New Dimensions in Engineering Technology Education – Introducing a Novel International Collaborative Component to the Undergraduate EET Senior Project Experience

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Abstract

This paper presents the outcomes of a new initiative that extends the current campus-centered EET Capstone Senior Project activity at DeVry North Brunswick, NJ campus to a collaborative international initiative that includes students from DeVry campus in Salvador, Brazil, creating a multi-team collaboration with geographically dispersed teams as part of this capstone Senior Project course. The main focus of the work described in this paper is comprised of three distinct parts. First, we define and characterize the salient characteristics of this experiment in collaborative education at the undergraduate level. Next, we identify challenges of a novel student-project framework that exposes students to a set of unique experiences intended to emulate the evolution of the engineering work environment that is becoming increasingly collaborative, and increasingly international in scope. This unique component of distance collaboration is absent in most Senior Project collaborations at the undergraduate level in Engineering Technology. Finally, we discuss outcomes and potential new directions of Senior Project initiatives at DeVry North Brunswick campus that leverage off this first experiment and serve to further explore new dimensions in Engineering Technology Education.

I. Introduction

The traditional EET Capstone Senior Project course at DeVry campus exposes students directly to employers and the professional world, thus catalyzing preparation for a career in their chosen profession. Students are required to do a “real-life” senior project and/or develop a forward-looking research prototype, grounded in the reality of the market pull from end-users in the business and private sectors. Feedback from our local Industry Advisory Council has offered only praise for benefits of the capstone design experience. Furthermore, ABET requires that “Baccalaureate degree programs must provide a capstone or integrating experience that develops student competencies in applying both technical and non-technical skills in solving problems”\(^1\), and the capstone project has become a critical component in engineering technology curricula nationwide \(^3\)–\(^5\).

The Engineering Faculty particularly encourages student-centered projects on evolving and future applications and technologies that have cogent business/marketing perspectives. Indeed this perspective has stimulated many compelling projects that have captured the attention of the press at DeVry’s, “Senior Project Day” event, held twice per year at DeVry’s campus in North Brunswick, NJ.
Over the years, the faculty in New Jersey has developed an infrastructure to facilitate the Senior Project experience. Key components of this infrastructure are:

1. Senior Project Database - The faculty have developed a systematic way of gathering, assessing and disseminating project ideas. All ideas are centralized in a database that is accessible to all faculty and deans through an “eCollege” URL.
2. Course Sequence Coordination - Key courses have been identified to support the Senior Project course. For example, all students are required to take a rigorous course in Project Management in the semester immediately preceding the Senior Project course so that they can hit the ground running.
3. Deliverable Guidelines - The faculty have compiled clear course requirements and sample projects that help students produce high-quality projects, year after year.
4. Senior Project Day - The Senior Project experience is culminated by demonstrations and Power-Point presentations of each project to prospective employers, and to members of the DeVry faculty and staff. This Senior Project exposition is typically a full-day event.

However, it has become increasingly clear that graduates not only need to possess sound technical knowledge in their chosen disciplines but they also need to be more adept in the areas of communication skills, teamwork, leadership and other allied professional skills. Despite the recognized importance of the aforementioned skill sets, it is not easy to develop and implement a curriculum that requires the use of these skills as a necessary component for success in a traditional undergraduate engineering technology setting. Also, subsequent outcome assessment of achieved skill levels in a collaborative setting is a new and important area of the undergraduate experience.

This paper describes the experiences of faculty and students from DeVry University in New Brunswick, NJ and DeVry University AREA1 in Salvador, Brazil in a distributed Senior Project initiative. The motivation for this initiative is that exposing engineering students to distance collaboration across geographical boundaries is an increasingly important skill-set needed for success in the evolving landscape of professional activities. Indeed, this era of industry collaboration amongst industrial and academic campuses is becoming a routine mode of interaction. Industries are evolving to multi-national and/or global-centric entities. Findings from this student – centered collaborative experience are discussed and some of the unique challenges are identified.

II. Literature Review

The literature pertaining to this field has grown rapidly and reflects a number of important characteristics. The field spans topics on “Student reflections on the use of Collaborative Technologies in a globally distributed student project” to "The design and implementation of a
learning collaboratory” that focuses on the process of collaborative learning. A summary of related research is described in this section.

