PURDUE UNIVERSITY

Attracting Students to STEM Careers

A WHITE PAPER SUBMITTED TO THE 2007-2013 PURDUE UNIVERSITY STRATEGIC PLANNING STEERING COMMITTEE

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EXECUTIVE SUMMARY

Well-documented trends have been reported nationally of declining interest, poor preparedness, a lack of diverse representation, and low persistence of U.S. students in STEM (Science, Technology, Engineering and Mathematics) disciplines. It is imperative that Purdue University responds proactively to the needs for education in STEM and STEM-influenced fields. In order to continue raising the profile of its educational programs nationally and internationally in all disciplines, Purdue must address numerous systemic and programmatic challenges that are fundamental to the education of our students.

We propose 3 initiatives, which are interrelated and interdependent.   We believe that the first initiative has three essential strategies that must occur together in order for any of these to succeed. In summary, these are:
1. STEM Student Experience and Success
   a. Address the Need for Better Prepared and More Diverse Entering Students
   b. Student Retention and Support
   c. Reforming Faculty Development and Reward Structure to Improve Pedagogy
2. STEM Public Policy and Leadership
3. Articulation between Research and Scholarship in P-20 STEM Teaching and Learning and Classroom Practice

Our resulting set of recommendations address issues along the educational continuum, beginning with students and their communities before they apply to Purdue, the current community of people (students, faculty and staff) at Purdue, and entities outside of Purdue that that can have an impact on regional, state and national policy.
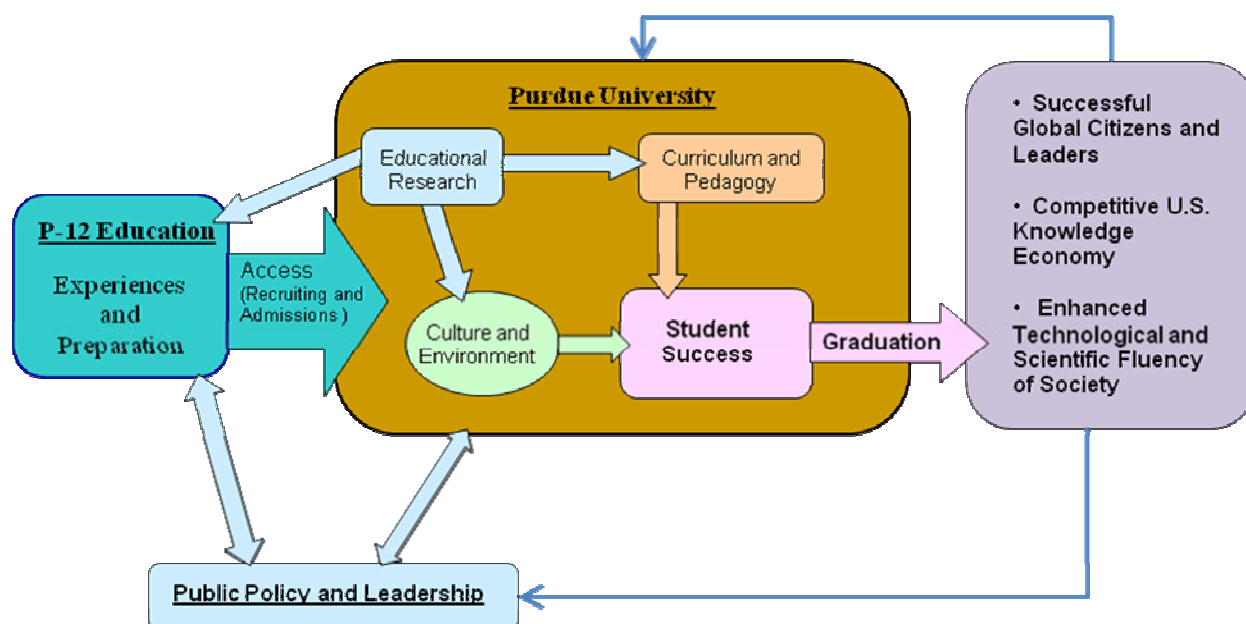
OVERVIEW

A national crisis has been identified in the area of global technological competitiveness [1, 2]. Statistics on the state of education in the United States indicate a decreasing trend in domestic students choosing to major in and successfully complete degrees in Science, Technology, Engineering and Mathematics (STEM) disciplines [3]. Leaders in STEM fields have recently called for major initiatives to be undertaken nationally to address these educational trends [1, 4, 5]. In engineering, the need for change has been highlighted by American Society for Engineering Education's (ASEE) Engineering Deans Council and the Corporate Roundtable (1994); the National Research Council (1995); the National Academy of Engineering (2002 and following); and the National Science Foundation.

These reports argue that tomorrow's graduate will compete in an emerging global economy fueled by rapid innovation and marked by an astonishing pace of technological breakthroughs. STEM graduates will navigate a shifting societal framework enhanced by technologies that lengthen life spans; enable yet-to-be imagined means of communication; create wealth and economic growth through accelerated product development cycles; require multidisciplinary efforts in emerging areas; and link virtual teams from global locations. The thorough integration of technology with society will challenge the analytical skills, creativity, and leadership of STEM graduates; demand participation in public policy; and require ethical adaptations to constraints of developing countries. Political and economic relations between nations, the global marketplace, national security issues and multilingual influences will dramatically shape the STEM practice [6].

But will our science and high technology sectors have the talented STEM graduates prepared to compete and be leaders in tomorrow's world?

Recently, U.S. high-tech workers have seen trends unanticipated 10 to 20 years ago: the outsourcing of mainstream engineering and computing jobs, less reliance on U.S.-born PhD graduates, a mandate for technological fluency, and the need to retrain in order to successfully change careers multiple times. Landmark studies, including the National Academy of Engineering's Committee to Assess the Capacity of the U.S. Engineering Research Enterprise and the Task Force on the Future of American Innovation's *The Knowledge Economy: Is the United States Losing it's Competitive Edge?*, negatively assess the health and competitive capacity of the U.S. high-tech enterprise. However, key stakeholders in industry, government, and academia are indicating accelerated interest and active commitment for innovative approaches to a national plan of action.

With these reports and their predicted consequences in mind, it is imperative that Purdue University responds proactively to the needs for education in STEM and STEM-influenced fields. Purdue University has long been recognized for strength in its STEM fields, and has also developed a world-class reputation in areas such as management, agriculture and veterinary medicine. In order to continue raising the profile of its educational programs nationally and internationally in all disciplines, Purdue must address numerous systemic and programmatic challenges that are fundamental to the education of our students. It is important to recognize

that many of the issues of national technological competitiveness are closely linked to the types of educational programs that Purdue offers in its STEM majors and disciplines, and it is therefore imperative that these be addressed specifically. However, a strong foundation in STEM courses and experiences provides the foundation of numerous fields of study at Purdue, both STEM and non-STEM, and has relevance even in the Liberal Arts disciplines. Indeed, we propose initiatives that will have an impact across the University, even though they are based in the need to improve the educational experience for students in STEM disciplines.

The recommendations of this working group are based on input from numerous sources, including graduate and undergraduate students, staff, faculty and administrators (Appendix A). In addition, the members of the committee have pooled their knowledge of educational research and examined institutional data to reach consensus about areas of critical need, and recommendations for addressing them. We are particularly concerned by Purdue-specific data that show a large percentage of students choosing to leave majors in the Colleges of Science and Engineering within the first year, and the high D, F and withdrawal (W) percentages in many courses that are foundational to the STEM and STEM-influenced disciplines. In addition, repeated comments regarding the lack of access to faculty or a perception of faculty who do not care about students compelled us to search for the sources of these issues. Our resulting set of recommendations address issues along the educational continuum, beginning with students and their communities before they apply to Purdue, the current community of people (students, faculty and staff) at Purdue, and entities outside of Purdue that that can have an impact on regional, state and national policy.
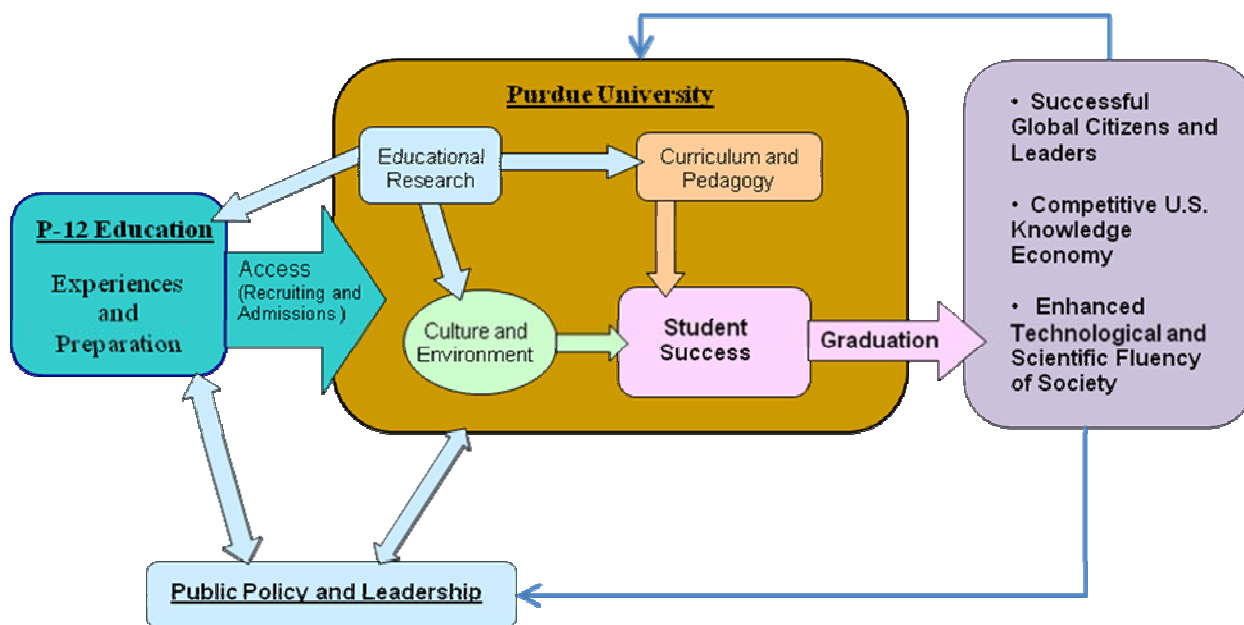
Figure 1. Stakeholders and Pathways of a Purdue Education.

We believe that the issue of primary focus should be that of retaining and empowering students in STEM disciplines in the first and second years at Purdue. However, the factors that contribute to achieving this are far-reaching, and encompass programs at the pre-college level, recruitment, admissions, and even faculty policies. Success in STEM courses and in STEM disciplines in the

first two years will serve as the lens through which each of the committee's three major recommendations will be focused, though their impact will ultimately be broader.

