Integration of Electronics, Math, & English and Its Impact on Retention

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Abstract:

At present, three forces are converging: 1) industry must compete globally in a rapidly changing technology, 2) the nature of the workforce is changing; new employees will be older and ethnically diverse, and will include more women, 3) the basic mathematical and communication skills of incoming students are steadily declining. The project is concerned with preparing underprepared students for the technical workforce in an environment of globalization, rapidly changing technology, and the declining of basic skills (communication and mathematics) of incoming students.

Our traditional approach to resolve these issues of underprepared students has been to offer discipline-based remedial courses. However, this compartmentalized teaching has not succeeded in meeting the expectations of these students and reducing the attrition rate which is generally higher than 60%.

Our project attempts to build a bridge between the skills of incoming students and the skills they must have to meet the demands of the future workforce. This bridge is being built on a strong foundation of interdisciplinary concepts supported in a learning community of students and faculty members. An Integrated Interdisciplinary Program (IIP) that includes electronics, mathematics, writing/reading, and computing skills was designed and implemented in the environment of a learning community that emphasized collaborative learning and team work.

This program, which is known as the Foundations of Technology Program [NSF Award: DUE 99-50019 Advanced Technology Education], is truly an integrated curriculum since the students experience it as a single entity and not as a group of separate experiences. The integration of courses and the environment of a learning community has had a dramatic positive impact on retention, which has already increased three-fold. This paper focuses on the issues of the integration of courses; the environment of a learning community; and the design of an interdisciplinary program.

Introduction:

In the last decade, three forces global competition, rapid technological change, and the composition of the American workforce began to converge. These forces are having a serious impact on our economy, and upon our ability to supply adequate numbers of well-trained technical employees. Unless educators and industry leaders work together, the current and often-lamented shortage of such employees will increase dramatically in the decades to come.

Industries must now demand a graduate with a different set of skills compared to those needed by workers entering the workforce two decades ago. Besides technical competence, employees should be able to perform a variety of tasks, communicate effectively, work as part of a team, and provide leadership. Technicians need to understand entire systems and processes, not merely their own often highly-specialized role or job function.[1] They must work in an environment that provides less supervision, while demanding more autonomy, accountability, and creativity.

The report from the Hudson Institute, *Workforce 2000*, asserts that the composition of the workforce is changing. In the future, employees will be older, will include more women, and will be more ethnically diverse. By the year 2025, the minority population of the United States will actually surpass the 50% mark. Diversity, especially in ethnic and racial background, must be a crucial consideration in designing our future programs. Understanding of and sensitivity to other cultures will be essential, both within our national workforce and in the new international and multi-national business climate. However, in an informal Internet survey of the national Engineering Technology Users Group, we found that minority students account for less than 15% of enrollment in engineering and technology.

While the demand for highly-trained, multi-skilled technical employees continues to grow, enrollment and retention in technology programs has reached a low point, and the basic mathematical and communication skills of incoming students are steadily declining. Nationwide, the attrition rate in introductory technology courses is 50% or higher. The lack of basic skills among entering students is a serious issue of national importance. A 1990 survey conducted by the Conference Board of the Mathematical Sciences found that 724,000 two-year college students across the United States were working at the developmental level, learning secondary or even primary material.[2] The vast majority of technology students are lacking basic algebraic and composition skills, making it impossible for them to be successful in technical courses. At our college, in the Spring of 1997, 50% of **all** new students registered for at least one course placed into English 099, a non-credit, remedial basic skills class. Half of our first-semester students, in other words, are unready for college-level work in **at least** one important area.

Our traditional approach to helping students at risk has been to provide discipline-based remedial courses offered by separate departments throughout the college. However, this compartmentalized teaching has not succeeded in meeting the needs and expectations of these students or reducing our attrition rate. Too often, students see little connection between their courses and their career. Therefore, many drop out before even experiencing any real exposure to the field they are interested in. Others get to try the gateway courses, but find them too daunting and quit.

