AC 2010-279: AN INTERDISCIPLINARY UNDERGRADUATE COURSE BRIDGING THE GAPS BETWEEN ENGINEERING, SCIENCE AND THE ARTS

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An Interdisciplinary Undergraduate Course Bridging the Gaps between Engineering, Science, and the Arts

Abstract

This paper presents an innovative interdisciplinary undergraduate course that simultaneously engages the disciplines of engineering, science and arts. This course is intended to motivate students to reach across the boundaries of their own disciplines and advance their critical thinking, creative problem-solving and computational thinking skills, while learning the relevant technical knowledge. The structure, objectives, assessment strategies, results, and student deliverables from the first course offering are the focus of this paper. These promising results provide a model with which to evaluate effective approaches for interdisciplinary higher education.

1. Introduction

Interdisciplinary education is becoming increasingly important in preparing undergraduate students to be able to participate in the emerging knowledge-based economy and meet complex social demands in the modern world[1,2,3,4]. It has grown at a progressively rapid rate in recent decades. More and more universities and federal funding agencies have set their initiatives in favor of and prioritized investment in interdisciplinary curricula and research activities[5]. The development of the course presented in this paper has been motivated by this trend. This course has gained broad institutional support and is funded by the National Science Foundation's (NSF) CreativeIT program.

Interdisciplinarity is acknowledged as an effective educational approach to engage students in critical thinking and synthesis beyond the capacity of a single discipline or major, and cultivate creative ideas, solutions and activities[1,2,6]. As these skills are crucial to engineering students, engineering educators particularly endorse this approach, and recognize interdisciplinarity as a critical component of modern engineering education[7]. Although a variety of interdisciplinary courses for engineering curricula have been developed[7,8,9], there still remains a lack of courses that involve disciplines that are fundamentally different from engineering such as arts, humanities, and social science. The course presented in this paper is an innovative example of a course that simultaneously engages the disciplines of engineering, science and arts.

This course, titled "Conducting Robots," uses an autonomous (robotic and/or graphic) musical conducting system as a vehicle to bring together students majoring in Mechanical Engineering (ME), Computer Science (CS), Interactive Multimedia (IMM) and Music in the same class. It is a project-oriented course that fosters critical thinking, creative problem-solving, and computational thinking skills through an open-ended team project requiring the synthesis of knowledge in all four core disciplines. Students work collaboratively to design and develop innovative robotic and graphical conducting systems that can direct an orchestra. Topics taught include robotics, visual music, abstract animation, computer vision, algorithms, data processing, music conducting, and project management.

This course was offered in the semester of Fall 2009 for the first time. It is a cross-listed elective course in the departments of ME, CS, IMM, and Music, and was taught collaboratively by the authors who are faculty members in the four departments. A total of 20 students from the four majors enrolled in this course, and they developed five different non-human conductor prototypes. These prototypes were tested with our college's Orchestra at the end of the semester, and were evaluated by both the orchestra musicians and an external faculty Advisory Board. The prototypes were determined to have achieved satisfactory results.

We believe that this course motivates engineering students to reach across the boundaries of their own discipline and find creative solutions to engineering problems. Since it features novel, "cool" applications of mechanical engineering, we believe that it would contribute to an increase in enrollment, retention rates and general interest in the field of mechanical engineering. We also expect that it will inspire artists and musicians to consider their potential roles as motivators for engineering.

2. Collaboration and Course Formation

Locating collaborators is the first step in any team effort. This is more challenging in engineer and non-engineer collaborations as disciplinary boundaries tend to prevent connections between engineers and non-engineers[7]. Both groups often stay on different sides of campus and attend unrelated professional conferences. Two general questions for these engineer and non-engineer collaborations are[7]: how do they find collaborators? And what structure do their interactions take?

Our collaboration originated from our scholarly work and mutual interests in teaching interdisciplinary courses. Our research areas are in the fields of robotics, computer vision and artificial intelligence, music conducting, and abstract animation and musical visualization, respectively. We collaborated and consulted with each other (pairwise) in our scholarly work before we created this course. For example, one coauthor worked with another on humanoid robots. This coauthor also worked with another on the computer vision based tracking of conducting gestures. Two of us taught a Game Design course together.