We propose three initiatives, which are interrelated and interdependent. We believe that the first initiative has three essential strategies that must occur together in order for any of these to succeed. In summary, these are:

1. STEM Student Experience and Success
   a. Address the Need for Better Prepared and More Diverse Entering Students
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PROPOSED INITIATIVES

INITIATIVE 1. STEM Student Experience and Success

Data regarding pathways to STEM careers indicate that a critical transition point exists in the first and second years of college[3]. A high percentage of students leave their intended STEM majors during this time. The trends also indicate that the percentage of students leaving these majors is higher for female students and higher still for under-represented minority students[3]. These national trends are also evident in data that is specific to Purdue (Appendix B). We note that these problems are particularly conspicuous in the STEM disciplines compared to others at Purdue. Furthermore, at Purdue, the trends in the College of Technology data are markedly different than those in Engineering and Science, leading to less concern for CoT programs than other STEM programs.

Research suggests that the reasons for these trends are not due to students' performance or attitude attributes, but instead are closely linked to an early loss of interest in science, perceptions of poor teaching, selecting a STEM major with insufficient information about the career, and feeling overwhelmed by the pace and load of the curriculum[7]. To reverse these trends at Purdue University and attract students to STEM careers, we believe three interrelated initiatives are needed. First it is imperative that we increase the level of academic preparation among the pool of students interested in STEM careers so they are prepared for the rigors of STEM education at Purdue. Second, we need to reform the pedagogy and culture of teaching at Purdue in order to create exciting and engaging STEM learning experiences for all students on campus. Finally, we must develop strong mentoring and support programs for students in STEM majors to ensure that those students maintain their interest in STEM disciplines and experience success along the path to graduation.

1a. Address the Need for Better Prepared and More Diverse Students

Institutional data about the qualifications of entering students clearly demonstrate that many students entering STEM disciplines at Purdue are not adequately prepared to succeed in college-level coursework (Appendix C). In addition, the entering student population at Purdue is 87% Caucasian/White. While the diversity of entering students is very similar to the distribution of Indiana high school graduates who take the SAT (Appendix D), there is a need to increase the diversity of the entering class beyond what the Indiana distribution offers. To increase the diversity of entering students, we need strategies that target out-of-state students. To increase the number of highly prepared students who apply to Purdue, we need strategies focused on both in and out of state students.

1. **Increase the overall academic profile of each entering class, as based on measures such as SAT scores, AP classes taken, AP scores, and number of math classes taken.**
   Student success in the rigorous academic programs at Purdue will be increased if students are well prepared when they enter (Appendix C). At the recruitment and admissions stages, there are a limited number of variables that affect the preparation of students enrolling at Purdue, such as: the level of preparation of students applying to Purdue (see #4 below), the criteria for students accepted, the number of students accepted, the number of students who actually enroll (the "yield") and the level of preparation of students who actually enroll. The fraction of students who enroll at Purdue (Appendix E) may not be capturing the students with the highest levels of preparation who apply and are admitted. For in-state students, there is a small percentage – such as the top 2-4% – who choose top-tier out-of-state schools. While this is a small percentage of the state's students, it could be a significant fraction of a Purdue entering class. It is important to develop strategies to attract these students to Purdue through aggressive recruiting and incentive efforts. We believe that every effort should be made to increase the number of well-prepared students who apply to STEM majors at Purdue and to enroll those students who have a strong preparation. The exact mechanisms for how to achieve this require further study and consideration. It is also important to ensure that students' interests and backgrounds are well-matched to their majors and colleges, rather than enrolling students in colleges for which they did not have a primary interest, thus increasing the chances of those students having a poor experience and leaving.
   We also support multiple pathways for admissions to STEM majors for students who initially have a lower level of preparation, such as admission through the regional campuses and the 2-year college system across the state. It is very important that Indiana students be given access to the Purdue system, while ensuring that students be in settings where they will be best served to develop a strong foundation for success.

2. **Develop and promote an attractive and inspirational message about the STEM disciplines at Purdue and the role they play in addressing global challenges.**
   We need a creative and exciting marketing campaign for STEM majors at Purdue that stimulates potential students to think about the technical fields in a new way that is attractive and inclusive. It is particularly important to highlight exciting job opportunities related to STEM discipline majors, and ensure that potential students see Purdue as a stepping stone to these stimulating professions by highlighting outstanding Purdue

programs. Among out-of-state students, this will help to raise Purdue's overall visibility – which is badly needed. Among in-state students, this will enable Purdue to attract the top 2-4% of students who opt for top-tier, out-of-state institutions.

3. **Increase out-of-state recruiting and expand financial packages for high-ability, out-of-state students.**

 Raising the level of Purdue's visibility in other states, from coast to coast, should be a high priority. Because the costs of an out-of-state education are often a disincentive for students to consider an institution, we recommend that substantial financial incentive packages be developed for high-ability out-of-state students. **Targeted recruitment in high diversity areas of the country is strongly recommended**. Efforts should be made to include varied, possibly non-traditional mechanisms in the admissions process to ensure a diverse pool with a process that allows talent of various forms to be showcased by applicants.

4. **Work with teachers and policy makers in Indiana to help raise the level of preparation of in-state students.**

 To increase the pool of well-prepared Indiana students who are interested in STEM careers, we recommend that Purdue continue and increase its active engagement with P-12 education across the state. Purdue can influence the academic preparation of P-12 students in Indiana and encourage them to achieve high levels of STEM literacy by **increasing the information about science and engineering careers** for P-12 students, teachers, counselors, and administrators and **emphasizing the need for solid math and science preparation required to be successful in the majors leading to these careers**. Purdue can also play a leadership role in ensuring that all students in the state have access to higher level STEM courses that are essential preparation for STEM careers, such as calculus and AP science courses, and helping to integrate STEM thinking process and content into the P-12 curriculum. This may take many forms, including working with teachers and schools directly through curriculum development and professional development programs or engaging teachers in on-campus activities at Purdue (such as serving as an AP training site) that catalyze communication between Purdue faculty and the state's teachers.

 Numerous individual efforts of this nature are taking place throughout campus, such as the I-STEM initiative, the Woodrow-Wilson Fellowship program ("STEM Goes Rural"), , the Advanced Life Science Education initiative and outreach activities from each college and centers like CRESME, GERI, and INSPIRE (Appendix F). While each of these has been successful on its own, it is important to **develop a unified philosophy and approach for these efforts, and to bring them under a single oversight entity**, such as the new P-12 Engagement Center or Discovery Learning Center. These activities need to be more completely catalogued across the campus, which will allow holes in our programmatic efforts to be identified. In this way, it may be possible to have greater impact on a larger scale throughout the state. Playing a leadership role to encourage a change in the preparation of Indiana students should likely also involve public policy level activities in which Purdue can use its position as a "pole star" educational institution to **encourage the state of Indiana to bolster math and science requirements for students across the state**, especially those planning to apply to in-state STEM majors.

5. **Continue and strengthen recruitment of international students.**
    STEM education and scholarship is an international priority but the United States is still considered to be a leader in this area. Therefore many international students would like to attend Purdue and universities across the globe would like to be affiliated. Purdue should consider expanding cooperative agreements with these universities. In addition every effort should be made to eliminate artificial barriers for those students to join us. Recruitment efforts for international students should be stepped up. In particular, Purdue should develop an international marketing plan that will utilize media and venues that are favored by international students.

1b. Student Retention and Support

There are numerous educational components of the early years at Purdue that are intended to challenge, engage and motivate students for further studies. However, it is evident that, in many cases, these goals are not being achieved. In fact, it is clear that quite the opposite is taking place in many of the courses and programs that our entering students find themselves a part of. It is imperative to create an environment for students that nurtures their skills and talents and encourages them to persevere, and one that engages their curiosity and creativity as part of their foundational learning. It is particularly important that changes in the experience of the first years and of ongoing support structures be made if we intend to retain students whom we specifically recruit Purdue to major in STEM disciplines. A high quality teaching experience will ultimately allow Purdue to attract more students to these majors.

1. **Change the Learning Experience in the First Two Years**
    College-based enrollment data from Purdue suggests that there are major losses out of the Colleges of Science and Engineering (Appendix G), and that these losses occur primarily within the first two years (Appendix B). The losses are higher for underrepresented minority students and, in science, higher for females (Appendix B). In addition, the 6-year graduation rates within those Colleges are undesirably low (Appendix H). In order to address this "flight from science and engineering" it is necessary to make dramatic, not incremental, changes in our approach to education in the early years.
    Learning Communities data for Purdue (Appendix I) show higher success rates for students engaged in these groups, with the largest impacts being on female and underrepresented minority students. However, University-wide only about 20% of first-year students are involved in learning communities (30% in Science, 29% in Engineering).

    To change the learning experience of the first two years in STEM, we recommend:
    - **Reduce class sizes of first and second year courses and provide opportunities to engage in smaller-group experiences associated with the large courses.** Research supports the inverse relationships between class size and student success and student retention[8]. Substantial efforts should be made to reduce the size of individual lecture sections that are currently larger than 120 students. Within large classes, there should be small-group "community building" opportunities, preferably involving no more than 25 students, that allow for high-quality student-student and

student-instructor interactions. These can use or build on the model of Learning Communities at Purdue which have demonstrated success at Purdue in being able to retain students and improve their performance (Appendix I). "Recitations" or labs with student TA's do not seem to be sufficient for this purpose, as demonstrated by courses with high DFW[1] rates which already have such structures in place.

- **Reduce the DFW rate of first and second year courses to no more than 25%.** Regular monitoring of these courses should take place, including enhanced teaching evaluation. Departments should provide a plan over the period of 3 years to reduce DFW rates for courses that are consistently over this limit. A Department-level accountability system should be put into place for courses that continue to have DFW rates consistently higher than this limit. **A reduction of DFW rates does not imply that a course must lose rigor,** but that research-based approaches to pedagogy should be put in place to create a learning environment in which students are supported to succeed (see Initiative 1c, below).

- **Institute a common first-year experience for all students at Purdue.** This experience should consist of one course each semester of the first year that is cross-disciplinary across colleges. Such courses should explore the connections between society, business, politics, culture, history and/or literature and topics in STEM.

- **Provide undergraduate experiential learning opportunities in the first two years for STEM students, such as undergraduate research and service learning.** Students should be provided early-on with opportunities to engage in the authentic activities of practitioners of their field. In addition to providing a better learning experience for our students, **this will also help us to recruit well-prepared students interested in STEM majors**. While the traditional form of student research (apprenticeship in a research group) can form some portion of this effort, other curricular-based models also exist and have supporting evidence for their efficacy (for example, EPICS, CASPiE and SENCER; see Appendix J) that can contribute to this effort by providing the remainder of students with these opportunities through coursework.

2. Increase Retention through Student Support and Mentoring

In addition to information about which courses to select for a given major, students have repeatedly expressed a need for support structures that will provide them additional information about careers available in their selected field, insights about how to succeed at a large university such as Purdue, mentoring and advocacy for difficult academic experiences, and a more personal relationship with professors, advisors and other students. Enhanced mentoring of students – both with respect to career information and academic advising – must begin as soon as a student is admitted to Purdue, and continue until they graduate.

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[1] DFW Rate refers to the percentage of students enrolled in a class who receive a grade of D or F or withdraw after the second week of the semester.

- **Provide unified student support services, including mentoring, tutoring and advocacy. Engage more senior students as mentors for entering students**. Successful examples of such peer mentoring approaches exists at other institutions around the country, and have demonstrated particular success in helping to retain female and underrepresented minority students. This could take place by expanding the services of the existing Student Access, Transitions and Success (SATS) office, or by creating a new umbrella Center for Student Success that will absorb some of the SATS programs.

