

Sustaining success in engineering programmes through the transformation of learning strategies

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ABSTRACT: Foundation courses are a prime component of university-level undergraduate engineering programmes in the USA, yet many students find it very difficult to pass such foundation courses, particularly in areas of mathematics and science, and remains one of the prime reasons for students leaving engineering programmes. However, the need for engineering graduates in the USA is continuing to grow and will be vital in maintaining a competitive edge in a global environment. The USA needs to have a well-trained engineering workforce so as to remain a world economic power and use the latest technological solutions for improvements in productivity and quality. As such, there is a strong need for transformation because this issue is critically severe in underrepresented groups, whose academic preparation may require additional support at the university level in order for them to be successful. The College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU), DeKalb, USA, has implemented major initiatives to recruit a top quality, diverse student body and has been extremely successful in these efforts. Various initiatives are described in the article, as well as their impacts in promoting student diversity and participation.

INTRODUCTION

Achieving high rates of success in foundation courses in areas including, but not limited to, mathematics, physics and chemistry is a major problem for academic programmes requiring these courses across the USA. This problem is severe for engineering programmes because more than 50% of their curriculum during the first two years consists of foundation courses. Due to low pass rates in these courses, close to 40% of students who start their academic careers in engineering or related fields are unable to complete their intended degrees. This inability to pass foundation courses in areas of mathematics and science remains one of the primary reasons for dropping out of engineering programmes.

In light of this phenomenon, some of the best recruitment programmes are ineffective because the retention of students is sub-optimal and unacceptable. This also has negative implications for statistics related to timely graduation and the number of degrees awarded, with further implications for budgets and accreditation.

This trend is disturbing as the need for engineering graduates in the USA is increasing and will be critical in maintaining the competitive edge of the country in a global environment. The USA must have a well-trained engineering workforce in order to remain a world economic power and utilise the latest technological solutions to improve productivity and quality.

There is a strong need for transformation, as this problem is critically severe in underrepresented groups, whose academic preparation may require additional support at the university level in order for them to be successful. Strong and effective intervention is needed in order to strengthen their knowledge in foundation courses. In the USA, the engineering field has been white-male dominated for a long time. Hard work is required to

attract a diverse student body, including women, into engineering programmes and to promote their success so that the workplace reflects true societal demographics.

COLLEGE OF ENGINEERING AND ENGINEERING TECHNOLOGY INITIATIVES

The College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU), DeKalb, USA, has engineering programmes, which have been accredited by the Accreditation Board for Engineering and Technology (ABET), housed in a new US\$40 million facility with 29 laboratories, and which have been equipped with more than US\$15 million worth of equipment. The CEET places high value on undergraduate education and is becoming the first choice institution for many residents of the state of Illinois. This fact is supported by the significant increase in student numbers (see Table 1) over the past few years, despite declining enrolments in engineering programmes across the USA.

The College has implemented major initiatives to recruit a high quality, diverse student body and has been extremely successful in this endeavour. The challenging aspect of retaining this student body cannot be achieved without transforming learning and teaching strategies during the early years of students' academic careers, which involve foundation courses. In light of the expectations of ABET, the state of Illinois and NIU, there could not be a better time to initiate this transformation.

The CEET has been unusually active in its commitment to bring diversity into its student body. Indeed, the CEET has written this proposal so as to develop a comprehensive model to improve the success of a diverse student body through transformation. The proposed programmes, once developed, will be self-sustaining in the long run and could also attract

Table 1: Enrolment changes from 1995-2000.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	1995-2000 Enrolment Change
Entering freshman class size	148	151	195	191	255	72%
Entering class size including transfer students	253	276	322	308	423	67%
Student enrolments in the College	932	937	1,022	1,045	1,268	36%

funding from external sources for expansion. The programmes will benefit all NIU students, including minority students. A recent analysis of student data within the College of Engineering and Engineering Technology has revealed the following important facts that are related to the success of the College's efforts in recruitment, thereby highlighting the need for the proposed programme to facilitate retention of the recruited students:

- The proportion of minority students (including women) in the CEET is at an impressive 37% of the student body, which is significantly better than national averages of regional engineering colleges.
- The proportion of women students in the CEET stands at 12.5% (highest ever).
- A majority of educationally disadvantaged students who come to the College through Educational and Special Programmes (ESP) are from underrepresented groups; they have shown signs of early success due to intervention and support services.
- The College has 116 students through the ESP programme, including 17 students with senior standing, 16 with junior standing, 49 sophomores and 34 freshmen. These students must be led to success by introducing and maintaining innovative and effective support programmes.

The general education courses offered by the CEET attract a diverse student body from colleges other than the CEET (about 700 non-CEET students annually). These students use the services proposed in the model, which includes the following subjects:

- Elements of Electronics (ELE 100);
- Fundamentals of Manufacturing Systems (IENG 100);
- Energy and the Environment (MEE 200);
- Technology and Cultural Relevance (TECH 294).

