foundation for the relationships among program inputs, activities and outcomes.[22] The program logic map offers program developers, program evaluators, and those who implement the activities with a way to view the key elements of the program, their interconnections, and the expected impact of program activities on participants, and an implicit plan for the use of the evaluation. It also helps to highlight the organizational infrastructure and processes necessary to transform the organization and sustain essential program components. The logic map guides the thinking about requirements for program improvement and accountability and the use of evaluation for these purposes. In addition, it can sensitize those responsible for the program and its evaluation to the context of the program, the relationship of program activities to both positive and negative unanticipated outcomes, and the use of information for decision-making.

The design of the program logic map encourages program developers and evaluators to articulate how program components connect with one another and how they lead to expected program outputs and outcomes. For example, the logic map of the CircLES program documents the pathways to and through students' majors and on to graduation. It also highlights the organizational structures and processes that need to be in place to support CircLES accomplishments. Before the CircLES program, a majority of entering STEM students had little or no exposure to faculty or staff in their areas of interests. Based on the research and the experience of STEM faculty and staff, CircLES established a linchpin course that is taught by STEM faculty or staff. In that way, entering students and faculty are intentionally paired.

Based on extended discussions with program administrators and those who implement the program, the project evaluator developed a map that provides a visualization of the connections among CircLES activities, institutional changes, and student outcomes that form a broad theory of action for the program. Information from the evaluation can be "mapped" to the representation of the program.

Outcomes are located at the top of the map. The representation stresses the expected accomplishments, intermediate and short-term outputs and outcomes. In this case, the CircLES program logic map makes explicit reasons for project evaluation to invest in the ongoing longitudinal study that tracks students through their academic experience. It emphasizes indicators of expected outputs and outcomes to be used as evidence for accountability requirements. It also forms the foundation for informed program improvement and stresses the purposes of the evaluation effort. In Figure 1, the logic map for the CircLES program is presented.

Figure 1. CIRCLES OF LEARING FOR ENTERING STUDENTS - LOGIC MAP



In the next two sections, we describe two types of findings from the longitudinal study of student persistence in STEM and at the university. The section labeled "Findings: Program Activities" describe student reports on the occurrence of types of activities that are associated with active learning approaches to teaching subject matter. Faculty and staff teaching the Freshman STEM Seminar are encouraged to implement active learning pedagogical strategies in their courses. The second section labeled "Findings: Student Retention" describes retention rates for one, two, and three-year retention after admission to and enrollment at the university.

IV. Findings: Program Activities

Since 1998, over 1,400 entering STEM students have participated in CircLES. To evaluate the implementation of the activities associated with the CircLES (Learning Communities) courses, we collected and analyzed student ratings of the occurrence and usefulness for learning of classroom activities and pedagogical strategies. At the end of the 1999, 2000, and 2001 fall semesters, students were asked to complete questionnaires asking them to assess the impact of their participation in the program. Figures 2 and 3 present student ratings of how often the activity described in an item occurred in the cluster courses. In general, the mean responses for the items across years were between 3.5 and 4.0 on a scale of 1 –5 with *Almost never=1, Less than 1/2 the time=2, About 1/2 the time= 3, More than 1/2 the time= 4, Almost always= 5, NA= 9.* Students reported that "about half the time" or "more than half the time" the participation in the clustered courses "provided them with opportunities to interact with professors," "encouraged them to work with other students to complete a project," " encouraged respect for others," "encouraged respect for diverse ideas," "increased confidence in their ability to do well in math," and "increased their interest in STEM."

Figure 2. CircLES Cluster Course Questionnaire Mean Scores for 1999, 2000, and 2001

