ENGAGE: A DSP LEARNING PARADIGM FOR AN ENGINEERING AGE

Michael Christensen, Rodolfo Troche, and Fred Taylor

The University of Florida

ABSTRACT

ENGAGE is an innovative engineering learning paradigm and technology based on presenting a student with challenges framed in real-world scenarios. Defined within a *scenario-based learning* model, this approach requires students to make technical and non-technical decisions to successfully complete a session. These activities therefore emulate the engineering decision-making processes found in the workplace. ENGAGE responds to incorrect answers or a flawed conceptual understanding with immediate remediation. Using software that only recently has become commercially available, scenario-based learning modules are being developed for use in undergraduate and graduate DSP instruction. This paper reports on these activities and accomplishments.

Index Terms— Education, Education Technologies

1. INTRODUCTION

Despite the observation that America's basic science, mathematics, engineering, and technology (SMET) industry is world-class, the SMET education delivery system remains troubled. Fortenberry of the National Academy of Engineering [1] noted that only 56% of undergraduate engineering students currently complete their studies. This is disturbing news in a period of anticipated increased engineering need and a forecasted decline in engineering graduates. Voices such as former Federal Reserve Chairman Alan Greenspan have felt the need to break with tradition to testify before Congress, not about interest rates or inflation, but about the importance of strengthening U.S. science, math, and technological education as the foundation to continued economic growth. Rosen [2] stated, "But by almost any measure – academic prizes, patents granted to US companies, the trade deficit in high-technology products – we're losing ground to countries like China, South Korea and India who are catching up fast. Unless things change, they will overtake us, and the breathtaking burst of discovery that has been driving our economy for the past half-century will be over." Thomas Friedman more fully developed this thesis in his 2005 best seller, *The World is Flat*.

There are forces that claim to be capable of mitigating these problems. Mitchell [3] noted, "For the last forty years, engineering educators have sharpened their students' analytical skills and theoretical understanding. Now a second major paradigm shift has begun." The described change is due to the fusion of engineering education and technology. The potential impact of the computer as an enabling engineering educational technology was forecasted in the now famous Neal Report [4], which gave the entire SMET community a rude wake-up call in 1986. Since then the world has changed, but the delivery system remains grounded in the past. In any event, engineering academicians must be fully prepared to critically evaluate their mission and honestly deal with a litany of systemic problems. Included on this list is the recognition that engineering education should assist students in not only learning facts, but also in understanding how these facts can be applied to problem solving. This need was amplified by the National Academy of Engineering, which warned that academia needs to change its emphasis from "knowing about" to "knowing how" [5], without which too many students will fail or fall into a marginal status, losing both hope and interest in engineering. The University of Florida's response to this challenge is called **ENG**ineering **AGE**, or **ENGAGE**.

2. SCENARIO-BASED LEARNING[1]

Engineering professors are often unaware of established classroom pedagogy or e-learning methods. Those who take a more holistic view of their profession realize that a basic pedagogical awareness leads to the following understanding [6]:

- Proven instructional techniques, developed elsewhere (*e.g.*, K-12), can make college-level teaching more effective.
- These methods can often be converted into practice with only a limited increase in cost, time, or effort.
- Assessment is important.

---

1 Scenario-based learning refers to learning activities that are framed in the context of a meaningful scenario and involves decision-making.

The ENGAGE paradigm is enabled by such awareness, specifically by a learning methodology called *scenario-based learning*. The concept of scenario-based learning is not new. Malcolm Knowles [7] pointed out that adult learners, unlike children, have "a reservoir of experience" which can be used as a "resource for learning." In this context, ENGAGE builds upon prior skills. Proponents of scenario-based learning argue that knowledge is best acquired through working with and resolving problems in settings that emulate reality. According to Miriappan et. al. [8], scenario-based learning can create realistic learning situations in which a sequence of events is presented along with possible choices that allow the learning to reach a successful outcome. Learning, it is claimed, occurs when the user goes through the scenario and is guided to discover basic principles and develop critical competencies. A scenario-based learning experience is intended to fully immerse the learner in a realistic situation, providing the student with a list of potential decisions, giving the learner a description of the expected outcomes and the consequences of choices, enable branching until a final outcome is realized [9, 10]. (It is worth noting that these are the standard actions taken by engineers in the workplace.) This process is motivated in Figure 1. The example given presents to the engineering student options that may be selected at each decision point, e.g. "If designing for economy, the next step is…" or "If designing for performance, the next step is…"

The number of options should be kept sufficiently low so as not to overwhelm the learner with choices. The complexity of the branching options is set by the learning module designer and may include both technical and non-technical decisions. Some decision paths may represent flawed or poor choices, others acceptable but suboptimal, others optimal. If the learner selects a flawed path, the designer may wish to correct the learner immediately or delay correction.