- **Increase the number of academic advisors** for STEM disciplines and link each student to a single academic advisor with whom they can develop a long-term advising relationship.

- **Provide ways for larger numbers of students to be part of Learning Communities**, which have demonstrated success at Purdue in being able to retain students and improve their performance (Appendix I).

- **Examine ways to enhance the success and reach of programs such as** Women in Science, Women in Engineering, and the Minority Engineering Program which are already active on campus and have been proven successful.

1c. Reforming Faculty Development and Reward Structure to Improve Pedagogy

In order to improve the experience of undergraduate students in their first two years at Purdue, it is essential to transform the culture of our educational approaches. Currently, students experience a largely impersonal environment during their freshman and sophomore years. Many STEM classes, in particular, tend to be large lecture classes with associated labs, where the emphasis is on the memorization of content and the following of prescribed procedures, rather than the use of STEM reasoning and applications to broader contexts or real-world issues. In addition, the faculty reward system focuses primarily on the Scholarship of Discovery so that teaching and educational endeavors have a low priority for many faculty and Departments. There are few incentives and rewards for faculty to engage in developing excellence in teaching and educational endeavors and some Colleges actually discourage junior faculty from making a heavy investment in teaching. The university needs ways to integrate high expectations for teaching and educational activities into the promotion and tenure process. In addition to this shift to a system that balances the Scholarship of Learning with the Scholarship of Discovery, it is also necessary to encourage a shift from thinking about pedagogy in terms of "teaching" to one that considers "learning" as the primary goal. This allows us to link pedagogy with learning outcomes, student experience, and assessment. To change the learning environment for students in the first two years, we need to fundamentally shift the pedagogical culture at Purdue to one in which students feel supported and connected and in which high-quality, informed teaching is valued, expected and rewarded.

In order for this shift to occur it is necessary for several steps to take place:

1. **Revise Promotion and Tenure (P&T) policies to increase emphasis on teaching and educational activities by faculty**. Demonstrated faculty activities should include:
   - Engaging in professional development activities in teaching with support of the Department and College, including course-release for such activities.
   - Demonstrating outcomes-based curriculum designs.
   - Discussing use of teaching methodologies in their courses that include active learning, collaboration, problems/issues-based connections and critical thinking.

2. **Engage all faculty members in professional development in education and pedagogy at Purdue** before their first semester of teaching at Purdue, with follow-up through the first semester of teaching (including receiving guidance on how to document these efforts for the purpose of P&T).
   - Providing for this item will entail developing professional development workshops/courses that are suited specifically to this purpose, beyond what the Center for Instructional Excellence (CIE) typically offers. This could be an effort that builds on the programs of CIE. The workshops should be based on research findings in the Scholarship of Teaching and their connection to best practices in the classroom.
   - Expect faculty who are already at PU to engage in ongoing, periodic professional development. Colleges and primary units should determine methods to ensure active participation by all faculty.

3. **Establish an oversight body** for this initiative that would carry out reviews of Departmental teaching practices, including items listed in #1 for all their faculty and courses, on a regular basis. This can consist of the Vice Provost for Academic Affairs and the Associate Deans for Undergraduate Education for each College.

4. **Develop a uniform structure and minimum criteria for training of all graduate-student teaching assistants (TA's).** TA training should focus on state-of-the-art pedagogy, student engagement and learning theories. This could be an enhancement of TA training programs currently offered (for example, by CIE or in Departments.) STEM and non-STEM criteria may need to be different.
   - Ensure that minimum criteria for English language proficiency for TA positions are adhered to and are sufficient to provide a high-quality STEM learning experience for Purdue undergraduates.

5. **Define guidelines for Departmental teaching review practices** for their faculty that provide certain minimum standards, including review of educational materials (exams, syllabi, lecture materials, websites, etc.), visits by peers to classes, and documents needed to demonstrate teaching quality. These should be tied to the requirements included in the North-Central Accreditation measures. It is necessary to ensure that teaching is not evaluated solely on the basis of student evaluations, and that these must be balanced with several other peer and professional measures.
   - Examine the validity of the PICES student evaluation tool as an instrument to measure the *quality of teaching*. Also examine the correlation of its ratings to course grade. Determine if the instrument needs to be revised, replaced or supplemented by another instrument.

It is critical that these changes take place simultaneously in order to properly reward and measure the recommended changes in pedagogy.   For example, requiring increased faculty development in pedagogy and new teaching evaluations will not be successful if these are not concomitant with changes in the P&T reward structure. The cultural shift to student learning can only take place if it is clear that this is valued, and the reward structure is a concrete indicator of what is expected and valued from faculty.

INITIATIVE 2. STEM Public Policy and Leadership

With reports such as those of the Spellings Commission and the NCLB movement, it is important that Purdue be a leader in shaping and influencing policy with respect to higher education. It would be particularly important to act proactively regarding the quality of undergraduate education before an NCLB-like approach becomes mandated for higher education.

Making the case for adequate and sustained funding and support is principally a matter of giving clear indication of the benefits to be accrued as well as periodic updates of progress to date. Given the current concerns about the global competiveness of the US economy, the recognized need for STEM education to prepare more adaptable and agile graduates for a rapidly evolving world, and the technological dimensions of national and global grand challenges, this case is already being made in a variety of fora[6, 9, 10]. While the case itself is relatively easy to make, it must be made to the proper audiences—those who control the purse strings not only within state and federal agencies, but also their Congressional and legislative overseers.

Though many legislators are concerned about their states' or the nation's competitiveness, most are not aware of STEM education and research, nor have they considered it as a policy option. Despite this lack of political momentum, a general interest in STEM education issues and a search for solutions among policymakers may be a sufficient opening to raise the profile of STEM education and research. We need to lead an advocacy effort with state and national legislators to influence national policy-making and increase the U.S. government's commitment to STEM education and research.

We also need to develop partnerships with national media to develop pop-culture appeal in television programming, music, and/or games, such as an award-winning television series, such as CSI, that features STEM careers at work. This can be partly accomplished by partnering with national professional organizations, major networks, television producers, educators, media consultants, etc., to develop concept, strategy, and content ideas.

To accomplish our goals it is proposed to **establish a multi-disciplinary Institute for STEM Public Policy and Leadership** that will strongly facilitate the ongoing mission and strategic vision of Purdue University. This Institute will be a conceptually innovative and interdisciplinary effort that addresses the urgent, and well-documented, national need to stem the rapid erosion of scientific and technological leadership in the United States and to build support for educating a competitive workforce for a global, technologically complex knowledge economy. This Institute

has the potential to become a role model for similar future endeavors across the country and will establish Purdue as a national leader in this important area.

INITIATIVE 3. *Articulation between Research and Scholarship in P-20 STEM Teaching and Learning and Classroom Practice*

Purdue has a growing core of STEM education researchers who are faculty members in content-area departments and/or education departments. In many cases, these faculty are associated with one or more umbrella organizations dealing with educational research on campus, such as Discovery Learning Center (DLC), the Center for Research and Engagement in Science and Mathematics Education (CRESME) or the Institute for P-12 Engineering Research and Learning (INSPIRE). The work of many of these researchers is nationally and internationally renowned. We recommend that steps be taken to help catalyze the articulation between this research field and teaching practice in P-20 classes, especially those at Purdue. To do so requires a strong cadre of people to carry out this type of *translational* research leading to best practices. Achieving this has the potential to provide Purdue with immense recognition, both nationally and internationally. As summarized in Figure 1 from the overview of this document, educational research reaches into several areas that affect student success, but only if the articulation to practice takes place. As a large university, Purdue can provide a leading example to other institutions for achieving excellence not only in the Scholarship of Teaching and Learning, but also in reflecting it in Purdue's student experience. Recommendations:

1. **Catalyze and support translational research in teaching and learning** and the development of *best practices* through a unifying body. For example, DLC can play a leadership role to build the STEM educational research community at Purdue and to catalyze these articulation activities across campus
2. **Increase targeted/cluster faculty hiring** to continue building core areas in STEM education research. The College of Science "focus area" hiring in Science Education can serve as a seed for this effort, but it should be University-wide.
3. **Create a public forum** in which anyone involved in teaching or educational endeavors can avail themselves of practical information from the scholarship and research on teaching and learning.
   - This may include an internal publication highlighting this work, equivalent to "rapid communications" publications in science.
   - This may include a connection to the recommended "professional development" activities for all faculty discussed in Initiative 1c.
   - This may include an annual University-wide lecture series in which a STEM-research faculty member presents their work both from a research perspective but also from an "articulation to practice" perspective.

Best Practices Associated with these Initiatives

Talent Enhancement
The overall focus of these initiatives is talent enhancement. There are multiple levels of talent enhancement: the culture of Purdue will become more focused on the identification

and development of student talent; P-12 teachers will become more effective enhancers of STEM talent; P-16 students will benefit from enhanced STEM talent development opportunities; and all Purdue faculty will have opportunities to enhance their teaching talents and become more effective talent enhancers for their students. In addition, we will build on the strength of our Research and Scholarship of Teaching and Learning efforts.

Diversity

Each component of these initiatives will help develop diversity among students in STEM disciplines and at Purdue as a whole. Initiative 1a, concerned with recruitment and admissions, will result in a more diverse applicant pool to Purdue and will ensure that a more diverse group of Indiana students are receiving opportunities to engage in high level math and science preparation. Initiative 1b, concerned with retention and support, recommends several steps that have already been recognized to have increased impact among female and minority students. Thus, these will help to ensure that diverse students can succeed in STEM disciplines and majors. Initiative 1c, concerned with faculty development, will enhance pedagogy at Purdue to be more inclusive of diverse student audiences, not just with respect to gender and race/ethnicity, but also with respect to learning styles. Among the types of professional development activities that faculty will engage in is diversity training as it relates to the classroom. This will help to ensure that faculty are providing all students with a high-quality, rewarding experience regardless of race/ethnicity, sex, religion, socio-economic status or physical disabilities. In addition, it is recommended that every effort be made to hire a diverse faculty to serve as role models for Purdue students. In recruitment, it would be important to have a diverse recruiting team, with STEM background, to be able to better attract diverse, high-ability students.

International Awareness

Research in STEM education is an international endeavor. A particular challenge in the field is to attract and retain students and to provide them a rigorous preparation that positions the nation for global competition in the knowledge economy. By successfully bridging the excellence in its research programs to excellence in the educational experience, Purdue can be a leading example for other nations seeking to do the same. Furthermore, this will position Purdue to attract talented international students to its programs.

Resources

Resources will be required to:
- support a course-release semester for faculty to engage in faculty development activities
- enhance services and programs of CIE
- provide proper development and oversight of teaching evaluation protocols and policies
- enhance out-of-state recruitment efforts, including an increase in the number and diversity of recruiters, and recruiters specifically with STEM background
- create financial packages for out-of-state students
- hire new faculty
- hire staff and director for an Institute on STEM Public Policy and Leadership

Potential sources include Federal, State and private sectors. In general, resources to support programs that facilitate STEM education are currently very popular because many stakeholders, from state and federal agencies to foundations and industrial partners, believe that changes can be made in STEM education through strategic infusions of funds.