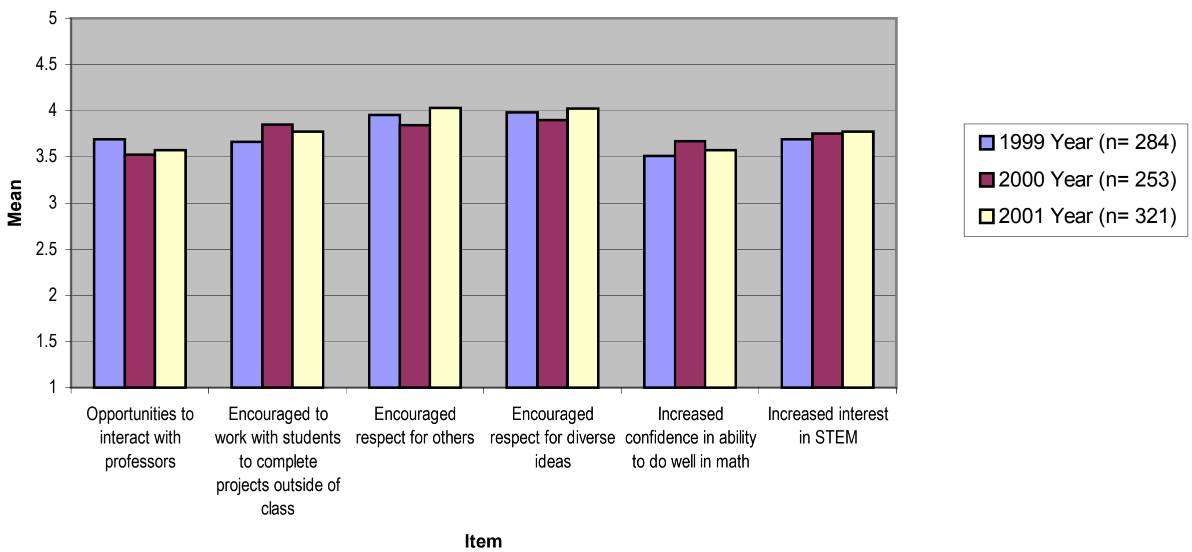
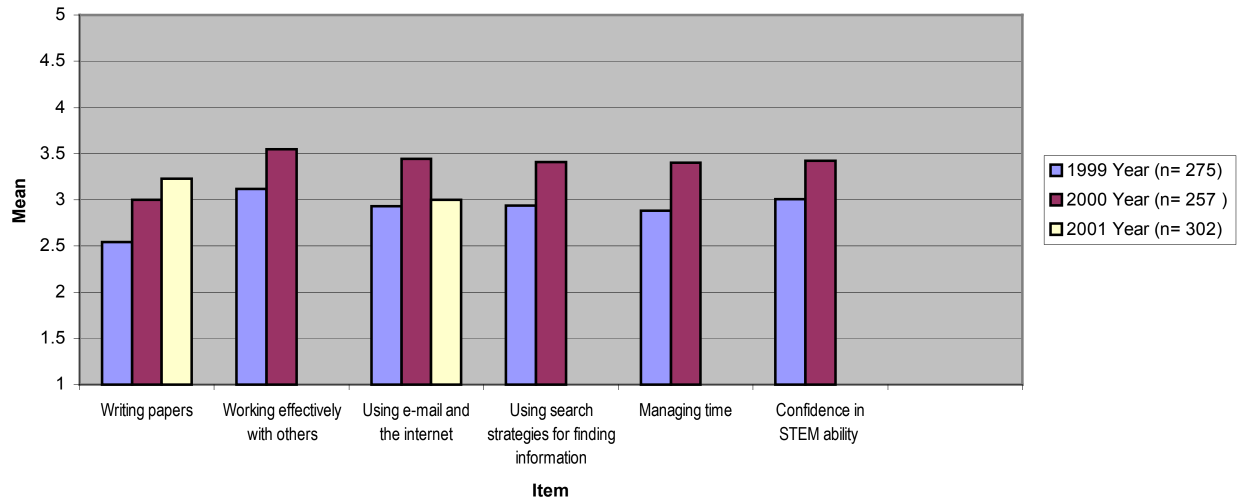


Figure 3. Learning Gains Questionnaire Mean Scores For 1999, 2000, and 2001



In addition to assessing the implementation of expected activities or outcomes, the evaluation documented the usefulness of selected activities in increasing student learning in the clustered courses. In most cases, student responses suggest that levels of usefulness increased as the program matured. Examination of the responses suggests that a more fine-grain data collection and analysis could help reveal how course activities increased self-reported levels of learning. Of particular interest are those cases in which unexpected fluctuations appear in reports of usefulness of activities and pedagogical strategies associated with active learning. The scale for the Learning Gains Questionnaire items is: No help= 1, A little help= 2, Moderate help= 3, Much help= 4, Very much help= 5, N/A= 9. Information on Figure 3 reveals an important trend across years in the item "writing papers". This item increased from 2.54 in 1999, to 3 in 2000 and 3.23 in 2001.

