Improving Student Retention: Engaging Students Through Integrated, Problem-based Courses

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Introduction

South Carolina industry leaders are echoing industry concerns heard around the country: the fast pace of product innovation and the increasing complexity of technology in the workplace are requiring a different type of workforce to remain competitive in a global market [1,2,3]. A shortage of highly qualified engineering technicians already exists in the state, according to the SC Department of Commerce and SC Technology Alliance, and the growth of technology-intensive companies is placing even more pressure on the SC Technical College System to meet the increasing demands for technicians [4].

The mission of the South Carolina Advanced Technological Education (SC ATE) Center of Excellence (partially supported by NSF grant DUE 9602440), a statewide systemic initiative, is to produce greater numbers of more highly skilled engineering graduates through the state's 16 technical colleges. "Re-engineering" engineering technology programs involves not only developing new curriculum approaches to make instruction relevant to the demands of the workplace, but it also includes implementing new pedagogy and current instructional technology to make instruction effective. Industry representatives have made it clear that technical skills alone will not be sufficient for the worker of the future. Technicians must have interdisciplinary skills that include both technical and non-technical competencies that enable them to analyze, solve problems, communicate effectively, and be able to learn continuously as the workplace changes. Engineering technology graduates must be able to work as a part of a team, communicate well, and solve problems by integrating knowledge and skills from many disciplines.

Problem

Two major factors contribute to a low graduation rate in South Carolina engineering technology programs. First, many students (up to 50 percent) entering the technical colleges do not meet the placement requirements to enter challenging engineering technology curricula. These students either begin remedial courses that they consider irrelevant to their chosen major or select programs that do not have high placement requirements. Even those who enter remedial courses become discouraged and drop out or change majors. Remedial courses offered outside the context of regular courses often create failure [5]. These realities result in a decrease of students entering engineering technology programs and continuing to graduation.

Second, for those students who do place in the entry-level courses, the retention rate in the freshman year for courses taught in the traditional-lecture, "stand-alone" mode is low (30–60 percent.) This retention rate is not sufficient to have a graduation rate that will meet industry demands. Many students in the "stand alone" course mode will postpone the freshman courses in mathematics, physics, and/or communications to later in the students' academic career, which results in the students' not having the benefit of the mathematics, physics, or communication competencies in their major courses. The graduation rate for engineering technology programs for the South Carolina Technical College System for the years of 1992 to1998 is 10 percent.

Curriculum Change

The SC ATE curriculum development project seeks to improve graduation rates by addressing these two problem areas and using the results of educational research. Educational research has shown that the majority of students entering associate degree programs do not learn as effectively in the traditional lecture, teacher-centered instructional mode as they can learn in a contextual, student- centered, active-learning environment [6,7,8]. The SC ATE curriculum is designed to model the workplace by developing an integrated, problem-based approach to teaching the traditional mathematics, physics, communications, and introductory technology courses[9,10]. For students who are under-prepared to enter beginning mathematics and communications courses, a one-semester Technology Gateway (pre-engineering technology) was developed. The Technology Gateway courses consist of three, three-credit courses (mathematics, communications, and technology). For students who qualify to enter engineering technology curricula, three semesters (ET Core) of integrated mathematics, physics, communications, and engineering technology were developed. All courses use the problem-based learning approach that provides the context for learning each of the disciplines and the focus for integration. These courses are team-taught and team-learned. Students are given a problem and, working in teams, simultaneously learn the mathematics, physics, communications, and the engineering technology skills needed to solve the problem. Each term has five to six problems that revolve around industrial-validated situations. Since all disciplines address the same problem, students are required to take all components simultaneously. The teaching team coordinates the SC ATE learning processes, which includes both individual and team accountability.

Pilot Testing

In the fall of 1998, the Technology Gateway and ET Core courses were pilot tested at four technical colleges in South Carolina. Two colleges piloted the Technology Gateway and two the ET Core. Each college used existing placement criteria to determine the eligibility of students into the Technology Gateway or ET Core sections. For the ET Core, the lower limits of

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mathematics and English were used. In the Technology Gateway sections, it was necessary to have both lower and upper limits for placement into the courses. The only other criteria for selection were that students could take the credit load and whose schedule of other courses permitted taking the block of courses. Placement into the Technology Gateway courses was low even though a large number of students enter under-prepared. The two colleges teaching the Technology Gateway required that student's placement was for both mathematics and English. Also the introduction of the technology component increased the number of hours that under-prepared students traditionally take. While some colleges have experienced larger Technology Gateway enrollments in the fall of 1999, future use of the Technology Gateway will examine the placement criteria and the advising process to ensure appropriate enrollments.

Students exiting the Technology Gateway courses were given the same final exam as students in traditional remedial courses. Test results showed that Technology Gateway students performed as well or better than students in traditional courses. In the ET Core courses, no traditional courses were taught concurrently with the Core courses to make a same-term comparison. . However, comparison to previous years shows that the students' academic performance is equal or better, and students who would not likely have been successful in traditional classes are succeeding. In addition to the traditional academic skills, the courses are intended to improve the students' ability to work in teams and to solve problems. Although no direct measure of these two skills has been made, the students have shown an improvement in their teaming, problem solving, and presentation skills. This observation is born out by feedback from industry (comparison of apprenticeship students taught by the traditional methods and the problem-based methods).

SC ATE results include:

- Retention in Technology Gateway courses for 1998 was 76 percent.
- Retention in the fall 1998 ET Core was 94 percent.
- Retention in the spring 1998 ET Core was 100 percent.
- Ninety percent of the students completing Technology Gateway or ET Core in 1998-99 are enrolled in technology majors in fall 1999.
- Even marginal students are exceeding instructor expectations.
- Of the five participating colleges in 1999-2000, four are offering Technology Gateway and two are offering ET Core.
- ATE enrollment has doubled to 100 students in the fall of 1999.
- The number of women and minority students has more than tripled from 1998-99 to 1999-2000.
- By next academic year, 2000-01, at least two colleges will offer the ATE approach as the regular delivery mode for engineering technology programs.
- Ninety percent of South Carolina technical colleges plan to implement some component of SC ATE within two years.

Pre- and post-course surveys of students' attitudes also support the changes in their perceived abilities in these areas. The Table below shows the results of student attitude surveys taken the fall of 1998.

Question: How capable do you feel to: (Note: Percentage of students answering "Very capable" or "Extremely capable")	Technology Gateway			ET Core		
	Start %	End %	Change in %	Start %	End %	Change in %
Work in teams	69	92	33	65	88	36
Use math to solve problems	31	62	100	41	76	86
Write about science and engineering	38	69	80	23	58	150
Investigate problems using the scientific method	31	69	125	29	82	180
Use computers and similar technology	62	77	25	23	76	225

Conclusions

Early results show a dramatic improvement in student retention in SC ATE engineering technology programs. Student attitude and motivation is greatly improved. We see improvement in the students' communication skills, ability to handle problems, and work in teams. Industry perspectives on SC ATE have been encouraging. One local industry that has consistently employed technical college graduates over the years has seen a marked improvement in the problem-solving ability of students who have gone through the SC ATE problem-based ET courses compared with those students who have gone through the traditional approach. The SC ATE approach also is being viewed enthusiastically by other industry leaders, many of whom are becoming involved in SC ATE at different levels. We are confident that SC ATE is on the verge of an exciting effort to transform engineering technician education to benefit both students and employers.

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