AC 2010-1459: A SUMMER TRANSITIONAL PROGRAM FOR AN UNDERGRADUATE INTERDISCIPLINARY RESEARCH PROJECT: PLANNING AND ASSESSMENT

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A Summer Transitional Program for an Undergraduate Interdisciplinary Research Project: Planning and Assessment

Abstract

This paper describes the planning and assessment of a summer transitional program as part of a multi-year undergraduate research project. The summer program is a focused, project-based learning experience for undergraduate students in engineering at two universities with significantly different demographics – one, a top-tier research university and the other, a smaller private university focusing on undergraduate education. The two universities are working closely with an industry partner who is providing materials and expertise and who may eventually incorporate into their manufacturing process the technology being developed in this project. The students are juniors and seniors involved in independent study or capstone project courses. The project is based in materials science and engineering and includes process design, characterization and testing.

Background/Motivation

One goal of engineering education is to prepare students to become effective members of multidisciplinary teams to address increasingly complex problems. Students who are taught to solve only those problems that have been set up specifically for the purpose of demonstrating or reinforcing a particular set of tools and analysis techniques will be at a disadvantage when faced with the highly complex issues of the real world[1]. Therefore, it is important that students be exposed to open-ended, real-world problems that incorporate design elements[2,3] while in a supportive academic environment.

Virginia Polytechnic Institute and State University (Virginia Tech) and the University of Hartford, along with an industrial partner, Taylor Guitars, have initiated a multi-year, joint senior research/independent study project involving three distinct engineering disciplines. The project, now in its second year, involves the development of a microwave curing process for polymer coatings on instrument woods. The first year involved two groups of students: three materials science and engineering majors from Virginia Tech and two acoustical engineering majors from the University of Hartford. The students worked independently on senior projects at their respective universities, but collaborated and shared materials and knowledge. The academic year culminated in a joint submission to the Journal of Undergraduate Materials Research and a visit to the industrial partner to share the results and plan the next step in the project.

Over the past academic year, a completely new set of students from each university worked on the project. Another group two of students in computer engineering joined the project to add a new dimension to the research that was not pursued in the first year of work. During the first year and in the transition process, several issues emerged as obstacles to technical progress and that demonstrated student deficiencies.

- Progress on undergraduate projects tends to stall as students graduate or leave and new students start.

- Students don't see how their work fits into the overall process
- Students don't understand the role of their counterparts in a different discipline and don't understand how much or what type of work they are doing.
- Students don't understand the engineering design process and come into the project with unrealistic expectations about what they will accomplish.
- Large-scale projects can be intimidating for undergraduates.

To address these issues, the authors propose a summer transitional program. There are two themes for the program: (1) the students will be fully engaged participants in results-oriented activities and experience the entire design process from initial concepts to final product and (2) the graduating seniors will serve as mentors for the next group of students taking up the research. Furthermore, there are two main goals for the summer transfer program:

- Technology/knowledge transfer: Incoming students will learn the project history, status, and potential directions for future work so that continuous progress may be made on the project.
- Closing the gap between disciplines: Students will travel to various locations to learn techniques other disciplines and put their work into a larger context.

Details of the summer transitional program and how to assess its effectiveness are discussed in detail in the following sections.

Proposed Summer Program Elements

The program will be five to six weeks long and the participants will be outgoing seniors who will serve as mentors, incoming students who will learn about the work completed during the previous academic year, and the faculty technical advisors who are overseeing the research. The program will consist of several phases as shown in Figure 1. Students will visit each university for approximately one week to learn the role of each group and work on each piece of the project. Also, the team will visit the industrial partner to see the full-scale manufacturing operation. The two other phases consist of a conference to present the technical results and a week-long workshop in which students will make their own product from start to finish.

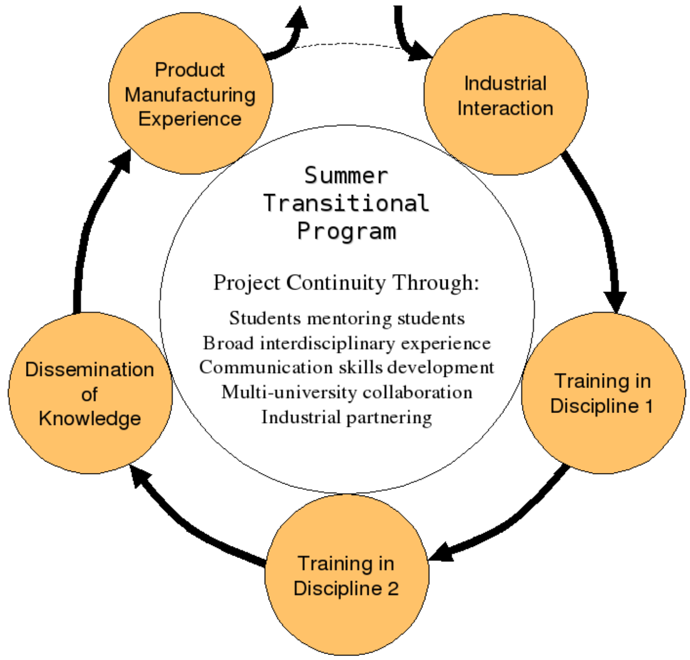

Figure 1: Outline of the proposed summer transitional program.