Adobe's Captivate 3 software (available for $200 academic) is being used to facilitate scenario-based learning for on-campus and off-campus environments in support of the multiple enrollment types at UF[2]. For example, scenario-based learning modules can be developed to demonstrate DSP programming disciplines such as those for use on a TI TMS320C6713 DSP Starter Kit (DSK) as a set of ill-conditioned design questions and activities. Such modules can be integrated into a number of basic content delivery formats such as a studio-based framework [11].

One of the expected benefits of a scenario-based delivery system is student engagement. The University of Florida has made a number of attempts to foster in-class technical dialog with students with only limited success; students continue to guard their apparently fragile egos with a veil of silence. Scenario-based learning experiences, however, can establish a virtual faculty-student dialog, thereby overcoming some of the interaction limitations found in the classroom.

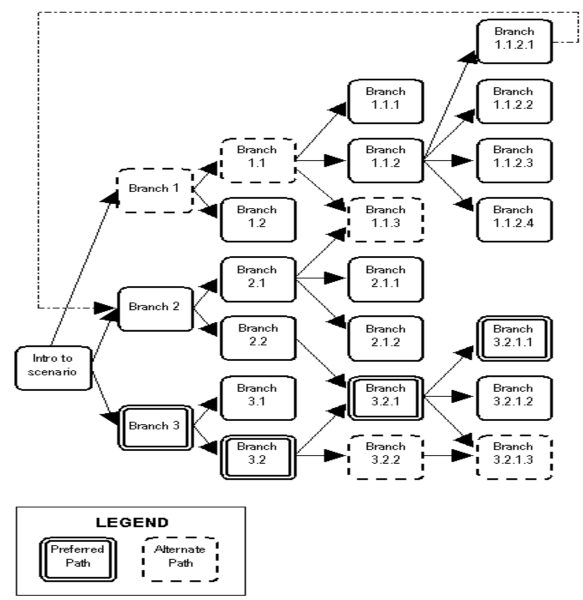


Figure 1: Example of Scenario-Based Learning.

Scenario-based lessons can also have a common DSP theme, such as audio special effects, that can be built into the lessons. If the lesson's primary mission is developing DSP programming skills, learning modules can be developed supporting software emulation while others can work with a $400 physical C6713 DSK board. In either mode, the student would be presented with a problem that is defined by its scenario, followed by a set of interconnected decisions and possibly ill-conditioned activities. Qualitative or soft responses can also be easily added to the lessons. Decision points will be primarily technical in nature, and be based on engineering choices. The student's progress can be monitored by analyzing the decisions made during the exercise and by completing randomized, auto-graded quizzes. The lesson would conclude with a summary report informing the student about both good and bad decision-making as well as quiz results. Additional supporting material, instructor notes, design tips, DSP product reviews, and other content can be added to the lesson. Since the ENGAGE scenario-based studies are guided activities, they can be equally applied to off- and on-campus learning instances.

3. EXAMPLE

A scenario-based learning module was constructed using Adobe's Captivate to implement a scripted scenario lesson. The object of the study is to expose the student to aliasing

[2] Adobe Captivate 3 is a full multimedia software package designed to support simulation, scenario-based training, and learning assessment.

and its mitigation. The lesson begins with the presentation of a scenario that motivates a specific study of aliasing. It is assumed that the student has been introduced to the sampling theorem and appreciates that aliasing occurs when the theorem is violated. Many students, however, have difficulty in recognizing aliasing when they see it. The following scenario-based learning module is designed to address this problem, as outlined in Figure 2.

