Working on a Start-Up: A Case for an Applied Entrepreneurship Oriented Course for Senior Undergraduates

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***Abstract*—In this paper, we describe a new teaching approach whose objective is to implement entrepreneurship-based learning. The proposed teaching approach is essentially a project-based approach, but, with two novel key components that give it the entrepreneurship emphasis. First, the main idea is to divide students into groups of four or five members and have each team go through the process of starting-up a company. This process tries to emulate all steps through which entrepreneurs go when a new start-up idea is taken from concept to product realization. These steps include proposing a novel start-up idea, writing a business plan, coming up with a solution, implementing and testing the solution, and reporting results. The only constraint of this "exercise" is that all start-up ideas must be related to the main topic of the course, which in our case is that of advanced hardware description language and field-programmable gate array (FPGA) digital design. As a second component, each student is required to maintain a so called individual reflective journal (IRJ). Students add new entries of about half a page each week to the IRJ, which plays the role of a diary. The objective of this component is to engage students in thinking about how the course activities tie into the three components of the KEEN framework: *curiosity*, *connections*, and *creation of value*. The projected outcomes of this teaching approach include: 1) help students to develop an entrepreneurial mindset, 2) foster creativity and self-learning, and 3) engage students more and enable them to be proactive and competition-aware.**

***Index Terms*—Project-based teaching; Entrepreneurship based learning; Start company; Senior engineering;**

I. Introduction

Some of the most promising new teaching styles include flipped class room and project-based learning [1], [2]. In the project-based approach, a special emphasis is placed on a series of projects that students must implement in order to experience a better hands-on learning. While this approach is great, it sometimes misses connections to concepts and scenarios encountered when young entrepreneurs start-up a new company. That is precisely what we try to address in the proposed teaching approach: the project-based learning is transformed into a single project-based experiment where the project activities will follow the primary steps that a real world start-up goes through. By adopting the proposed teaching method, we help and prepare students to develop entrepreneurial mindsets and foster creativity while also exposing them to concepts such as lean start-up and developing business plans [3].

The proposed teaching method was designed for senior undergraduates. Specifically, we applied it to *EECE-4740 Advanced VHDL and FPGA Design*, which is a course in the computer engineering program at Marquette University. However, we believe that the proposed approach can be applied to any other engineering major in junior and senior classes. The approach presented here was applied to an elective course for senior undergraduates in computer engineering, with a number of twelve students enrolled. In this short paper, we present details of the course implementation and discuss some results that were achieved at the end of the semester.

II. Description of KEEN Framework

Entrepreneurial minded learning (EML) is a course enhancement technique championed at Marquette University through the KEEN faculty development program. The KEEN network is a national partnership of universities with the shared mission to graduate engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work [4]. Therefore, the objectives of the EML approach is to cultivate an entrepreneurial mindset, which is fostered through the realization of three primary student outcomes, referred to as the 3C's.

1) Curiosity - Demonstrate curiosity about our changing world; explore a contrarian view of accepted solutions.
2) Connections - Integrate information from many sources to gain insight; asses and manage risk.
3) Creation of value - Identify unexpected opportunities to create extraordinary value; persist through and learn from failure.

A more detailed description of each of the three student outcomes will be provided in the next section. Also, for more information about the KEEN network, participating institutions, and related activities, please see [4].

III. The Start-Up Oriented Project-Based Learning

A. The Course as a Start-Up

The first and primary component of the proposed teaching approach is that each student must go through the process of starting-up a company as a member of a team of four or five

students. That is the main idea. In this process, each student first proposes a novel start-up idea and pitches it to the class in a three minute oral presentation. This is the ideation phase. In this way, a pool of ideas is created and each idea is graded by all students during the pitch presentations. After this, the top scored ideas are selected as the winning ideas that teams will work on in the remaining part of the semester.

Next, the class is divided into teams of four or five students. This is the team formation phase. The student who proposed one of the winning ideas automatically becomes the *chief executive officer (CEO)* of the team selected to work on the idea. The other team members become the *engineers* working under the direction of the CEO. All CEOs of all start-up teams report to the instructor of the class.