Strategies for Teaching and Learning:
Faced with a huge disparity between the demands for a versatile, highly skilled technical graduate and the actual skills of incoming students, we clearly need a new way of thinking about our curriculum and our pedagogy. We can generalize several shared needs among a great majority of our incoming students. They need:

(a) developmental work in mathematics and communication skills to succeed in technical programs.

(b) to sense relevance of the courses to their career goals.

Our program is attempting to build a bridge between the skills of incoming students and the skills they must have to meet the demands of the future workforce. This bridge is being built on a strong foundation of interdisciplinary concepts supported in a learning community of students and faculty members. The primary goal of the program is to motivate and retain students in engineering technology programs by exposing them to hands-on, application-oriented interdisciplinary courses in a learning community environment. Our one-semester program includes the following strategies and features:

1. an integrated, interdisciplinary curriculum (IIP)
2. a simulated industrial environment
3. a learning community.

Integrated Interdisciplinary Curriculum:
The traditional approach has failed because of both motivational and intellectual reasons. Students are reluctant to study topics which don t seem directly relevant to their chosen discipline. They often fail to see the connections between skills and concepts in different courses, and they are likely to have trouble mastering what they see as an unconnected hodge-podge of new material. Too often, the results have been frustration and failure.

In cooperation with local industries we designed a cluster of interdisciplinary, modular courses that include electronics skills, mathematical skills, composition skills, and computing skills. At the core of our interdisciplinary approach is one application-oriented electronics course that highly motivates students, and incorporates the critical language tools: mathematics (a mode of communication within the world of technology) and writing (a vehicle for interaction with the external world.). The electronics course, Foundations of Electronics , is a motivational, hands-on introduction to the field of electronics. It was designed in the context of interdisciplinary concepts. Support courses include math and reading/writing offerings geared in content and applications specifically to remedial technology students. The intent of this consolidation is:

(a) to reinforce new information and concepts by synchronizing coverage of topics in math, writing, and electronics

(b) to offer ample demonstration of the relevance of each course by showing the interconnections among all parts of the curriculum; to teach students how to integrate concepts from each separate discipline and apply them to the other academic fields being studied. (This is important since students normally view their course schedules as a hodge-podge of unrelated and mutually exclusive academic offerings.)

There is abundant research supporting our proposed strategy. We have long recognized the

critical importance of a solid grounding in the academic basics , particularly in the technologies: Acquisition of new skills is facilitated when a worker has a solid grounding in the basics .[3] But there is equally persuasive evidence of the need for individuals, trained in technical subject matter, to possess mastery of analytical, problem solving and social skills, as well as competence in math and communication.[4]

Recent literature in the fields of mathematics and English also supports the need for an interdisciplinary approach. The report, *Crossroads in Mathematics Standards for Introductory College Mathematics Before Calculus,* recommends: (1) an increased use of technology; (2) interactive and collaborative learning; and (3) an emphasis on problem solving.[5] In our approach, math concepts reinforce, and are specifically applied to, technology applications. For instance, students analyzing current and voltage characteristics of series circuits in their electronics laboratory experiments are simultaneously covering related topics in their math course.

 Overcoming the resistance of technical students to writing involves a recognition that students (especially adults) need to see a clear rationale for all parts of the curriculum. Linking composition to a technology course leads to better writing, for as Zinsser asserts, The student who freezes at the mention of Shakespeare or Shelley can write surprisingly well about how oxidation causes rust or could if anyone asked him to. [6] Writing also facilitates learning by forcing students to explain new, problematical material themselves, in language that is their own. It *gives them a tool with which to approach the unknown.* It also transforms learning into a collaborative, community-based activity, allowing students in what L.S. Vygotsky calls the zone of proximal development to advance toward understanding and mastery. As Miles Myers says, The student is grappling with new ideas at the frontier of his or her learning and needs to lean on tools and other people to get help in internalizing those new ideas. [7] With this in mind, writing assignments in the English course will ask students to explain concepts being studied in the electronics course to a non-specialist audience. For example, they might have to research a specific technological invention or practice (such as SDRAM memory modules, DVD drives, or fiber optic transmissions) and write an article for a specific popular publication explaining it to an audience of lay people. Other assignments may allow students to focus on career interests and educational opportunities.