V. Findings: Student retention

The longitudinal study[§] is designed to track the retention rates of entering students by student cohort. Entering students who are classified as participating in the CircLES program met the following three criteria: (1) declared major in STEM as reported in the institutional student records, (2) attended a one-week STEM summer orientation, and (3) participated in the STEM-oriented learning communities. Since the 1998 scale-up of the program, participation in the summer orientation and enrollment in a STEM learning community have been required of all first-time full-time entering students who are interested in STEM fields and who place into either developmental mathematics, pre-Calculus, or Calculus I. As a result, comparison groups with

[§] Statistical analysis was conducted with partial support from the National Institutes of Health (RCMI G12-RR08124).

matched groups cannot be constructed. However, the impact of the CircLES program on retention may be explored by examining the retention rates of entering student cohorts over the past five years compared to baseline measures.

Tracking of these students consists of verifying that students are enrolled at the university one year after their admission to the university and in subsequent years after their initial admission. Moreover, student retention in STEM disciplines is examined and verified through student records. Although every effort is made to enroll all first-time full-time STEM students into the CircLES program, every year there are some STEM students who do not participate in the program. The students are grouped and examined for comparative purposes. For first-time full-time STEM entering students, we have categorized student cohorts into four categories.[**]

1. Baseline: STEM students who did not participate in the initial STEM learning community pilot program offered in Fall 1997. The course-taking behavior of baseline entering STEM students mirrored the traditional course behavior of incoming STEM students at the university and in STEM. Students in this group enrolled in the required general education courses.
2. Pilot: STEM students who selected (and were eligible) to participate in the initial STEM learning community pilot program offered in Fall 1997. Based on a student's mathematics placement test score, students were assigned to a STEM learning community that consisted of a mathematics course, an English course, and a course designed to introduce students to STEM disciplines, the university, and student success skills. This latter course evolved into a First-Year Seminar course.
3. CircLES: STEM students who participate in the summer orientation and who are enrolled full time in the required STEM learning communities during their first semester at the university. A group of approximately twenty-five students are enrolled in the same three to four courses (Mathematics, English, a STEM-oriented Freshman Seminar and a discipline-specific course). Students are placed in their Mathematics and English courses based on their placement scores. The students grouped in these courses form a STEM learning community. There are approximately fifteen to eighteen learning communities per year. Each entering student cohort is identified by the year in which students entered the university.
4. Non-CircLES: STEM students who do not participate in the required STEM learning community during their first semester at the university. Each non-CircLES cohort is further identified by the year in which students entered the university. These students enroll in freshman level general education core courses, based on student interest, Mathematics and English placement scores, and availability of the courses. Even though these students do not participate in the learning communities, they may take part in the other activities supported by the CircLES program.

[**] All entering students must take the required Mathematics and English placement examinations before they enroll at the university.

The one-year retention rates and performance of these cohorts of students were examined for the 1997-1998, 1998-1999, 1999-2000, 2000-2001, and 2001-2002 academic years. In addition to examining one-year retention rates of these cohorts of students, subsequent retention rates were examined by mathematics placement, ethnicity, gender, and college.

This paper concentrates on comparisons of student cohorts in three categories, baseline, CircLES (participation in the summer orientation and STEM learning communities) and non-CircLES (no participation in CircLES learning communities). Although the following analyses cannot provide conclusive evidence to support the efficacy of a required summer orientation and participation in first-semester STEM learning communities in addressing student persistence and academic performance, the analyses provide moderately strong support for the claim that student participation in a summer orientation and a first semester learning community positively impacts student retention in college, persistence in STEM disciplines, and student performance.

For STEM students who entered the university in Fall 1997, the one-year retention rate for the self-selected pilot group (n=60) was 77% while the retention rate for the baseline group (n=276) was 68%. Since the 1998-1999 academic year during which all first-time full-time entering STEM students were required to participate in a summer orientation and enroll in a first-semester STEM learning community, the one year retention rates for student cohorts have remained stable across the years at approximately 80%. The project has maintained a 10% increase in the one-year retention rate over the baseline one-year retention rate for the past four years. The one-year retention rates for students who did not participate in the learning communities after the 1998 scale-up are 72% (Non-CircLES 2000; n=185) and 77% (Non-CircLES 2001; n=97) respectively.

