Interdisciplinary Project Experiences: Collaboration between Majors and Non-Majors

Debra L. Smarkusky
dls102@psu.edu
Information Sciences and Technology

Sharon A. Toman
sat11@psu.edu
Music Department

Penn State University
Dunmore, PA 18512, USA

Abstract

Students in computer science and information technology should be engaged in solving real-world problems received from government and industry as well as those that expose them to various areas of application. In this paper, we discuss interdisciplinary project experiences between majors and non-majors that offered a creative and innovative opportunity for collaborative learning. Active-learning exercises allowed students to express their creativity and apply concepts learned from each discipline. Feedback from this effort resulted in the development of the Seven C's (Competencies) for collaborative learning that were ascertained for successful completion of an interdisciplinary project. We feel that these interdisciplinary and collaborative efforts increased student appreciation, enhanced team skills, and created a positive learning environment for the application of concepts.

Keywords: Collaborative Learning, Interdisciplinary Project, Team Skills, Technology, Music

1. MOTIVATION AND RELATED WORK

Collaborative learning is effective in academic development because it engages more students with the subject matter. By replacing the traditional lecture style delivery method with team-based learning, students in an introductory computer science course showed significant improvement in retention rates, enhanced programming skills and increased confidence in their ability to program (Lasserre & Szostak, 2011).

To enhance individuality and diversity, Falkner and Munro created a collaborative learning environment in an introductory computer science course where faculty worked with students to set goals and tasks, establish processes to solve an authentic problem, engage and motivate students to work together and focus on problem solving as the task for constructing collaborations to develop social support structures (Falkner & Munro, 2009). As a means to share discoveries, perspectives and technical skills, researchers have discovered a growing interest in computational thinking at the university level to support exploratory and innovative computing research. By utilizing computational thinking, students can focus explicitly on interdisciplinary collaboration, leverage computational methods, and work "collaboratively to design tools that will let team members express themselves directly in computational terms and explore their own computational questions" (Stone, 2008).

Within the environments of pair programming, problem solving and agile software development projects, McKinney and Denton noted that their students demonstrated "deeper learning, developing skills wanted by industry, having fun, higher retention, higher achievement, higher course success rates, higher interest, and higher sense of belonging" as benefits of collaborative learning (McKinney & Denton, 2006). The completion of an international collaborative project between students from two schools with varying backgrounds and cultures, provided an opportunity for building trust and solidarity while focusing on project management, distribution of efforts and communications (Laxer, Daniels, Cajander & Wollowski, 2009).

To enhance individual foundation principles and increase success in future team projects, Coleman and Lang recommend the teaching of communication skills, small group interaction and collaborative projects that meet the following project guidelines (Coleman & Lang, 2012):

- *Supervised assignments either assigned in class or in a laboratory give teams mutual accountability.*
- *Assignments that revolve around a single concept provide student teams with a shared understanding of their task.*
- *Pair-programming limits the complexity of the team mechanics and results in a collectively-produced product.*
- *Time is set aside for reflective discussion of team experiences, so that elements that drive team success are highlighted.*

Salgian developed a "Conducting Robots" project where students majoring in computer science, mechanical engineering, interactive multimedia and music designed and developed a robotic and graphical conducting system to direct an orchestra and provided an opportunity for students to focus on critical thinking, creative problem solving, and computational thinking skills (Salgian, Ault, Nakra, Wang & Stone, 2011). Glasser asserted that: being active while learning is better than being inactive. Most people learn only 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they talk over with others, 80% of what they use and do in real life and 95% when they teach someone else (Glasser, 1998).

Interdisciplinary collaboration provides opportunities for innovation, problem solving and increased technical abilities. The motivation for this paper was to create a learning environment where majors and non-majors would need to collaborate for the successful completion of a project. In this paper, we discuss the interdisciplinary project definition with information about the Information Sciences and Technology (IST) majors and students enrolled in a Music Theory - General Education Arts course who participated in teams for the completion of the project. We share team process requirements, collaborative learning experiences and describe the Seven C's (Competencies) for collaborative learning that resulted from this effort. We conclude with student comments, feedback and reflection from a faculty perspective.

2. INTERDISCIPLINARY PROJECT

This collaborative learning experience was an interdisciplinary project between IST majors enrolled in a Distributed Computing course and students from various majors enrolled in a Music Theory course, as shown in Figure 1. Unlike other projects discussed in the literature that assessed projects assigned to students in specific majors, this project was unique in that it was completed by IST majors working with General Education students.