McDermott, et al.\(^6\) report on “Student reflections on Collaborative Technology (CT) in a globally distributed student project,” “It enables collaboration, but the specific choice of technology also imposes constraints on how projects are conducted.” This paper investigates the manner in which students reflected on their patterns of CT use within the collaborative setting. It is observed that these reflections were found to be superficial and descriptive, “exhibiting a reductive view of CT as a set of technological features, which acted as a neutral medium for communication and participation.” One consequence of this was a lack of awareness of the ways in which the technology influenced the behavior of individual students or the collaborative nature of the group. It is observed that difficulties faced by the students have important pedagogical implications for courses in which the learning objectives include the development of suitable competencies for working in a global collaborative environment.

Cajander, et al.\(^7\) report that the use of such CTs in the context of students collaborating in a globally distributed project has not been extensively explored. It is suggested that a better understanding would provide opportunities for improving the collaboration, and more importantly is that a better understanding would improve the possibility of scaffolding, and student learning in general. In this paper the authors present results from a study of students’ use of CTs in a globally distributed project with a focus on the challenges encountered in trying to collaborate using this technology. The study is focused on how a combination of CTs could be effectively used and it identified some pivotal learning and collaborative aspects associated with their set up and adaption that can have an impact on the quality and overall outcomes of collaboration.

Silliman, et al.\(^8\) shows that research experiences are optimized when they include collaboration not only among faculty and students, but also among professionals who are practicing in the field.

Moon, et al.\(^9\) stimulates and encourages proposals from the industrial sector to reform engineering education that has been too stagnant throughout past few decades. Their new message is that graduates not only need to possess sound technical knowledge in their chosen disciplines but also need to be better educated and more adept in the areas of communication skills, teamwork, leadership and other professional skills. Despite the recognized importance of these skill sets, it is not easy to develop and implement a curriculum that deterministically fosters such skills. Also, subsequent outcome assessment of the achieved skill levels poses many challenges and demands much creativity. Moon, et al. describes a joint experience between Syracuse University in USA and Carlos III University in Spain. The context is the education of engineering students in fundamental business processes and integration using an industry-scale enterprise resource planning (ERP) system. Groups of multinational engineering students from the two schools carried out a project of developing an executable ERP system using various
distributed collaboration tools. Findings from this experience are discussed and other on-going efforts are described in this paper.

Dorneich, et al.\textsuperscript{10} report on “The design and implementation of a learning collaboratory, the work focuses on collaborative learning processes, and the idea of a collaboratory as a virtual space for work. The paper describes a design process to support the development and use of collaborative learning technologies. It integrates methods and concepts from cognitive systems engineering, theories of learning and instruction, distributed computing and computer-supported collaborative learning (CSCL). This body of work is instantiated in an actual software tested, entitled “Collaborative Learning Environment for Operational Systems (CLEOS)”. CLEOS is a collaboratory for teachers, students and practitioners in the physical sciences, and in particular is used for spectroscopy and X-ray diffraction experiments.

III. Observations from the Literature Review

The aforementioned body of literature (and other literature searches conducted by the authors) does not significantly intersect with the central theme of the work reported in this paper. The principle motivation of the distributed student project collaboration is to add a new dimension to the traditional Capstone Senior Project course by introducing an international multi-team collaborative component with a distributed “management team of students, professors and/or advisors”. As discusses in the literature review, others have reported on collaborative initiatives in education and research. However, we believe that the nature of the collaboration reported in this paper in unique and novel. Another multi-team project structure, which is quite common in the work place but not within student capstone project, is multi-location (and it could be international in scope) team project with a common project manager\textsuperscript{11}.

The project structure of our international multi-team student -project is significantly less restrictive than most industrial and academic collaborative work initiatives with geographically dispersed teams. Since each team works under a different advisor, a different environment, different schedule constraints, separate regulations and standards, and within the boundaries of a unique culture that is significantly different from the characteristics of the other team. As we have mentioned, this “hybrid” arrangement allows direct technical interaction between teams, between the student project manager, and the remote team members. However, most of the project logistics and resource allocation issues are addressed primarily between the advisors/coordinators of each remote team. This arrangement allows students to experiment with a multi-team, multi-location project environment. However, the advisors/coordinators are still actively involved in the overall project and they continuously make adjustments and corrections. This level of intervention is justified since the project needs to be completed within the constraints of time and available resources.
At the early stages of the project, each team must have a set of independent “sub-projects” that are separable but mutually dependent for realizing the final end-to-end system. Of course, the nature of collaboration reported in this paper requires that distinct and significant sub-sets of the project can be specified to allow independent execution by each remote team. Of course, all student projects are not necessarily suitable for this kind of a bifurcation.

