Smart Environments for assisted living: a multidisciplinary collaboration in engineering and architecture education

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Abstract

This paper presents a description of a collaborative project-based on the integration of technology development in the built environment for assisted living. The multidisciplinary collaboration is developed as a cooperative commitment to provide support for cross-border, collective projects. It was initiated as a project based learning setting between undergraduate engineering students, and four years later the program shifted to include undergraduate architecture students and engineering master's students. The learning experience opens the gate to a completely new collaborative setting, yet to be established, independent from its predecessor setting of project-based learning, focusing now towards an interdisciplinarity setting in cross-border collaboration. The new collaborative projects focus on smart environments for assisted living, with an emphasis on technology development and retrofitting of the built environment. The four participating programs are from three different leader higher education institutions, from both sides of the US and Mexico border.

Smart Environments (SmE), design, and technology applications are relevant topics across multiple and diverse disciplines and areas of contemporary life. Different kinds of SmE in the domain of smart homes have been developed in academia and industry. Healthcare and assisted living development highlights include monitoring the behavior, emergency detection, cognitive and physical information, emotional information, etc., to offer a variety of useful services, solutions or benefits to patients, disabled, and the elderly. This is relevant because it has been suggested as a viable solution to maintain independence, functionality, well-being, and higher quality of life of elders who will increase in number worldwide approximately 20% by 2050. However, incorporating physical and digital technologies (technologies 4.0) into building retrofitting is a feature of scalability and configurability for a future generation of smart applications.

This paper summarizes the current applications of multidisciplinary collaboration in the Computer Systems Engineering, Architectural, and Engineering Technology fields. It describes a work in progress as a key element in international, multidisciplinary research in undergraduate education, intending to share challenges, lessons learned, and future work.

Introduction

This paper focuses on multidisciplinary collaboration in undergraduate engineering and architecture education. The project developed is a study in smart environments, with a special focus on health applications and built environment retrofitting for healthcare applications. The

purpose of the project is to provide students with the needed skills to address the complex problems that arise in the contemporary built environment. The description is based on the experience gained through the participation, involving students from the USA and Mexico. The purpose international collaboration is to prepare students to become active members in an international setting. One project team consists of students from Computer Systems Engineering, Engineering Technology, and Architecture.

One of the first questions that faculty asked in order to define the research guidelines is: why is it important to study the built environment? We can find diverse answers to it, but in the international setting has been found that it shapes collective actions and reactions. This specific interaction can be studied from an educational environment and place the student into a specific learning setting, and explore the options to transform a specific area within the built environment.

This paper does not provide a specific technical listing of the research, thus, it presents the design and integration process, providing an interesting insight of multidisciplinary collaboration, and the importance of future interdisciplinary communication, to promote competitive creativity. The importance of promoting cross-border interaction provides an interesting area to expand technology development research opportunities in the region known as the Rio Grande Valley, located in southeast Texas, and northern Tamaulipas, Mexico.

Multidisciplinary collaboration in undergraduate education

The border learning environment provides the setting to develop skills related to critical thinking, teamwork, and communication while addressing complex problems. The participating programs are from two different countries: the US and Mexico; the three institutions are considered as leaders with ample experience in education. On the US side, we have the participation of the Engineering Technology (ET) program from The University of Texas Rio Grande Valley (UTRGV) Brownsville campus, and the Architecture (ARCH) program from Texas Southmost College (TSC); and on the Mexico's side, the participation of two programs from the Tecnologico Nacional de Mexico (TecNM): Computer Systems Engineering from the Matamoros campus, and the Master in Computer Science from the Leon campus.

Nowadays, the importance of critical thinking as a learning outcome must be implemented on every step of undergraduate education. The global problems society is facing require the ability to comprehend complex problems and analyze them bearing in mind diverse perspectives. For this reason, the faculty defined a series of projects to study how the built environment can be envisioned. Diverse examples of project collaborations between engineering and architecture programs are to contribute to the education of future professionals to be able to operate in a collaborative environment, though leadership and innovation coordinated activities [1][2].