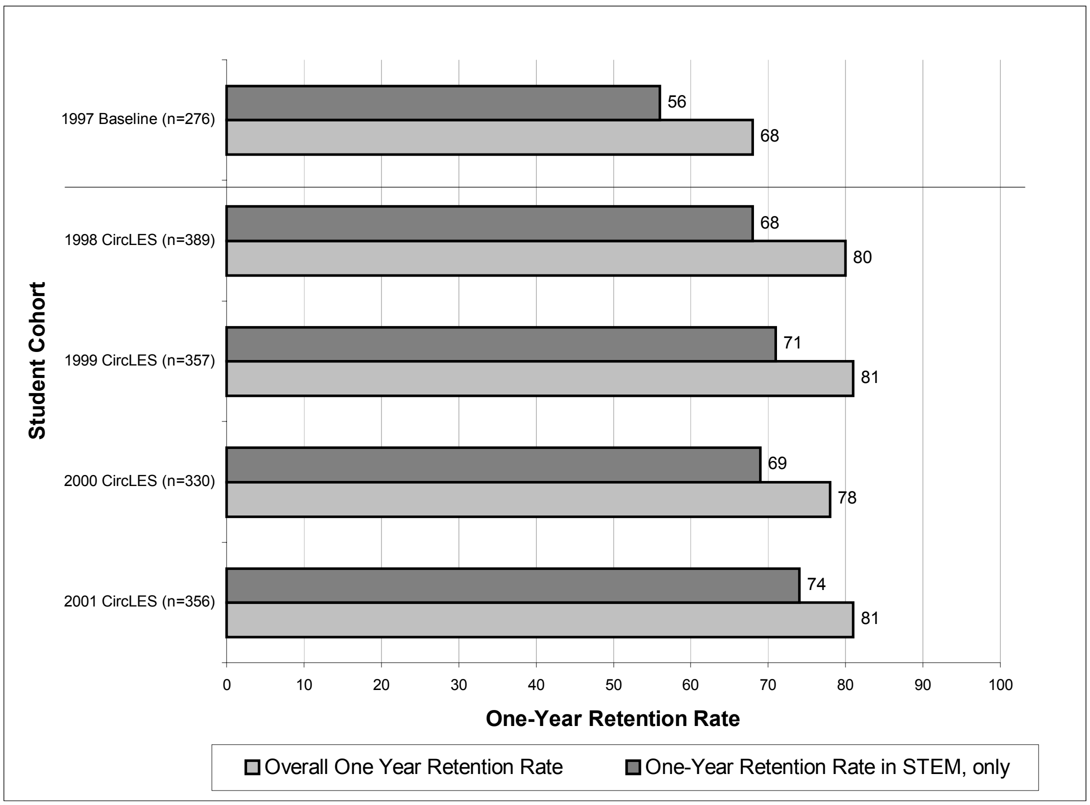
A Chi-Square test comparing the one-year retention rates of the 1997 baseline, the 1998 CircLES, the 1999 CircLES, the 2000 CircLES and the 2001 CircLES shows a significant difference (p-value=0.0019) among the five cohorts. A further partitioning of the Chi-Square shows similarities in the one-year retention for the four CircLES cohorts (1998, 1999, 2000, 2001) with p-value = 0.8380. However, there is a significant difference in one-year retention for the 1997 baseline with a 68% retention rate versus the four CircLES Cohorts combined with a 80% one-year retention rate (p-value < 0.0001).

While student retention at the university is an important goal for the CircLES program, the expectation is that student participation in CircLES activities will increase student retention in STEM. An examination of student retention in STEM was conducted by analyzing student retention data and verifying that after one year, students were listed in institutional records as being in STEM programs. Just as one-year retention rates increased over the baseline one-year retention rate, persistence in STEM disciplines has increased over the baseline one-year retention rate in STEM (56%) and has also remained fairly stable (1998 CircLES (68%); 1999 CircLES (71%); 2000 CircLES (69%); and 2001 CircLES (74%)). Persistence in STEM disciplines for

[††] Cumulative Grade Point Average (CGPA) is computed using the courses that students have taken that count toward graduation at the end of the first academic year and subsequent years after initial admission to the university.

students who did not participate in STEM learning communities after the 1998 scale-up are 64% (Non-CircLES 2000; n=185) and 68% (Non-CircLES 2001; n=97) respectively. A test comparing the one-year STEM retention rates of the 1997 baseline, the 1998 CircLES, the 1999 CircLES, the 2000 CircLES and the 2001 CircLES shows a significant difference (p-value<0.0001) among the five cohorts. A further partitioning of the Chi-Square Test shows similarities in the one-year STEM retention for the four CircLES cohorts (1998, 1999, 2000, 2001) with p-value = 0.3945. However, there is a significant difference in one-year STEM retention for the 1997 baseline with a 56% retention rate versus the four CircLES Cohorts combined with a 71% one-year STEM retention rate (p-value < 0.0001). Figure 4 shows the one-year retention rates at the university and in STEM by year of admission compared to baseline one-year retention rates at the university and in STEM.

