A Real PLUSS: An Intrusive Advising Program for Underprepared STEM Students

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Increasing numbers of underprepared students are admitted to colleges and universities with aspirations of earning a degree in a science, technology, engineering, or mathematics (STEM) discipline. Transitioning to college is difficult for all students, but can be especially challenging for the underprepared STEM student. Many of these students are capable of completing STEM degrees if given additional support during their first-year advising sessions as well as opportunities to strengthen their foundational knowledge prior to enrolling in major-level course work. Pathways Leading to Undergraduate Success in the Sciences (PLUSS) is an intrusive advising program the University of Southern Indiana designed to provide at-risk undergraduate STEM majors with increased academic support. The PLUSS program is associated with increased retention rates.

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High school students across the United States hear the message of parents, educators, policy makers, and community leaders that they need to earn a college degree to gain meaningful employment and enter a successful career. As a result, more students seek a college education than ever did before; approximately 70% of secondary graduates enroll in college within 2 years of high school graduation. The majority (80%) will attend high-access universities (Swail, 2006); however, many matriculants do not get on a pathway that leads to degree completion. The factors that contribute to college success create complex connections difficult to align; however, according to Cuseo (2003), academic advising is the foundational factor in student retention and degree completion.

The transition from secondary school to college is an adjustment for everyone but proves particularly challenging for academically underprepared students wishing to earn a degree in a scientific field. These underprepared students often complete the first semester with a low GPA and a diminished self-image. To address this problem, the University of Southern Indiana initiated the Pathways Leading to Undergraduate Success in the Sciences (PLUSS) program featuring intrusive advising designed to provide at-risk science, technology, engineering, and mathematics (STEM) majors with increased academic support. The goals of the program include increasing the retention rates of underprepared STEM majors, assisting them in developing academic pathways leading to degrees in a STEM discipline, educating them on the academic requirements of postsecondary science education, and helping them develop realistic academic goals. The program offers a unique compilation of proven strategies: intrusive advising, cohort classes in developmental mathematics, and a freshman seminar class.

Intrusive advising is a proactive approach to help motivate students and involve them in postsecondary education experiences. By identifying at-risk students and partnering them with advisors who have professional experience with and who are dedicated to helping this cohort of students succeed, advising administrators invoke strategies to avoid crisis points that may derail academic success. As Earl (1987) stated, intrusive advising provides students with the message, "You have this problem; here is a help service" (¶ 5).

The Setting

We conducted the research at a public, comprehensive institution of approximately 11,000 students interested in a STEM major: biology, biophysics, biochemistry, chemistry, engineering, geology, industrial supervision, advanced manufacturing, mathematics, mathematics teaching, or science teaching. STEM programs have been identified as study areas vital to the long-term competitive success for the United States in the global market (U.S. Department of Labor, 2007).

According to the Center for Institutional Data Exchange and Analysis (C-IDEA), 197 institutions indicated a slight increase in the number of

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Table 1. Profile scores of PLUSS-eligible students and non-PLUSS-eligible STEM students (2001–2006)

Criteria	PLUSS Eligible Students	Non-PLUSS STEM Eligible Students
SAT-Verbal	469.00	516.72
SAT-Math	472.00	564.03
ACT-Comp	20.00	25.11
H.S. GPA	2.997	3.370
PLEA Average Score*	56.96	97.15

Note. *Placement score—elementary algebra; raw, not a percentage, score

students enrolling in STEM disciplines from 2004 to 2005. This growth did not counter the offsetting 32% attrition rate of those completing the freshman year and the 52% drop-out rate after the sophomore year. Only 37% of the students who entered a STEM field graduated within 6 years (C-IDEA, 2005). At our university, the data were equally troubling: The total number of STEM majors enrolled over the last 5 years (2007–2012) had remained constant at approximately 200 to 250 students per year, but the disproportional relationship between the number of majors and the number of degrees awarded led to the primary concern. In 2006, the last year of available data prior to the implementation of the pilot PLUSS program, the attrition rate of those completing their freshman year was approximately 50%, and nearly 73% of sophomores did not return; fewer than 10% of students in STEM majors graduated in 4 years.

These numbers indicate that the 31% of new students entering our university with deficiencies in basic math, English, or reading courses will particularly struggle pursuing their intended STEM major. Without proper support in introductory science courses, these students often feel overwhelmed, and with disappointing grades, ultimately relinquish their plans to earn a major within a STEM discipline. While not all students are capable of completing STEM degrees, those behind the PLUSS program contend that many can succeed when given support and guidance prior to enrolling in major-level course work.