Methodology

Terms such as ubiquitous computing and cloud computing have been embedded in a diversity of disciplines, due to its broad applications. Novel schemes in ubiquitous computing enable the opportunity to embed technology into the activities of everyday life; this interconnectivity should allow not only to collect information, but to provide services [3][4]. For its correct functioning, the required interconnection of objects envisions an additional necessity: to include novel paradigms, such as cloud computing.

The first phase of the project was the definition of the project scope. The cross-border team has been working in project-based learning assignments, finding limitations due to the time restriction of the course calendars. The team required the integration of a graduate student, and the definition of a learning setting that could assure the continuation of the project, not only during the period of a course. The inclusion of graduate students from the Computer Science program was planned to assist the professor in the redefinition phase, for future implementation of novel approaches in the study of the built. This change provided an opportunity to propose a future interdisciplinary approach through the interaction of the different disciplines, not only the integration of them, as the project has been running.

The second stage of the project was to define the responsibilities of each discipline. In previous projects, pertaining to technical development, we found that the lack of the design profession as part of the team, was a problem for the proper implementation and evaluation of the effects of the proposed changes to the built environment. The integration of the architecture program was made considering the importance of the architects' role in interdisciplinary collaborative design [5], to create a transitional learning environment.

As part of the third phase, the students are required to submit their work to undergraduate research scholar events, where reviewers from academy and industry can evaluate their work, and provide feedback and observations. This section of the project is a vital element because it will deliver an additional vision of the possibilities and opportunities for improvement in each proposal. Furthermore, this will make available a different stage to improve the students' communication and teamwork skills, while engaging the team in activities outside the classroom.

Challenges of multidisciplinary international collaboration

Current trends in societal interaction require novel approaches to solve existing communication problems. Initial issues related to interpersonal communication, however, technology development and social media have drastically modified the way we interact with other people and with our environment. This situation unlocks the need for novel applications to address the interaction with our immediate surroundings environment, and the educational environment.

One of the primary problems we face in international cross-border collaboration is the restrictions in meeting times. Institutional schedules differ due to national holidays and scholar activities, reducing the meetings to mostly online communication. As a team, we do not consider this situation a problem, but an interesting opportunity to improve and expand the team's communication skills. An additional benefit in communication is that the students are practicing their communication in a different language, other than their primary one: students from the USA are practicing their communication in Spanish, while students from Mexico practice their communication skills in English. This situation provides a good opportunity to learn technical terms and integrate them into their projects: the students from the diverse programs are learning important terms from other disciplines, and how it is vital to associate and integrate definitions.