Figure 4. Comparison of One-Year Retention Rates Overall at the University and in STEM between Baseline and the CircLES Student Cohorts.



Findings from the on-going longitudinal study show that students who participated in CircLES activities have higher one-year retention rates than the one-year baseline retention rate. Furthermore, these students had higher retention rates in STEM than students in the baseline group who did not participate in CircLES. These data do not account for the reasons why students left or if they continued their schooling elsewhere. However, analysis of cumulative grade point averages (CGPA) of students who participated in and did not participate in CircLES activities and have not persisted find that a majority of the students have average CGPA of below

2.0 on a scale of 4 with 4 being equal to a grade of "A". A CGPA of below 2.00 is the indicator that is used by the university to place a student on probation.

Table 1 shows the results of the analysis of student retention data by mathematics placement. Findings indicate significant differences in the one year retention rates across student cohorts for students enrolled in the developmental mathematics or who did not enroll in mathematics (p-value = 0.0023); no significant difference was found for students in college-level Pre-Calculus and Calculus mathematics courses (p-value=0.9110). However, there is an overall association with a tendency for CircLES-cohorts to have higher retention rates than non-CircLES cohorts (the Mantel Haenszel Chi-Square test statistic 5.01, 1 degree of freedom and p-value = 0.0252). Therefore there is some association between cohort (CircLES versus non-CircLES) and retention rate, adjusted for mathematics placement.

Table 1
One-Year Retention Rate (%) by Cohort and Mathematics Placement

	Developmental Mathematics[a]		Pre-Calculus and Calculus[b]	
	N	%	N	%
1997 Baseline	176	63	100	79
1998 CircLES	215	78	174	82
1999 CircLES	164	79	193	82
2000 CircLES	148	75	182	81
2001 CircLES	147	77	209	83

[a] Rates significantly different for Developmental Mathematics Placement (χ^2-value = 16.64, p-value < 0.005)
[b] Rates not significantly different for Pre-Calculus and Calculus Mathematics Placement (χ^2-value = 0.99, p-value > 0.05)

Table 2 shows the results of the analysis of student retention data by gender. Findings indicate that the one-year retention rate is significantly different for males who participate in CircLES activities, but no significant difference is found for female students. Frequencies and percentages are presented in Table 2 for females and males for the one-year retention for the baseline (1997), 1998 CircLES, 1999 CircLES, 2000 CircLES and 2001 CircLES. The Chi-Square test results that follow indicate significance only for males (p-value = 0.0098). For females, the p-value was equal to 0.3136. It should be noted that there are a smaller number of females. However, the associations found reinforce each other, so that the overall association is stronger than that seen by gender (the Mantel Haenszel Chi-Square test statistic = 7.4331, 1 degree of freedom and p-value = 0.0064). That is, both males and females show that the one-year retention rate for the 1997 Baseline cohort is lower than that found for the CircLES cohorts.

Table 2
One-Year Retention Rate (%) by Cohort and Gender

	Female[a]		Male[b]	
	N	%	N	%
1997 Baseline	84	73	192	67
1998 CircLES	141	83	248	78
1999 CircLES	140	84	217	79
2000 CircLES	116	80	214	77
2001 CircLES	125	81	231	81

[a] Rates not significantly different for Female (χ^2-value = 4.75, p-value > 0.05)
[b] Rates significantly different for Male (χ^2-value = 13.33, p-value <0.005)

Table 3 shows the results of the analysis of student retention data by ethnicity. Findings indicate that there is a significant difference for Hispanics who participate in CircLES activities compared to Hispanics who do not participate, but no difference for non-Hispanics. Non-Hispanics include all ethnicities other than Hispanic (Anglo, African American, Asian, Native American, and International students). Frequencies and percentages are presented for Hispanics and non-Hispanics for the one-year retention for the baseline (1997), 1998 CircLES, 1999 CircLES, 2000 CircLES and 2001 CircLES. The Chi-Square tests indicate significance only for Hispanics (p-value = 0.0126), while none exists for non-Hispanics (p-value = 0.1632). Again, there is a smaller number of non-Hispanics that could affect results. However the associations found reinforce each other, so that the overall association is evident (Mantel-Haenszel Chi-Square test statistic = 7.5707, 1 degree of freedom and p-value = 0.0059). Both the Hispanic and non-Hispanic groups have lower one-year retention rates for the 1997 Baseline cohort than the CircLES cohorts.