The Program

To explain the low graduation rates of STEM majors the college administrators at our institution could have pointed to underlying factors such as no stated admission requirements for the declaration of a STEM major or the fact that nearly 60% of first-year college students are not academically ready for college-level work (Howard & Madison-Harris, 2006); however, they chose instead to search for strategies to reverse the low graduation and high attrition rates. The first step involved identifying the cohort of students at risk in STEM majors. Two obstacles frustrated the early identification of these students: the poor timing of both the placement tests and initial advising appointments.

Math placement testing is mandatory for those with a Math SAT/ACT score lower than 600/26. Data from a 1998 study by the Department of Mathematics indicated that student success in mathematics courses was enhanced by requiring all students not exempt from math testing (minimum) to enroll in the recommended course (Rodgers & Wilding, 1998). However, the majority of students attending orientation sessions do not take their mathematics placement tests until the morning of orientation, leaving little time to make adjustments to advising schedules.

Advising appointments for all new students are scheduled by the Office of Student Development 2 to 3 days prior to each orientation session. Without the criteria to identify the potentially at-risk students, such as data garnered from placement tests, advisors have little information available upon which to guide incoming students.

The Students

After analyzing English, reading, and math placement data from 2001 through 2005, we found that 57% of the students who placed into GENS 097 (algebra review, a general studies, noncredit course) and MATH 100 (intermediate algebra, a second course in developmental mathematics) had high-school GPAs less than 3.0 on a 4.0 scale. Additionally, over 50% had Math SAT (M-SAT) scores lower than 540. The data from 2001 through 2006 (Table 1) of PLUSS eligible students (students declaring a STEM major and placing into algebra review or intermediate algebra) scored lower in all categories than did students declaring a STEM major who had placed into a college algebra or higher level course. This information provided the basis

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for preliminarily designating students as at risk for retention in a STEM major and as candidates for the PLUSS program.

The PLUSS Initiative Overview

The PLUSS staff selected proven strategies on research showing that student retention is linked to the freshman year experience (Lotkowski, Robbins, & Noeth, 2004; Tinto, 2002). They also understand that many at-risk students learn to succeed with the proper intervention strategies (Earl, 1987). They recognize that the PLUSS cohort, in particular, must connect to the university and seek help for, rather than ignore, challenges.

Specifically, using a low student-advisor ratio of 15:1, the PLUSS advisor monitors advisees' progress throughout the first year, encourages them to participate in guided study times, and serves as a mentor as they transition from the academic demands of high school to college. This strategy highlights the developmental advising nature of the PLUSS program; it shows similarities to the academic coaching model (see, e.g., McClellan & Moser, 2011), as characterized by the small advising caseload and the numerous one-on-one advising meetings held with each student. Further, the advisor encourages advisees to take responsibility for their actions and inactions; students are taught to seek solutions to problems such that the advisor does not provide all the fixes to students' difficulties (National Academic Advising Association [NACADA], 2005). Key concepts of the PLUSS program included developing profiles to identify at-risk students, careful selection of faculty members to serve as PLUSS advisors, extensive advisor training, formal and informal student advising sessions, student support to aid in the transition to a college environment, and a first-year seminar course (STEM 101) that focused on strategies for successful completion of a STEM major.

Of the 281 students analyzed for this study, 90 (32%) had placed into algebra review and 191 (68%) were placed into intermediate algebra. Additionally, many of these students tested into reading and writing placements below the level required for college work; advisors worked with these students to schedule the appropriate developmental courses to address specific weaknesses. Initially, PLUSS students taking intermediate algebra enrolled in STEM 101; PLUSS students in algebra review enrolled in UNIV 101, a general studies, first-year seminar course.

In 2006, the PLUSS staff submitted a National Science Foundation (NSF) Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) grant in 2006; the reviews were positive, but the grant was not initially funded. Because of upper-level university commitment to address the low retention rates for the STEM students, the administration provided funding for a pilot program. Launched in 2007, the pilot led to three key changes: Students enrolled in the developmental algebra review course were included in the STEM 101 seminar class rather than a general studies university seminar class, two sections of intermediate algebra were reserved for PLUSS students, and an additional advisor was employed.

Together the changes helped create a learning community and provided more opportunities for student–advisee interaction. In particular, cohort classes in mathematics underscore the value of structured class delivery models. Students who work in cohorts benefit from the support of their peers and the synergy that comes from focusing on the same content as well as sharing the same course-completion goals (Complete College America, 2010). We resubmitted the NSF grant and PLUSS was funded in 2008 for 5 subsequent years.