Scenario: A dialog is established with students, which motivates the proposition that modern technology now allows individuals, like themselves, to create a personal audio and voice recording studio at home. Furthermore, there is now a definable market (e.g., Voice123) for high-quality voice-overs, narrations, pre-recorded messages, etc. Using a PC, quality microphones, analog pre-amplifiers, and sound editing software (*e.g.*, Shure SM7B microphone, Symetrix 528E amplifier, Sound Forge audio editor), a capable studio can be created for a thousand dollars. The lesson informs the student that they are now in this business. The student's first potential customer gives him/her an excerpt of a 15 minute professionally recorded voice track as a .WAV file. This short sample represents acceptable work and is to be used as a standard.

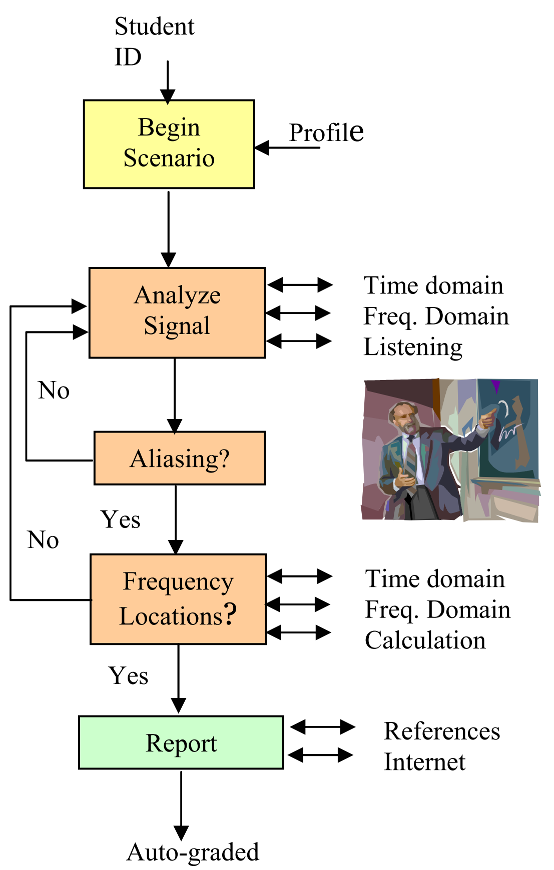


Figure 2: Example study.

Activity: The student is provided with short 10-20 second audio (speech) .WAV files sampled at 44.1k, 22.05k, 11.025k, and 5.5125k sample rates. The student listens to each .WAV file and also views its pre-computed magnitude FFT; one such example is shown in Figure 3. The student is asked to determine what the memory storage requirements would be for each 15 minute uncompressed file at each sample rate. This analysis defines file size expectations and motivates the selection of the lowest possible sample rate that will yield a high quality audio file (an auto-graded response). Upon making a sample rate selection, the scenario software branches to the next level along with a briefing of file size limitations and industry-recognized compression protocols. In addition, ENGAGE provides the student with a presentation of what decisions professional audio experts would have made.

Continuation: At the next level, the student is guided to choose a sample rate of 44.1k Sa/s using a ΔΣ ADC. (Analog Devices standard parts are explored on-screen.) ENGAGE instructs the student to listen to a pre-recorded 10-20 second audio file using his/her studio. The audio file is to be used to evaluate the quality of their studio equipment.

Activity: The student is instructed to evaluate the test recording and determine if the sampled signal is aliased. Unbeknown to the student, the predefined 44.1k Sa/s audio record is corrupted by an on-board analog circuit leaking first harmonic 15 kHz and third harmonic 45 kHz tones. The student plays the .WAV file and finds an unexpected tone present. Upon the student's request, a magnitude FFT, calibrated by harmonic number, is displayed. The student has to determine at which frequency or frequencies these extraneous tones reside (auto-graded).