Table 3
One-Year Retention Rate (%) by Cohort and Ethnicity

	Hispanic[a]		Non-Hispanic[b]	
	N	%	N	%
1997 Baseline	209	69	67	66
1998 CircLES	292	81	97	76
1999 CircLES	257	80	100	82
2000 CircLES	263	79	67	75
2001 CircLES	269	81	87	79

[a] Rates significantly different for Hispanic (χ^2-value = 12.75, p-value < 0.05)
[b] Rates not significantly different for Non-Hispanic (χ^2-value = 6.52, p-value > 0.05)

Analysis of one-year retention rates by college and gender (Table 4) find that one-year retention rates are statistically significant for males in the College of Science and marginally significantly different for females and males in the College of Engineering. One-year retention rates for females in the College of Science are not significantly different.

Table 4
One-Year Retention Rate (%) by Cohort, Major and Gender

	Engineering, Female[a]		Engineering, Male[b]		Science, Female[c]		Science, Male[d]	
	N	%	N	%	N	%	N	%
1997 Baseline	30	63	137	68	54	78	55	64
1998 CircLES	63	87	197	77	78	80	51	80
1999 CircLES	48	88	170	77	92	82	47	85
2000 CircLES	48	77	174	81	68	82	40	60
2001 CircLES	53	79	189	80	72	82	42	81

[a] Rates marginally significantly different for Engineering, Female (χ^2-value = 9.42, p-value = 0.0513)
[b] Rates marginally significantly different for Engineering, Male (χ^2-value = 9.32, p-value =0.0537)
[c] Rates not significantly different for Science, Female (χ^2-value = 0.60, p-value > 0.05)
[d] Rates significantly different for Science, Male (χ^2-value = 12.31, p-value < 0.05)

VI. Subsequent Retention Findings

Table 5 examines subsequent retention rates associated with CircLES and Non-CircLES student cohorts compared to the 1997 baseline measures. One of the goals of the CircLES program is to provide students with the tools for academic success. CircLES activities are viewed as influencing student persistence. The following analysis does not account for any other curricular or co-curricular activities or personal events that might have influenced students' reasons for continuing in STEM, changing to non-STEM majors, or not persisting in school.

Table 5 depicts one-year, two-year, three-year, and four-year raw retention and five-year raw retention combined with graduation rates. The average "years to graduation" is approximately six years for students who attend the university.

‡‡ The Five-Year retention rate and graduation rate have been combined for this analysis. Historically, graduation rates have been approximately 26% for students who begin and complete their undergraduate degree programs at UTEP.

Table 5
Raw University and STEM Retention Rates of First-Time Full-Time Freshmen by Year and CircLES Status

Student Cohort	Number of Freshmen	Retention Rate									
		1-Year		2-Year		3-Year		4-Year		5-Year + Graduation Rates	
		UTEP	STEM	UTEP	STEM	UTEP	STEM	UTEP	STEM	UTEP	STEM
1997 Baseline	276	68	56	55	41	46	32	45	27	41	21
1997 Pilot	60	77	59	60	40	65	40	50	25	46	21
1998 CircLES	389	80	68	69	53	57	40	56	39		
1999 CircLES	357	81	71	68	54	64	45				
2000 CircLES	330	78	69	71	57						
2000 Non-CircLES	185	72	64	59	49						
2001 CircLES	356	81	74								
2001 Non-CircLES	97	77	68								

A Chi-Square test comparing the two-year STEM retention rates of the 1997 baseline, the 1998 CircLES, the 1999 CircLES and the 2000 CircLES shows a significant difference (Chi-Square value=16.6930; df=3; p-value=0.0008) among the four cohorts. A further partitioning of the Chi-Square shows similarities in the two-year retention for the CircLES cohorts (1998, 1999, 2000) with Chi-Square value = 1.2140; df = 2; p-value = 0.5450. However, there is a significant difference in two-year retention for the 1997 baseline with a 41% STEM retention rate versus the three CircLES Cohorts combined with a 55% two-year STEM retention rate (Chi-Square value = 15.4789; df=1; p-value <0.0001). A test comparing the three-year STEM retention rates of the 1997 baseline (32%) versus the 1998 CircLES and the 1999 CircLES combined (47%) shows a significant difference (Chi-Square value = 9.4153, 1 degree of freedom and p-value = 0.0022). The three-year STEM retention rates for the 1998 CircLES versus the 1999 CircLES were not significantly different from each other (Chi-Square value = 2.1034, 1 degree of freedom and p-value = 0.1470).