**IV. Logistics and Challenges of the Collaborative Senior Project Experience**

During the initial planning period, it became clear that an understanding of the impact of language and cultural differences needed to be integrated into our collaborative framework. Although the objectives of each of the teams were essentially the same, each set of collaborator’s had to adjust to communication protocols between professors and students that are uniquely different at each location. Also, the structure and deliverables associated with the project had to be tuned and matched to the academic calendars, specific curriculum requirements and academic requirements unique to each campus.

Unlike most colleges and universities in the United States, that work primarily on semester/trimester based system; most Brazilian universities’ schedules are organized into five-month periods beginning in February and August, interspersed with holidays in between these periods. Therefore, senior project collaboration can only be organized around the January and May semesters for DeVry in the US versus the February period for DeVry Brazil. Other related activities must be organized as special projects within the normal schedule at each location.

In addition to schedule discontinuities at each campus, the supervision of student projects varies by campus location. This introduces additional collaborative challenges that are tractable, but add to the “overhead” of collaboration at a distance. Full-time members of the faculty supervise senior project teams at DeVry campuses in the US. Senior projects at DeVry Brazil campus are organized as individual projects. Each student will have one project advisor who can be either a full-time or an adjunct professor. Adjunct professors do not have the authority to make decisions regarding any aspect of the collaborative project. Also, since incremental compensation is given to adjunct faculty for supervision of a Senior Project, additional funding requires approval from college administrators before an adjunct professor can engage in this activity. Hence, the collaboration framework is relatively rigid.

**V. Project Design and Implementation**

At DeVry US campuses, the EET students have four terms (Project Development, Senior Project Designs I, II and III) to complete the senior projects, spanning eight months totally. At DeVry campus in Brazil, senior projects are usually allocated to one semester (five months). In order to
keep the time frames aligned and the collaboration tightly coupled, implementation must be organized in the following three stages.

In the initial stage, at the DeVry US campus, students are expected to do research and brainstorm ideas, finally focusing on a specific project of significance. The advising faculty and the senior project groups discuss and analyze each projects to ensure the possibility of appropriate rigor, within the constraints of time and capital budgets. Consideration is also given to the potential of expanding the project to a collaborative partnership with students at the DeVry campus in Brazil. Of course, the project collaboration must also be matched to the skill-sets and academic strengths of students and faculty at each campus location. The appropriateness of the collaboration and partitioning of project responsibilities are determined by the following two key considerations: 1) The EET students at DeVry US campuses are extensively trained to gain skills to perform the embedded system design, peripheral interfacing, troubleshooting, and integration between hardware and software. 2) The EE students at DeVry Brazil campus, on the other hand, are extremely strong in high-level mathematics, they have a good knowledge base in the theory and design of communication and control systems and they have strong competence in high-level programming, needed to create graphical user interfaces. With the project subsystems clearly classified, we determine if one of more of the subsystems requires intensive GUI programming or data analysis using mathematical modeling. Following the standard PMI cycle, in this stage, the project is identified, initiated and defined. A set of detailed project requirements and specifications are determined, and a project plan is established.

In the second stage, we initiate and propose the collaboration with our project partner at DeVry Brazil campus. The project proposals and the specific subsystem(s) or tasks that need help from DeVry Brazil team are prepared by DeVry US team and presented to our partner at DeVry Brazil. Then, a search is initiated to find qualified advisors and EE students who are interested in joining the team to develop the project. This process may take one to two months. Typically, the teams consist of 3-4 students, including one project manager, at the DeVry US campus and 2-3 students at the DeVry Brazil campus; the number of students will vary depending on the complexity of the project. In addition, each site has a faculty advisor and a project coordinator. The student project manager responsibilities includes coordinating the project teams (including the remote team(s)), keeping the project on track, following the project requirements and delivery schedules, acquiring necessary hardware/software assets, and generally communicating with the faculty advisor regarding progress and roadblocks. The primary task of the Faculty advisor is to keep track of the project development cycle, provide technical advise to the students and manage the schedule.