In the next phase, each team must write a business plan following a real business plan template. The team must also propose a solution with a road map of action items to be executed and intermediate deliverables that will be turned in for grading. These activities require students to read and search about topics outside the strict engineering topics of the course such as how to write a business plan. In addition, creating a road map fosters long term planning and scheduling skills. Then, in the remainder of the semester, each team works on implementing and testing the proposed solution and on reporting results. The final destination is a working prototype to be delivered by the end of the semester. In addition, each team must give a demonstration of their product and a presentation in the *design day competition* organized by the college of engineering at the end of the semester.

The above activities span the last two thirds of the semester. In the first one third of the semester, the class follows a traditional route where the instructor teaches the main topics of the course in a compressed fast-track like approach. In the particular case of our course, those topics are related to VHDL (VHSIC hardware description language) and FPGAs (field-programmable gate arrays). VHDL is a hardware description language used in electronic design to describe complex digital and mixed-signal integrated circuits. Programming in VHDL is an essential skill for any computer engineering major because, today, virtually any real digital circuit is designed using a hardware description language such as VHDL or Verilog.

B. The Three C's

As a second component of the proposed teaching approach, each student is required to maintain an individual reflective journal (IRJ). Students add new entries of about half a page each week to the IRJ, which plays the role of a diary. The objective of this component is to engage students in thinking about how the course activities tie into the three components of the KEEN framework: *curiosity*, *connections*, and *creation of value*.

More specifically, in order to touch upon the 3C's designed to foster an entrepreneurial mindset, students must demonstrate:

1) Curiosity - Describe activities done within the last week, which can be characterized as demonstrating curiosity. Examples may include but are not limited to: find an interesting recent article, which is shared with the instructor and with the rest of the class; ask questions in and outside the class; be proactive and try new/different design ideas, and then demo or share new design insights with the class, etc.
2) Connections - Describe connections or associations identified between things learned in this course (including those learned through activities in the first C) and everything else a student knows. How do these things relate to one's own plan of achievements set for this class? Emphasize decisions that are made, especially through the perspective of assessing risk - in order to minimize it and be safe or not but with the potential of higher reward. For example, a student can make a connection between a specific controller designed in the course and its potential application in the senior design project that the student as a senior works on in the same semester. As another example, a student can decide to reuse VHDL source code provided by the instructor to solve an assignment; in this way, the risk of running out of time is reduced.
3) Creation of value - Students reflect on how they see that value has been created through what has been done or might be created if various courses of action would be pursued. The meaning of *value* here is more than the value one gets out of strictly understanding the topics taught during lectures. Think like someone who wants to start a company. What idea or study or product could be created, and which would provide a solution to a problem that you identified? For example, if you created a website for video sharing (call it youtube), what would be the value of it to society?

IV. Implementation Example

We implemented this new teaching approach during the Spring of 2016 semester in *EECE-4740 Advanced VHDL and FPGA Design*, a course in the computer engineering program at Marquette University. The primary FPGA hardware utilized in all projects was the popular DE1-SoC development and education board [5]. This board uses Altera's Cyclone V SoC FPGA chip [6]. As such, the core functionality if each of the three start-up projects was programmed in VHDL. However, additional programming in C and Python as well as programming for Android or iOS were also used. WiFi and Bluetooth modules were used for various wireless connectivity needs. The enrollment in the class was 12 students who worked on three different *novel* start-up ideas, which are described briefly in the next sections. As a thought exercise for the reader: *please read each of the next start-up ideas and then try to explain how each of the three C's described earlier is touched upon by each of these ideas*.

A. Start-up #1: Voice controlled oscilloscope

In this start-up project, the proposed FPGA system acquires electric signals, which are sent wirelessly via Bluetooth to

an Android smartphone that displays the signals inside a smartphone app. The app is developed as part of the proposed solution. Voice controls are used to perform basic actions including *zoom in*, *zoom out*, and *switch channel*. The voice controls are given through the smartphone app. More specifically, this product, the Voicilloscope, is small, lightweight, and could be used as a mobile signal measuring device. It can analyze signals in terms of voltage, current, frequency, period, and duty-cycle. Part of the novelty of this idea is that it uses a mobile device to serve as the voice input and display output of a portable FPGA based oscilloscope capable of taking up to two input signals. The final poster of this project is shown in Fig.1.