Access to this support is facilitated at all levels beginning with individual researchers as the "broader impacts" section of their grant proposals, to the campus Development Office for foundations and alums including efforts coordinated through Departmental and Research Office personnel to governmental affairs officers. For example, all agencies in the federal government based in STEM expertise provide support. These include the bigger players like the National Science Foundation, the Department of Education, the National Institutes of Health as well as others like DOE, NASA, NIST, and NOAA. Each of these agencies should be mined for funding. Many of the agencies concentrate on undergraduate research experiences and the development of STEM students through to the PhD.   NSF also sponsors projects for course and laboratory development, through the Course, Curriculum and Laboratory Improvement (CCLI) programs.

Our state government is interested in increasing the aspirations of Indiana students to a more rigorous course of study. For some of these programs our congressional delegation may be helpful, particularly with the D. of Ed.   Foundations and industrial partners also focus on the preparation of science teachers and raising student aspirations particularly from the point of view of competing in a flat world and for educational equity. Recently the State of Ohio received a large grant from the Gates foundation. We should also approach this program with a campus-wide systemic improvement proposal. The Howard Hughes Medical Institute (HHM)I also supports systemic education grants in the life sciences.

Many of these ideas resonate with alums who in particular would like to see Purdue maintain its reputation for overall quality in STEM degree programs. The current campus fund raising campaign has as its theme student success. This may be an opportunity to receive funds to build our student support services for retention of majors.

Finally, there are sources of funds from on-going student fees that may be tapped to pay for supplemental instructional services that are important for the retention of some of our students.

Facilities

Many classroom spaces are designed as lecture halls for tremendous numbers of students at one time – a design dating back thousands of years to early Greek architecture. The physical arrangement of these spaces make it nearly impossible to carry out any other kind of teaching and may, in fact, help to perpetuate the misconception that talking at students is an effective way to help students learn. In order to facilitate a shift to pedagogies that engage the learner and promote collaborative team work, efforts will need to be undertaken to redesign classroom spaces. Furthermore, additional spaces that allow for informal learning in groups and allow for the nurturing of student communities should be developed in every classroom building.

Management/Stewardship

These initiatives can be co-directed by the Vice Provost for Academic Affairs and the Vice Provost for Engagement, with the assistance of the Director of Admissions, the P-12

Engagement Center Director, the Director of the Discovery Learning Center and the Associate Deans for Undergraduate Education.

Communication/Positioning

The recommendations proposed in these initiatives would position Purdue to play a leadership role nationally in the Scholarship of Teaching and Learning, and within the state with respect to improving education. These will position Purdue to attract more students with high levels of preparation and interest in STEM disciplines, which will in turn help to drive Purdue's excellent research activities.

For communication on campus, it is recommended that a STEM leadership council be created of key campus individuals in the area of STEM education (i.e., Discovery Learning Center Director, Discovery Park K-12 Director; K-12 Engagement Coordinator in the Vice-Provost for Engagement Office, Director of the Center for Instructional Services) who will serve to disseminate information, including developing an annual report summarizing Purdue's accomplishments in the area of STEM education, research and engagement. For communication off campus, it is recommended to organize an external advisory committee of key stakeholders in the area of STEM education that would meet biannually or annually, both to provide input to Purdue on its efforts, but also to learn about what is taking place. This committee should consist of government leaders, educators and K-12 educational leaders, researchers, and academic leaders at other higher education institutions.

Evaluation/Metrics

- Number and diversity of students admitted as a % of those who applied by College and major.
- Number and diversity of in- and out-of-state students applying to STEM majors by major.
- Number and diversity of students graduating from Indiana high schools with the background needed for admission into STEM majors at Purdue.
- AP Performance levels of in-state students.
- Number of P-12 STEM initiatives undertaken with impact data on the effectiveness of those initiative in improving P-12 STEM learning.
- D/F/W rates from first and second year STEM classes.
- Dropout and CODO rates from STEM majors.
- Student attitudes about their major programs.
- Department reports of curricular and faculty evaluation revisions.
- # STEM courses conducted in inquiry-based, problem-based, or issue-based formats.
- Learning outcomes assessments from freshman and sophomore STEM classes that focus on the thinking and problem solving processes critical to the STEM disciplines.
- Graduation and one-year retention rates of students, by College, by gender and by race/ethnicity.
- Faculty perceptions of the relative weight of discovery, learning and engagement in the P&T process.
- # of grants submitted that have a STEM education focus
- Annual dollar amount of research expenditures on grants with a primary focus on STEM education
- Number and percentage of faculty involved in STEM education research
- Impact data on the effectiveness of STEM education models

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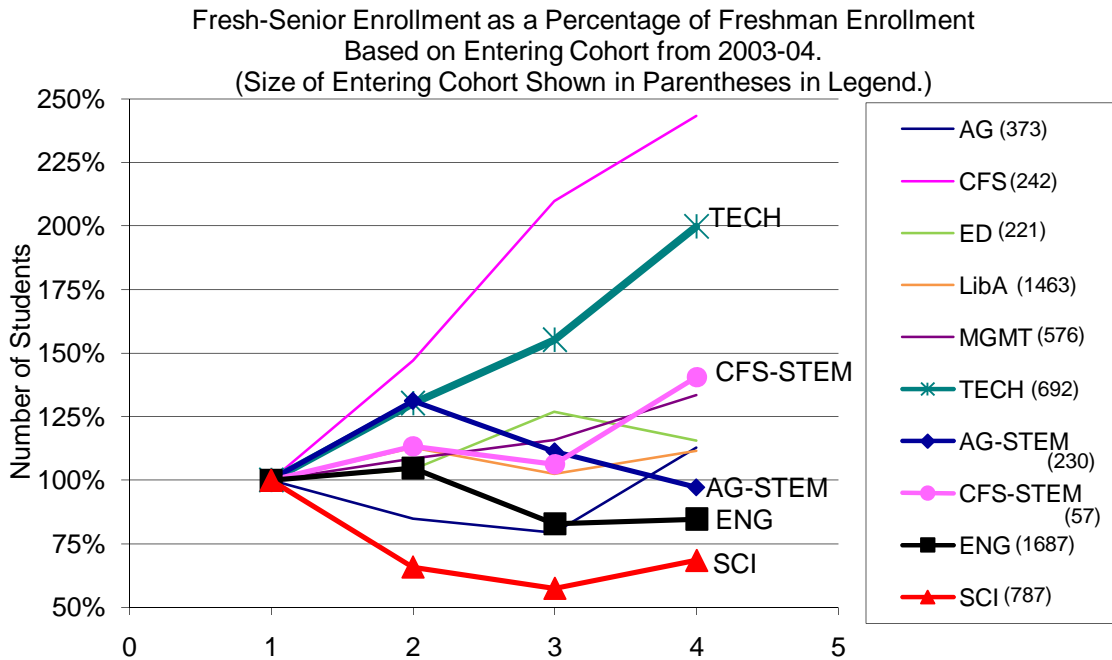
APPENDIX A: SOURCES OF INPUT TO THE STEM CAREERS WORKING GROUP

- Office of Institutional Research – statistical data.
- Meetings with undergraduate and graduate student governments.
- Attended presentation by Office of Enrollment Management.
- Meeting with Center directors and staff (CRESME, DLC, INSPIRE, GERI).
- Meeting with EPICS Director, William Oakes.
- Meeting with Center for Instructional Excellence Director, Marne Helgeson.
- Meeting with Dale Whittaker, Associate Dean of Agriculture.
- Meetings with other team chairs, Susan Curtis (*Synergies*) and Jackie Jimerson (*Student Success*)
- Open Fora (December 10, 2007 and January 24, 2008). Guiding Questions used:
  1. What are your suggestions for things that could be done to help retain and graduate students who enter a STEM major at Purdue University?
  2. What are your suggestions for initiatives/activities that would increase the number, diversity, and quality of students who apply to a STEM major at Purdue University?
  3. What factors contribute to students leaving the STEM disciplines (either as change of degree objective or as withdrawal)?
  4. What factors encourage students to choose a STEM discipline as a major?
- Brown-bag Discussion on January 10, 2008, with Undergrad Education personnel in each college (30 attendees).
- Student-focused Open Forum (February 13, 2008). Guiding Questions used:
  1. What are your suggestions for ways to ensure that the first and second year experiences help students excel and succeed in their STEM coursework?
  2. What are your suggestions for ways to inspire and support students who enter with a declared major in STEM to graduate in their intended major?
- Strategic Planning Blog Site, (47 postings).
- Meetings with Director of Admissions, Pamela Horne.