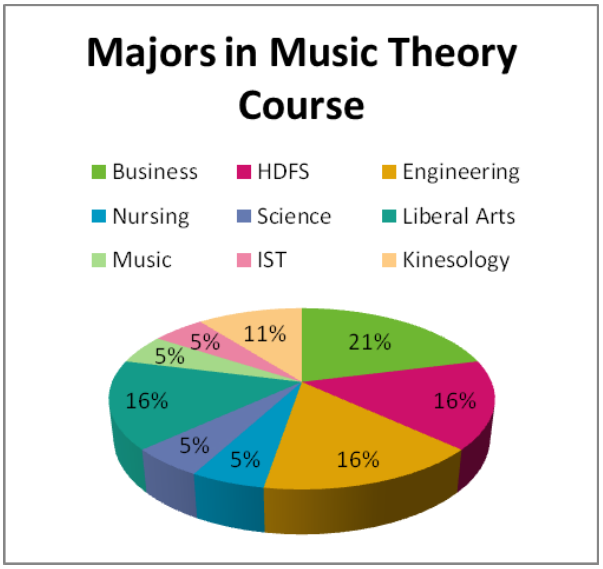


Figure 1. Majors in Music Theory Course

Project Definition
For our project, the Music students were tasked with creating digital musical scores and the IST students were tasked with writing Java applications for robot movements that when coalesced would complete a robot dance where the movements of robot couples were synchronized to the rhythm of the music (Smarkusky & Toman, 2013). The design and implementation of the choreography would be the bridge between discipline areas.

A goal of this project was to utilize the seven principles for good practice in undergraduate education as presented by Chickering and Gamson, shown in Table 1 (Chickering & Gamson, 1987).

Encourages contacts between students and faculty.
Develops reciprocity and cooperation among students.
Uses active learning techniques.
Gives prompt feedback.
Emphasizes time on task.
Communicates high expectations.
Respects diverse talents and ways of learning.

Table 1. Seven Principles for Undergraduate Education

The project was planned well in advance with courses being offered on the same days, same time slots, and in proximity to each other on campus for the spring semester. Both the IST and Music courses were taught in computer labs for the completion of individual and joint efforts. The syllabi for each course contained the dates on which students would be working on individual assignments and meeting with students from other disciplines for completion of the project. The faculty members teaching each course were present during all individual and joint meetings to assist students when needed. Additional office hours and lab times were scheduled during the project to allow students ample time to meet with team members and work on the project.

Faculty asked students in their specific courses to challenge the students in the other discipline. We wanted students from each discipline to be well-prepared for the project, so both faculty members utilized active-learning exercises to expose students to the respective music theory, animation and programming components that together would provide the foundation for this project.

Technologies
For the music component of the project, we elected to utilize Sibelius (Sibelius, 2012), a sophisticated music notation software for composers and arrangers that can be utilized by beginners and students with a small learning curve. Its user interface is task-oriented and allows users to have the ability to create and edit a musical score. For the creation of the robot dance, IST students utilized the LEGO® MINDSTORMS® NXT (The Lego Group, 2012) with leJOS NXJ (leJOS Team, 2007), since it utilizes the high-level Java programming language, supports object-oriented programming, and provides students with an opportunity to use open source software. Applications can be developed using the NetBeans (www.netbeans.org) or Eclipse (www.eclipse.org) Integrated Development Environment (IDE) with available plugins for both environments. Students used the respective software applications to realize a design in music or choreography and implement a solution. Iterative development coupled with various forms of visual and audio feedback enhanced the student learning experience.

Assessment
The grading criteria for the project was based on the correctness and completeness of technical requirements for each discipline, with each team dependent upon the choreography for success and integration of the final project. The digital music scores, created by the music students, needed to include correct staves, key signature, time signature, notes, rhythmic durations, slurs, expressive and tempo markings, dynamics, musical symbols, correct number of measures repeat signs, etc. The Music students were also required to incorporate additional instruments to the basic piano score included flute, clarinet, trumpet, saxophone, guitar, bass, and drum set.

Although the choreography was initially designed by the Music students, it was the responsibility of the IST student to ensure that the dance moves were creative, complicated and complex while remaining synchronized to specific timings and movements within the music. For the IST students, the grading criteria for the animation component of the project was based on the creativity and complexity of the choreography for two robots; synchronization of movements between two robots; synchronization (timing) of movements to the music file for both robots; overall appearance and quality of the choreographed dance for the two robots; and submission of project deliverables. These assessment criteria for the music and animation components were provided to the students to help identify the roles of each team member, provide a guideline for project success, and promote a positive learning experience for students in an interdisciplinary team.