The CEET offers some of the most demanding academic programmes at NIU. Due to the basic nature of engineering and technology programmes, the programmes not only require a strong commitment on the part of students but also an effective infrastructure of support services and initiatives to take them to degree completion. The CEET proposes an eight-component model, which will address the transformation needs of the existing models to provide effective support to students at NIU. The components of the proposed model are described below.

Success in Math and Physics by Linkage to Engineering

Success in Math and Physics by Linkage to Engineering (SIMPLE) covers the retention issues in engineering programmes are greatly influenced by students' inability to pass physics and mathematics classes in their first attempt. The pass rate for 200 level courses is close to 50%. In the wake of the Illinois Board of Higher Education's Illinois Commitment,

ABET 2000 and various assessment instruments, these figures will have to improve in order for students to achieve an affordable and quality education, leading to timely graduation.

It is important to note that linkage to engineering is not just meant to handle problems of engineering students. On the contrary, it is easier for any student to relate mathematics and science to real life problems. Care will be taken to choose technical problems that create interest for all students at NIU, are real life oriented, and require understanding of mathematics and physics at the high school level. Problems that relate to cars, gadgets, games, rockets, robots, appliances, etc, will be chosen to spark general interest. Therefore, all NIU students who pass physics and mathematics will be able to take on this component and will thus have a higher probability of understanding physics and mathematics.

Successful study strategies will also be discussed to increase student success in mathematics and physics. This initiative will be based on the fact that, in order to establish rewarding learning environments, the courses and programmes must be relevant, interesting and connected to real professional situations. This component will be offered as a 3-4 hour workshop (split into one hour sessions on a specific topic). All university resources for mathematics and physics tutoring will also be introduced at this workshop. The CEET intends to take a leadership role in this initiative for the rest of the University. If needed, other colleges could also undertake similar endeavours in the future. A follow-up workshop for two hours will be offered to answer student questions and concerns. Senior and junior students will be used in the latter workshop to present students' perspectives on the issue.

Bridge to University Success

It is envisaged that the Bridge to University Success programme will be a 2-week residential programme that brings high school seniors to the NIU campus and prepares them for success in academic programmes. This bridge will be offered in collaboration with the Worldwide Youth in Science and Engineering (WYSE) organisation. The two-week residential programme will cover hands-on activities in the areas of mathematics, physics, CAD, engineering, chemistry and writing.

There will be teams to address issues related to the appreciation and acceptance of diversity. Concepts will include problem solving, decision-making, and learning to be accountable. Key administrators at NIU, including deans and chairs, will be requested to volunteer their time (ranging from a one-time donation of a minimum of two hours to half a day maximum) to lead the activities of the campus.

Students will gain an insight into university life and will obtain tips about the placement standards in mathematics and physics.

This will provide them with information and time to review their high school curriculum to fare better on the placement tests. It must be kept in mind that despite students' placement in mathematics classes by NIU's mathematics department, their pass rate is not better than 45-50%. A bridge programme will not only reinforce selected high school curriculum, but will also generate professional interest and provide students with additional skills for success. Most importantly, it will expose them to living and working together in a diverse environment with students from different races and ethnic backgrounds.

The two-week programme will be offered as a bridge summer camp. Shadowing a junior or a senior for half a day will be a part of the camp activity. The possibility of restricting the camp to prospective NIU students only will be discussed looking at the enrolment in the pilot camp. This camp will carry tuition so will be a self-sustaining activity after the first year.

Freshmen Mentoring for All

All students coming to the CEET, as freshmen or transfer students, will be provided with a mentor, preferably of a different race/gender/ethnicity. The Office of the Associate Dean will match these students. Mentorship is already an acknowledged successful strategy, and inclusion of diversity in the process will enhance its value to student success in a culturally diverse learning environment.

After the first year, other colleges will also be invited to join the initiative. Also, mentorship among engineering and other science-related disciplines will be started in the Science, Engineering and Technology (SET) academic residential floors in Douglas Hall. This initiative will promote undergraduate research in interdisciplinary areas and expose students to diverse team environments, thus preparing them for a real-life work environment.

Teamwork and Engaged/Active Learning

In addition to being positive work habits, teamwork and engaged/active learning attributes are expected by industry of all students. Also, working in a diverse team environment provides them with an opportunity and time to appreciate other perspectives, going beyond race and colour. Fortunately, engineering courses are such that teams can easily be formed to encourage students to work with each other and develop networking relationships that last over a long time.

The need for students to understand their peers, irrespective of race, culture or colour, will provide for a better learning environment and will certainly enhance resources for students. All research data points to improved success through active/engaged learning. Students will be able to learn from each other and create study and support groups that result in better success.

Eleven faculty from CEET attended a recent workshop on collaborative learning. Their expertise will be used to promote active learning in engineering classes taken during the first two years. This will eventually prepare students to engage in similar activities in other foundation courses beyond engineering and technology. The College has 15 student professional engineering society chapters, which will be used to implement this component of the model.

