Gateway to Technology

Ashok K. Agrawal, Terrence L. Freeman
St. Louis Community College at Florissant Valley

Abstract

One of the critical challenges in recruiting and retaining students in engineering and engineering technology is overcoming the hurdle of time spent in developmental courses. Many of the students who express interest in technological careers find that they must address deficiencies in reading, English, or mathematics before beginning a technological program. During this process many students are diverted from their original academic goal by the difficulties encountered in developmental courses that are designed for technical students. Students may also lose interest by not experiencing hands-on engineering technology.

St. Louis Community College at Florissant Valley is addressing this problem through its Gateway To Technology Program (GTTP). The GTTP is one of the three components of the *Gateway to Manufacturing Excellence* project funded by the National Science Foundation through the Advanced Technological Education program The GTTP is a one-semester integrated curriculum that prepares a cohort of students for immediate entry into one of several engineering technology programs offered at the college. This course would typically combine College Orientation, Engineering Technology Orientation, Developmental Reading, Developmental English, Intermediate Algebra, and Technology Applications providing the student with 14 credit hours of academic work. The GTTP is team taught by faculty from Engineering/Technology, mathematics, reading, and English departments. The integrated design of the coursework provides reinforcement across disciplines for the student who begins working immediately on real world problems while developing academic success skills. Since students enroll as a cohort, they benefit from convenient scheduling and consistent class enrollment. Resources from academic advising and counseling are also included to minimize attrition. The challenge in creating this program is that the structure is outside of the typical structure for courses, enrollment and faculty load calculations. This paper discusses the rationale, benefits, and process for developing this new program.

Introduction

Student success has received considerable attention during this time[1]. Administrators and researchers in colleges and universities have increasingly focused their attention on retention and attrition rates in higher education[2,3,4,5]. The difficulty of meeting the engineering needs of the U.S. economy is exacerbated by a disturbing trend. Over the past twenty years there has been an increase in attrition of engineering students. In 1975, the attrition rate for engineering freshmen was 12% and by 1990 it had grown to 24%[6]. Less than half of the students who start college as engineering majors actually graduate with an engineering degree. The attrition for minority students is approximately 70%[7]. This decline in engineering interest and persistence while the demand for engineers continues to rise is a major concern for industry and society.

The American Association of Community Colleges (AACC) provides statistics that demonstrate why the community college may be an important participant in meeting the

postsecondary engineering challenge[8]. The most recent published data from AACC (1996-97) reports that 1132 community colleges serve 5.4 million credit seeking students nationally[9] approximately 46% of all first-time freshmen and 44% of U.S. undergraduates are enrolled in community colleges, and nearly half a million associate degrees are awarded annually. The student population is 58% female and 36% full-time (12 credit hours or more). Community colleges serve 46% of all African-American students, 55% of all Hispanic students, 46% of all Asian/Pacific Islander students, and 55% of all Native American students in higher education. The community college is an affordable postsecondary option with an average annual tuition of $1,518 and only a third of community college students receive any financial aid. The National Center for Education Statistics (NCES) reports that there are currently over 40,000 community college students graduating annually with associate degrees in engineering and related engineering technologies and over 90% of these degrees are awarded in engineering technology[10]. According to NCES, the absolute number of 18-year olds in the United States will reach 4 million by 2004 and 75% of that cohort will graduate from high school. If current trends continue, 80% of those graduates will pursue postsecondary education immediately after high school graduation. Almost half of that population will attend a community college[11].

The Integrated Curriculum[12]

Since structural and cultural factors play early and significant roles in the persistence of engineering students, many colleges and universities are re-examining the first-year academic experience of their students. The National science Foundation has funded a number of programs designed to improve the pedagogy and curricula for traditional and non-traditional students in engineering. Learning is something that is done by the learner and not to the learner. Research indicates that integrated curricula can have a significantly positive impact on retention and performance by creating environments that facilitate the process of learning. There are a number of potential advantages to integrated curricula:

- Instructors are better informed about the overall curriculum, what their colleagues have presented, and how their presentations connect.
- Class time can be saved by introducing common topics once and reinforcing them in ways that appeal to different learning preferences.
- By arranging topics so that related concepts are taught simultaneously, students can develop and retain a broader understanding of the material.
- Students can develop a greater understanding of the links and transition between subjects and disciplines in ways that are more consistent with the real-world practice of engineering.
- Integrated curricula can also enhance the students' abilities to work in teams through direct experience and through observation of instructors who are functioning as a team.

Differences in institutional mission, culture, and student population preclude developing a singular approach to first-year integrated curricula, but most institutions can benefit from the coordination and linkage of courses, topics and faculty. Al-Holou et al. (1999) reviewed a number of first-year integrated curricula initiatives.