Motivated by the NSF CreativeIT program, we decided to transform our existing scholarly collaborations into a novel interdisciplinary course that bridges our subjects in engineering, science, and arts. All of our collaborative work can be connected to the development of a non-human autonomous conductor. Since this course and its open-ended design project require the knowledge and expertise of four instructors (the first 4 authors), we all attend every class regardless of who teaches. Faculty weighted hours (faculty credit hours) for teaching this course are shared equally by the four instructors.

3. Course Model

Several books have systematically studied the history, impact, practice and assessment of interdisciplinary education [1,2,3]. Best practices related to interdisciplinarity have been summarized in [1,2] . The course model we designed is the combination of two of these best practices: theme-based learning and student-centered pedagogy.

3.1 Theme-based learning

Theme-based learning "shifts the role of curriculum from mastery of disciplinary content to the critical integration of multiple bodies of knowledge relative to a specific question."[1]

The theme of our course is to develop robotic and/or graphic conducting systems to direct an orchestra. In order to fulfill this theme, students need to learn related subjects from several disciplines instead of a single one. At the very least, they need to equip themselves with notions of robotics from mechanical engineering, conducting theory and practice from music, abstract/multimedia animation from IMM, algorithms, data structures, and artificial intelligence from computer science.

3.2 Student-centered pedagogy

Student-centered pedagogy "encourages students' independence and critical-thinking skills; allows students' interests to shape issues of application"[1].

Our course is offered as a 3-hour class per week for 14 weeks (i.e. one semester). For the first 8 weeks, we spent about 2 hours on lecture and 1 hour on hands-on labs. These labs were computer-oriented, including topics such as project management software, visualization software, and Matlab simulations of algorithms, data processing, spatial representation and forward kinematics of robotic manipulators. For the remaining six weeks, students worked in interdisciplinary teams on their projects in class. Every team gave informal presentations on their project and progress in front of the class every other week. When one team presented, the rest of the students and all instructors served as consultants and critics to question, suggest, or praise their work.

Through this scheme, we arranged for approximately 43% (6 out of 14 weeks) of the total class time to be completely led by students and only advised by instructors. Though the remaining 57% (8 out of 14 weeks) of the total class time was mainly controlled by instructors, we were able to dedicate about one third of each class period to student-centered, hands-on labs.

3.3 Breath, depth and coherence

We aimed to offer an interdisciplinary course that featured breadth, depth and coherence. In the 3-hour class period, we focused on the breadth and coherence of the course of study. The depth of the topics was offered in a tutorial format to the relevant groups of students either in class when there were no formal lectures, or during office hours. The topic of greatest depth for the engineering students was robotics. An additional 1-hour design section was required only for engineering students due to the engineering curriculum requirements for elective courses. During this time we achieved an increased depth in the robotics topics.

4. Course Objective

This course is cross-listed as an elective course in the ME, CS, IMM and Music Departments. Enrolled students have different backgrounds, concentrations and goals. We established individual course objectives for each major based on their disciplinary background, as well as common course objectives for all students. Course objectives for each major are listed as follows (as stated in the course syllabus):

Mechanical Engineering majors will:
- Understand the fundamentals of robotics including spatial description, forward and inverse kinematics and trajectory generation;
- Gain hands-on experience on the design and development of a robotic system;
- Get training in the skills required for creative problem-solving, and computational thinking;
- Interpret the music conducting behavior from engineering point of view.

Computer Science majors will:
- Gain hands-on experience in problem statement, algorithm design and analysis, implementation and testing;
- Gain hands-on experience in switching between various hardware and software platforms;
- Become familiar with artificial intelligence techniques, including computer vision and music information retrieval;
- Be able to express ideas in reports and documentations.

Interactive Multimedia majors will:
- Gain an aptitude for the key concepts, skills, tools and processes vital to other disciplines involved in the course;
- Explore the use of graphical elements — color, shape, motion, etc. — to convey information, ranging from the straightforward to the subtle;
- Leverage popular GUI conventions from software and games to clearly communicate with users;
- Consider the advantages/disadvantages of non-standard, physical input to and output from computational systems, including robotics, cameras and other sensors;
- Design two-way systems that not only produce output but also respond and adapt to various forms of user input.

