AC 2010-2151: PROJECT BASED MULTIDISCIPLINARY EDUCATION FOR UNDERGRADUATES

Huanmei Wu, IUPUI

Dr. Huanmei Wu is an assistant professor at the Department of Computer and Information Technology, Purdue School of Engineering and Technology, IUPUI, joint with Indiana University School of Informatics. Her research is focusing on database, data mining, and tumor motion management in image guided radiation treatment.

Project Based Multidisciplinary Education for Undergraduates

Abstract

Motivation: Integrating the multidisciplinary technologies, informatics, and the corresponding real-life applications is an important stimulating approach to promote the interests of students, especially undergraduates, in engineering study. A project based approach has been designed for engineering education based on multidisciplinary undergraduate research projects. The goal is to enhance student learning through a collaborative learning environment.

Approaches: The project based approach is carried out in a series of steps, including project design to be done by the mentors, student recruitment through various advertising strategies, group assignments for the recruited students, the harmonized work on the project (with weekly group meetings, student progress report, and group discussion), the outcomes dissemination at diverse local and national conferences, and project assessment by both student and mentors at the end of projects. This project based multidisciplinary education integrates classroom presentations, innovative teaching techniques, student active learning, group activities, and hands-on experience.

Results: Many multidisciplinary projects have been carried out at the Purdue School of Engineering and Technology, IUPUI. Both the mentors and students have very positive feedback on the education and learning experiences. Students participating in the projects not only gained interdisciplinary education but also achieved research experience. Most of the students have attended or are going to graduate school with the confidence obtained from the projects. The multidisciplinary background gives advantages in their graduate school admissions and scholarship applications.

1. Introduction

Engineering education is critical for nurturing competitive and skilled engineers and has great influence for a nation's competition ability in the current international high technology markets[1]. For most complex engineering and science problems, the solution can not be handled by one individual discipline. As most engineers required working on a project involving teamwork in a multidisciplinary environment, it is essential to tailor engineering education in a unique interdisciplinary atmosphere and cultivate our engineering students to be the leaders in the rapidly changing engineering fields.

It is a challenging task to design an effective interdisciplinary course or project. The collaborative experience model for construction undergraduates has been initiated to promote collaboration between architecture and construction management students[2]. The cooperative model is important to promote interaction between design and building education, and to develop other multidisciplinary approaches for integrating pedagogical models in many discipline-specific topics.

Many efforts have been made on design engineering capstone courses[3-5]. For example, integrating senior capstone courses using different pedagogical strategies have been designed for participatory learning and creative problem solving[6]. A multidisciplinary curriculum model is implemented for senior undergraduates to work with faculty advisors to solve constrained engineering problems for industrial clients[1]. Effective instruction with active and cooperative learning has also been developed in capstone design course[7]. The integration of experimental teaching and practical communications has been carried out in the undergraduate education of aerospace engineering[8]. A great number of capstone courses on game development and programming have also been designed[9-11].

The contributions of multidisciplinary knowledge on team building have also been assessed for design-and-build competitions, which are useful tools in creative engineering design [12]. Interaction between academic engineering programs and industrial partners showed that capstone courses can create useful business products, produce corporate-ready students, and provide experience for faculty in future curriculum development[13].

However, there are little efforts in designing interdisciplinary courses or projects to promote undergraduate students in engineering in research. Integrating the multidisciplinary technologies, informatics, and the corresponding real-life applications is an important stimulating approach to promote the interests in research of undergraduates in engineering. This paper will introduce a project based approach based on multidisciplinary undergraduate research projects. Student learning is enhanced and the research interested is plowed through a collaborative and creative environment.

The rest of the paper is organized in the following. Section 2 will introduce the details of the multidisciplinary project process. Section 3 provides concise results generated by the multidisciplinary research projects. A brief summary is introduced in Section 4.

