**Work in Progress - Music Synthesizers: A Tool in Engineering Education**

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**Abstract** - To improve the rates of retention in all academic programs NYIT created the Office of Academic Support and Retention Services (OoASRS). In spite of this initiative, the rate of freshman-related retention in the School of Engineering and Computing Sciences (SoECS) has not improved significantly. Contextual Teaching and Learning (CLT) is a concept of instruction that relates subject matter content to the real world and motivates students to make connections between knowledge and its applications.

To improve retention rates the faculty of the SoECS requires all freshmen to take ETCS 105 “Career Discovery”. The course uses the educational philosophy and strategies of CLT to enable students to find “meaningfulness” in their education and offers a place for meaning and content to merge.

Last semester, we developed a new 8-week CLT module for this course which used a modular music synthesizer to introduce freshmen to an extremely wide range of engineering concepts in an engaging way. This “Work in Progress” will describe the module’s lessons and provide a preliminary assessment of student engagement and retention rates.

**Index Terms** – Contextual Teaching and Learning, Music Synthesizers, Retention, Supplemental Instruction, Academic Monitoring, Save Our Student (SOS) Alert System, Math and Writing Resource Centers

In spite of these initiatives, the successful transition of engineering freshmen into the School of Engineering and Computing Sciences (SoECS) and their continued academic success through graduation has not improved significantly.

The faculty of the School of Engineering and Computing Sciences (SoECS) strongly believes that the single largest factor for the high rate of attrition in the freshman year is that the majority of students in our programs are unable to make connections between what they are learning and how that knowledge will be used. The traditional methods of instruction using an abstract theoretical lecture style fails to provide a motivation for learning. Students desperately need to understand abstract concepts as they relate to the real world applications of these ideas.

Rather than expecting students to make these connections on their own, the SoECS requires all freshmen to take ETCS 105 “Career Discovery”. This course experience is intended to provide students with an introduction to a professional engineering career with elements of Contextual Teaching and Learning (CLT).

This course emphasizes the relationship of course content to real-life situations and incorporates:

- hands-on activities
- work-based learning experiences and
- project-based learning.

Last semester, we developed a new 8-week module for this course which allowed students to understand through “doing” some very abstract and complex engineering topics such as filter design, resonance, radio frequency (RF) modulation and sideband concepts, and Fourier series.

**ETCS 105: “CAREER DISCOVERY”**

This course uses a real hardware based modular music synthesizer to introduce students to an extremely wide range of engineering concepts in an engaging way for the first 8 weeks. There is hands-on use of the synthesizer, including sonic examples that use the students own ears to make complex concepts such as amplitude and frequency...
modulation simple to understand in a way that makes sense on a sensory level.

Examples of how electronic circuits can be used to simulate acoustic properties of real musical instruments such as the bow of a violin, the reed of a clarinet, and the resonant cavity of a drum allows students to understand engineering concepts such as, resonance, RF modulation and sidebands, Fourier series and many others hat students often find too abstract or mathematical.

Each module of the synthesizer has its own lesson. For example, the first module, the voltage controlled oscillator (VCO) is very similar to the function generators students use in their electronics laboratory experiments. Audible and visual examples of concepts such as, frequency, period, duty-cycle, and modulation will allow students to grasp these difficult concepts easily on a sensory level.

The course is based on a professional modular synthesizer. There are enough stations allowing students to have hands-on experience working together in small groups. Each module has inputs and outputs which are connected and routed together allowing the students to see the flow of sound signals and modulation control voltages and how they shape the sounds they are producing. Students are also shown where to download a free software simulation of a modular synthesizer that they can use to experiment with at home.

Resources for future experimentation will include circuit design “cookbooks”, prototyping tools and companies that sell kits and other devices.

COURSE OUTLINE

Week 1 – Introduction
Pioneers of electronic music, voltage control, additive synthesis

Week 2 – Oscillators (Voltage Controlled Oscillator - VCO Module)
Waveform types and properties, low frequency oscillators (LFO), Frequency modulation (FM), sidebands, Fourier series.

For this class, the students connect the output of the synthesizer’s oscillator to a sound system so that they can hear the differences between a sine wave, which has no harmonics, and sawtooth, square and pulse waveforms. At the same time, a laboratory oscilloscope is used to view the waveform, so that the student can see the relationship between what a wave looks like and what it sounds like. In addition, a Spectrum Analyzer is also connected to display the waves in the frequency domain which allows them to simultaneously see and hear changes in the harmonic content of sound waves. The oscilloscope and spectrum analyzer are also used to display the effect of Frequency Modulation (FM) while listening to the waveforms at the same time.

Week 3 – Noise (Noise Generator module)
Random waveforms, white and pink noise generators, Sample and hold circuits.

Week 4 – Filters (Voltage Controlled Filter - VCF module)
Lowpass, Highpass, Bandpass filters, resonance, subtractive synthesis.

Week 5 – Amplitude (Voltage Controlled Amplifier – VCA Module)
Amplitude modulation (AM), sidebands, properties of acoustic instrument amplitude envelopes

Week 6 – Controllers
Keyboards, sequencers, guitar/wind instrument controllers, exotic controllers (musical clothing, sound rooms, etc)

Week 7 – Envelope Generators
ADSR generators, amplitude and filter envelopes, envelope followers.

Now that all the modules have been explained and used separately, students connect a full instrument “patch” using the keyboard, VCO, VCA, VCF, and Envelope Generators. They experiment playing melodies manually on the keyboard, and automatically, using the sequencer.

Students compete to create the most realistic imitation of a violin, piano and organ sound and vote on the winner. The final competition is for the most “unusual” sound.

Week 8 – Advanced Concepts
Sampling, A/D and D/A conversion, aliasing, vocoders, frequency spectrum analysis.

PRELIMINARY ASSESSMENT

The faculty of the SoECS noted that in past years 30% of the freshman who enrolled in ETCS 105 in the fall semester did not register for the spring semester. This spring semester only 12% failed to continue their studies in the spring. While this is preliminary data, the Student Instructional Reports (SIRs) indicate an enthusiasm for the course on the part of students and may be the precipitating factor in the improved retention. In the future, we will administer a before/after questionnaire to assess more rigorously, using empirical and quantitative methods, how student attitudes toward (STEM) concepts have changed as a result of this course.

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