- In addition, the STEM Careers working group met 16 times on the following dates:
  - Tue. Nov 12, 2007
  - Mon. Dec 3, 2007
  - Mon. Dec 10, 2007
  - Mon. Dec 17, 2007
  - Thu. Jan 3, 2008
  - Mon. Jan 7, 2008
  - Mon. Jan 14, 2008
  - Tue. Jan 22, 2008
  - Mon. Jan 28, 2008
  - Thu. Jan 31, 2008
  - Mon. Feb 4, 2008
  - Fri. Feb 8, 2008
  - Mon. Feb 11,2008
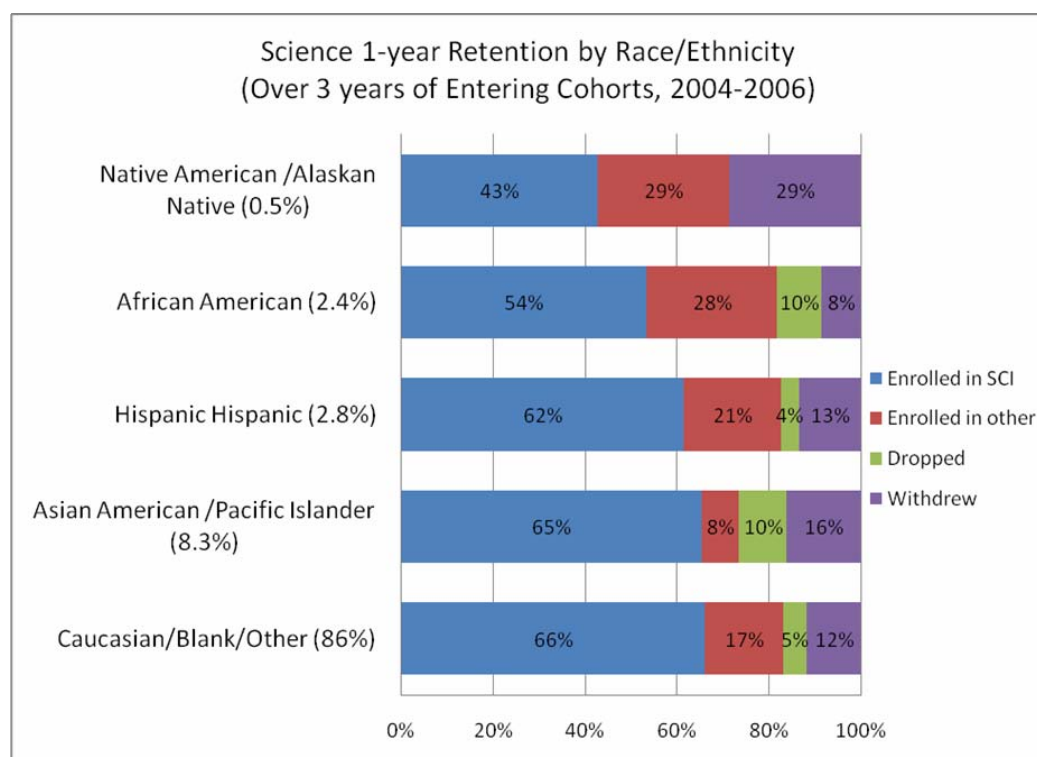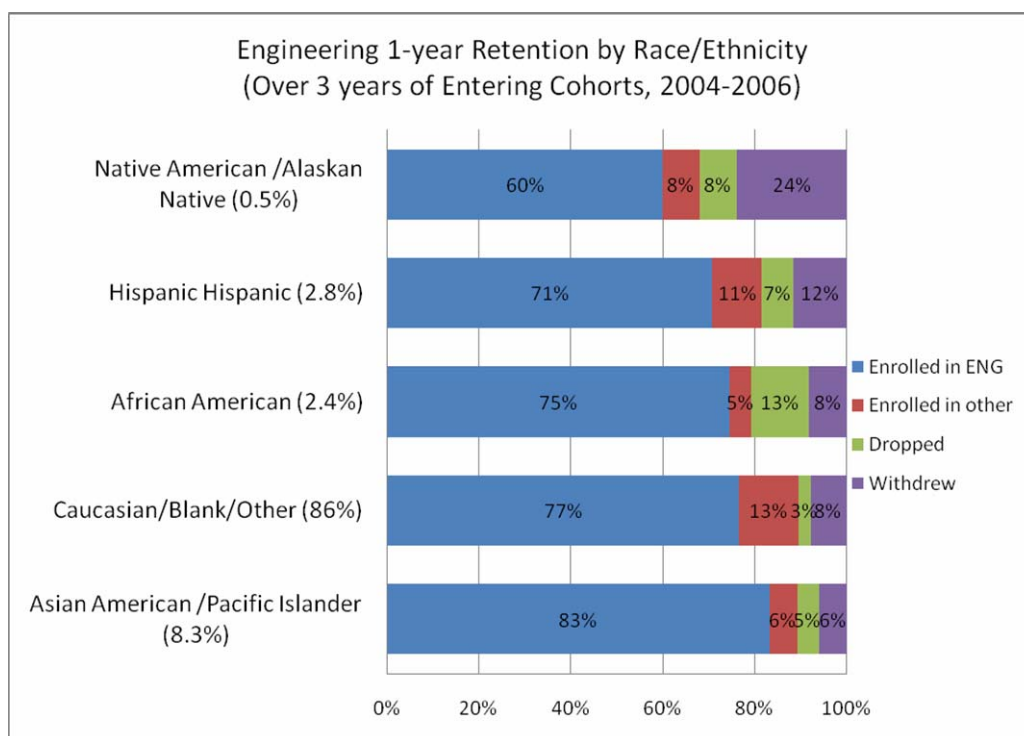 - Thu. Feb 14, 2008
  - Mon. Feb 18, 2008
  - Fri. Feb 22, 2008

APPENDIX B: PURDUE ENROLLMENT TRENDS

In the Colleges of Science and Engineering, significant drops in enrollment occur early on.

Fresh-Senior Enrollment as a Percentage of Freshman Enrollment
Based on Entering Cohort from 2003-04.
(Size of Entering Cohort Shown in Parentheses in Legend.)

Overall 1-year retention rates at Purdue are approximately 85% (±1 over 10 years). The value is lower for Science and for Engineering (see charts on next page).

1-year retention rates indicate that there is a disparity in retention of underrepresented minority students versus majority students (see charts on next page).

Engineering 1-year Retention by Race/Ethnicity
(Over 3 years of Entering Cohorts, 2004-2006)

Science 1-year Retention by Race/Ethnicity
(Over 3 years of Entering Cohorts, 2004-2006)

The 1-year retention by gender does not show as large a disparity.

1-year Retention by Gender for Science and Engineering
(Over 3 years of entering cohorts, 2004-2006)
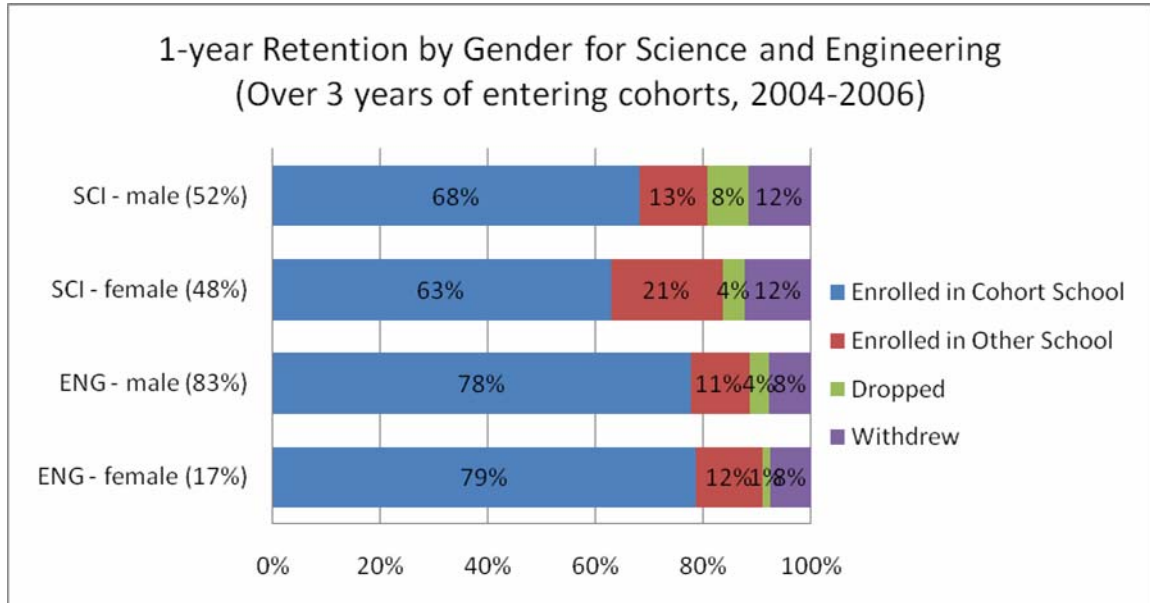
APPENDIX C: PREPARATION OF ENTERING PURDUE STUDENTS

Comparisons to Peer Institutions:

Average SAT Scores of Enrolled Freshman at Peer Institutions

75th Percentile Math and Verbal SAT Scores of Enrolled Freshman at Peer Institutions
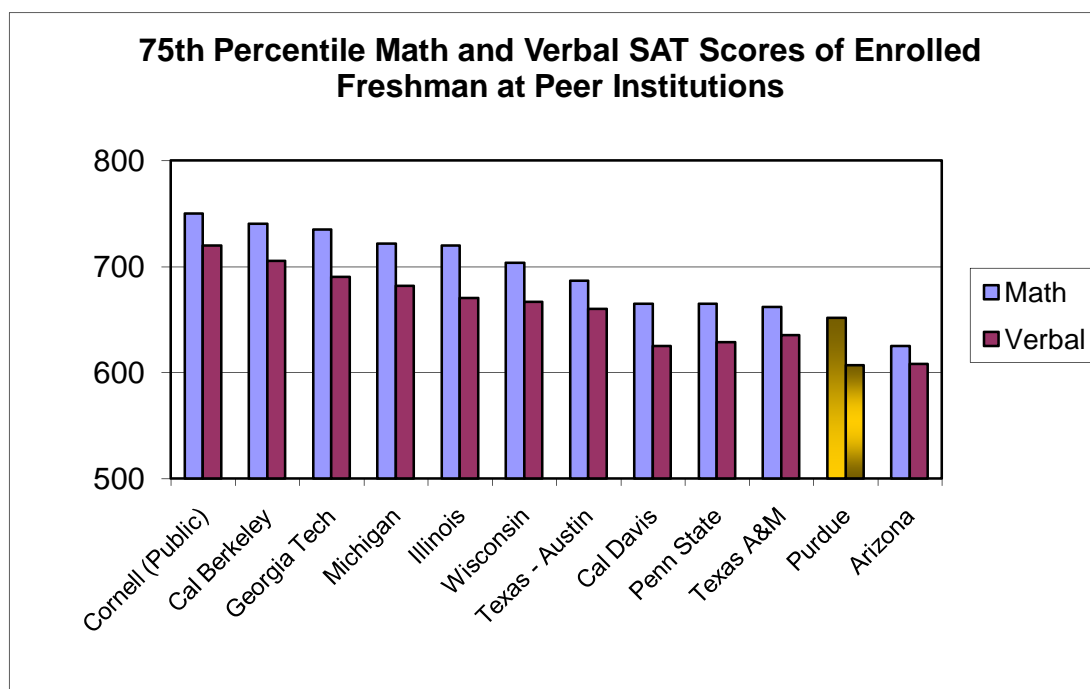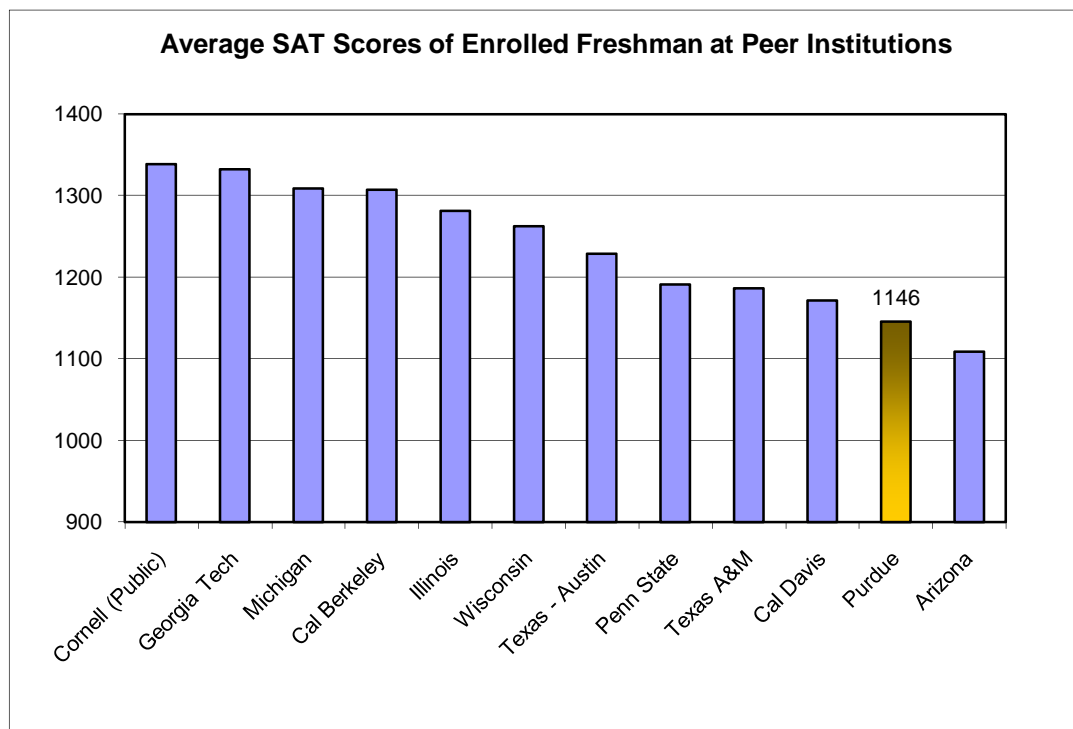
Academic Profiles of Entering Students