Music majors will:
- Gain hands-on experience in designing robotic and software systems and working with others to build them;
- Undertake an important team role in evaluating success and providing artistic quality-control as the expert musician among students with engineering and technical skills;
- Learn how to express, in quantitative and algorithmic terms, the mechanics of orchestral conducting and performing;
- Share their musical skills and knowledge in order to inspire their fellow students to find more creative and successful solutions to engineering problems.

All students will:
- Develop strategies and processes for managing a complex project involving diverse areas of expertise;

- Develop competencies in collaborative learning and working strategies through interdisciplinary team activities;
- Develop competencies in fields other than their major.

5. Course Objective Assessment

The objectives of this course are mainly assessed through topic-related graded individual homework assignments, graded teamwork assignments, self and team evaluation forms, and students' anonymous reflection journals.

5.1. Graded individual homework assignments

These individual homework assignments are mainly used to assess technical knowledge related to course objectives. These assignments are required to be completed by all students individually regardless of the nature of the homework and students' majors, and require knowledge of robotics, algorithms and data structures, design proposals, conducting, music visualization and project management. Completed assignments are submitted in a variety of formats including written essays, problem sets, class presentations, and computer programs and simulations, depending on the nature of the assigned topics. By emphasizing the identical treatments for all students on these individual assignments regardless of their major, we created opportunities and motivation for students from different majors to interact and communicate with each other. Students were strongly encouraged to seek advice from peer students for assignments that were not in their fields.

Nine assignments were given in the first eight weeks of the semester and accounted for 40% of the final grade. Student grade information on these assignments is given below in Table 1. The average score in all areas is above 80%.

Table 1: Student grades on individual homework assignments

Homework Area	Average grade %	Minimum grade %	Maximum grade %
Robotics	82.6	20	100
Algorithms and data structures	84.4	35	100
Design proposals	87.2	34	95
Conducting and music visualization	89.1	57	100
Project management	93.2	90	95

The average grades on these individual homework assignments are listed by majors in Table 2. In-major students did well on in-major assignments, while music majors were weak in engineering and computer science assignments due to the math and programming skills required. However, under this interdisciplinary environment, they had the opportunity to try, and some were able to complete these assignments. IMM students did well on all the assignments. It was thought that the engineering students would do well on all the assignments as well. It turned out that they did poorly on the computer science assignments. Though the results in this table indicate some correlations between major and corresponding assignments, we cannot draw any conclusions about these correlations as the data set is small (a total of twenty students).

Table 2: Average grades on individual homework assignments by majors

Homework Area	ME	CS	IMM	MUSIC
Robotics (ME)	90	80	89	74
Algorithms and data structures (CS)	74	92	91	77
Design proposals	92	82	87	92
Conducting and music visualization (Music)	90	90	86	91
Project management (IMM)	92	95	93	93

5.2 Graded teamwork assignment

The teamwork assignment was used to evaluate the students' skill, hands-on experience, interdisciplinary collaboration, and certain technical knowledge related to the course objectives. The assignment included a 20-page final report, a 15-minute final presentation, and a working prototype. When aggregated together, these accounted for 45% of the final grade in the course.

Although this course is project-oriented, with students working in interdisciplinary teams to fulfill the project, the teams were formed in the middle of the semester. We believed that students' interactions with others (except for their team members) would have decreased if we did so. The majority of the students didn't know each other previously, as they were from different departments. Students formed teams by themselves in about the 7th week of the semester after they got acquainted with each other. 20 students enrolled for this class in the Fall 2009 semester. Ideally, we had anticipated having five students from each major. In reality, we had 3 ME students, 5 Music students, 7 CS students and 5 IMM students. The whole class was divided into 5 interdisciplinary teams with 4 students per team. Three teams had a representative from each major. The other 2 teams replaced the ME major with a CS major, for a total of 2 CS majors.

Five different non-human autonomous conductor prototypes were developed. These prototypes achieved satisfactory results during their demonstration with our college's Orchestra. Three examples of these prototypes are given in Section 6. The average team assignment grade is 88.4% with a minimum of 83% and maximum of 96%. Individual grades were adjusted based on the results obtained from a survey on Self and Team Evaluation filled by all students described below.

5.3 Self and Team Evaluation Form

The self and team evaluation form was mainly used to assess the interdisciplinary teamwork-related course objectives. The rubric was developed based on Smith's work[10]. Five teamwork attributes were evaluated: process, communication, interpersonal skills and social interaction, contributions, and shared responsibility. The definitions of each attribute are listed in Table 2. Students were required to complete this form online, for everyone including themselves. Each attribute was scored on a scale of 1 (weak) to 4 (excellent). Thus the maximum score was 20 points and the minimum was 5 points. Instructors were the only ones able to read these evaluations.