Majors and Non-Majors

The project included eight students in the Distributed Computing course and nineteen students in the Music Theory course. All students enrolled in the Distributed Computing course were majoring in Information, Sciences and Technology and were required to complete this course to satisfy a requirement for the major. All of the students enrolled in the Music Theory course elected to enroll in this course to satisfy three credits of the General Education - Arts requirements. The fundamental guidelines for a General Education course at our university states that a course must "aid students in developing intellectual curiosity, strengthened ability to think, and a deeper sense of aesthetic appreciation" (Baccalaureate Degree Curriculum, 2012). In meeting these criteria, we wanted to excite students about the use of technology while being creative, and utilize active-learning exercises to aid in the retention of knowledge.

We selected students from each course and assigned interdisciplinary teams based on student performance from previous course assignments, complexity of assigned song, and perceived student expectations based on individual work ethics in the classroom. Each team consisted of one IST student and two or three Music Theory students. Faculty created teams and associated file-sharing space in A New Global Environment for Learning (ANGEL), our Course Management System. This shared space provide a repository for students to post and share their Sibelius files, WAV files, choreography design, and the Java source code files.

For this project, the IST students brought problem solving skills, technical knowledge and programming skills needed for the NXT Mindstorms, and soft skills from previous team projects. The Music students provided the creativity needed for the development of the choreography as well as the knowledge and creation of a musical score that includes tempo, notation, instrumentation, and style of the background music. Students from each discipline needed to utilize course concepts, knowledge, and develop combined team skills for successful completion of the project.

3. COLLABORATIVE EXPERIENCES

At the onset of the project, faculty held a joint meeting between classes to provide an overview of the music and animation requirements. Student teams and songs were assigned during this meeting with the remainder of class time used for initial team building, brainstorming of ideas, and selecting a theme for the choreography. This project included an element of creativity that allowed students from both disciplines to work together towards a common goal. By providing students with an opportunity for participatory learning and defining an assessment that included a set of learning objectives linked to grading criteria, we could level the playing field for different types of students (Carter, Bouvier, Cardell-Oliver, Hamilton, Kurkovsky, Markham, McClung, McDermott, Riedesel, Shi & White, 2011).

Similar to the experiences of students in an international collaborative project (Laxer et. al., 2009) and a conducting robots project (Salgian, et. al, 2011), our students were initially apprehensive about the project and how it would proceed because they were working with students from other disciplines. Before student teams were introduced, Music students were intimidated by the IST students whom they referred to as the "smart" students. After the initial team meeting, the confidence level of the Music students increased because they soon realized that the IST students didn't have the required knowledge to create a digital musical score and also didn't feel comfortable designing the choreographed dance. Similarly, the IST students realized that the Music students didn't have any knowledge about software development or how to program the robots to implement the dance routine. The choreography and digital musical scores created by the Music students would stipulate the parameters of the robot dance that was to be implemented by the IST student. To enhance the choreography and synchronize the movements to the digital musical score, the Music and IST students would need to work together as a team and integrate concepts learned in both courses.

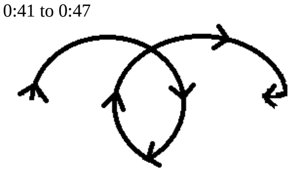
Progression

For the first three weeks of the project, the teams in the music course worked diligently to complete the digital musical scores that would be the background music for the robot dance and establish an initial design of the choreography that would be implemented by the IST students. While the Music students were implementing the musical score, the IST students were becoming familiar with the LeJOS platform, Bluetooth communication protocols, and the movement capabilities of the NXT robots. As part of their curriculum, our IST students had previous team experience and were familiar with competencies for team performance (Smith & Smarkusky, 2005). We encouraged the IST students to utilize these skills to mentor the Music students as most of these students were freshmen or sophomores and had little experience with team projects or the associated expectations for successful team performance.

During the final phase of the project, both Music and IST students further defined the dance routine to include forward and backward movements, right and left turns, box steps, spins and arcs. A snippet of choreography is shown in Figure 2. Together the IST and Music students observed the robot movements, listened to the music, and precisely documented the start/stop times for each movement as they followed the design of the choreography. Knowing that the timing of the movements was

3) 0:33 to 0:40
- Spins clockwise/counterclockwise then [stops back to back 45 angle]

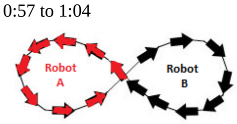
4) 0:41 to 0:47



5) 0:48 to 0:50
- Quickly comes forward together face to face

6) 0:51 to 0:56
- Backward arc moving away

7) 0:57 to 1:04



[Final position stands as 45 degree angle]

8) 1:05 to 1:12
- Backward Arc

Figure 2. Snippet of Choreography for Robot Dance

critical to the quality of the dance, the IST students worked on the project during class meetings and additional lab hours to realize the movements of the dance with the robot couples.