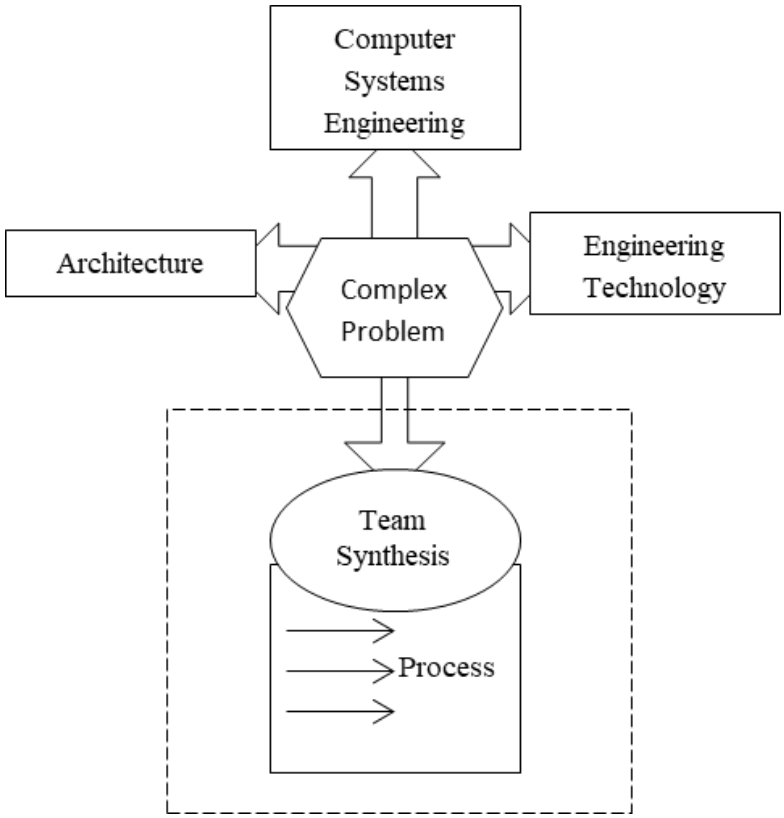
We can find a consensus on the most suitable definition of interdisciplinary collaboration for academic purposes, as described in [6], [7], and [8], where the authors adopt the importance of interdisciplinarity as a pedagogical approach. This definition states that interdisciplinarity is a process of solving a problem that is too broad or complex to be adequately addressed only by one discipline, therefore, the integration of multiple perspectives is required. Involvement and integration are key elements to develop methods and approaches across disciplines [8].

Lessons learned and Future Work

The learning assessment in a problem-oriented setting should focus on the process to generate a solution. One of the critical phases in multidisciplinary collaborations is to develop a group understanding of complex problems. The complexity of the problem alone requires each profession to share its perspective of the problem, and as a team, translate it into a synthesized process description that will lead to a solution, as described in Figure 1.

The essential part of a collaborative project lies in the capacity of synthesis and providing a process that will eventually create a solution. The final proposal, by itself, can be a form of experimentation, and the outlined process will assist in the identification of the steps that served as the framework. This can be identified as the modification of the diverse lines of communication, among the student, the team, and the learning environment created.

Figure1 Multidiscipline analysis



From the previous diagram, we have listed the following questions, which are proposed to outline future work:

- Did this collaboration result in new knowledge to the students?
- How could collaboration be improved?
- How multidisciplinary education pedagogic approaches benefit the students' learning experience?
- How to establish a path towards interdisciplinary collaboration?
- How to assess the type of knowledge gained through collaboration?

One element in common between Architecture, Engineering, and Computer Systems engineering undergraduate education is that students learn by doing. As a result, additional suggestions are being added to the opportunities for growth that are in the process of integration to the collaboration framework:

- Invite external reviewers to enhance the evaluation process
- Promote student’s participation in undergraduate research scholarly events
- Evaluate community service as a parallel activity in research
- Integrate service learning in the process
- Integrate interdisciplinary collaboration

Conclusions

Scholar activities in a bi-national collaborative learning environment provide an opportunity to experiment a new perspective on the approach to solve a complex problem. It enhances a diversity of skills that students will find essential during their professional careers. To name the importance of communication and collaboration skills, which go beyond only teamwork experience; as well as important features such as respect for diversity, and tolerance, among others.

It has been found that making the rest of the team aware of each profession's particular perspective of the problem, results crucial at the moment a deeper insight is needed to solve complex problems. Previous work and current approaches served to set the foundation for future interdisciplinary collaboration in undergraduate engineering and architecture education.

By developing novel forms of experimentation in collaboration, the students have the opportunity to explore and interact with different disciplines, learn new technical skills, while addressing complex topics. The students will be able to learn by experimenting beyond their respective academic content. Multidisciplinary collaboration provides an opportunity to reevaluate educational structures and to analyze the potential in pedagogical approaches on the implementation of more rigorous forms of evaluation and learning assessment.

International preparedness represents one of the crucial results of this collaboration. The next step in new projects includes the definition of interdisciplinary pedagogical approaches in undergraduate research in engineering and architectural education.

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