Table 3 gives the frequency analysis results. This table shows that the frequency of the "weak" scale on all these attributes is equal to or less than 3.75%, and the frequency of the "excellent" scale is over 58%.

Table 3: Frequency analysis results

Evaluated teamwork attribute	Weak (1pts)	Adequate (2 pts)	Good (3 pts)	Excellent (4 pts)
Process: * Models a caring attribute about goals * Exhibits leadership skills * Helps direct the group in setting goals * Helps direct group in meeting goals * Exhibits on-task behavior consistently	3.75% (3/80)	8.75% (7/80)	28.75% (23/80)	58.75% (47/80)
Communication: * Shares many ideas related to the goals * Encourages all group members to share their ideas * Listens attentively to others * Asks questions for clarification * Builds upon other's comments	2.5% (2/80)	3.75% (3/80)	32.5% (26/80)	62.25% (49/80)
Interpersonal Skills and Social Interaction: * Involves whole group in problem-solving * Actively participates helping the group work together * Respects the view of others * Reflects awareness of other's views and opinions in discussions * Empathetic to other people's feelings and ideas	1.25% (1/80)	2.5% (2/80)	26.25% (21/80)	70% (56/80)
Contributions: * Contributes in a positive way to the group work * Contributes to decision making * Encourages groups to evaluate how well they work together	2.5% (2/80)	3.75% (3/80)	20% (16/80)	73.75% (59/80)
Shares Responsibility: * Participates actively * Thoroughly completes assigned tasks * Ensures responsibility for task is shared evenly	3.75% (3/80)	8.75% (7/80)	22.5% (18/80)	65% (52/80)

Table 4 gives the histogram of the average score range obtained by the students on all attributes. The maximum averaged evaluation score achieved by students was 4 points and minimum was 2.65 points. None of the students had a "weak" average score. 85% of the students (17 out of 20) achieved a "good" average score, and the remaining 15% of the students (3 out of 20) got an "adequate" average score.

Table 4: Number of students corresponding to the score range

Averaged score on all attributes	4	3- 3.9	2-2.9	1-1.9
Number of students	1	16	3	0

5.4 Students' reflection journal

The course objectives are also assessed through students' confidential testimony in the format of biweekly reflection journals. An independent evaluator oversaw the students' reflection journals. Students sent their reflection journals electronically directly to the independent evaluator who summarized their contents and reported the summary back to the instructors with no identifying information, so the instructors did not know who wrote what.

Students wrote journals biweekly reporting the most important thing they learned in each class and who they learned it from. They also documented their "aha" moments (i.e. a breakthrough moment, when new understanding "fell into place"), along with what conversation, interaction or activity lead them to a different way of looking at or solving an issue with respect to a class assignment or course related problem and challenge. These biweekly feedbacks had provided instructors with timely and constructive suggestions to the course developments, and led to several significant changes of class direction.

All the students reported "aha" moments during the semester and that they had a better understanding and appreciation of the other disciplines. The majority of the students said they learned different ways to look at or solve a problem through conversation or interaction with students from the other majors.

Two interesting comments are quoted below:

"It was shocking to *hear that all the other students from the "smart" majors (ME and CS) were* as confused about conducting and music as I had been about their subject areas."

"Trying to wrap my mind around having my right hand do something and my left hand do something entirely different was surprisingly difficult. It was really trying it (conducting) out for myself that made me realize how much cognitive multitasking this feat required."

6. Prototypes Delivered by Students

The proposed non-human conducting systems were required to conduct 1-5 minutes of Beethoven's VII Symphony, movement 2. These systems were required to communicate beats, volume, and cues. They did not necessarily have to use the same gestures/signals that a professional human conductor does.

The majority of the students didn't have a music conducting background. Some of them had not even attended a classical concert before. Four activities were arranged to give students first-hand experience on conducting in addition to the regular class:

- All students attended orchestra rehearsals on campus for one or two times.
- Students attended a formal concert performed by The Philadelphia Orchestra, and they were seated in the "Conductor's Circle" in the Kimmel Center. Some of the students could not attend the concert due to time conflicts.
- The conductor of our college orchestra was personally interviewed by all teams.
- All the students practiced a simple conducting activity guided by the conductor of our college orchestra.