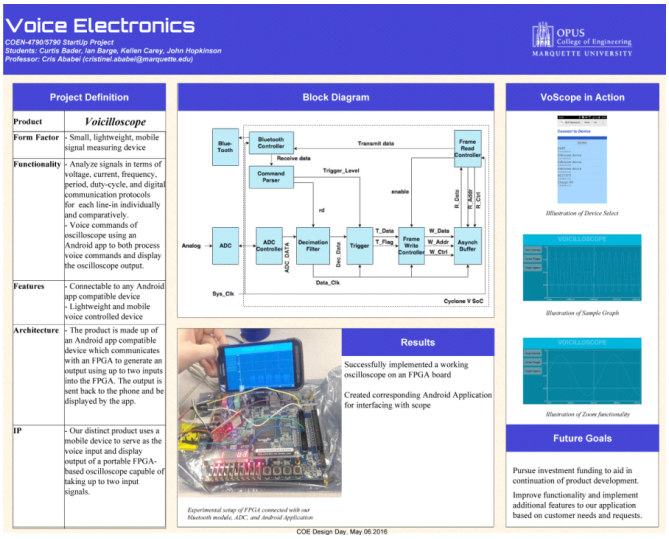

Fig. 1. The voice controlled scope poster.

B. Start-up #2: Weasley clock

In this project, the proposed FPGA system controls a special analog clock, the Weasley clock, that shows where four different family members are located at any time. The Weasley clock is one of the key features in the Weasley household from the movie "Harry Potter and the Chamber of Secrets". The objective of this project is to recreate that clock using an FPGA based solution, a server, and an app for the iPhone or an Android device. The possible locations displayed by the Weasley clock include: home, school, work, and lost. The app sends a person's phone location to a server via WiFi. The server receives the phone location and stores it. The FPGA device periodically gets the locations and updates the servo motors of the clock as needed. The final product of this start-up is a completely new device. The target market is represented by the huge fan base of the Harry Potter movie series. The poster of this project is shown in Fig.2.

C. Start-up #3: Snoopy, the internet traffic monitor

The idea of this project is to create a server traffic monitor that is implemented on an FPGA device for the purpose of protecting the server from external attacks. The monitor is

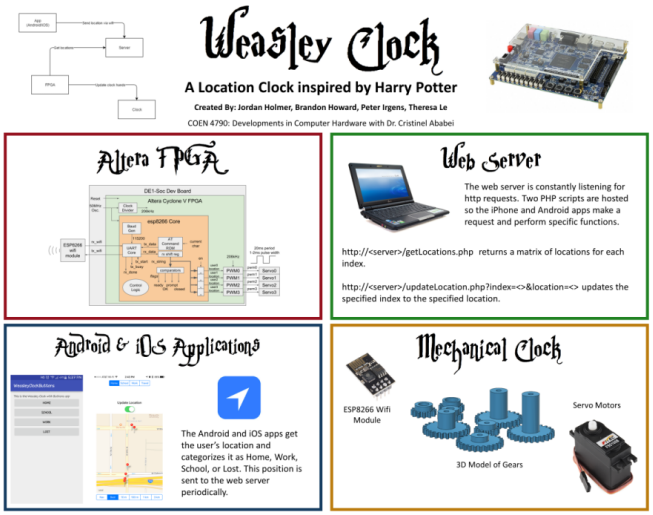

Fig. 2. The Weasley clock poster.

designed to physically sit between the Internet router and the server that needs to be protected. Such a monitor can, in realtime, monitor the traffic between the server and the outside world, keep track of past history, and identify perceived threats. Such identifications could be used to trigger immediate hard disconnections from the Internet as possible measures to stop malicious activities that target the server. The final poster of this project is shown in Fig.3.