PLUSS Advisor Selection and Professional Development

An early connection of a student with an academic advisor is of paramount importance because students are more receptive to advice upon matriculation than at any other time in their postsecondary academic career (Black, 2007). PLUSS students received enhanced advising experiences starting at orientation with the assignment of a PLUSS advisor, rather than an advisor from an academic department, who introduced the program as a positive opportunity for a successful path to degree completion.

PLUSS advisors are faculty members selected based on the strength of their experience teaching entry-level course work within the college, enthusiasm for the program, and extensive knowledge of university policies and advising techniques. We limited the number of students assigned to each advisor to assist in promoting a positive relationship through intrusive advising techniques.

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Prior to the implementation of the PLUSS program, only the tenured and tenure-track faculty had served as academic advisors for students with declared majors; the instructor-level faculty did not have assigned advisees. By utilizing the pool of instructor-level faculty members, we tapped into those who regularly taught developmental and entry-level courses. All PLUSS advisors had been teaching at the university for a minimum of 3 years and had been advising informally through interactions with students in their classes, but few had participated in advising conferences, seminars, or training opportunities.

These advisors needed to feel comfortable and confident with the skills and tools used in their advising sessions, especially the introductory meetings held during orientation (Black, 2007). They also needed to gain an understanding of the differences, challenges, and opportunities presented by the STEM cohort and develop strategies for meeting the needs of first-generation college students, many of whom came from small community high schools or did not have a clear understanding of the curriculum associated with their declared majors (Darling & Woodside, 2007). Therefore, the initial cohort of seven PLUSS advisors participated in a required, on-campus, 6-hour workshop where they extensively used NACADA materials infused with specific university policies. In particular, they learned about the conceptual, relational, and informational components of advising (Walsh, 2003). The workshop also emphasized the importance of academic advising and its relationship to retention as well as advising theory and the benefits and challenges of using different advising models (Darling & Woodside, 2007). Workshop time was also devoted to presenting the specific demographics of PLUSS students. Based on advisor availability and limited financial resources, four advisors also attended the NACADA Summer Institutes in 2007 and 2008.

In addition, during the workshop, PLUSS advisors collaborated to outline an advising philosophy and develop a common advising syllabus, which clearly defined the expectations and responsibilities of both advisor and advisee. Advisors used an advising calendar to help students acclimate to university life, identify and correct potential problems before they became major obstacles to success, and define their own academic goals.

Advising and Seminar Course

To keep the 15:1 advisee–advisor ratio, advisors met with each student at least five times throughout the semester. During new student orientation sessions held in the summer months, each PLUSS student met with an advisor for approximately 45 minutes to create a schedule and lay the foundation for developing a positive advisor–advisee relationship. Advisors corresponded with the advisee via e-mail until classes began. Advisors scheduled a 2nd session during the first week of the semester to answer questions and help students start the semester in a positive manner. They met again with advisees in the 3rd week to check on the students' progress in their mathematics classes, in the 7th week to discuss academic progress at midterm, in the 11th week to prepare for priority registration for the next semester, and during the 15th week to help students develop strategies for final exam preparation.

A first-year seminar course that incorporates an instructor assisting students in the development of an academic program and a career plan compatible with each student's individual skills and interests provides opportunities for the instructor, who in this case was also a PLUSS advisor, to develop stronger relationships with students. This strategy for reaching students comports with the NACADA Statement of Core Values of Academic Advising (NACADA, 2005) and King's (1995) description of the freshman seminar.

PLUSS advisors taught all sections of the STEM 101 seminar course, which provided an additional opportunity for them to interact with PLUSS students. STEM 101 gives students the chance to build peer support networks, strengthen foundational knowledge of academic resources, learn the proper techniques for giving class presentations, and develop a realistic academic plan. After the successful completion of college algebra, students were transitioned from their PLUSS advisors to faculty academic advisors within their chosen majors. Each department chair took an active role in assigning PLUSS students to selected advisors who would continue working closely with these transitioning students.

