How to Develop an Exciting, Motivating Course Using Four Course Design Concepts

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I. Introduction

In this paper, we will describe how we used four course design concepts to develop two new courses that have been successful in exciting and motivating students. Our efforts to include motivation and excitement as course design parameters are tied to increasing importance being placed on retention rates, graduation rates, and student satisfaction with their college experience in recent years [2-3]. Faculty members are beginning to buy into the idea that retention rates and graduation rates must be improved in order to bring public accountability to the table in curriculum planning. Developing courses that are motivating and exciting will certainly help this cause. This is in contrast to the prior faculty beliefs that (1) it is not their responsibility to motivate and excite students, (2) students should be motivated by what the future will bring when they earn their degrees, and (3) should be excited by the course materials under the assumption that they chose their major based on interest.

Anderson-Rowland [4] reported that a students's reaction to first-year engineering courses is a key to retention, and Tinto [5] reported that persistence depends on the student's level of integration into the college environment. Interviews with students and surveys of student satisfaction have led us to conclude that they are not necessarily as committed as we thought, take too heavy a course load for the number of hours they work per week on income producing jobs, and place higher priority on courses that they find motivating and exciting. Thus, in order to improve student satisfaction, motivation, and retention and to promote student success, we developed the two courses with various combinations of the four course design concepts covered in this paper.

The four course design concepts that we will describe are just-in-time delivery of instruction [1, 6-9], attached learning [6, 7, 9], integration of knowledge [8, 9], and only-as-needed selection of the course contents [8, 9]. Since they have been described extensively elsewhere, they will be reviewed in this paper only briefly. The two courses, developed under separate grants from the Department of Education's Fund for Improvement in Post-secondary Education (FIPSE), include "Introduction to Engineering Methodology," a course for freshman students, and "Electronic Fundamentals for Electric Vehicles," an elective for seniors that brings together senior EE and EET students for a common design experience. The former course illustrates the use of just-in-time delivery and attached learning, while the latter course illustrates the use of both integration of knowledge and the only-as-needed method for selecting course contents. We will describe these four concepts, explain how they work to motivate and excite students, and describe how the two courses use the four concepts. The paper also reports the results of four years of assessing student satisfaction.

II. The Four Course Design Concepts

2.1 Just-in-Time Delivery of Course Materials

While attached learning, integration of knowledge, and only-as-needed course design concepts are emerging concepts used by the authors in recent years, just-in-time delivery of course materials became part of the mainstream of course development in engineering education several years ago [1]. In its first incarnation, it meant that course topics are introduced “just-in-time” for its application, not several weeks prior its need and certainly not a semester or two before it is needed. Quite commonly in core courses, faculty tell students, “Learn this now because you will need in next semester.” Just-in-time delivery avoids the “learn for the sake of learning” mode which does not seem to work as well as it used to, with students thinking, “If I’ll need it later, I’ll learn it later.” Thus, to keep students involved in their own learning as well as to give them hands-on experiences that help them make sense of conceptual knowledge, we found it helpful and satisfying to let students quickly make the transition from conceptual learning to hands-on learning, and the success of the close tie between theory and application has led us to consider introducing laboratory experiences in courses that have traditionally been lecture-only courses. The just-in-time design principle led us to conceptualize the other three course design concepts.

2.2 Attached Learning.

Attached learning [6, 7, 9] is a course development principle which requires that instructors openly promise students that all course contents would not only be delivered just-in-time for application on their weekly laboratory projects, but will also help them be successful on an exciting, hands-on, industry-style design project. Thus, all course contents would be “attached” to something they will look forward to with high anticipation. This is analogous to the novice tennis player who so looks forward to becoming a successful tennis player that he or she makes the commitment to learn the basic skills. The success of this principle requires early announcement a design project that students will find exciting so that it can command the attention of the students. Freshman students seem to be more interested in designing gadgets similar to what they see in real life than to work on theoretically elegant projects which have to basis in day to day life.

Attached learning by itself is not enough to keep students motivated throughout the course. The just-in-time concept requires that exciting weekly hands-on experiences be coordinated with the new lesson materials.

<u>An Example</u>

In our freshman engineering design course, students learn to use MatLab and PSpice as simulation tools, and they learn elementary digital logic design methods and printed circuit board layout techniques using PSpice. Students apply these tools to an exciting, substantial design project. Under the principle of attached learning, the projects are described early in the semester to motivate students to assimilate the tools. The weekly hands-on laboratory experiences are not sufficient to keep students interested and motivated. The term projects for this freshman course include the design, simulation, and testing of products such as light sensors, music synthesizers, touch-tone decoders, computer-based temperature sensors, and updown counters.