- Rose-Hulman Institute of Technology has offered an integrated, First-Year Curriculum in Science, Engineering, and Mathematics (IFYCSEM) since 1990. Assessment data indicate

that participating students did 10-15% better in retention and 0.3 -0.5 better in sophomore GPA than students in matched comparison groups.

- The SUCCEED Coalition supported an integrated freshman-sophomore curriculum experiment for two years at the University of Florida starting in 1994. Retention improved by 10% and mathematics GPA increased 0.1-0.2 points.
- Texas A&M University at Kingsville has offered its First-Year Integrated Engineering Curriculum (FYIEC) since 1995. The retention was up to 17% higher for participating students with a GPA increase of 0.1-0.5 points. In addition, the number of earned math, science, and engineering credits in the first year of the FYIEC students was almost twice that of the comparison group.
- Ohio State University has offered an integrated first-year curriculum since 1993. Participating students showed improvement in GPA along with a 10-20% increase in retention. Participation in co-op/internship experiences also increased for participating students.
- Texas A&M has offered a Foundation Coalition first-year engineering program since 1994. Participating students, especially women, Hispanic, and African-American engineering students are retained at levels 15-20% higher than traditional students. Although there was not a significant change in GPA, the percentage of withdrawals or D & F grades in mathematics, physics, and English was reduced by more than one-half.
- The University of Alabama began offering the Teaming, Integration and Design in Engineering Curriculum (TIDE) in 1994. TIDE participants were retained at levels 10-20% higher than the comparison group and their GPAs were 0.2-0.3 points higher.
- Drexel University stated their Enhanced Educational Experience for Engineers (E^4) in 1989. Their results are consistent with other studies showing increased retention levels of 18-23% and GPA improvement of 0.2-0.5 points.

The accumulating research continues to assert that adopting an integrated first-year curricula can have a significant impact on the persistence and performance of engineering students. The advantages of these programs are particularly well-suited for addressing attrition of underrepresented groups.

Building the Curriculum

Although there are several models available for an integrated curriculum it is important to view them as models and not necessarily end products for an institution. Each academic institution has its own unique characteristics and it is important to assemble a team that is prepared to go through the process of developing the curriculum. The curriculum development process is critical to developing a common vision for the program. Defining the overlapping areas, agreeing on approach and evaluation, making sure that the curriculum is flexible yet capable of satisfying prerequisites, blending distinct personalities into a cohesive unit are only some of the challenges that face the development/implementation team. The Gateway to Technology curriculum was loosely modeled after the Technology Gateway which was provided by the South Carolina Advanced Technological Center of Excellence. Like their program, the Gateway to Technology is a problem-based curriculum that combines several courses. The Gateway is equivalent to 16 hours of coursework in four areas: reading, English, mathematics, and engineering. The major challenge is to write the curriculum so that the topics are interconnected and reinforcing. Since several

topics overlapped, eliminating duplication saved time. The common topics of the Gateway to Technology curriculum are:

- Authenticity
- Questioning/problem posing/solving
- Reading/writing
- Technical language/vocabulary
- Basic skills/reading, writing, math
- Good study habits
- Critical reading
- Make meaning from charts, diagrams, graphs and other visuals
- Understanding patterns, relationships, connections
- Oral communication
- Interpersonal skills and team dynamics
- Exploration of technical fields/careers
- Understanding systems & systematic analysis
- Self-evaluation/reflection
- Interpretation of results & prediction
- Basic computer literacy/ word processing
- Create graphs, charts, and visuals to display data
- Creative/lateral thinking

The reading component addresses the following topics:

- Ability to analyze and decipher directions for meaning making
- Draw inferences from context
- Find answers to questions answered explicitly or in paraphrase in a passage
- Determine important information from filler
- Follow the structure of a written passage with meaning
- Make predictions and skim to assess accuracy of predictions
- Make interpretations from print
- State conclusions after reading printed selections
- Summarize main ideas
- Assess facts from concepts, ideas,
- State patterns, relationships, connections throughout a passage and from passage to passage

The English component consists of the following topics:

- Prewriting/brainstorming techniques
- Write and organize letters, memos, and short reports
- Organize data into appropriate rhetorical elements
- Audience analysis
- Edit and revise documents
- Outline in standard formats
- Work/write/edit/revise in groups/teams
- Peer review and evaluation
- Basic standard grammar, spelling, mechanics, and appropriate vocabulary
- WWW sites research & evaluation
- Basic library research skills
- Note taking techniques

- Simple documentation format
- Use graphs, charts, and visuals in word-processed documents
- Short oral reports using multimedia

The mathematics component provides a foundation in:

- Factoring techniques
- Solving/applications of equations
- Basic operations on rational expressions
- Solving rational equations & their applications
- Graphing basic linear equations
- Functions & analysis of functions
- Radical expressions
- Binary operations
- Pythagorean theorem
- Basic complex numbers
- Quadratics