It is important to add that the math and writing components of this program satisfy all requirements of their regular course corollaries. However, IIP optimizes student learning by focusing attention on highly relevant applications and illustrations, and, most importantly, by close coordination among all instructors in every phase of the program from course design to day-to-day teaching. Dr. Rogers from the Rose-Hulman Institute of Technology stated at the 1992 ASEE Annual Conference that students enrolled in the Integrated First Year Curriculum at Rose-Hulman scored higher on grade point average and had lower dropout rates (3% vs. 18%) compared to randomly selected students in traditional classes.[8]

Simulated Industrial Environment:

To provide a realistic semblance of the working environment, our entire program is taught in a simulated industrial environment. For example, faculty members are assigned roles of department managers in a fictitious electronics company called Abatech Tools, Inc. , and students are viewed and treated as trainee technicians of that company. On their first day on the job , they are provided a booklet outlining the Company s expectations and guidelines regarding their work duties, attendance requirements and other Company policies all composed in appropriate industry legalese . Trainees are expected to attend classes five days a week, beginning at 8:00 a.m. Trainees are allowed a fixed number of absences for the duration of the training session, which must be officially called in; if a trainee exceeds that limit without a valid reason, s/he is asked to leave the company (i.e., dropped from the program). Trainee teams are asked to design and/or analyze realistic industry projects in their electronics and computer lab sessions, and are expected to present several oral and written proposals or presentations to outside audiences, as Company representatives. Department managers periodically attend each others training sessions, in an atmosphere of department meeting planning sessions . And in addition, trainees undergo performance reviews twice a semester, conducted by all of their managers. (Based on student feedback, it appears that they highly value these performance reviews.)

Learning Community:

Nationwide, the first-semester attrition rate in technology programs is around 50% (Internet survey); this figure is similar to the data reported at the Fall, 1997 New York State Engineering Technology Conference at Morrisville, NY. At our college, attrition exceeds 60% of the entering class. There are many reasons for such a high attrition rate, but they tend to fall primarily into two broad categories: academic and social maladjustments. There are many research studies that have examined the issues of retention (persistence), and many colleges have implemented programs such as freshman year seminars, mentoring, and orientation courses. In general, retention programs and services have been relegated to the Student Services or Enrollment Management Office. However, Vincent Tinto, in a *Review of Higher Education* article,[9] alleges that educational experiences of students have remained largely unchanged, their education relatively unaffected by research on persistence. Tinto, further, argues that individuals are more likely to persist when they are either academically or socially integrated and even more likely to persist when both forms of integration occur. This program provides both types of integration.

Many institutions of higher learning are establishing learning communities organized around specific intellectual themes.[10] These themes provide participants with an integrated learning experience in a family-like environment. According to Matthews, these learning communities play a critical role, especially for non-traditional students, by providing an avenue for their integration into college life. The strength of the learning community lies in their sense of purpose. [11] In this program, the intellectual theme is a hands-on electronics technology course that persuades students to explore the world of electronics and may lead to a career of their choice. The necessary skills (math, writing, and computing) are interwoven around this theme. The interdisciplinary program should provide the requisite academic integration.

Social integration in a commuter college setting is not as easy as in four-year residential campuses. Most community college students attend classes and then go home or to jobs. The interaction among peers is very limited. However, this program provides the necessary social interaction by scheduling classes together and by using Internet technology outside the classroom. Because all students in the program take the same classes, they experience a maximum interaction while they are on campus. We cannot provide the same opportunity for social interaction as exists in residential four-year colleges, but we can provide virtual social interaction through our Internet user group. To create a virtual social interaction, every student must have a computer. These days, 70 80% of students already have computers at home; for the rest, our program lends them PCs for a semester. Our user group and chat room facilities provide them an opportunity to communicate, to study together, to assist each other, and to form a community of learners that can build a sense of group identity and cohesion. Data collected at Daytona Beach and LaGuardia Colleges reinforce the hypothesis that learning communities contribute to student success and retention.