2.3 Integration of Knowledge

Our campus has developed a set of campus-wide general education principles, called the Principles of Undergraduate Learning, which all departments on campus must assess to demonstrate successful student learning. One of the principles is the Integration of Knowledge. Faculty members on our campus have decided that it is important for students to be able to integrate knowledge from different learning experiences, either within a major or across majors. We were awarded our second FIPSE course development by proposing that we develop a senior technical elective in the design of instrumentation for electric vehicles incorporating integration of knowledge [8, 9] and the principle of attached learning. Normally, students are asked to integrate knowledge from several courses only on a design project in a capstone course. In traditional courses at the senior level, where a particular topic is pursued deeper and deeper, the course materials are self integrating; that is, the materials integrate themselves since a single specialty such as digital signal processing or digital controls is pursued. Under the principle of integration of knowledge concept, the course contents are selected from design methods that cut across specialties, all selected for their applications to carefully selected design projects. It becomes the responsibility of the student to integrate, or pull together, the diverse design methodologies with the help of carefully planned projects

<u>An Example</u>
For our senior elective course in the design of electronic subsystems for electric vehicles, we have incorporated a second integrating feature--a state-of-the art electric vehicle propulsion system from General Motors' EV-1, donated to the university by GM. Having a high-profile, high-tech test bed such as the EV-1 propulsion system for laboratory work and design projects helps keep students motivated and excited. The diverse design methodologies are selected based on their applicability to designing suitable subsystems for the propulsion system.

For our senior elective, we selected design methodologies from such diverse topics as the following:

- Fuzzy logic
- Neural networks
- Power electronics
- Microcontroller applications
- Digital signal processing
- Solid state devices
- Battery technology, and
- Virtual instrumentation.

Students use combinations of these design methods on projects such as:

- Design and simulation of a propulsion system to meet prescribed specifications,
- Design of a Lab View-based computer interface to access electronic sensors in the propulsion system to monitor its voltage and current waveforms,
- Design of a battery prototype to meet prescribed charging, discharging, and cooling rate specifications, and

- Design of hardware and software using DSP controllers to attain speed and acceleration profiles.

Needless to say, this senior elective also makes use of just-in-time and attached learning course design principles. All design methods are delivered just-in-time for application for weekly laboratory experiences, and all design methods are attached to both the propulsion system and the end-of-semester design projects.

2.4 Only-As-Needed Methods of Selecting Course Contents

In traditional courses, students are asked to learn concepts and design methods that they may never be asked to apply to laboratory experiments or projects. This leads to a "learning for the sake of learning" approach to engineering education, an honorable endeavor, but not one that is known to motivate our students. The only-as-needed method of selecting course topics makes sure that all of the topics selected for the course are accompanied by laboratory and project experiences. When used, the only-as-needed method of selecting course contents must be used with care to prevent the course from becoming a disjointed collection of elementary design methods. One way to accomplish this is to make sure that the weekly projects and assignments are assimilated by assuring students that successful performance on the term project requires that they delve into the reading materials and become motivated learners.

The only-as-needed selection of topics listed in Section 2.3 and the integration of knowledge concept worked hand in hand in the design of our senior electric vehicle course [8, 9].

III. Assessment of Student Satisfaction

Because the two courses were developed with funding from FIPSE, we were required to carry out extensive assessments of them. Complete results have been published [6-8]. In [6, 7], we showed that student satisfaction with their experience in the new freshman engineering course rose considerably in all items assessed compared with students who took the old course, including the following:

- They were more motivated to pursue the engineering degree.
- They were motivated to learn to use productivity design software
- They enjoyed working in teams
- They enjoyed learning what engineers do when designing products
- They were more motivated to learn solving problems.

In no single item did students express a lower level of satisfaction in the new course.

In [8, 9]we were not able to compare student satisfaction with an old version of course because there was no old course to compare with. Thus we reported on absolute levels of students satisfaction instead of improvements in the same, with students reported a high level of satisfaction Using a scale where 5.0 = very satisfied, 4.0 = satisfied, 3.0 = neutral, 2.0 = satisfied, and 1 = very dissatisfied, and students responded with an average rating of 4.5 or better on twelve of fourteen assessed items, including the use of simulation software, being motivated by the course, continuing work in electric vehicle design, learner-centered instruction, integration of knowledge, and learning how real engineers do design. The other two items elicited response averages between 4.0 and 4.5, still indicating satisfaction, but not at the same level as the other twelve items. The two items in question deal with doing research in electric vehicles and working in the electric vehicle industry.

IV. Concluding Remarks

The course design team has learned several valuable lessons that should have been obvious to use if we had only thought about it. The freshman engineering course taught us that students could become excited and motivated if we made learning exciting and motivating instead of merely focusing on skill building for future courses. In the senior course, we learned that students could integrate knowledge and be successful in learner-centered environments, and we learned that students would be motivated by industrial-like design experiences. We also learned that only-as-needed method of selecting course contents, while necessarily eliminating any opportunity to pursue a single design methodology in detail, does not necessarily produce a weak course. From both courses, we learned that exciting courses can motivate students to put more effort into other courses and to make a stronger commitment to engineering as a career path.

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