Five different prototypes were developed. The two teams without engineering majors focused on graphical conducting systems. The other three teams with engineering majors either focused on the robotic conductor or the robotic conductor complemented with graphical visual abstraction. Lego Mindstorm NXT robotic kits were provided for building the robotic conductors.

All five prototypes were tested during two special sessions of our college orchestra at the end of the semester. The quality of these prototypes was judged by the performing musicians by filling a survey form. The form provided scores in six different areas: tempo, dynamics, section cuing, conducting style/beat pattern, articulation and level of interaction (as follows):

1. How effective was the system's portrayal of the piece's tempo?
2. How effective was the system's portrayal of the piece's dynamics?
3. How effective was the system's portrayal of the piece's section cueing?
4. How effective was the system's portrayal of the piece's articulation (staccato, legato, etc…)?
5. How effective was the system's conducting style and beat pattern?
6. What was the level of interaction between the conducting system and you, the orchestra?
7. Any other comments.

For the survey questions 1 to 6, they were rated on a scale from 1 to 10 with 1 meaning "not at all" and 10 "very".

Due to the small size of the robotic conductors and nature of the musical score, only the string section (violins, violas, and celli) of the orchestra attended the rehearsals (25 musicians). The movements of the robotic conductors were also projected on a big screen for visibility. Surprisingly, all of the prototypes got satisfactory results though it was the first time we offered this type of interdisciplinary course and non-human conductor project. We believe that our focus on interdisciplinarity was an important component of this success. Video clips of the performance are available at http://www.tcnj.edu/~conducto/. Three of the five prototypes are illustrated below.

A. Example of Robotic Conductor (named Cybernetic Conducting Contraption, or C^3)

Figure 1 shows one of the robotic conductors and two images taken from its onsite performance. This robot had two arms: the right arm had two degrees of freedom and was used to conduct beat and dynamics; the left arm had one degree of freedom and was used for cueing. The functionality of the robot was greatly constrained by the ability of the hardware and software provided by Lego Mindstorm NXT robotic kits. For example, the NXT robot can only control up to three motors.

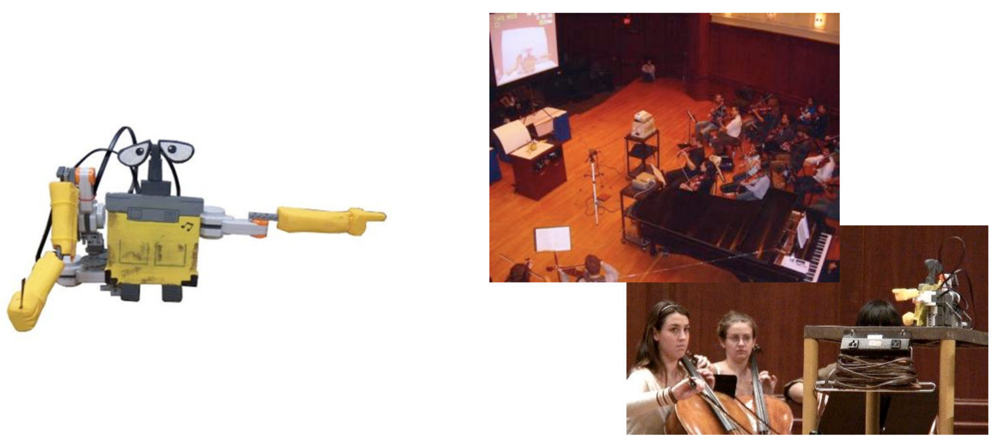

Figure 1: Robotic conductor (left) and images from its on-site performance (right)

B. Example of Graphic Conductor using abstract format (named Aha!simo)

Figure 2 shows an example of a graphic conductor using abstract visualization. It was implemented using the software of Processing API. The two pulsing circles on the top left were used to represent the beats, and toggled at the rate of the beat. A dynamic bar on the right side was used to control the volume of the piece. The measure currently played was displayed just above the dynamic bar. The cueing worked similarly to the Guitar Hero video game. A silhouette of the instruments to be cued appeared near the bottom of the screen. Animage of the instrument moved slowly from the top of the screen toward the outline shape; when the two overlapped, the corresponding instrumentalists started to play. Although it was a novel way to conduct a musical piece, the musicians were able to quickly understand this graphic system after a short explanation.