The engineering technology component covers topics and challenges on

- Technology team
- Observation and meaning
- Measurement systems
- Basic statistics
- Estimation and computational skills
- Laboratory experimentation, observation & reporting
- Simple machines
- Basic electricity/electronic
- Optics
- Heat Transfer
- Analogs
- Operational & manipulative use of technology
- Data analysis
- Ethics

The Gateway to Technology curriculum is presented around several problems designed to capture the interest and imagination of the students. The initial phase of the program focuses on orientation, teambuilding, study skills, the technology team, and a history of technology. This phase is designed to give students the opportunity to connect and gain some perspective on technology. Projects will follow on simple machines, electronics, heat transfer, and a design challenge. Each project will present a challenge and students will be evaluated on their ability to analyze the problem, brainstorm and evaluate solutions, generate a written report, and make an oral presentation.

Examples of some of the problems are:

Simple Machines: Fifty pound boxes (2'x2'x2') need to be unloaded from trucks and moved to a second floor storage area. Eight hundred boxes need to be moved. One solution is to walk them up a narrow flight of stairs. A second

possibility is for you to develop human-powered simple machines to make this project more comfortable for the three employees responsible for the move. A large window is located approximately fifteen feet above the ground.

Electronics: You would like to convert your detached garage to a recreation/party room to entertain friends for various activities. What are the power requirements for your project? What is the estimated cost of the renovation? List any assumptions or anticipated problems.

Heat Transfer: After renovating your garage you realized that you did not address heating and cooling. Provide dimensions and the materials used in the construction of your garage. Based on typical St. Louis weather patterns, what would you recommend for heating and cooling the garage?

The design component of the curriculum is a competitive design project that might be any challenge from bridges to mechanical car races. Students will brainstorm and discuss the options for this design phase. In summary, the Gateway to Technology is an exciting new team taught-integrated curriculum that will provide students with a one-stop, one semester opportunity to prepare for an exciting career in engineering technology.

Acknowledgement: *The Gateway to Technology Program (GTTP) is one of the three components of the Gateway to Manufacturing Excellence project (DUE # 0202247) funded by the National Science Foundation through its Advanced Technological Education program.*

TERRENCE L. FREEMAN
Terrence L. Freeman is an Associate Professor of Mechanical Engineering at St. Louis Community College at Florissant Valley. He graduated from Rensselaer Polytechnic Institute with a B.S. in Mechanical Engineering and received a M.S. from Massachusetts Institute of Technology. He is currently the Engineering Science Coordinator at Florissant Valley and has served as the Coordinator of the Minority Engineering Transfer Program.

ASHOK K. AGRAWAL
Ashok Agrawal is Professor and Chair of the Engineering and Technology Department at St. Louis Community College. He holds MS degrees in Metallurgical Engineering and Mining Engineering from the University of Kentucky and a BS degree in Metallurgical Engineering from India. He is a registered professional engineer in the state of West Virginia.

References

1. Grossett, J., *A conceptual framework for describing the causes of student attrition*. 1989, ERIC Document Reproduction Services No. ED 310 189.
2. DeVoll, D., *Toward a defintion of student persistence at the community college*. 1989, (ERIC Document Reproduction Service No. ED 307 932).
3. Bers, T.H. and K.E. Smith, *Persistence of community college students: The influence of students intent and academic and social integration.* Research in Higher Education, 1991.

32(5): p. 539-556.
4. Feldman, M.J., *Factors associated with one-year retention in a community college.* Research in Higher Education, 1993. **34**(4): p. 503-512.
5. Brawer, F., *Retention-attrition in the nineties*. 1996, (ERIC Document Reproduction Service No. 393 510).
6. Besterfield-Sacre, M., C.J. Atman, and L.J. Shuman, *Characteristics of freshman engineering students: Models for determining student attrition in engineering.* Journal of Engineering Education, 1997. **86**(2): p. 139-149.
7. Morning, C. and J. Fleming, *Project preserve: A program to retain minorities in engineering.* Journal of Engineering Educatioin, 1994. **83**(2): p. 237-242.
8. *American Association of Community Colleges*, in *Data dispels college transfer myths*. 2000, http://www.aacc.nche.edu/headline/120600head1.htm.
9. *American Association of Community Colleges*, in *National community snapshot*. 1997, http://www.aacc.nche.edu/allaboutcc/snapshot.htm.
10. *National Center for Education Statistics*, in *1995 digest of education statistics: Table 38*. 1995b, U.S. Department of Education: Washington, DC.
11. *National Center for Education Statistics*, in *Trends among high school seniors, 1972-1992*. 1995a, U.S. Department of Education: Washington, DC.
12. Al-Holou, N., et al., *First-year integrated curricula: Alternatives and examples.* Journal of Engineering Educatioin, 1999. **88**(4).