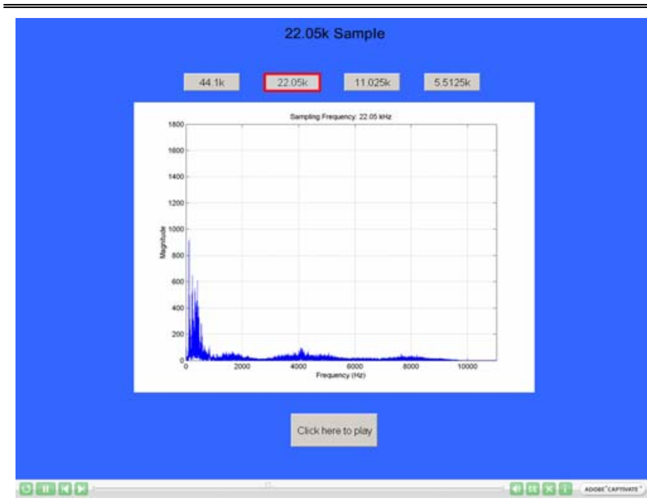


Figure 3: Example Screen from Adobe Captivate.

Continuation: The student has been guided to investigate if aliasing has occurred and if the extraneous components are harmonically related. He/she is led to conclude that the 15 kHz component, while appearing in the signal's FFT, is too high a frequency to be heard. The signal component at 900 Hz, however, remains a mystery.

Activity: The student is asked to identify a possible cause for the aliased signal component (auto-graded) and makes a selection, branching to the next level. The software interprets a wrong answer in terms of frequency warping and *modulo*(f_s) arguments using simulations and illustrations that explain the 900 Hz tone.

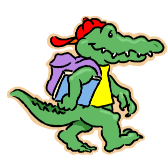
Conclusion: Student performance is assessed. Tips and basic principles are reviewed in those areas in which the student had difficulty. Additional (optional) problems are also assigned in the problem area. The role and physical instantiation of the anti-aliasing filter is further discussed in both a fixed and variable sample rate instance. Finally, the student completes a brief formative survey that captures the student's impressions regarding the learning experience and performance of the software.

4. ASSESSMENT

A formative assessment study is scheduled for Q1 of 2008 in a senior level DSP course (EEL4750). A more formal summative assessment is planned in a pending NSF EEP project.

5. SUMMARY

A new approach to engaging undergraduate DSP students in authentic and motivating studies has been reported. The new learning paradigm under study is based on a scenario-based model developed for K-12 audiences. The scenario-based model appears to be well suited to engineering, requiring students to make decisions, test and validate these choices, and engage some virtual mentoring agent at a higher-level.



ENGAGE

11. REFERENCES

1. IEEE, "Engineering Schools That Tie Theory and Practice Together Retain More Students," *IEEE SPECTRUM Online*, Sept 19, 2007.
2. Rosen, J., "Are We Losing Our Edge?" *Time Magazine*, February 13, 2006.
3. Mitchell, E., "Engineering Education, Technology, and Change," A Syllabus, March 1996.
4. National Science Board, Task Committee on Undergraduate Science and Engineering Education, Homer A. Neal (Chairman), Undergraduate Science, Mathematics, and Engineering Education; Role for the National Science Foundation and Recommendations for Action by Other Sectors to Strengthen Collegiate Education and Pursue Excellence in the Next Generation of U.S. Leadership in Science and Technology, Washington DC: National Science Foundation, 1986, NSB 86-100.
5. "Science and Mathematics in the Schools: Report of a Convocation," National Academy of Sciences and National Academy of Engineering, May 1982, ISBN 0-309-03330-6.
6. R.M. Felder and R. Brent, "Understanding Student Differences." Journal on Engineering Education. An Exploration of Differences in Student Learning Styles: Approaches to Learning (Deep, Surface, and Strategic), 2005.
7. Knowles, M. S. (1980). The Modern Practice of Adult Education: Andragogy versus Pedagogy. Englewood Cliffs: Prentice Hall/Cambridge.
8. Mariappan, J., Shih, A., and Schrader, P., "Use of Scenario-Based Learning Approach in Teaching Statics," Proceedings of the 2004 ASEE Conference.
9. Ayers, C. and Ostrander, J., "Scenario-Based Learning for a More Relevant Student Experience," league.org publication, 2004.
10. Glasgow, J., Active Learning Strategies: Scenario-Based Learning, scope/citl/ohiou.edu, 2005.
11. Taylor, F., Frankel, R., and Nezis, N., "The InvestiGATOR: A Studio-Based DSP Learning Paradigm," IEEE ICASSP 2004, May 2004.