The program is designed to address each of the deficiencies listed in the previous section. The following themes are incorporated into the various phases of the program.

- Have incoming students work on the project in the summer so they can immediately contribute rather than re-doing the previous work once the semester starts.
- The students
  - Visit a full-scale manufacturing operation associated with the project topic.
  - Experience the entire manufacturing process in a hands-on fashion and see where their piece fits.
- The students travel to each other's location to work directly with their counterparts on each aspect of the project.
- The outgoing students teach the incoming students what they've done, and in the process, realize how much they actually did accomplish and how much work was involved.
- The outgoing students mentor the incoming students and give them insight into what it's like to work on the project.

The students will be engaged in several activities related to these themes. The following plan describes each element of the program in detail for the context of this particular project.

<u>Element 1 – Industrial Interaction at Taylor Guitars (4 days)</u>:

Module Goals – Gain personal knowledge of the manufacturing operation related to the specific project; interact with industrial participants.

Student Participants: Incoming and Outgoing

Activities –

- Tour the design and manufacturing facility.
- Present and discuss year-long project results with industry managers/designers.
- With input from all the participants, determine the goals for the next phase of the project.

Element 2 – Training in Discipline 1 at Virginia Tech (7-10 days):

Module Goals – Transfer knowledge about using microwave heat treatments to cure the polymer coatings on selected wood substrate; gain an appreciation of the partnering discipline.

Student Participants: Incoming as Students; Outgoing as Mentors

Activities –

- Learn to process materials using technology developed by students during the academic year.
- Learn materials characterization techniques.
- Participate in design activities to gain basic knowledge about microwave energy and processing.
- Tour the facilities and become acquainted with various forms of characterization/testing that can be used on the project.
- Generate samples for testing.
- Attend guest lectures and activities – Life Cycle Analysis/Green Engineering.
- Tour the campus and participate in recreational activities to gain appreciation of local culture.

Element 3 – Training in Discipline 2 at the University of Hartford (5-7 days):

Module Goals – Transfer knowledge about acoustics/vibrations testing; gain an appreciation of the partnering discipline.

Student Participants: Incoming as Students; Outgoing as Mentors

Activities –

- Learn about acoustical properties, testing, and applications for this technology.
- Learn to conduct vibrations tests on wood samples prepared during Element 2.
- Participate in design activity to gain basic knowledge about acoustics and its application.
- Tour the campus and participate in recreational activities to gain appreciation of local culture.

Element 4 – Dissemination of Knowledge at an Appropriate Conference (3-4 days):

Module Goal – Students gain experience in disseminating knowledge.

Student Participants: Outgoing as Presenters; Incoming as Attendees (if sufficient funding available)

Activities –

- Attend a conference to present technical work to a professional audience.
- Attend other paper sessions/expo and meet professionals in their fields.
- Seniors prepare/submit a joint manuscript with colleagues from a different discipline at a distance.

Element 5 – Product Manufacturing Experience at Purdue Guitar Workshop (5-7 days):
Module Goal – Participants experience the design and manufacturing operation from start to finish for the project product versus experiencing only one aspect that they are developing in their work.

Student participants: Outgoing; Incoming (if sufficient funding available)

Activities –

- Build an instrument from scratch.
- Learn the importance of details of manufacturing as well as the product at the macroscale.
- Make the connection between the instrument-making process and microwave heat treatment design process.

Assessing the Program Components

The program will be assessed using several techniques, including but not limited to: (1) faculty input on the ability of mentored teams to initiate continuation projects, (2) surveys of student knowledge and perceptions prior to and after summer program as well as prior to and after capstone experience, (3) number of submitted publications resulting from the capstone projects, and (4) surveys of industry partner perceptions related to student progress. Additionally, alumni from the summer program will be interviewed at one, three, and five years following graduation to develop an understanding of long-term effects of their participation in the program.

Assessment tools are being developed for each of the areas identified below. As the program still is in its early stages, data has not yet been compiled and analyzed. For the assessment areas identified above, more specific metric components are listed below.

(1) Faculty input on the ability of mentored teams to initiate continuation projects
- do students understand the goals and objectives of the long-term project
- can students operate the processing equipment and conduct characterization/testing
- are the students engaged early in the project in designing the approach to anticipated technical questions

(2) Surveys of student knowledge and perceptions prior to and after summer program as well as prior to and after capstone experience
- determine the basic knowledge of the fundamentals of the science and technology required to address the design problem

- conduct follow-up surveys for immediately following the summer program and over the course of the senior capstone project period

(3) Total the number of submitted publications resulting from the capstone projects (success based in part on the number of students and faculty involved in the program)
  - student papers
  - scholarly work by faculty based on the work initiated in the capstone projects

(4) Surveys of industry partner perceptions related to student progress
  - gauge relevance and technical contributions of the student work as perceived by the industry partners

(5) Program alumni surveys
  - total value perceived for graduate studies or professional career
  - specific benefits attributed to each program component
  - recommendations for additional activities or elimination of some program components based on perceived benefits

Individual assessment of student performance is left within the capstone design courses at each university. The student teams are evaluated on their technical accomplishments and individual contributions to the projects, as well as their communication skills (written and oral presentation). However, in a project such as this one involving students separated by discipline and distance, time management is crucial. The students working at each university require specific outcomes from each other in order to complete the individual embedded components within the overall project. Timely production of samples, data and written material to meet publication deadlines provide additional methods for assessing the progress of the individual groups, as well as of the overall team.