At this stage, detailed project requirements and specifications are shared with the DeVry Brazil team. Also, detailed individual-team-centered task descriptions are generated. It is critical that one or more of the Brazilian student team members, as well as the coordinator, are able to communicate relatively fluently in English.
The third stage takes three to four months. During this period, students and faculty members at DeVry US campus work closely with the advisors and students at the DeVry Brazil campus to ensure the collaborative work meet the final project specifications and overall functional requirements. The communications between both DeVry campuses are exchanged on a regular basis between students, as well as between advisors/coordinators. Generally, the coordinator and faculty advisor from both teams will meet using “Adobe Connect” (the official tool), “Skype”, or “Google Chat” (depending on the availability of these collaborative tools) on a weekly basis to discuss project status, unresolved issues, resource bottlenecks, etc. Project reports for each project task are regularly added/updated, and stored in a common Dropbox or in Google drive. The student project manager is responsible for ensuring each task are completed on time and copied to the common repository.

VI. Project Description

The first project selected as the collaborative capstone pilot project was called C.A.S.M (Children’s Apparatus for Stimulation Measurement). The project was conceived and initiated by the DeVry US North Brunswick team. The project was inspired by recognition of the necessity for a sensing system that could detect self-stimming (repetitive movement relating to physical sensation) in Autistic children. Self-stimming correlates highly with an onset of ASD (Autism Spectrum Disorder). This particular project was selected considering that it synergistically leverages off the strong theoretical base of DeVry AREA1 Brazil students and the practical digital/analog hands-on abilities of the students at DeVry US. The DeVry US team consists of 4 students and 2 students from DeVry Brazil were expected to join the DeVry US team. A detailed project requirement and most of the project specification was completed during this stage. An initial Data Acquisition System design for the CASM project was completed and the required parts was ordered.

In the second stage, the idea was socialized with the DeVry Brazil teams and the project tasks were defined and partitioned. It was agreed that all of the data acquisition hardware and software will be completed at the DeVry North Brunswick campus; and the data analysis and the graphical user interface (GUI) modules will be developed by the DeVry team in Brazil. This project arrangement was designed to allow both teams to work as independently as possible. The search for a qualified advisors and students who were interested in joining the teams was conducted. One advisor and two students from the computer-engineering department were recruited. The DeVry Brazil team promptly completed a proposed data analysis module specification based on the requirement provided by the DeVry North Brunswick US team.
During the third stage students at DeVry North Brunswick worked on completing the hardware and software for the CASM data acquisition [Fig.1.a and b], as well as a simple self-stimming detection system that was based on frequency differentiation method. The detection technique is based on the data gathered from few autistic patients. Using similar data, the DeVry Brazil team came out with a different approach using a visual analysis technique [Fig.2.a and b]. This technique offers a visual aid to the clinicians and caretakers to help identify self-stimming in order to detect an autistic onset as early as possible. Other techniques are currently being evaluated and tested.

This capstone collaboration exemplifies how the two teams synergistically leveraged their strengths to accomplish a useful capstone project that is not only technically challenging, but
also offers a solution that can potentially benefit society. A novel system is synthesized to monitor and detect self-stimming (repetitive movement relating to physical sensation) that is uniquely matched to the needs of clinicians.

VII. Benefits and Challenges of the Collaboration

We believe that the collaborative work provides the following benefits:

1. Working with international students in a team environment, students gained a very challenging real life experience in collaboration with partners from different continents who communicate in a different language. To make the collaborative effort fruitful, they must be more dedicated, more accommodating, more careful with planning and time management.
2. When combining the skills of students from both DeVry US and DeVry Brazil, the project can be potentially more significant and applicable. Hence, the students learn more and feel more accomplished.
3. Many employers’ value graduates with abilities and experiences in an international work-collaboration. Therefore, these additional skill-sets may make our students more marketable in the workplace.

