A Plan to Diffuse Mobile Hands-On Teaching and Learning in Puerto Rico

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Abstract

Decades of engineering education research have resulted in excellent progress, innovation and understanding of the teaching and learning process; however, diffusion of these developments into the engineering classroom is a challenge that has yet to be resolved at a systemic level. As a result, the majority of the engineering faculty in Puerto Rico and the USA still use the traditional model of teaching and learning that is based on the simple transfer of knowledge from teacher to student. Many of the educational innovations that have been researched are founded on constructivist methodologies. These are based on the widely accepted principle that students construct their own versions of reality rather than simply absorbing versions presented by their teachers. Constructivist methodologies provide students with the opportunity to explore new concepts. It recognizes that conflicts will emerge between the new material and the prior experience that each student brings into the classroom. Assistance is provided to help students overcome these conflicts to help them succeed in creating the new knowledge. Knowledge transfer from the teacher to the student (traditional method) can be very effective if the instructor times it correctly to resolve these conflicts. This paper discusses the plans to begin a systemic spread of constructivist methodologies in all the engineering schools in Puerto Rico. This initial effort specifically addresses courses in electrical circuits and electronic instrumentation. The Analog Discovery Board, essentially a circuits laboratory that fits in the palm of one's hand, will be used as the medium to explore the course concepts. The primary means for diffusion will consist of two NSF-funded faculty workshops in Puerto Rico designed and led by two of the

authors who have ample experience with the device and with these methodologies, including its successful application in distance learning. NSF has provided funding for two years, from October 2014 to September 2016, to allow the researchers to obtain initial data on diffusion rates and to perform additional assessment to determine effectiveness and the satisfaction level of faculty and students.

Introduction

Diffusion of educational innovations is a challenge that has defied a satisfactory solution for decades as evidenced by the many references in the literature; for example, Borrego [1] states that "*despite decades of effort focused on improvement of engineering education, many recent advances have not resulted in systemic change*". Felder and Hadgraft [2] state *"We believe that if engineering education research were stopped completely right now (which we are in no way advocating), and engineering faculties could be induced to put into practice everything we currently know about teaching and learning from past research, cognitive science, and experience, then we would achieve innovation with impact to an extent beyond the wildest dreams of the most idealistic reformers. The question then becomes, how can we do that?"*

The School of Engineering at Universidad del Turabo has been experimenting for the past three and a half years with innovative teaching methods. The origin of this effort can be traced to the outcomes assessment process that was started in 1999 to meet the requirements of ABET accreditation (refer to [3] for a full description of the evolution of the assessment process at this School of Engineering). Students regularly commented in the Exit Survey of Graduating Students that there was "too much theory without context" presented in classes. In 2012 a Summer Faculty Immersion Program (SFIP) was created to ignite the use of innovative and effective teaching practices in a manner that would promote lasting change in engineering and physics faculty. SFIP promotes the use of inductive teaching and learning with real-world examples that provide context for the theory that is presented to students. The basis for the SFIP has been established by Morales [4]. The results of the first three years of implementation are recorded in references [5], [6] and [7] by Morales and Prince. Results for the first three years of SFIP show that the program has been well received by the faculty; that the faculty members are enjoying the experiences with innovative teaching methodologies in the classroom; that the students are more engaged in the classroom; that diffusion of the methodology is taking place as evidenced by the use of the innovations in 60% of the lectures; and that additional diffusion is taking place as evidenced by the fact that faculty members are beginning to transform, on their own time, courses other than those transformed during the SFIP summer (40% of the lectures). The most challenging issue for implementing these innovations is "time to cover the syllabus". Better time management is required in the classroom that is still yet to be resolved. A

satisfactory solution to the issue of "time" could be the key to achieving very high diffusion rates.