Entry into the Real World Seminar Series

There are many freshmen success courses offered by colleges and universities to inform freshman students about university resources and success strategies. But there are fewer courses/seminars at the junior level to smoothen the transition of students into the real professional world.

The CEET has an active alumni association called the Engineering and Technology Alumni Association (ETAS). The seminar series will be conducted by special guests and members of ETAS to apprise junior level students of the expectations in real life environments. The five seminars will focus on the following:

- Human factors and personal relations in a work environment;
- Mock interviews for the first professional employment;
- The need, importance and methodology of continuing education;
- Information technology and global competitiveness;
- Conflict management and dealing with differences.

These seminars will be offered to engineering students and other NIU students at the rate of two to three per semester.

Focus Tutoring Programme (CARE)

The CEET plans to survey students in all 200 level courses and, if needed, constitute focus tutoring sessions for individual courses. Each focus tutoring initiative will be 5-6 hours in duration and will be held in a classroom setting by a senior or a graduate student to review the course in question and allow students an opportunity to ask questions. If need be, message boards and chat rooms will also be created for these courses to allow for the free exchange of questions and to view the answers to all questions on a shared platform for the benefit of everyone involved.

Under project CARE, all 100 and 200 level professors will be requested to make attendance a part of the grading process and to provide extra credit for attending all recitation sessions. Research data correlates attendance in class and recitation to superior grades.

At the CEET, all professors are provided with a graduate assistant, therefore, holding recitation sessions in a classroom setting for all foundation courses will not be a major problem. Awareness and convincing faculty to adopt CARE will be a major task, for which resources from this proposal will be utilised.

Social Climate (Informal Dialogue on Race and Gender)

An informal dialogue on race and gender will be initiated through minority student organisations, such as the Society of Women Engineers (SWE), the National Society of Black Engineers (NSBE) and the Society of Hispanic Professional Engineers (SHPE). Video series and short retreats will be used to bring students from diverse backgrounds to discuss their own fears and expectation of others.

The first year will be used to officially facilitate the process through faculty advisors and experts. Starting with the second year, the process will be self-sustaining.

Peer-Advising, Tutoring, And Learning (PATAL)

The project dubbed PATAL, which stands for Peer-Advising, Tutoring, And Learning, was funded by the NIU Foundation two years ago and then funded by the provost's office this year. PATAL has been an extremely successful project and has provided tutoring in more than 20 engineering, mathematics and physics courses.

As anticipated, several mentor and role model relationships were developed as a result of PATAL. It is expected that PATAL, which is an ongoing activity, will mesh well with the Focus Tutoring Programme (CARE) and eventually make it self-sustaining and successful.

SUMMARY

The College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU) has developed several important initiatives in order to sustain success in engineering programmes through the transformation of learning strategies. Figure 1 shows how these are integrated. Importantly, the engineering profession should also reflect the diversity of the community it serves.

The article has shown that initial results are quite promising, with great potential for future growth and adoption by other engineering colleges, and has described the main programmes involved in this endeavour.

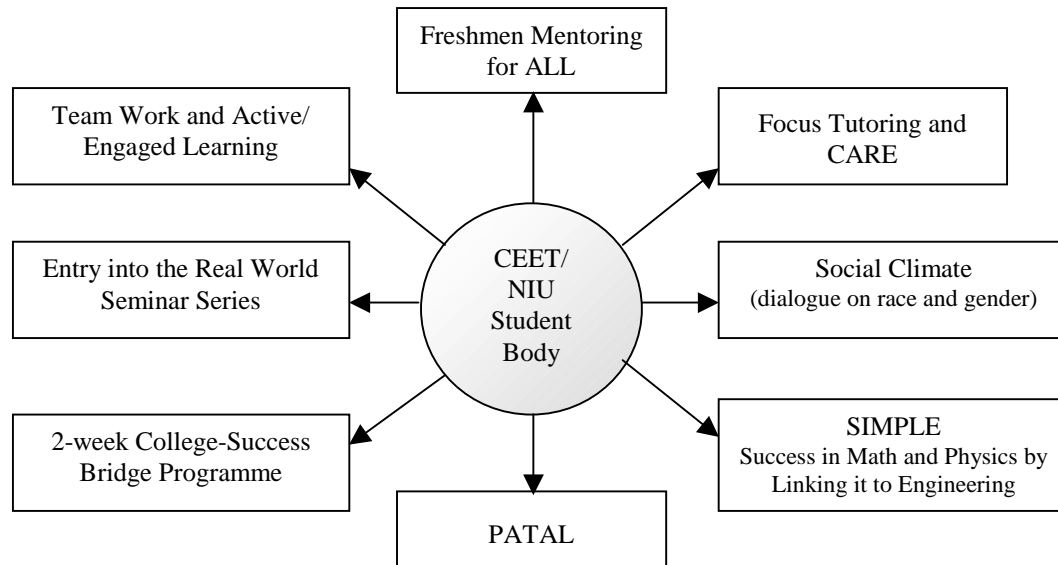


Figure 1: Interaction of the key CEET initiatives.