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Integrated Instructional Innovation*

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Repackaging of the engineering program in innovative ways exemplifies a vision for the 21st century. It is anticipated that there will be a need for faculty who specialize in their expertise yet generalize in the class-room. Examples are presented of interdisciplinary common core courses. The extraordinary need for intertwined instruction in the teaching of engineering design is illustrated.

INTRODUCTION

WHEN an engineering group designs a product or system—whether it be a power plant, chemical process, electronic circuit or other combination of elements—the group usually searches for the optimum arrangement in order to maximize the desired result. Universities need to take such an approach to engineering education. Has engineering education been structured in an optimal manner? Is a change needed as the 21st century approaches?

The time has come to evaluate carefully the way an instructional program in engineering is taught and the way the student learns. Certainly, one of the primary aspects of a successful program is student motivation to learn. Many would agree that the students' viewpoint must be broadened to include multidisciplinary and interdisciplinary topics. These peripheral factors must be blended in an engineering education such that the student learns their importance. For example, factors such as economics, safety, environment, politics, global interactions, culture and sociology should be part of an instructional program for the 21st century.

The current approach to engineering education introduces these topics as separate courses or parts of a course rather than as an integral part of an educational program. The current approach requires, in most cases, studying the building blocks (such as chemistry, physics, mathematics, etc.) before problem solving can be attempted. Is this an appropriate approach when it has been found that real problems are one of the best ways to motivate students to learn? Indeed, there has been much research in recent years concerning 'accelerated learning' or 'integrated learning' where considerable attention has been focused on how the student learns the material. Similar concepts are developed in 'expert systems', 'artificial intelligence', 'interaction analysis' and 'self-actualization psychology'.

The results of these studies show that the way information is presented can have a tremendous effect on the way a student learns. As a consequence, an improvement in the way information is presented, and thus an overall improvement in the efficiency of engineering education and the quality of engineering education, can be envisioned if a new approach is considered.

CURRENT ENGINEERING CURRICULUM

A review of the particular curriculum requirements associated with each engineering discipline suggests an overall structure. Generally, courses are required that deal specifically with the basic sciences, mathematics, engineering sciences, humanities, social sciences, perhaps language and generally engineering design. These courses advance in an orderly progression from the fundamental to the more complex. In the United States, this approach has been essentially the same for the past five decades. Such an approach has been successful, but also has drawbacks. The engineering student studies physics as a physics student or calculus as a mathematics student without understanding the relationship to engineering. The engineering student is not motivated to study the subject because he or she lacks an understanding of how that specific subject relates to the practice of engineering. Thus a vision for 21st century education suggests a change in this process—a change that provides the student with a strong motivation to study the broad range of subject material essential for the future.

PROPOSED ENGINEERING CURRICULUM

The vision is for an engineering curriculum that immediately confronts the entering students with real problems that must be solved. Such an approach is not unique, as it has been successfully used in industry at higher levels (e.g. Advanced Engineering Program, General Electric Company) and in elementary schools at lower levels (e.g. Clara Barton School, Minneapolis, Minn.). For a strong engineering education, the problems that the students are confronted with should be real problems.

Contrary to popular belief, most young people have a humanistic approach and wish to do their part in improving the world. Thus attractive problems will be those that deal with highly visible accidents or dilemmas connected with engineering operations. The young student beginning an engineering education, then, can focus on those problems and decide how he or she could play a role in solving the problem and assisting humanity. For example, typical real-world problems might include the Chernobyl meltdown, the Space Shuttle accident, passenger airline safety, hazardous waste disposal, solid waste disposal, environmental pollution, etc.

The approach with students would be to set the stage by analyzing the accident or problem in detail, discussing what the causes might be, and then deciding what the students need to know to deal intelligently with the problem. At this stage, the students would be put in a position that there are certain basic subjects that they must learn in sufficient detail to proceed with the treatment of the accident or problem. Concurrently, they would see that economics, politics, environment, culture, etc. are involved and would require further reading and study. This approach, built on the analysis of an accident or problem, provides the students with a reason for their coursework. Their educational program becomes interdisciplinary and the coursework becomes integrated instead of the traditional stand-alone approach. The computers and library play an intense role in the students' education from the first day of instruction in this new approach. Special note is made of the present availability of CD-ROMs. These 'Compact Disk Read-Only Memory' optical storage devices can store the equivalent of 1500 floppy diskettes worth of data making the entire contents of reference works such as encyclopaedias promptly available on the computer screen.

The proposed approach is that of an integrated curriculum creating a learning environment such that the information is presented in a way that motivates the student to learn. It becomes the student's responsibility to establish a solid foundation in specific areas and then see how these specific areas apply to a particular problem. Although such approaches are often referred to as accelerated learning because of the high motivational factor, it must be recognized that the student develops a depth of understanding of a specific area and its relationship to other areas as well as an ability to think and reason. This approach provides the emotion, the positive emotion, for the student to learn. It puts challenge and satisfaction in the learning process. It also provides a synergy between fellow students that usually does not occur in the traditional educational approaches.

DISCUSSION

This new approach to engineering education provides a number of benefits because the student is put in a learning environment where he or she can more rapidly learn specific information, as well as its relationship to other aspects of the problem. The student thus learns the fundamental material of a traditional engineering education, while at the same time developing a technique for solving problems—an ability that is so important to an engineering career. The student that discovers (learns) scientific facts from necessity will retain those facts in addition to having the satisfaction of the discovery. Of course, those same facts could be taught in the traditional way, but it is not likely that the student would have learned them as well.

What are the problems with this vision for 21st century education? The most obvious would be the faculty. There is a need for faculty who specialize in their expertise yet can generalize in their instruction. The faculty will need to broaden their intellectual approach to problem solving and need to present the material properly. There may be times when the faculty would have to work co-operatively with other faculty on very complex problems. Certainly, the students would be expected to work co-operatively. The students would have to be taught in such a way that the learning process would be emphasized. Contrary to earlier instructional approaches, students should be informed that working together to achieve a result is necessary for success. Working co-operatively, interacting with other students and keeping each other involved in the necessity for learning specifics in order to generalize is an essential aspect of this vision. Students become their own best teachers, augmenting the instruction provided by the faculty.

Our vision for engineering education in the 21st century will not be popular. Traditional engineering education defines the teacher as an information delivery system. The student absorbs the information delivered and endeavours to learn the information once it is disseminated. This vision for 21st century engineering education defines the faculty member as the primary motivator for the students' learning process. The student who develops a learning process for the engineering education methods outlined should develop five key attributes prior to completing an engineering education program:

- Creativity and inquisitiveness.
- Knowledge of fundamentals, including communication skills.
- Desire for continued learning.
- Ability to work effectively with others in a group environment.
- Ability to respond to change as well as adapt to change.

CONCLUSION

The integrated instructional program described herein could become a reality for the 21st century. Its success will be primarily dependent on the

faculty, and the restructuring of the learning process. At the same time, the students should not be underrated. Students have the capability to learn in such an environment—a challenge that will be met by most students. These engineering graduates would be recognized for their ability to identify and solve problems efficiently, and the image of engineers as a whole will be enhanced.

In concert with our vision for engineering education in the 21st century we pose a challenge. Is there an institution that is willing to try this approach or faculty that will undertake this opportunity to create a better learning environment for engineering students?

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