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DESIGN COLLABORATION BETWEEN HIGH SCHOOL, ON-CAMPUS, AND DISTANCE ENGINEERING STUDENTS

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ABSTRACT

A collaborative design project has been implemented in a junior-level materials selection and manufacturing course. The team-based design problem involved the design of playground equipment for elementary school children. Focus groups of elementary students and a review of applicable construction standards were used to set design requirements. Each team comprised undergraduate on-campus students, undergraduate distance education students and junior/senior high school technology students. Initial design choices were made by the entire group. Subsequent calculations of stress, deformations, etc. to refine the design as well as choices of materials and manufacturing processes were primarily the purview of the undergraduate students. Drafting and integration of the design segments into a complete computer model was the responsibility of the high school students. Continuous communication between the groups was required for the process to be successful. This collaboration was facilitated via online forums and site visits. An overview of the project structure is presented along with a summary of the project outcomes and recommendations for improving the process.

INTRODUCTION

The University of North Dakota (UND) currently offers the only ABET-accredited degree-at-a-distance engineering programs. The Distance Engineering Degree Program (DEDP) began over a decade ago with the help of 3M as a way of providing job training and advancement for 3M employees. Since then, the program has grown significantly and typically enrolls over 50 students in a given semester. A major foundation for the program's ABET accreditation is UND's commitment to provide an educational experience that is as identical as possible for every distance and on-campus engineering student. An example of this commitment is the integration of on-line and virtual laboratory activities for all students in some UND classes [1]. Bourne *et al*. discuss some general issues associated with laboratory projects in the distance education setting [2].

Within the DEDP, collaborative and team-based activities remain challenging due to the asynchronous delivery of the lecture material to the distance students, as well as their physical separation from campus. Each lecture is given in a classroom of on-campus students while being recorded remotely. It is then posted to a Blackboard® [3] course website in a package containing the lecture audio, a low-resolution video of the professor and a higher resolution screen image of the visual lecture material. The package is typically available for download several hours after the conclusion of the class. Depending on their work/family schedule and what hours of the week they have set aside for studying, DEDP students may access the lectures soon after they are posted or several days later.

The present work details the implementation of a collaborative design project into this class structure. Design teams comprised both on-campus and DEDP students. In addition, each team included a number of students from the technical education classes at one of Grand Forks' two high schools. The high school/undergraduate collaboration initially came about as part of Grand Forks Public Schools Technical Education Program's implementation of Project Lead the Way (PLTW). One aspect of PLTW is collaboration between high schools and the community [4]. For the authors, one manifestation of this collaboration was a cooperative design project in the Spring 2006 semester between on-campus and high school students. Full results of the effort including student perceptions of the project can be found in [5]. Additional examples of project-based undergraduate/high school collaborations can also be found in the literature [6,7].

The Spring 2007 semester was the second iteration of the collaborative project and the first to involve DEDP students. The remainder of the paper gives background information on the classes in which the project was assigned and discusses the project timeline and requirements. Results and analyses are presented from student feedback gathered at the conclusion of the activity. Some suggestions for similar projects are provided at the end of the paper.

PROJECT OVERVIEW

Course Background

Most high school student involved in the project were juniors or seniors, in approximately equal proportion. The class itself is an elective than focuses primarily on computer-aided design. On the UND side, the class is also an elective, taken primarily by junior mechanical engineering majors. The main objectives of the class are for students to 1) understand the relationship between material properties and manufacturing and 2) use this understanding to select appropriate materials. Materials and manufacturing information from the CES software is used extensively [8].

Project Goals

Several broad goals for the project can be articulated. One goal was for the teamwork and communication skills of all involved to be improved, especially of the on-campus and distance engineering students. Another goal was that the undergraduate students would gain a more complete understanding of materials and materials selection issues by having to articulate and explain them to their high school teammates. High school students were expected to gain a better understanding of the engineering profession while honing their computer and design skills. A final goal of the project was for the project experience of all undergraduates to be as similar as possible, whether on-campus or at a distance.