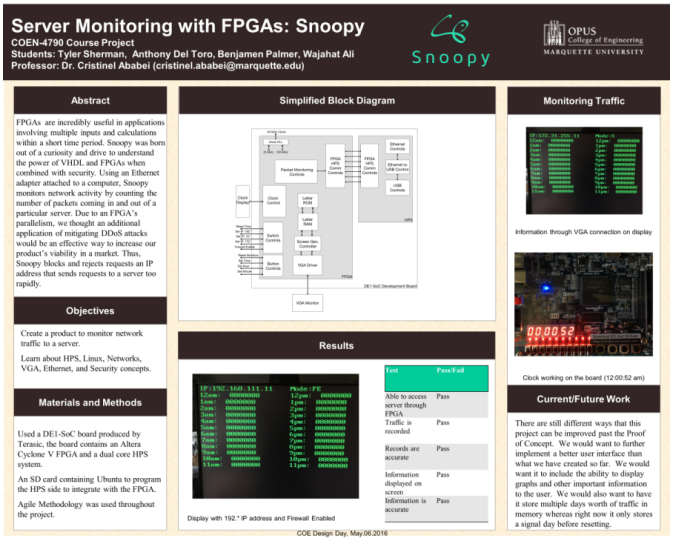

Fig. 3. The internet traffic monitor poster.

V. Discussion and Future Plans

We would like to reiterate that our objective in this paper is to describe a new project-based teaching approach, which was designed to bring more entrepreneurship related concepts and activities to the engineering classroom. We describe here what we did and make recommendations to the potentially interested engineering educator who might want to adopt this

teaching approach. That is what the main contribution of this paper is. Our objective is not to show that this new entrepreneurship oriented teaching approach is better than other existing teaching approaches; we do not have data to be able to quantify metrics that would prove anything like that.

The desired learning outcomes of the presented teaching approach included:

1) *Motivate students to be creative and to take bigger risks compared to traditional courses* - We achieved that through asking students to propose their own start-up ideas and to maintain a reflective journal (i.e., the IRJ). We found that the IRJ was a powerful instrument and discovered very interesting connections that students made with topics outside the course. Those connections, helped the instructor to adjust the follow up discussions in class accordingly in order to reinforce those connections via real world examples.
2) *Train students to recognize novelty and to be able to distinguish novel aspects of their ideas compared to prior art* - Students had to write reports and communicate via oral presentations their work and results. A main focus of these activities was to emphasize the novelty of the proposed ideas.
3) *Foster self-learning and proactiveness* - The project-based learning inherently fosters that because students must spend more time outside the classroom to do research and to execute product development. In addition, the fact that students worked on their own ideas increased the likelihood of them enjoying doing that.
4) *Help students develop entrepreneurial mindsets* - This was addressed via reading assignments of successful start-up stories. The fact that each start-up idea was supposed to create a product that solved a problem or provided a service that could be monetized reinforced the entrepreneurial mindset.
5) *Expose students to basic steps of starting-up a company* - This was achieved through assignments that included writing a business plan and additional online readings.

We believe that our implementation of this teaching approach was a success. It was pleasant to read the course evaluations at the end of the semester. Students appreciated the different-from-traditional style of running a course and that learning about how to start and run a company in the early phases was a valuable exercise that prepared them better for life after graduation. Furthermore, our approach to bring entrepreneurship to the classroom is very timely too. The recently released ACM/IEEE curriculum guidelines for computer engineering programs recommend the need for *entrepreneurial innovation courses* [7].

We plan to continue to teach our own course in this format and document results on the website that we maintain for our course [8]. We highly recommend it to other educators as well from all engineering disciplines. The only restriction we would put is that it should be done in senior level courses only. That is because by that time students have already done all foundational courses and because they are about to transition from being a full time student to being a full time employee or entrepreneur.

VI. Conclusion

We described the implementation of a new entrepreneurship oriented project-based teaching approach, which was designed to engage students into thinking and working in activities that tie into the three components of the KEEN framework: curiosity, connections, and creation of value. Curiosity is to demonstrate curiosity about our changing world; explore a contrarian view of accepted solutions. Connections is to integrate information from many sources to gain insight; asses and manage risk. Creation of value is to identify unexpected opportunities to create extraordinary value; persist through and learn from failure. The realization of three primary student outcomes, referred to as the 3C's, is expected to foster an entrepreneurial mindset. We applied this teaching approach to a senior level elective class, which was a positive experience for both the instructor and the students.

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