Students in our program are provided an educational environment that will give them a sense of belonging and an opportunity for maximum social interaction both in their classes and through the use of the Internet.

Retention and Assessment:
In the Fall of 1999, our program was pilot tested with a small group of students. The number of students admitted was 11, out of which six students completed the program successfully (54%). In the Spring 2000 semester, nine out of 14 students (64%) completed the program, as did 12 of 14 students (85%) in the Fall of 2000. The average success rate of our FTP graduates in subsequent technology programs, according to our first round of tracking, and excluding pilot semester data, is around 75% a much higher retention rate than that of the regular (non-remedial) students admitted in our two-year technology programs (typically 50 60%). However, the assessment of our program by FTP students, conducted through questionnaires and group interviews, was perhaps even more revealing and enlightening than our quantitative retention data.

Students had very positive comments about the program and instructors, as elements of their learning community. They enjoyed the camaraderie, spirit of cooperation and mutual help they received from one another, as a result of their membership in a cohort. Those who came to the academic world after spending a considerable number of years in the real world appreciated the connections between real world expectations and their IIP training sessions. Intellectually, what they enjoyed and were most impressed by was experiencing the deep and carefully crafted interconnections that have been designed into their electronics, math, and writing courses.

Summary:
Our program is attempting to build a bridge between the skills of incoming underprepared students (at risk students) in two-year technology programs and the skills they must have to meet the demands of the future workforce. This bridge is being built on a strong foundation of interdisciplinary concepts, supported in a learning community of students and faculty members.

An Integrated Interdisciplinary Program (IIP) that includes electronics, mathematics, writing/reading, and computing skills was designed and implemented in the environment of a learning community that emphasizes collaborative learning and team work. The IIP is truly an integrated program since the students experience it as a single entity and not as a group of separate experiences. The integration of courses and the environment of a learning community has had a dramatic positive impact on retention, which has increased considerably in comparison to the traditional retention rate in typical two-year technology programs.

References:

1. Richman, Louis, The New Worker Elite (*Fortune*, August 22, 1994).

2. Albers, D. J., et al., *Statistical Abstracts of Undergraduate Programs in the Mathematical Sciences and Computer Science in the United States, 1990-1991 CBMS Survey*; (Washington, D.C., Mathematical Association of America, MAA Notes, Number 23, 1992).

3. Carnevale, Gainer and Meltzer, *Workplace Basics: The Skills Employers Want* (Alexandria, Va., U.S. Government Printing Office, 1988), p. 1.

4. Ibid.

5. Cohen, D. (Ed.), *Crossroads in Mathematics Standards for Introductory Mathematics Before Calculus* (Memphis, TN., American Mathematical Association of Two-Year Colleges, 1995).

6. Zinsser, William, *Writing to Learn* (New York, Harper & Row, 1988), pp. vii-viii.

7. Myers, Miles, *Changing Our Minds: Negotiating English and Literacy* (Urbana, IL., National Council of Teachers of English), p. 159.

8. Rogers, Gloria Martin, *Integrated First-Year Curriculum in Science, Engineering and Mathematics: The Sophomore-Year Experience, Rose-Hulman Institute of Technology* (ASEE Conference, Anaheim, CA., June, 1992).

9. Tinto, Vincent, *Colleges as Communities: Taking Research on Student Persistence Seriously* (Review of Higher Education, Vol. 21, 1998), 167-77.

10. Matthews, Roberta, *Learning Communities in the Community College* (AACJC Journal, Oct./Nov. 1996, 44-7).

11. Ibid.

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