Design Problem

All groups were presented with the same challenge: design a set of playground equipment for elementary-age children. The final equipment arrangement needed to contain at least one climbing element, one swinging element and one sliding element [9,10]. In addition, the setup had to have at least one element for each undergraduate team member (see 'Group Structure,' below). The engineering calculations and materials/manufacturing selection for each of these components would be graded. Additional elements could be included but they did not need to be assessed individually. It was expected that each group would produce, at a minimum, sketches of the final design (ideally, CAD images generated by the high school students) and material/manufacturing recommendations for each element based on a mechanics of materials-level analysis by the undergraduate students. Two presentations as well as a final written report were required.

Group Structure

Twelve project groups were assigned by the instructors prior to the first group meeting (see 'Project Timeline,' below). Each group contained two on-campus undergraduates, one or two DEDP undergraduates, and three to five high school students. A total of 83 students were involved with the project, 44 high school students and 39 undergraduates. Of the undergraduate students, 24 were on-campus and 15 were DEDP students. Dr. Cavalli nominated one on-campus team member to be the group leader, responsible for coordinating team activities and submitting short weekly progress summaries to the Dr. Cavalli. Teams were free to select and alternate leader, if desired (and two groups did).

Access to the course Blackboard site was given to all undergraduate and high school team members. This was a change from the Spring 2006 project and greatly improved communication. All handouts provided by the instructors were available electronically. Recordings of the class presentations could be downloaded and viewed by the high school and distance team members. A separate discussion board was established for each team within the site. The discussion board was monitored periodically by the instructors but was primarily for the groups to use as they saw fit.

The undergraduates were expected to prepare two presentations (preliminary and final) and a final project report during the course of the project. A major consideration in formulating the project was how the grading of these activities would be handled. It was decided that each grade would be separated into group and individual components. For the presentations, the DEDP students would be expected to prepare the slides and would be held accountable for color choices, grammar, formatting, etc. The on-campus students, in contrast, would be held accountable for their performance during the presentation—body language, dress, responses to questions, etc. All team members would be expected to contribute to the technical presentation content, and so all were graded equally on this category. Similarly, the final report consisted of an extended memo to which all team members were expected to contribute (group grade) and appendices for each equipment element containing the technical analysis performed by each student (individual grade). In all cases, the group portion of the grade comprised approximately 60% of the total grade.

Project Timeline

During the Spring 2006 semester, the collaborative project stretched over approximately a one month time period [5]. Student and instructor feedback indicated that additional time would be helpful. As the project progresses outside of class, however, undergraduate students are still learning about materials properties and selection. Similarly, high school students are learning more about computer-aided design. A balance between students having enough preliminary information and allowing enough time for project completion is needed. During the Spring 2007 semester, project activities stretched over two-and-a-half months of class time with the majority of effort falling in the final month-and-a-half. The full project timeline (as presented to the undergraduate students at the outset of the project) is shown in Table 1.

DESIGN EXAMPLE

Figure 1 shows a prototype of one design proposed as part of the project. The computer-generated sketch created by the high school team members was used to generate the polymer model using a rapid prototype machine. The sliding, climbing and swinging elements are identified on the figure.