In some cases, developing equipment and processing or testing procedures are vital steps in the project development. The design, failure and redesign of these project components provide valuable assessment tools, especially for the technical activities.

Progress to Date – Components and Assessment

The summer transitional program is being developed around a specific project[4], and the two main goals include: transfer technology and knowledge to the next group of researchers; and, close the gap between groups of researchers so as to maintain project momentum. Three phases to the summer program were identified. At the midpoint of the second year of the student projects, some aspects of each phase of the program have been accomplished or initiated. Progress is discussed below with respect to each phase.

Phase I: incoming seniors from both schools to be mentored by the outgoing seniors
- A graduate from the processing group portion of the project at Virginia Tech spent time training an incoming junior to take over the project during this academic year (starting in August 2009).

- Training sessions were held once per month throughout the fall 2009 semester (first semester of the new student's work on the project).

Phase II: outgoing and incoming students as well as faculty visit the industry partner site for tours and collaborative meetings to report on progress to date and plan for the next year's activities

- P;Five students completing their senior capstone work for this project (three from Virginia Tech and two from the University of Hartford) and two of the three faculty involved during year one (one from each university) visited the industry partner's plant in May 2009.
- The two primary plant managers conducted a detailed, behind-the-scenes plant tour for the visiting university researchers.
- During a full-day meeting, the student researchers presented their results to the industry representatives. The third faculty member joined this meeting via teleconference.
- During the visit, plans were made for emphasis to be made during the coming year's research.

Phase III: students and faculty prepare presentations/manuscripts to disseminate technical knowledge regarding the project and the academic experience

- The students from both universities collaborated on a technical paper submitted to an undergraduate student technical journal (Journal of Undergraduate Materials Research). Following peer-review, this paper was accepted for publication.
- The project so impressed the editors of the undergraduate journal that it was selected as the feature for the volume containing the student paper. A separate feature on collaborative learning was written by an undergraduate student from the Department of English at Virginia Tech, including quotes from faculty and administrators from both universities. The cover also featured work from this project[5].
- The work presented at the 2009 ASEE Annual Conference and Exhibition, Austin, TX and the paper published in the proceedings[1].
- The students from Virginia Tech presented a poster on their work at the 2009 Materials Science and Technology Conference in Pittsburgh, PA. Their paper was published in the proceedings. It contained work generated by the students at the University of Hartford and acknowledged the contributions by these students.

In addition to these accomplishments, activities that further developed the project and established a close relationship between the students and faculty at the participating universities were conducted. These activities have served as the initiation of the basic components of the summer transitional program, even though some have taken place during the academic year.

- Students and faculty have visited each other's campuses to tour facilities, learn about each other's capabilities and to plan technical project activities. Students from Virginia Tech traveled to the University of Hartford in the fall of 2008. Students from University of Hartford traveled to Virginia Tech in spring of 2010.

- In addition to the student visits described above, the primary faculty members from Virginia Tech and the University of Hartford traveled to each other's universities several times over the course of the last two years for planning and research purposes.
- Proposals have been submitted by the lead faculty at each university in response to various university based solicitations.
- The two primary faculty members traveled to Arlington, VA to meet with program managers at the National Science Foundation. A summary of the transitional program was developed to distribute to potential funding agencies.

Already, the core project upon which this collaborative program is based has been expanded. A new student project on modeling and simulation was initiated in the spring 2010 semester as the third individual component of the collaboration. This project added a third discipline, computer engineering, to those already involved, materials science and engineering and acoustical engineering.

As the project progresses, it is anticipated that sufficient knowledge will be generated by the student researchers that more technical depth will be developed. Scholarly work based on the technical project as well as on the development of the academic transitional program will be developed by the faculty members involved.

Strategy for Developing the Transitional Program

Over the past three years, the program concept and some program components have been developed and implemented. Although these activities have not yet been incorporated into the concentrated five-week program design, the benefit to the participants and the overall project already are evident. In only one year, two student papers and two faculty papers have been produced, project milestones have been achieved and the breadth of the project has expanded.

In order to implement the program as designed, significant funding will be required. In the meantime, collaborations will continue between the universities as well as between the academic researchers and the industry end-user. Near-term goals include: further develop a major proposal for the complete summer transitional program, obtain sufficient financial support for this year's industry visit, meet with faculty at a potential partner university to develop a program module on manufacturing training relevant to the project, meet with potential local high school contacts to develop a pre-college component to the summer program and initiate faculty research based on student results to increase the depth of the research.

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