2005-06 Beginners						
School	Group	HSGPA	HSRANK	SAT CR	SAT MATH	ACT COMP
Agriculture	NONSTEM	3.39	64.86	528	547	23
	STEM	N/A	N/A	N/A	N/A	N/A
Engineering	STEM	3.65	61.71	596	665	28
Science	STEM	3.36	55.51	577	629	26
CFS	NONSTEM	3.34	53.36	536	543	23
	STEM	3.51	72.09	536	554	24

2006-07 Beginners						
School	Group	HSGPA	HSRANK	SAT CR	SAT MATH	ACT COMP
Agriculture	NONSTEM	3.39	64.59	524	543	23
	STEM	N/A	N/A	N/A	N/A	N/A
Engineering	STEM	3.66	59.46	593	667	28
Science	STEM	3.43	52.41	566	626	26
CFS	NONSTEM	3.40	57.81	525	549	24
	STEM	3.37	57.27	525	538	22

2007-08 Beginners						
School	Group	HSGPA	HSRANK	SAT CR	SAT MATH	ACT COMP
Agriculture	NONSTEM	3.43	67.44	532	548	24
	STEM	3.50	87.00	543	547	24
Engineering	STEM	3.66	58.27	593	667	28
Science	STEM	3.50	58.91	566	609	26
CFS	NONSTEM	3.42	55.43	525	544	23
	STEM	3.56	53.56	537	554	24

Relationship between amount of high-school math and graduation rate:

College of Science Data
(3-yr averages, 1995-97 Freshman Cohorts)

Distribution of High School Math Preparation (3-yr averages, 1995-97 Freshman Cohorts, College of Science)
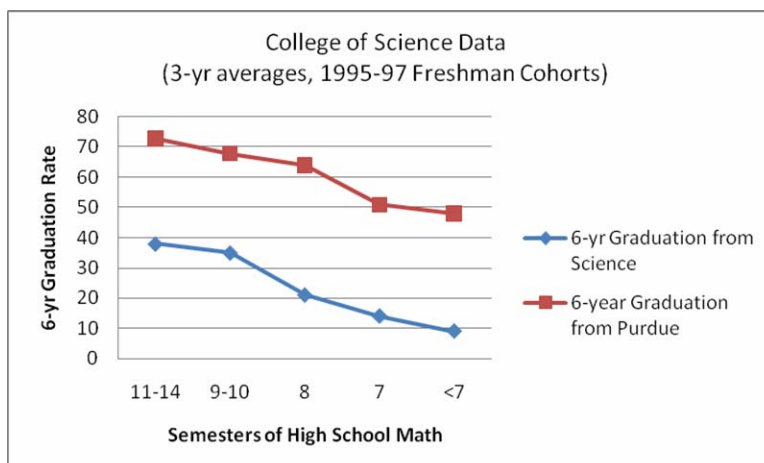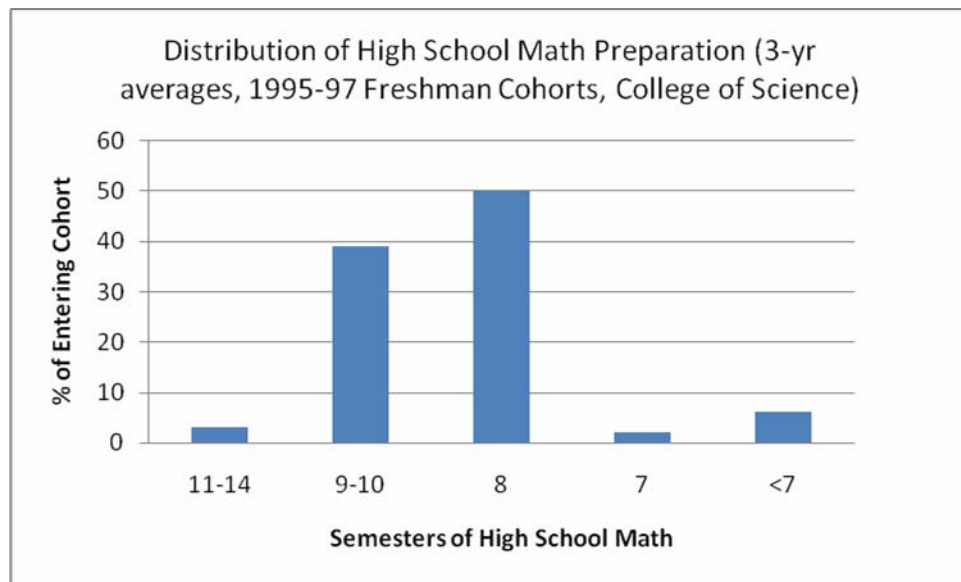
APPENDIX D: DIVERSITY OF ENTERING PURDUE STUDENTS

	PU Overall	Colleges of SCI & ENG	PU STEM Total	Non-STEM Total	Indiana SAT takers*
AFRICAN AMERICAN, NONHISPANIC	4%	3%	3%	4%	6%
ASIAN AMERICAN / PACIFIC ISLANDER	5%	7%	6%	5%	3%
HISPANIC AMERICAN	3%	3%	3%	3%	3%
NATIVE AMERICAN / ALASKAN NATIVE	1%	0%	0%	1%	1%
CAUCASIAN/BLANK/OTHER	87%	87%	88%	87%	87%

APPENDIX E: ADMISSIONS RATES

Comparisons to Peer Institutions:

Admissions Rates Comparisons
(asterisk denotes peer institutions)
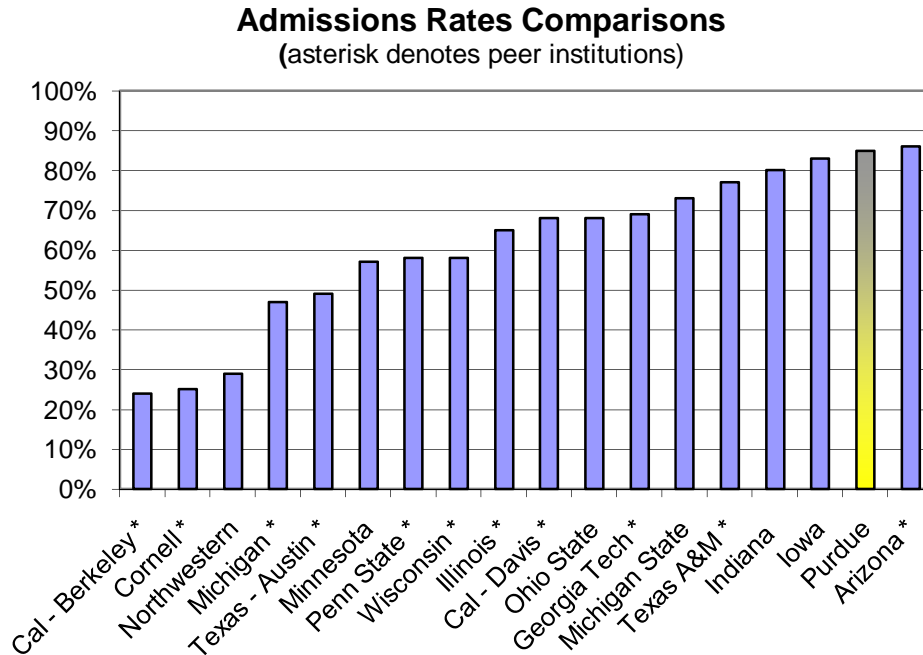
Comparisons by College within Purdue:

2007 Percentages of Students Admitted, Enrolled.
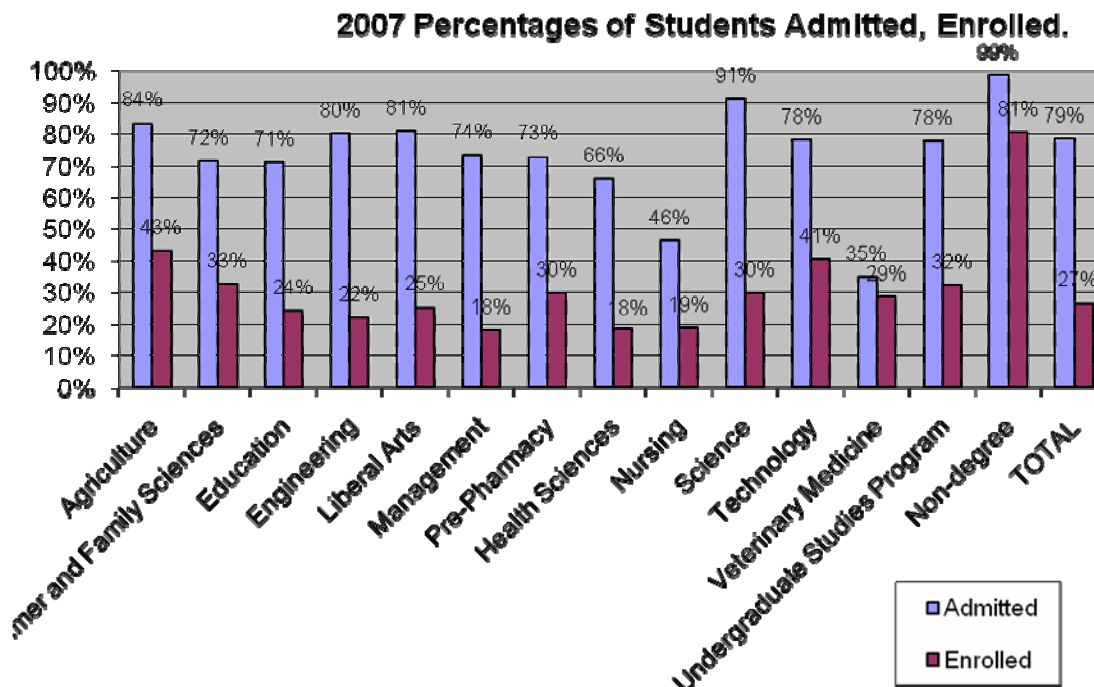
APPENDIX F: A SAMPLE OF EDUCATIONAL OUTREACH EFFORTS THAT ALREADY EXIST AT PURDUE

There are a number of programs, initiatives and activities that faculty and staff are engaged in Purdue that help contribute to the improvement of STEM education in the state of Indiana. Listed here are only a small subsample of these, to serve as an example of the larger set.

I-STEM
The Indiana Science, Technology, Engineering and Mathematics resource network support K-12 education towards STEM literacy for all students. I-STEM focuses on teaching, learning, applied research, community partnerships and network development. Purdue is the lead institution of I-STEM, with eleven regional lead institutions across the state. (http://www.istemnetwork.org)

The Indiana Interdisciplinary GK-12: Bringing Authentic Problem Solving in STEM to Rural Middle Schools
This program offers a unique one-year fellowship for doctoral students in the STEM disciplines (Science, Technology, Engineering, and Mathematics) to serve as "visiting scientists" in a program designed to instill the excitement of learning science into middle school classrooms. Teamed with 6th, 7th, and 8th grade science and math teachers, fellows develop lesson plans and teach interdisciplinary-focused experiments that support and extend the science curriculum. (http://www.purdue.edu/dp/gk12/).