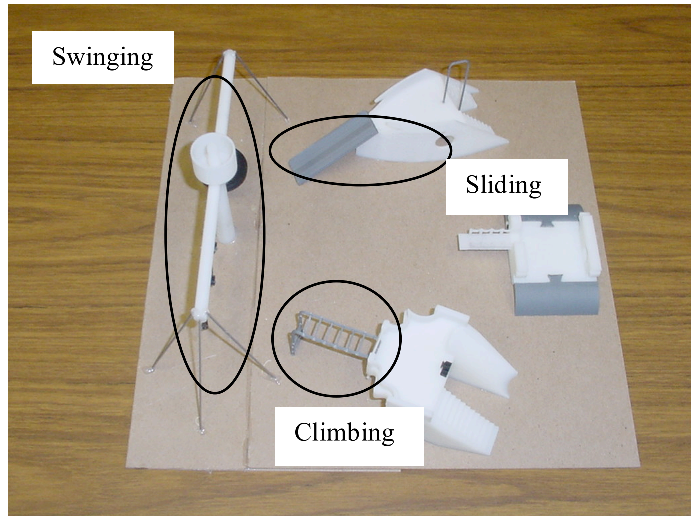

Figure 1: Example of playground equipment design

The design in Figure 1 is one of several submitted to focus on a particular theme. In this example, the theme is a shipwreck, with each piece of equipment designed to resemble a portion of a sunken ship. Other themes included castles, ships (intact) and underwater creatures. About half of the teams chose not to include a theme in their design.

STUDENT FEEDBACK

Input was gathered from students at various stages during the project. After the preliminary project presentations, students were asked to make suggestions of ways to improve the project as well as to rate the effort of all undergraduate team members to that point. Dr. Cavalli combined these responses with his own impressions from the preliminary presentations and posted a summary on the course website.

Following the final project presentations (which occurred during the final week of the class), students were again asked to assess the percent effort from each team member. They were also asked to respond to 12 questions on a scale of 1-5 (1 being strongly disagree and 5 being strongly agree). Of the 24 on-campus students enrolled, 16 students submitted these final questions, a response rate of 67%. The return rate for the DEDP was lower, approximately 40%. Results of the survey are discussed below by category. Responses labeled 'C' refer to on-campus students and responses labeled 'D' refer to DEDP students.

'The collaborative design project was a valuable part of my experience in ME313'

Both groups of students felt the project was a valuable addition to the course (3.5/5 – C, 3.7/5 – D). Most students responded either '3' or '4'. Within the C group, however, two students responded '1', one student responded '2' and one student responded '5'.

'I would have liked to participate in a similar experience while in High School'

Average responses to this statement were slightly higher (3.5 – C, 3.8 – D) and there tended to be more scatter in the data. For example, seven C students responded '5' but three responded '1'. All D responses were '3' or '4' with the exception of one '5'.

'My team communicated effectively throughout the project'

Communication was the single biggest hurdle to be overcome in the course of the project. Some distance students currently work in a technical environment where collaboration across companies and time zones is the norm. They expect team members to check email/voicemail regularly and to respond. Some campus students, in contrast, check email infrequently and respond at a relatively slow rate. Dr. Cavalli discussed expectations for communication during the peer reviews for the preliminary presentation, which helped team members to understand the required level of performance. There is no doubt that the responses would have been much lower even a couple of weeks earlier in the project, but by the end, average responses were 3.2 – C and 2.3 –D. Three out of four '1' responses from the distance students on the survey came on this statement. In contrast, only one campus student responded '1'. Three campus students responded '5'. It is unclear if communication problems seem amplified to the distance students because they already feel somewhat isolated or if other factors are involved.

'Team members completed their tasks correctly and on time'

There were actually three survey statements on this theme. One statement read, 'On-campus team members…,' the second read, 'DEDP team members…,' and the third read, 'High School team members…" Responses from the two groups were almost exactly reversed on the on-campus/DEDP statements. Average responses were 4.3 – C, 3.3 – D to the on-campus statement and 3.3 – C, 4.3 – D to the DEDP statement. Even the range of responses was similar. Responses were identical for the High School question (3.0/5). These numbers may include some lingering effects of the communication problems described above. They may also indicate some uncertainty on the part of the students as to what constitutes 'correctly and on time' for each group.

'I put in the required amount of effort to make the project successful'

Both groups of students felt they had put in the required amount of time (4.6 – C, 4.3 – D). This would appear to be more than general self-aggrandizement as students showed themselves to be willing to admit lack of participation during the preliminary peer reviews.