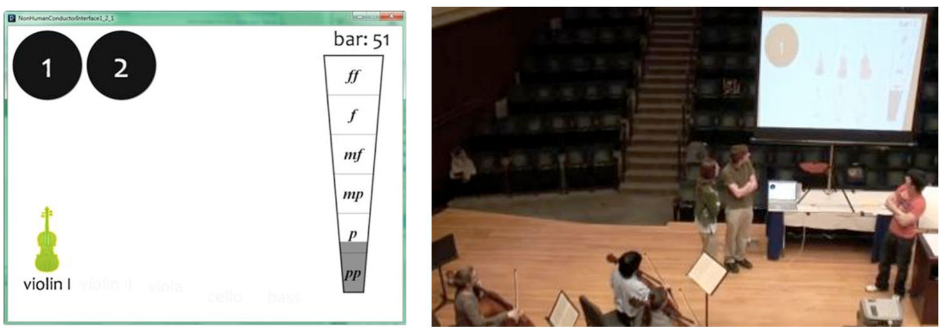

Figure 2: Abstract graphic conductor (left) and one image of its on-site performance (right)

C. Example of graphic conductor using a humanoid format (named GUS)

Figure 3 shows a humanoid graphic conductor and one image of its on-site performance. It was implemented using the Maya animation software. Each arm had three degrees of freedom. The right arm was used for beat and dynamics, while the left arm was used for cueing. The screen (face) of GUS was originally intended to contain an abstract animation (replacing the functions of facial expressions by a human conductor) as shown in Figure 4, but it was not integrated with the main body due to technical difficulties.

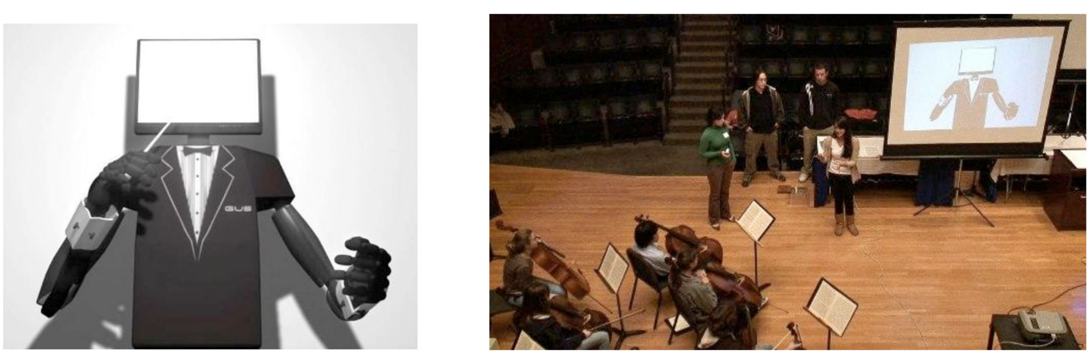

Figure 3: Humanoid graphic conductor (left) and one image of its on-site performance (right)

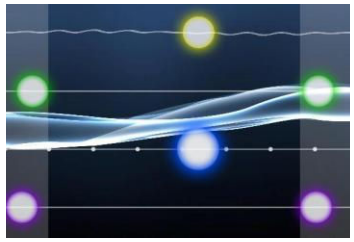

Figure 4: The face (screen part) of GUS

The evaluation results obtained from the 25 performing musicians on these three prototypes are given in Table 3. It can be seen that the results on tempo, beat pattern and cueing are all above 6 on a scale from 1 to 10. These are the three areas that we required the non-human conductor to achieve. The goal of this course is not to develop a perfect and fully functional non-human conductor. Instead, the non-human conductor is used as a vehicle to bridge engineering, science and the arts. Hence, we conclude that all prototypes got satisfactory results.

Table 3: Averaged evaluation results from 25 performing musicians on a scale from 1 to 10.

	Tempo	Dynamics	Cueing	Articulation	Beat Pattern	Interaction
C3	8.3	7.34	8.39	4.86	7.04	5.7
Aha!simo	7.92	7.67	7.96	1.63	6.29	5.79
GUS	9.52	3.12	6.6	3.28	9.04	7.28

7. Some Challenging Issues

This section illustrates some course related challenges we met.