The following formidable challenges had to be addressed in this collaborative initiative:

1. Language barriers -- Brazilians speak Portuguese, only some faculty members and students speak fluent English. Sometimes, the project documentation had to be translated from English to Portuguese. This is a significant overhead in the project.
2. Academic calendar and time differences -- DeVry Brazil campus has two semesters and DeVry US campus run three trimester or six terms a year. Aligning the project collaboration time frames was difficult at times. Also, the time difference between the two regions changes from 2 to 3 hours depending on the seasons. Therefore, regular videoconferences is challenging for all participants.

VIII. Future Projects under Consideration

One of the next projects under consideration is a secure multi-point audio communications system. A system level view is given in Figure 3. Each end-user’s audio appliance is connected to a “centralized bridge”. The bridge combines or adds each of the encrypted signals received from each station. (The centralized bridge synchronously adds simultaneous encrypted signals, modulo a known number $P$, and broadcasts the result to the participants. Each terminal, using a secret key, then decrypts the modular sum of encrypted signals to obtain the desired ordinary sum of unencrypted signals.)
The bridge selectively combines each of the received signals and connects the combined signal to the appropriate station. As shown in Figure 3, station A receives the sum of encrypted audio signals associated with stations B, C, and D. Operation is similar for all of the other stations connected to the bridge.

Figure 3. Centralized Audio Bridging System

An alternative approach eliminates the centralized bridge and moves the bridging or combining function to the end stations as shown in figure 4.

Figure 4. Distributed Audio Bridging – The Combining Function is accomplished at Each Station

Near term activities for the secure multi-point audio communications system include the following:
– System analysis of a centralized vs. distributed bridging system
– Development of a set of systems specifications
– Development of end-to-end system architecture
– Allocation of prototyping responsibilities amongst the two groups
– Development of project schedules and identification of key project deliverables
– Development of test plans
Prototyping tasks also include the development of a graphical user interface for call set-up and control of the user interface (GUI). The GUI should display call setup procedures and show the image and voice activity of each end-user. It is envisioned that, as in the previous collaboration, the DeVry North Brunswick team will broadly assume hardware prototyping activities. The team in Brazil will perform the graphical user interface plus software realizations of bridging and the encryption/decryption functions at the end-user stations for the distributed bridging configuration. It is anticipated that system-integration testing will be performed at DeVry North Brunswick campus.

IX. Summary and Conclusions

This paper presents the outcomes of a new Senior Project Capstone initiative that extends the current campus-centered EET Capstone Senior Project activity at DeVry North Brunswick, NJ campus to an international collaborative initiative that includes students and professors from DeVry campus in Salvador, Brazil, creating a multi-team collaboration with geographically dispersed teams of students. This initial collaboration provided an existence proof of a fruitful collaboration that served to meet many of our pedagogical and project-specific goals of a challenging and technically rich Senior Project. This endeavor, intended to emulate current trends in collaboration amongst geographically distributed working groups, with mutual dependencies for success, was indeed challenging for all participants. Unfortunately, the student team from Brazil was unable to join DeVry US team on campus for final unit and system integration and testing because of unexpected Visa issues.

However, the collaborative component of the Senior Project Capstone initiative added a refreshing and renewed recognition of need for clarity in written and verbal communications amongst the participating students. An enhanced sense of mutual dependencies for success stimulated the pace and quality of team contributions at each location. A new reality of the importance of meeting external project deliverables with quality, and within the constraints hard deadlines, stimulated each team to strive for timely completion of project deliverables. Also, a sense of mutual competitiveness added an important dimension to the energy level of the project. These positive attributes could be leveraged in future student project collaborations at local, national, and/or international collaborative student-project initiatives. These results are generally consistent with some results reported by Silliman, et al. indicating that research experiences are optimized when they include collaboration amongst faculty and students. The nature of the first completed project is described in this paper and a proposal for an ongoing project for the next stage of collaboration is also outlined in this paper. We are bolstered by the positive outcomes of the first collaboration and much insight has been developed that will serve to make the second collaboration easier to manage and potentially more productive. As explained in this paper, as a next step, we are planning to follow-up with new project collaboration. It is fully expected that
this new project will serve to expand this fledging incubator of collaborative education to other DeVry campuses within the US.

Bibliography