2. Approaches

The basic idea of multidisciplinary teaching and learning through a research project is to share the love of technologies, informatics, and their real-life applications in different programs and their fascinating combination among students and faculty mentors. In the class, it is essential to integrate innovative teaching techniques, student active learning, group activities, and hands-on experience together during the project period. A collaborative learning environment is created so that students can learn from and help each other. The faculty mentors are a helper in this learning process and provide guidance and help. Students are encouraged and expected to be actively involved and held accountable for their own action. The project based approach is carried out in a series of steps.

[1] *Design of new interdisciplinary projects:* The first step is the project design to be done by the mentors. An appropriate project should be small enough for a group of students to finish in about six months. Projects more than one year are not suitable for the team, as some of the team member may finish their study in the middle. On the other hand, the project should cover two or more disciplines. The project can be divided into distinctive tasks. Each task can be solved with the knowledge of one discipline. However, the combinations of these tasks together provide a unique solution to the problem, which can not be handled by knowledge from just one specific discipline.

For example, one multidisciplinary project we designed for patient vital signal monitoring and analysis involving the following tasks: (i) development of the techniques for vital signal acquisition, (ii) design of the database for storage of the acquired vital signal, (iii) mathematical model development for signal processing in real-time, (iv) programming to implement the algorithms, and (v) medical backgrounds for vital signal interpretations and patient information classifications. Task (i) can be accomplished by students from mechanical engineering, electrical engineering, or some control technologies. Task (ii) can be done by students in database. Task (iii) can be achieved by students in mathematics or computer science. Task (iv) can be realized by students in computer programming. Last, task (v) can be completed by students in biomedical engineering or health informatics. However, the solution to the project needs combinations of all the knowledge from these miscellaneous domains.

To give another example, in a project to develop a system for medical error reduction/prevention based on insurance claim data. A few tasks are designed including the design of different cases for medical error prevention, database design, patient information de-identification, programming for the prototype development, and the design of a friendly graphical user interface for non-technical personnel to use the system and retrieve the necessary summary information. The final solution of the project requires comprehension of medical errors, pharmacy (for medical errors caused by adverse drug events), database, programming, statistics, and interface design.

[2] *Student recruitment:* Once the project is designed and the tasks are categorized, the next step is student recruitment. As most undergraduates are not active in research, especially for some disciplines where research environment is not strong. Advertising to attract students is necessary. This is not a trivial problem as several projects have been postponed due to lack of interested students from some specific disciplines. The mentors may want to fully utilize their networks in other departments to advertise the opportunities of the multidisciplinary learning opportunities. For instance, the mentors can mention the project in their classes and ask referrals by the students. In addition, mentors can ask their colleagues in other departments to advertise it through email lists and class. For some disciplines with much more students applied, a screening process will be carried out to limit the number of the students for best educational results. The recruiting advertisement should be concise and specific on the requirement for the students' background and expected skills to carry out the project. This way, it is easy to attract interest students with those skills and only students with those skills will be applied.

[3] *Task distributions and group assignments:* With all the students on demand, each student is assigned with a task which can be worked out by the individual student alone. Following is to distribute individual students to small task groups. The members of each task group have complementary skills so that students can learn from each others. For instances, students from electronic engineering have more programming and data mining skills while students from biomedical engineering have more health/medical background. A task group with students from each discipline will facilitate the work on patient vital signal behavior analysis.

To give an example, in the medical error prevention project described above, a small task group involving one student from health informatics and one student from computer technology. The student from Informatics has health/medical background while the student from computer technology has more hands-on experience in database design and programming. The informatics student had designed different cases for medical error, including drug-drug interaction, wrong lab orders, and invalid lab test results, improper dose of the prescribed medicine prescription. The technology student had implemented a database system prototype to incorporate these medical error rules and automatically check potential medical errors for new incoming insurance claims.

[4] *Harmonized project progress:* The next step is the harmonized work on the project. Weekly group meetings will be held, featuring mentor presentation for general background education, student progress report for the specific tasks they were working, and group discussion for experiential learning.