A. Class schedule

This course involves students from 4 different departments in 3 different schools. It is extremely difficult to find a common time to fit majority of the eligible students for this class. The same situation is true for the 4 instructors. Due to the time conflicts with other required courses for engineering students, only 3 mechanical students were able to sign up for this class for the semester of Fall 2009, although quite a few engineering students would have liked to attend this class.

B. Student Evaluation

In almost all universities (including ours), all instructors are required to be evaluated by students through filling out a standard computer-readable evaluation form within the last two weeks of the semester. This was not an easy task for an engineer and non-engineer collaborative teaching course. We have 4 instructors from 4 different departments. It is meaningless for students to fill out one form for all instructors. However, student evaluations are usually required, and they play a vital role in the tenure and promotion process for undergraduate institutions like ours. We have not yet figured out an effective solution to this problem. We adopted a tedious method: students filled out four copies of the same form (i.e. one for each instructor). A member of the staff helped us to administer this process and collect the forms for each instructor.

C. Students' Different Background

This course was an upper level elective course. Both robotics and computer science topics require math, classical mechanics or a programming background through prerequisite courses. But Arts students do not have these backgrounds. Balancing the depth of knowledge of our students was a challenging task. Since class time proved insufficient, we provided extra tutorial sections/office hours for Arts majors to fill the background gaps, and recap and explain in more detail certain parts of the lectures.

D. Instructional Style

Instructional styles in engineering and the arts are quite different due to the fundamental disciplinary difference on topics to be delivered. Arts students felt the lectures were tough and boring when engineering/science topics were delivered by engineering/science instructors. These topics were usually introduced in terms of definition/concept/principle and explained through logic derivation and application examples with proper math background. At the same time engineering students thought they learned little in Arts topics as these were usually introduced through students' discussion in class and often there was no right or wrong answer.

E. Subjective Grading Assignments

The judgment and baseline for a good written report is different from engineering and the arts. For engineering majors, a good report is a data-driven, fact-based, and concisely written technique report. For arts majors, a good report is a detailed "story-telling" style argument and analysis. In our case, we required a 20-page writing report detailing student projects from the design phase to prototyping and testing. We (the four instructors) graded all the reports individually, and realized the challenge when we met to discuss the grades. We ended up adjusting our individual grades after each instructor's deliberations on each report. Students received an average score.

8. Course Sustainability

A. Sustainability Plan

Phase 1: Course implementation
The first phase is to implement the proposed course addressing the knowledge, logistic and administrative challenges raised by such collaboration. We successfully offered this course in Fall 2009 and document our results in this article.

Phase 2: Data collection, evaluation and improvement
This course will be offered four times, in four consecutive semesters (including the first offer in Fall 2009). This arrangement is agreed by our college and ensured by our NSF grant. We will keep collecting and evaluating data, and improving the course in each offering. By offering it for

four consecutive times, we believe that we will be able to collect enough information to improve it and shape it into a sustainable course.

Phase 3: Dissemination
Disseminable lecture notes and class handouts will be developed during this phase.

B. Project building materials

Another strategy we used to sustain this course is to adopt commonly used (inexpensive) hardware and software for developing the non-human conductors. The hardware can be reused, and the software is commonly used in the corresponding disciplines. They are listed as follows.

- Robotics kit: Lego Mindstorm NXT, VEX robotics kit
- Animation Software: Maya
- Music Midi software: Logic, Finale
- Programming languages: C, Matlab, Processing

The goal of this class is not to develop a professional or commercial product. The non-human conductor serves as a vehicle to create the proposed interdisciplinary environment. The above hardware and software is satisfactory for the purpose of our course.

At our college, we had several successful examples on sustainable interdisciplinary courses.

9. Conclusion

The development and practice of an interdisciplinary course involving engineering, science and the arts are presented in this paper. The achieving of course objectives is confirmed by four types of assessment results and the prototype demonstrations. By creating this interdisciplinary course, we introduced an innovative educational approach that fostered and rewarded creativity in teaching, learning and problem-solving activities. The experience and practice gained through this course could improve one's understanding on effective approaches to teach interdisciplinary courses in undergraduate collaborative learning environments. Using what we learned from this first offering, we will team teach this course again in the semester of spring 2010.

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