The NSF workshops addressed in this paper strengthen and extend the ideas explored in the SFIP program. The workshops, which focus on the hands-on use of the Analog Discovery Board in circuits and instrumentation courses, will provide the opportunity to interact with co-authors Dr. Yacob Astatke and Dr. Ken Connor, the two workshop providers. Both have many years of experience teaching with the type of hands-on learning promoted in SFIP and have dealt with time issues in innovative ways such as flipping the classroom [8, 9]. All five engineering schools in Puerto Rico have been invited to participate in the workshops with the vision that, by broadening the base of participants, we can all work together in trying to answer the question posed by Felder and Hadgraft: "How can we do that (to put into practice all we know about effective teaching and learning)?"

The NSF Workshops

This project will also build upon what the Center for Mobile Hands-On Learning STEM has accomplished with HBCU's during the past few years [10] and extend it to all the Hispanic engineering schools in Puerto Rico. It is yet to be determined if mobile hands-on learning is universally accepted [10]. This project will provide initial data to test the hypothesis that mobile hands-on learning can be successfully diffused within the Hispanic undergraduate student and faculty community of Puerto Rico.

The goal of this project is to ignite state-wide diffusion of mobile hands-on learning in Puerto Rico through two (2) workshops that will train Electrical Engineering (EE) faculty participants on the use of the Analog Discovery board in the classroom and related active learning pedagogies, followed by the assessment of implemented educational strategies to determine effectiveness in an underrepresented Hispanic student setting.

Preliminary Design of the Workshops

Two workshops are proposed. Each workshop will have a duration of one (1) full day, from 8:00 am – 5:00 pm. The workshops will take place at Universidad del Turabo located in Gurabo, Puerto Rico. The first workshop is slated for February 21, 2015. The second workshop will take place in the Fall of 2015.

First Workshop (February 21, 2015)

The first workshop will introduce the Analog Discovery board and parts kit to the participants. A board and kit will be provided to the participants from each institution from their allotted quantity. The workshop will also introduce the pedagogical materials that have been developed for mobile hands-on learning, including videos that can be used in a "flipped classroom" environment [9]. The workshop will be interactive, just like the transformed classroom is expected to become. Dr. Astatke and Dr. Connor will share their experiences with mobile hands-on learning and will work through selected pedagogical activities throughout the day. The courses that will be addressed are Circuits I and Electronics Instrumentation. By the end of the first workshop, each faculty participant should be ready to immediately start exploring mobile hands-on learning in their classrooms.

Second Workshop (Fall 2015)

The second workshop will provide an opportunity for participants to share and discuss their initial impressions after having used mobile hands-on learning in the classroom in a few class sessions. Dr. Astatke and Dr. Connor will provide feedback to the participants. More advanced pedagogical activities will also be presented by the two leaders in the second workshop. By the end of the second workshop, each faculty participant should have answered their concerns and should be in position to include additional mobile hands-on pedagogical activities in their classroom.

List of Participating Engineering Schools

1. University of Puerto Rico – Mayagüez Campus
2. Polytechnic University of Puerto Rico
3. Interamerican University – Bayamón Campus
4. Caribbean University
5. Universidad del Turabo

Expectation of Faculty Participants

The faculty participants are expected to fulfill the following conditions:

1. Attend the two workshops.
2. Perform all the required homework to achieve expertise in the use of the Analog Discovery board and related pedagogical materials.
3. Gradually implement the innovative pedagogy in courses.

4. Perform a limited amount of assessment, in coordination with the PI and Co-PI's, to determine the impact of the innovative pedagogy.
5. Communicate periodically with the PI and Co-PIs to discuss issues related to the implementation of the new pedagogy.

Broader Impacts

This proposal has the potential to impact society at many different levels, as follows:

- It includes a research component with the potential to continue filling the gap regarding a satisfactory solution to the problem of diffusing engineering education innovations.
- It represents a state-wide level partnership between all the engineering institutions in Puerto Rico.
- It improves the training and development of STEM educators.
- The workshop directly benefits underrepresented Hispanic faculty members, as well as their Hispanic students indirectly.
- The project has the potential to network with faculty and students from Historically Black Colleges and Universities (HBCU's), as well as US institutions that have already implemented mobile hands-on learning in the classroom.

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