GERI
The Gifted Education Resource Institute at Purdue University conducts research into the psychology of gifted and talented individuals and effective educational practices for high ability youth. Super Saturday and the GERI Summer Camps, GERI's youth talent development programs, provide challenging learning opportunities and a healthy social environment to a diverse population of high ability children and teens. (http://www.geri.soe.purdue.edu/).

Woodrow-Wilson Fellowships
The Woodrow Wilson National Fellowship Foundation has selected Indiana as the first site for its new national fellowship for high school teachers, intended to help overhaul teacher education and encourage exceptionally able teacher candidates to seek long-term careers in high-need classrooms. A grant from the Lilly Endowment of $10,161,106 will support the Indiana program, which focuses on high school math and science teaching. The Woodrow Wilson Indiana Teaching Fellowship will provide Fellows with a $30,000 stipend to complete a year-long master's program at one of four selected Indiana universities - Ball State University, Indiana University-Purdue University Indianapolis, Purdue University, and the University of Indianapolis. Fellows are then placed in a high-need urban or rural school that has committed to provide ongoing mentoring. In turn, they agree to teach in Indiana for three years. Purdue's program focuses on teaching in rural schools.

APPENDIX G: PURDUE DATA ON *CHANGE OF DEGREE OBJECTIVE* (CODO)

CODO out of a Particular College:

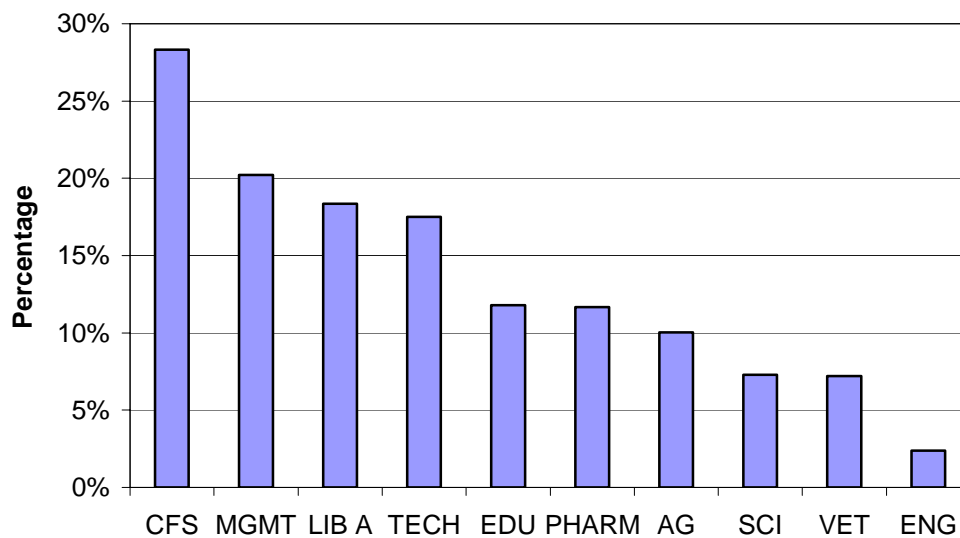**Annual average proportion of <u>outbound</u> transfers**
(proportions relate to individual college enrollement)
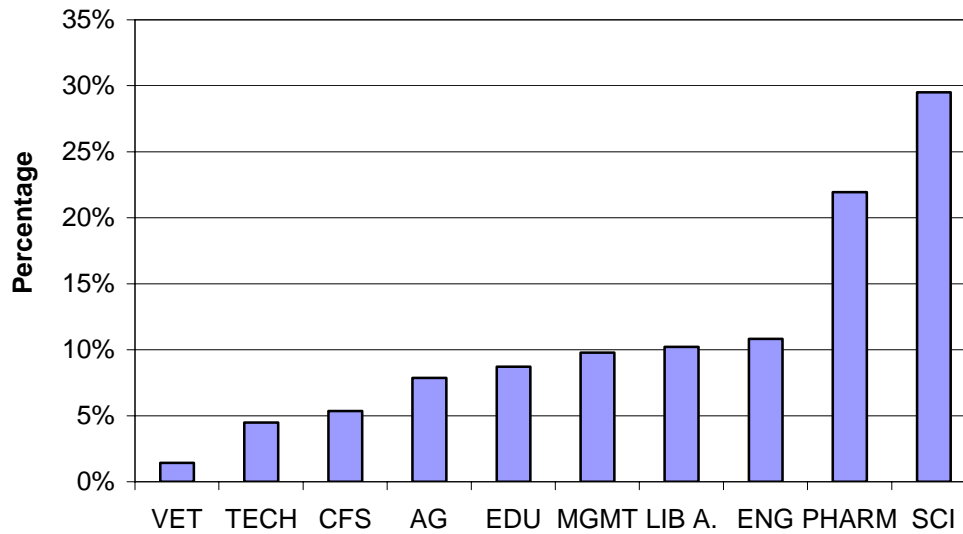
CODO into a Particular College

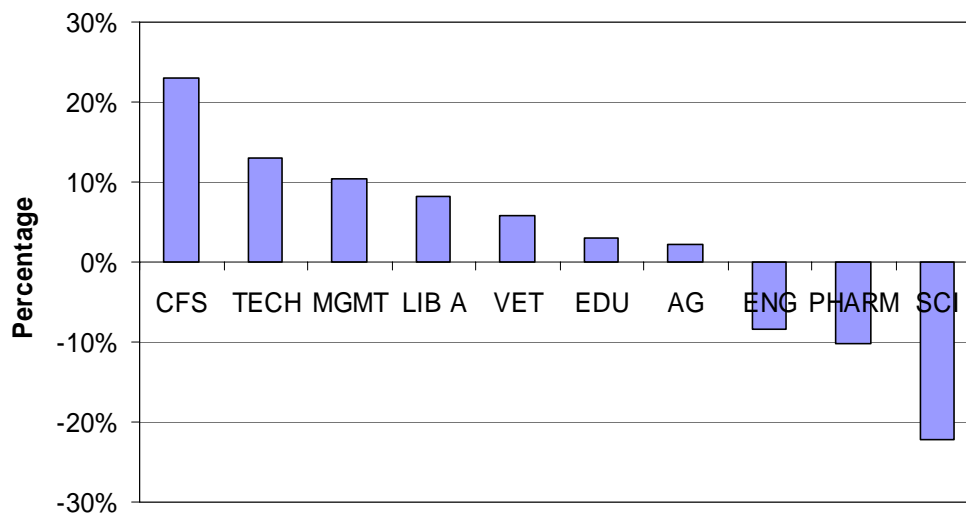**Annual average proportion of <u>inbound</u> transfers**
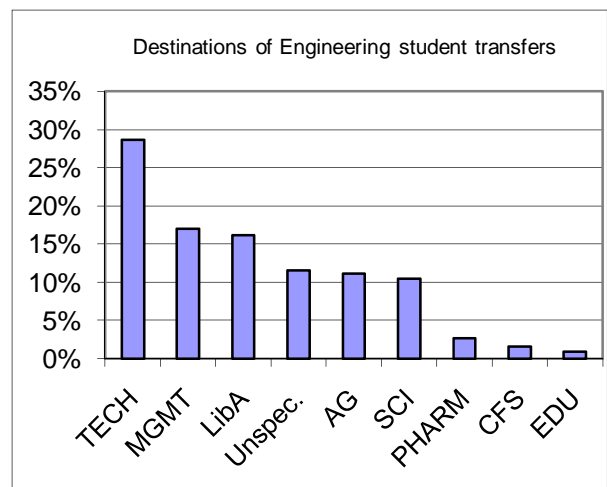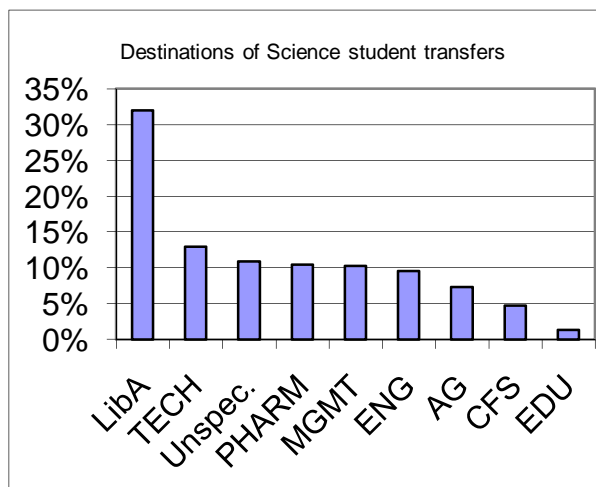(proportions relate to individual college enrollement)

Net CODO Rates

Annual net transfer rates for Purdue colleges

(values are relative to individual college enrollment, with positive values indicating net gains, and negative values indicating net losses)

Where students transfer to, from Colleges of Science and Engineering

APPENDIX H: PURDUE GRADUATION RATES

Overall Purdue Retention and Graduation Rates (data from Office of Enrollment Management, presentation given on January 14, 2008).

Cohort Year of Entry	Number in Cohort	Retention Rate		Cumulative Graduation Rate		
		1-Year	2-Year	4-year	5-Year	6-Year
1996	6,529	82.9%	73.9%	33.4%	60.4%	65.9%
1997	6,603	84.6%	74.6%	35.5%	61.7%	67.3%
1998	6,844	82.6%	72.6%	34.9%	60.2%	65.6%
1999	7,119	84.8%	74.9%	36.1%	62.2%	68.0%
2000	6,588	86.4%	77.8%	40.2%	66.6%	71.9%
2001	6,720	85.9%	77.3%	39.2%	65.0%	70.7%
2002	6,383	86.4%	78.4%	39.9%	66.4%	
2003	6,507	85.5%	77.0%	39.4%		
2004	6,852	85.1%	76.4%			
2005	7,270	84.0%	75.5%			
2006	7,523	84.8%				

Comparison to other Big Ten Universities (data from Office of Enrollment Management, presentation given on January 14, 2008).