Methods

We employed a quasi-experimental design to compare retention rates of first-time, full-time students declaring a major in a STEM discipline. One group was comprised of first-time, full-time

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students declaring a STEM major during the 5 years (2001–2006) prior to initiating the PLUSS program. Another group was comprised of first-time, full-time students declaring a STEM major during the initial 4 years (2008–2011) of the PLUSS program (2007 was the pilot year and not included in the study.) The pre-program group contained a subgroup with characteristics consistent with PLUSS eligibility and another subgroup considered non-PLUSS eligible. The group enrolled after PLUSS initiation was likewise split into those who were and were not eligible to participate in the PLUSS program. We compared the retention rates after 1, 2, and 3 enrollment years.

Hypotheses

We developed six hypotheses to guide the study of PLUSS students and retention. We tested the significance of the percentage differences of each group (those participating and those eligible before PLUSS program initiation as well as those STEM students not eligible in either time period) using post hoc *t* tests.

Hypothesis 1

$H1_0$. The 1-year retention rates for the PLUSS-eligible students, as measured prior to PLUSS initiation (2001–2006), and the PLUSS students are equal.

$H1_1$. The 1-year retention rates for PLUSS students are higher than the retention rates for PLUSS-eligible students in STEM programs prior to the initiation of PLUSS.

Hypothesis 2

$H2_0$. The 1-year retention rates for non-PLUSS students in STEM majors prior to PLUSS initiation and the non-PLUSS students after the initiation of the program are equal.

$H2_1$. The 1-year retention rates for students not eligible for the PLUSS program prior to and after initiation are not equal.

Hypothesis 3

$H3_0$. The 2-year retention rates for PLUSS-eligible students enrolled in STEM majors before PLUSS initiation and PLUSS students are equal.

$H3_1$. The 2-year retention rates for PLUSS students are higher than the retention rates for PLUSS-eligible students in STEM majors prior to PLUSS initiation.

Hypothesis 4

$H4_0$. The 2-year retention rates for students ineligible for PLUSS, as measured prior to PLUSS initiation, and the non-PLUSS students in STEM majors after PLUSS initiation are equal.

$H4_1$. The 2-year retention rates for students ineligible for the PLUSS program either before or after program initiation vary minimally.

Hypothesis 5

$H5_0$. The 3-year retention rates for PLUSS-eligible students enrolled in STEM majors before PLUSS initiation and participating PLUSS students are equal.

$H5_1$. The 3-year retention rates for PLUSS students are higher than the retention rates for PLUSS-eligible students enrolled in STEM majors prior to PLUSS initiation.

Hypothesis 6

$H6_0$. The 3-year retention rates for students ineligible for PLUSS before or after program initiation are equal.

$H6_1$. The 3-year retention rates for students ineligible for the PLUSS program either before or after initiation vary minimally.

Results

We performed a simple post-hoc *t* test for all hypothesis comparisons, with a statistical significance value set at $p = 0.05$. $H1_0$ was rejected ($z = 5.632$, $p = 0.00$) in favor of the alternate hypothesis. That is, 1-year retention rates for PLUSS students were higher than the retention rates for PLUSS-eligible students enrolled in STEM majors prior to implementation of the PLUSS program. $H2_0$ could not be rejected ($z = 0.788$, $p = 0.431$), indicating that the 1-year retention rates for those ineligible for PLUSS, as measured before and after program initiation, varied minimally. See Table 2.

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Table 2. Percentages of students retained after 1, 2, and 3 years

Students	%	*n*	%	*n*	% Increase or Decrease
Year 1	**2001–2006***		**2008–2011**		
PLUSS Students	32	432	53	281	66
Non-PLUSS STEM Majors	58	881	56	670	−3
Year 2	**2001–2006***		**2008–2010 & 2009–2011**		
PLUSS Students	16	432	24	143	50
Non-PLUSS STEM Majors	40	881	41	670	3
Year 3	**2001–2006***		**2008–2011**		
PLUSS Students	11	432	38	62	50
Non-PLUSS STEM Majors	35	881	35	670	0

Note. *Data collected prior to the implementation of the PLUSS program from students who would have been eligible for it

$H3_0$ was rejected ($z = 2.008$, $p = 0.022$) in favor of the alternate hypothesis: Two-year retention rates for PLUSS students were higher than the retention rates for PLUSS-eligible students enrolled prior to implementation of the PLUSS program. $H4_0$ could not be rejected ($z = 0.397$, $p = 0.691$) indicating that the 2-year retention rates for non-PLUSS students enrolled in STEM majors before and after PLUSS program varied minimally.

$H5_0$ was rejected ($z = 3.014$, $p = 0.001$) in favor of the alternate hypothesis: Three-year retention rates for PLUSS students were higher than the retention rates for PLUSS-eligible students enrolled in STEM majors prior to PLUSS program initiation. $H6_0$ could not be rejected ($z = 0$, $p = 1.000$) indicating that the 3-year retention rates for non-PLUSS students varied minimally.