VII. Conclusion

In 1997, the Model Institutions for Excellence (MIE) initiative at the University of Texas at El Paso conducted a pilot study of a program for entering students interested in science, technology, engineering, and mathematics. By the summer of 1998, a comprehensive program for entering students was designed and implemented. All entering students interested in STEM majors were required to participate in the STEM summer orientation and enroll in a first-semester STEM-oriented learning community. The CircLES of Learning for Entering Students program is a component of the university's MIE initiative. The goals of the program are to develop a model of undergraduate education in STEM and to increase student persistence toward graduation.

The evaluation of the MIE CircLES program was developed and designed with a program logic map as its foundation. The logic map provided a visualization of the CircLES program and its activities and highlighted student and institutional outcomes. The map is a representation of the program based on extended conversations between the evaluator, program administrators and those who implement the program. As a major activity of the evaluation of CircLES, an ongoing longitudinal study was designed to track the progress of students who participated and did not participate in the program. Tracking includes documenting students' persistence at the university and in STEM. Overall retention rates are then disaggregated by gender, ethnicity, entry level mathematics course, and college.

When viewed through a five-year lens, findings from the five-year longitudinal study show that student one-year retention rates in science, technology, engineering, and mathematics and at the university are significantly higher than baseline rates. The rates for CircLES student cohorts have remained higher than the 1997 baseline retention rate and have remained consistent over five years (the 1997 pilot group and 1998 through 2001 entering student cohorts). Although not conclusive, the findings provide evidence that the comprehensive entering students program is making a difference in one-year retention rates and student persistence. Moreover, subsequent retention rates show increases over baseline rates. That is, two and three year retention rates are significantly higher for students who have participated in the CircLES program compared to students in the 1997 baseline group. But, as the findings show, retention rates still decline as students move through their programs of study in STEM disciplines and at the university. These findings indicate that a good start at the entering student level can increase student persistence while they reveal at the same time that students need continual academic and student support as they persist toward graduation. Without other forms of evidence to support the claim that a comprehensive entering student program can increase retention beyond one-year, the most that can be strongly supported is that participation in the CircLES program does increase one-year retention.

Findings from the disaggregated data by gender show that, in general, male students' one-year retention rates are significantly higher if they participate in CircLES than if they do not participate. For female pre-engineering students, one-year retention rates are marginally significantly different for those who participate compared to those in the baseline one-year retention rate. Female pre-science students' one-year retention rates are not significantly different from the baseline one-year retention rates for female pre-science students. Findings from the disaggregated data by ethnicity show one-year retention rates for Hispanic students who participate in CircLES are significantly higher than the one-year retention rates for Hispanic students who do not participate in the program. Students who enter the university at the developmental mathematics level and who participate in the CircLES program have significantly higher one-year retention rates than the retention rates of developmental mathematics students in the baseline group.

Based on the stability of one-year retention rates across five years, we claim that the entering students program can prevent students from leaving the university or STEM after the first year. Examination of the retention data suggests that students still leave after the beginning of their second or third years at the university. A more fine-grained analysis of the data is needed to point to areas in which more research and programmatic activities can be designed to find ways to significantly improve student persistence in the semester leading up to acceptance into the major and subsequent student persistence in the major.

The development of a program logic map that is tied to the evaluation and selection of key indicators provides a clear articulation of the theory of action underlying a program. This articulation encourages program administrators and evaluators to agree upon the ways in which the program components connect with one another and how they can lead to expected program outputs and outcomes. In addition, the program logic can provide a "picture" of what and how institutional mechanisms and infrastructure need to be transformed and sustained in order to retain program outcomes.

This is the first step in the investigation of the efficacy of an entering students program in increasing student persistence in STEM. Next steps in the study include: 1) conducting a more fine-grained study of program activities to better understand how they contribute to student persistence at UTEP and 2) a focused study on the adaptation and implementation of the CircLES program at another site to develop a model of dissemination.

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