1998-2000 Cohorts

Big Ten Publics	Overall	Actual vs. Predicted	African American	American Indian	Asian/ Pacific Islander	Hispanic American
Illinois	80.8%	7.3%	63.1%	70.7%	84.2%	66.8%
Indiana	71.5%	12.7%	51.0%	60.5%	72.5%	66.8%
Iowa	65.9%	5.0%	46.5%	48.4%	61.1%	57.5%
Michigan	86.7%	7.0%	70.3%	62.9%	89.4%	78.9%
Michigan State	74.9%	13.7%	58.9%	49.8%	71.1%	58.8%
Minnesota	59.3%	-5.0%	42.2%	28.6%	48.6%	45.6%
Ohio State	67.0%	5.0%	52.2%	53.8%	72.3%	57.3%
Penn State	86.7%	16.7%	70.1%	66.7%	83.0%	71.8%
Purdue	67.8%	6.7%	54.6%	37.6%	64.5%	55.4%
Wisconsin	79.0%	4.3%	56.0%	47.5%	70.1%	59.8%
Mean (excluding Purdue)	74.6%	7.4%	56.7%	54.3%	72.5%	62.6%

Comparisons by Race/Ethnicity within Colleges of Science and Engineering demonstrate that we are not doing a good job of graduating underrepresented minority students in particular.
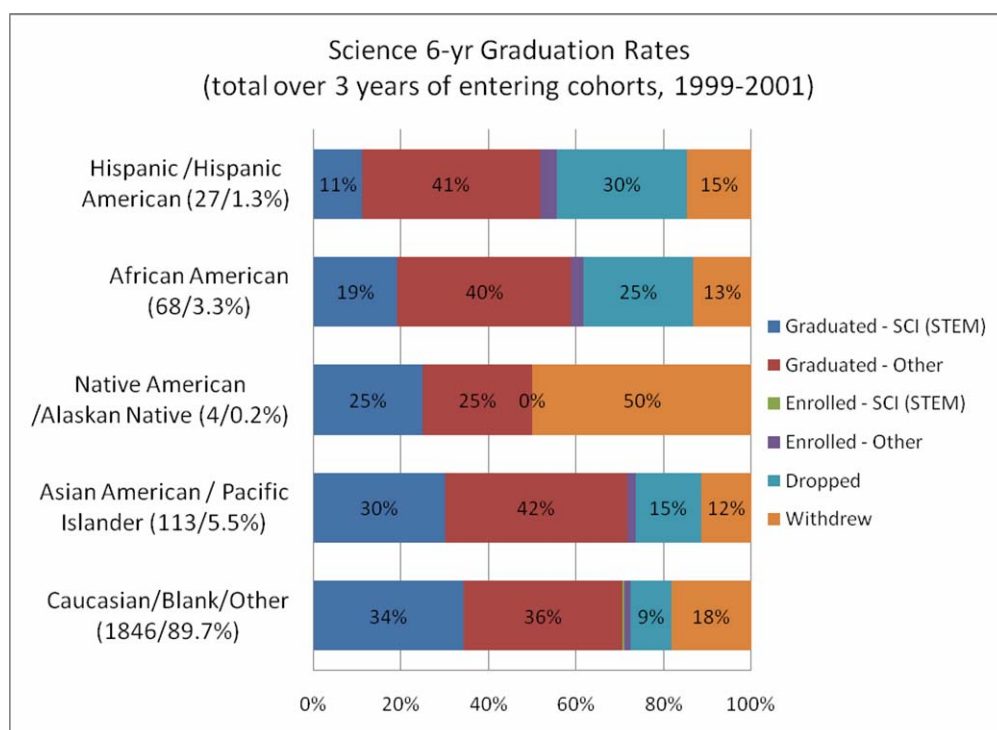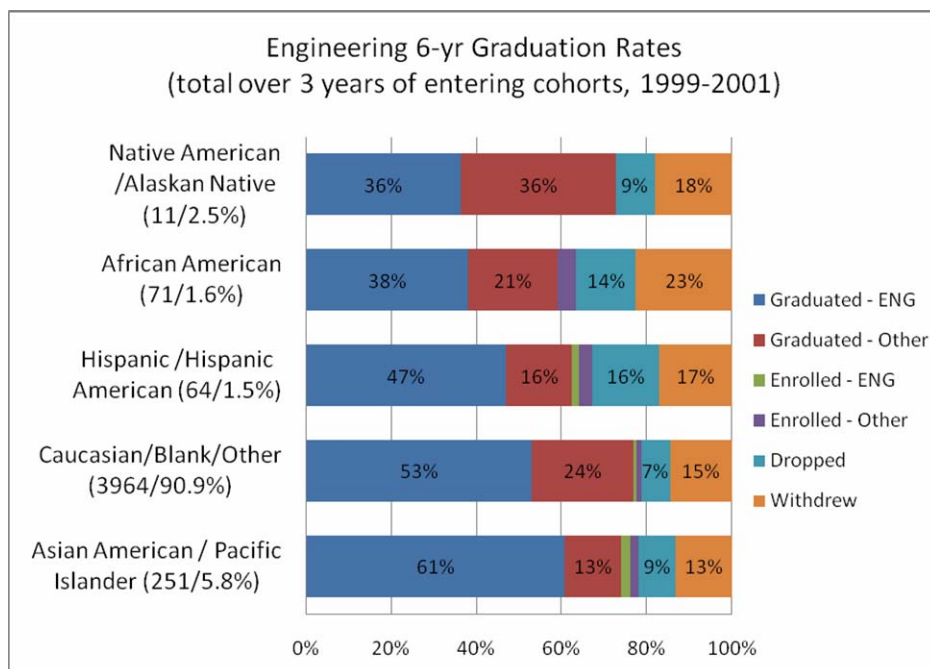
Comparisons by gender within the Colleges of Science and Engineering that there may be better persistence for female students in Engineering. However, the percentage of female students in

that College is undesirably low. In the College of Science, the gender discrepancies are insignificant with respect to 6-year graduation and representation.

6-Year Retention by Gender - College of Engineering (2001-2002 Cohort)

Category and Number of Students	Graduated - ENG	Graduated - Other	Enrolled - ENG / Enrolled - Other	Dropped	Withdrew
Female (267)	64%	20%	3%		12%
Male (1388)	57%	19%		8%	13%

Legend:
- ▪ Graduated - ENG
- ▪ Graduated - Other
- ▫ Enrolled - ENG
- ▫ Enrolled - Other
- ▪ Dropped
- ▪ Withdrew

6-Year Retention by Gender - College of Science (2001-2002 Cohort)

Category and Number of Students	Graduated - SCI	Graduated - other	Enrolled - SCI / Enrolled - other	Dropped	Withdrew
Female (252)	37%	40%		5%	16%
Male (227)	35%	33%		11%	19%

Legend:
- ▪ Graduated - SCI
- ▪ Graduated - other
- ▫ Enrolled - SCI
- ▫ Enrolled - other
- ▪ Dropped
- ▪ Withdrew

APPENDIX I: LEARNING COMMUNITIES RETENTION RATES

(Data and information from Office of Enrollment Management, presentation given on January 14, 2008)

At Purdue, Learning Communities (LCs) are defined as academic programs that:
- Co-enroll a group of 20-30 first-year students in two or more courses based on an academic major or theme; or,
- Place a group of first-year students on the same residence hall based on an academic major or theme; or,
- Do both.

Fall 2007 student participation:
- 1,395 first-year students
- Minorities constituted 17.92% of the Learning Communities participants compared to 13.65% of the new first-year class
- Women constituted 55.84% of the Learning Communities participants compared to 43.48% of the new first-year class.

Learning community participants show higher retention and better performance, relative to comparable groups who are not in learning communities.

Aggregate Retention Rates for Learning Community Participants and Non- Participants Inclusive of the 1999-2005 Fall Cohorts of New Beginner First Year Students		1st Year Retention	2nd Year Retention	3rd Year Retention
Male	Participants	87.4% [2]	78.6% [3]	72.7%
	Non-participants	84.7%	76.8%	71.8%
Female	Participants	88.9% [1]	82.1% [1]	77.5% [1]
	Non-participants	84.8%	77.3%	72.0%
Caucasian	Participants	88.6% [1]	81.3% [1]	76.0% [1]
	Non-participants	85.4%	78.0%	67.0%
Minority*	Participants	85.3% [3]	74.3%	70.1% [4]
	Non-participants	80.7%	72.2%	65.9%
Total	*Participants*	*88.14%* [1]	*80.19%* [2]	*75.23%* [3]
	Non-participants	*84.98%*	*77.47%*	*72.45%*
* Includes African American, Asian American, Hispanic/Latino and Native American students. These classifications are self reported by students.				
1 difference significant at p <.0001				
2 difference significant at p <.001				
3 difference significant at p <.01				
4 difference significant at p <.10				

APPENDIX J: EXPERIENTIAL OPPORTUNITIES FOR STEM UNDERGRADUATES

EPICS – Engineering Projects in Community Service
EPICS is a unique program in which teams of undergraduates are designing, building, and deploying real systems to solve engineering-based problems for local community service and education organizations. EPICS was founded at Purdue University in Fall 1995. Each team has a multi-year partnership with a community service or education organization. Projects are in four broad areas: human services, access and abilities, education and outreach, and the environment. Purdue EPICS teams have delivered over 150 projects to their community partners. Each team of 8 to 18 students includes freshmen, sophomores, juniors, and seniors. Teams are advised by Purdue faculty, staff, and engineers from local industry, along with graduate teaching assistants. Students earn 1 or 2 academic credits each semester and may register for up to four years. Projects may last several years, so tasks of significant size and impact can be tackled.

In the 2003-2004 academic year, over 400 Purdue students from 20 different departments participated on 25 multidisciplinary teams. Over 2000 Purdue students have participated in EPICS to date. Purdue's EPICS program is the national model in engineering for marrying learning and engagement. With support from the National Science Foundation and the Corporation for National and Community Service plus Microsoft Research, Hewlett-Packard, and National Instruments, EPICS programs are operating at 15 universities. Over 1350 students participated on 140 teams in 2003-04. Peer teams at multiple EPICS sites are collaborating to address community problems of national scope. Purdue is headquarters for the National EPICS Program. (http://epics.ecn.purdue.edu/).

CASPiE – The Center for Authentic Science Practice in Education
The goal of the CASPiE program is to provide students with research experiences as part of the curriculum in their mainstream science courses, rather than making research an extracurricular activity for students. In this project the laboratory experiments are a component of a larger research project of a scientist. Students are engaged in experimental design and hypothesis testing within the scope of the larger research question, and thus gain experience with the authentic process of science. In turn, the data that the students collect are intended to be used as part of that researcher's work and, if possible, contribute to publishable work. CASPiE is funded through the *Undergraduate Research Centers* (URC) program of the Division of Chemistry at the National Science Foundation. It was the first URC funded in the nation. The primary institution is Purdue University, with a network of higher education institutions that includes six 2-year colleges, primarily undergraduate institutions and research institutions. To date, CASPiE has been used at 11 institutions and has involved over 1700 students in research experiences through courses in the first and second-year Chemistry curriculum. (http://www.caspie.org).

SENCER – Science Education for New Civic Engagements and Responsibilities.
SENCER is a model for engaging in service learning in science. The SENCER Institute makes available educational materials that are suitable as the curricular materials for undergraduate courses of many levels and science disciplines. SENCER was initiated in 2001 under the

National Science Foundation's CCLI national dissemination track. Since then, SENCER has established and supported an ever-growing community of faculty, students, academic leaders, and others to improve undergraduate STEM education by connecting learning to critical civic questions. SENCER is the signature program of the National Center for Science and Civic Engagement, which was established in affiliation with Harrisburg University of Science and Technology. SENCER improves science education by focusing on real world problems and, by so doing, extends the impact of this learning across the curriculum to the broader community and society. This is accomplished by developing faculty expertise in teaching "to" basic, canonical science and mathematics "through" complex, capacious, often unsolved problems of civic consequence. Using materials, assessment instruments, and research developed in the SENCER project, faculty design curricular projects that connect science learning to real world challenges. (http://www.sencer.net/).