Discussion

Specific Implications for the PLUSS Program

Since implementation of the PLUSS program, retention rates (1-, 2-, and 3-year) of underprepared STEM majors have increased. For the 6 years prior to the implementation of the PLUSS initiative, the rate of retention for underprepared students to the university stood at 55% and the rate of retention of STEM majors was 32%. For the four PLUSS cohorts (2008, 2009, 2010, and 2011) for which data are available, 1-year retention of underprepared students increased to an average of 70% and retention within the STEM disciplines increased to an average of 53%. Since the Fall 2008 semester, 281 incoming freshmen have participated in PLUSS, representing 25% of incoming students with declared majors in STEM disciplines. Students included in the PLUSS program have mathematics placement scores that do not allow them access to college algebra.

The PLUSS program has increased awareness of the importance of academic advising throughout the Pott College of Science and Engineering, resulting in additional professional development opportunities for all faculty members, anecdotal information from advisors and students indicating improved advising satisfaction among all science students, increased communication between and within disciplines concerning advising issues, and increased retention within the college. Advising at-risk students is often time intensive. Transferring the advising responsibilities of the at-risk students to the PLUSS advisors provided faculty advisors within the disciplines more time to spend with their other advisees, an unanticipated positive consequence of the PLUSS program.

Sixty percent of PLUSS students passed the general studies algebra review course with a C or better on their first attempt; the success rate for all non-STEM University of Southern Indiana freshmen on their first attempt was 51%. In a similar trend, 69% of PLUSS students earned grades of C or better on the first attempt; 55% first-time freshmen were successful on their first attempt. Because they needed to start with lower-level mathematics courses (M-SAT scores of 472, well below the value indicating readiness for calculus), few PLUSS students have progressed into calculus; however, 38% of those who have enrolled in higher math have been successful. Ninety percent of the PLUSS students completing STEM 101 have been successful; those who were unsuccessful either withdrew from the course after changing their majors, did not participate, or stopped attending.

In addition to increased awareness of advising, students and faculty members enjoy benefits associated with PLUSS. Faculty members receive

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more internal professional development opportunities for advising, especially helpful for working with students on academic probation. Non-STEM departments have expressed interest in developing similar programs for their students. A presentation on the PLUSS program received positive attention by the university trustees, and the university has included advising as a major component of the new strategic plan. PLUSS successes were presented at NACADA annual conferences in 2009 and 2010 and the American Association of Colleges and Universities (AAC&U) Next Generation STEM Learning conference in 2012.

General Implications

By gathering, reviewing, and analyzing retention and graduation data, any college can identify specific problems with advising first-year STEM majors and develop a program to address student needs. Furthermore, they can adapt a PLUSS-style program to improve retention of students in non-STEM majors. By using evidence-based decisions to develop customized advising plans, universities can realize gains in retention and graduation rates, and students will have enhanced opportunities to reach their academic goals. By providing additional resources, such as customized and comprehensive academic advising based on data, postsecondary institutions can foster an environment that is conducive to meeting students' needs, regardless of their level of preparedness upon admission, and strategically manage enrollments.

The uniqueness of this initiative comes from a compilation of proven strategies: identifying at-risk students, careful selection of faculty advisors, extensive advisor training, formal and informal timely student-advising sessions, and a first-year seminar course. These initiatives are not discipline specific nor are they tailored to a specific university setting. Other colleges or universities implementing similar programs could realistically expect results similar to those obtained by our university—an increased awareness of the importance of academic advising, an increase in student retention rates, and a cohort of academic advisors receiving timely professional development.

Summary

When comparing the retention rates for students in the PLUSS program to those for all incoming freshmen, we saw clear increases across three categories: 1-, 2-, and 3-year retention rate. While they do not reflect optimum levels, the 3-year retention rate (2008–2011) for the PLUSS cohort continues to trend upward (11 to 19%) while the retention rates for the non-PLUSS incoming freshmen remain unchanged at 35%. As reported by the PLUSS advisors, the relationships built while students are in the program remain strong after students transition to discipline-specific advisors. Therefore, we anticipate that the expanded academic advising provided by the PLUSS program will translate to increased graduation rates. PLUSS provides the framework for the ultimate goals of enhancing student success through timely and accurate advising information and by empowering students to make wise educational decisions.

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