During project progress, the mentors will guide and advise the students to make sure that they are on the right track. In the weekly group meeting, the mentors will give a presentation to all the students, focusing on the generally topics and will lead the group discussion. The mentors will also meet separately with each task group to give detailed guidance and suggestions to make progress on the project. For example, the mentors can introduce the basic research procedure on how to choose research project, how to narrow down the project and other general research tips. They can give lectures on conference abstract and poster preparations in general. One way to do this is to discuss with students by presenting a template for abstract and poster. The student will work on the draft of the abstract and poster and the mentor will then modify the draft and explain in detail the rationale for the modification. The same is for the project summary. The mentors will give the specific format and ask the students to work on it first and then revised by the mentors.

The project members (both students and the mentors) can discuss with each other through remote web and email communications. In addition, members of each small task group can meet as needed according to their own schedule. They will discuss the problems they are working and propose a solution first. The solution will be then presented to the mentors for suggestions.

[5] *Outcome dissemination and project evaluation:* In the end, the outcomes of the education and learning are disseminated by both students and mentors at different hierarchical events, including campus symposiums, local workshops, and national conferences. Students are also involved in project summary and conference presentations. Conference and journal papers are another way to present the project outcomes. Student and mentor evaluations are also carried out at the end of projects. Students will also evaluate the mentors and give tips to the mentors for future projects.

During the project period, one focus is to improve the soft skills of students. Soft skills are important to complement technical requirements of a job. However, improving the soft skills of students through education is a challenging task. Students' soft skills can be improved through a set of methods, such as boosted confidence in group discussion, public presentation skills, reviewing experiences and writing capability[14, 15].

Another focus of the project based education is active involvement of students. All the team members are required to evaluate information sources, to integrate subject matter learned during the project period, and to applying their previous knowledge into the current project. Students are responsible for the design of the detailed steps to carry out the project, the implementation of the prototype, the analysis of the results, and the documentation of the project. The mentor will work closely with the students for each of these steps to give feedback and guidance. Many projects have been of such high quality that they have served as the foundation for follow-up research projects. In addition, some project results have been accepted as papers or presentations at national or international conferences.

3. Results

Both the mentors and students have very positive feedback on the education and learning experiences as both gain benefits from the projects. From the projects, students learned to solve problems using what they learned in school, learned from other students, and integrated their results in a team work. Students not only learned the basics in research, but also are motivated in advanced studies. For the mentors, not only the projects been completed. The results of some projects have been used as preliminary results in external funding proposal of the mentors.

Students participating in the projects not only gained interdisciplinary education but also achieved research experience. They learned the basis of multidisciplinary research and have publications to show their research results. Most of the students working on the multidisciplinary projects are pursuing further graduate study. The multidisciplinary research background and publications gave them big advantages in their graduate school admissions and scholarship applications. Some juniors and seniors are planning to go to graduate school with the confidence obtained from the projects.

For example, the author also designed six multidisciplinary projects in the last five years and the results are wonderful. About 20 students from 6 different disciplines were involved. The students are at different stages of their undergraduate study, including freshman, juniors and seniors. Four presentations have been accepted by peer-reviewed high-respected national conferences. Two conference papers have published and two manuscripts are under revision. The students also produced many posters (more than 15) at the local symposiums and workshops. In addition, all five graduated students from three disciplines are admitted to graduate school across the country. Three of them are awarded full scholarship for their graduate study. In addition, the projects have strengthened the advisor's funding application as the results provided solid preliminary data and proved the feasibility of the proposed work. Two awards for the advisor, one internal and one external, has benefit from these multidisciplinary projects accomplished by the undergraduate.

4. Conclusion

The project based multidisciplinary education integrates classroom presentations, innovative teaching techniques, student active learning, group activities, and hands-on experience. Both the mentors and students have benefits from the multidisciplinary projects.

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