'The time spend on the project was appropriate'

Multiple statements (2) are included in this category, one related to the amount of in-class time spent on the project and the other related to the overall project timeline. Distance students tended to agree with both statements more strongly than campus students. On the issue of in-class time, responses were 3.2 – C, 4.2 – D. Responses on the issue of the overall project timeline were 3.9 – C, 4.5 – D.

'I was well-prepared for the project based on previous work in this and other classes'

Both groups felt they were well-prepared for the project (4.4 – C, 4.2 – D). This should have been the case as the technical demands were relatively light (analyses limited to mechanics of materials-level stress and deformation). Since the primary focus of the course is on material properties and selection, most of the emphasis was placed on how an engineer makes good use of analysis results, not necessarily how results are obtained for end effects, etc.

'The instructor clearly conveyed his expectations for the project'

Responses to this statement were generally positive with a slightly higher average from campus students (4.1 – C, 3.8 – D). All responses were in the range from 3-5.

'The instructor's expectations were reasonable for the time/resources available'

Students from both groups responded positively (and similarly) to this statement (4.1 – C, 4.2 – D). Again, all responses were in the range from 3-5.

CONCLUSIONS

The use of the preliminary presentations seemed to provide a useful benchmark for the groups and an opportunity for the instructors to provide/receive feedback about what was working and what wasn't. With few exceptions, students were receptive to constructive criticism regarding their level or participation (and typically already knew what needed to change). Few comments or complaints were received regarding the group/individual grading scheme and this seemed to be an effective means of integrating contributions from on-campus and distance group members.

Judging not only by the student feedback but also by the instructor's evaluation of the final analyses and designs, the project was a success. Communication between on-campus, distance and high school team members proved, as expected, to be the most challenging aspect of the project. Most groups struggled initially and then adjusted their behavior following the initial peer review. This resulted in fewer complaints to Dr. Cavalli and higher satisfaction with the project near the end. Two teams, in particular, struggled with communication issues throughout the course of the project. In the opinion of the instructor, these teams seemed to have the unfortunate combination of on-campus students willing to 'let things slide' and DEDP students who were extremely organized and 'on the ball'. These types of conflicts are probably inevitable to some degree but care should be used early in any such project to monitor both communication and team dynamics.

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TABLES

Table 1: Project Timeline

Week of 2/19	Standards related to playground equipment are identified by on-campus and DEDP students.
Week of 2/26	Teams assigned and design requirements meeting with elementary students. Notes from the meeting will be emailed to the DEDP group members by their on-campus counterparts.
3/8	First Group Meeting (Central or Red River) – on-campus and HS students meet with preliminary design discussions. DEDP students may participate via live chat on Blackboard if their schedule permits. If not, a designated recorder for the group will convey the main points of the discussion.
3/28	Design Meeting (UND) – integration of elements. Between 3/21 and 3/28, students will communicate via Blackboard/phone/etc. about ways to integrate the various components into a complete design. Groups will decide on a final layout. On 3/28, on-campus and HS team members will meet to discuss issues of materials, dimensions, etc. to aid the HS students in drafting the final design and ME in materials/manufacturing selection. The conversations will be recorded by a member of the group for the benefit of the DEDP team members. High School students will be responsible for constructing the final CAD files of the designs. ME 313 students will be responsible for specifying limits on dimensions based on engineering calculations, specifying materials and choosing manufacturing processes.
4/13 and 4/16	Preliminary Design Presentations (UND). The DEDP team members will be primarily responsible for putting together the slides and the on-campus students will be primarily responsible for giving the presentation.
4/27, 4/30, 5/2	Based on feedback from the preliminary presentations, final presentations will be prepared and presented in class. Again, the DEDP students will be responsible for preparation of the slides and the on-campus students will be responsible for making the presentation.
5/2	Final design reports due.