Team Building

By adapting the Tuckman model to represent that the skill level of a team will generally increase, and the enthusiasm of the team will fluctuate during life of the project, Largent and Lüer showed this model was an effective tool to teach teamwork and monitor team development (Largent & Lüer, 2010). As our interdisciplinary teams worked side-by-side on the completion of this project, we perceived the collaborative learning between interdisciplinary members. Students started using a common language to describe the dance steps, assigning tasks, setting deadlines, planning for future changes, and working together as a cohesive team.

Similar to the objectives for team skills defined by McKinney and Denton for introductory computer science students which included "communicate with students and faculty about course concepts and practices; cooperate with a team in an effort to solve problems and develop software; and demonstrate a strong work ethic by attending class and participating fully" (McKinney and Denton, 2006), students in our courses utilized these skills and others for the successful completion of the project. Teams were very excited about the outcome of the robot dance project and would often stay after class to work on their projects so that their dance would be better than other teams. During this process, the IST student appreciated the time and effort that the Music student had put into the digital musical score and the choreography, and the Music student appreciated the attention to detail and knowledge that was shown by the IST student for the implementation of the robot dance.

The Seven Competencies

Since our project was an effort between majors and non-majors, we conducted a survey to gather information from a student perspective to determine a ranking among team competencies with regard to the successful completion of our interdisciplinary team project. All 27 students (19 Music and 8 IST) completed the survey. The Seven C's (Competencies) for Collaborative Learning that resulted from this survey are shown in Table 2 of the Appendix. This table includes the Seven C's (Competencies) with associated description, number and percentage of students that identified each competency as having an impact on the success of the interdisciplinary project.

All students (100%) agreed that **Communication**, both written and verbal, was the most important competency. Students utilized various diagrams and written step by step descriptions for the definition of the choreography. **Commitment** ranked second (88.89%), with students needed to have a strong work ethic and dedication to the completion of the project. **Cooperation** (70.37%) and **Comprehension** (66.67%) ranked third and fourth, respectively. Being an interdisciplinary project, students needed to cooperate on the completion of the choreography and yet have respective knowledge in their own discipline for a quality integration of effort.

Requiring students to complete technical requirements for projects in each discipline, students from each course needed to be held accountable. Since students had an understanding of the time required to complete each task, students needed to take responsibility for their individual contributions. Students indicated the importance of a leadership role and motivating others to deliver an integrated quality product. Students relied on trust between team members for the successful completion of the project within the stated deadlines. These collaborations resulted in identification of **Contract** and **Command** at 59.26% and 55.56%, respectively. Due to the creative nature of this project, 51.85% of the students responded that **Creativity** was a critical factor in the successful completion of the robot dance project. At the end of the project, all students were proud of what they accomplished and satisfied with what they had learned.

4. FEEDBACK AND REFLECTION

The majority of the feedback that we received from students was positive. Students indicated that they enjoyed using robots as an area of application and working with other majors. Student feedback included phrases that included "fun and challenging", "being able to let loose", "fun interesting team dynamic", "well organized", "a fun experience where I got to experience everything I learned", "allowed you to be more creative and work with people you did not know", and "unique and interesting project". The only negative comments that students included were that they wished they had more class time to work together on the project and students from both disciplines requested that they would like to have more involvement, even if just at an introductory level, in the completion of tasks for the opposite discipline.

Additional feedback from the students was collected via the completion of a survey using a 5-point Liker Scale (where 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, and 5 = Strongly Agree). The percentage of positive responses include all responses with Agree with Strongly Agree and indicated that 92.59% of the students thought this project was a creative learning experience, 88.89% of the students enjoyed working with students in other disciplines, 96.30% of the students felt that both Music and IST students worked together as a team to create a successful and complete project, and 88.89% of the students would recommend offering this project again to Music/IST students in the future.

Overall, this project was a success. Students felt that they were able to incorporate the content learned in both courses into the robot dance, to include the background music, choreography and the implementation of the movements using Java. We noted that students were encouraged and wanted to ensure that their final project was complete and of high quality, especially since their projects would be demonstrated to class members and invited members of the campus community.

Although we grouped teams together based on previous academic assessments, complexity of song and student expectations from previous exercises, we noticed that teams of average performers seemed to work better as a whole, were more creative, and seemed to have more fun with the project. We previously discussed student apprehension and varying team project experience among students. To address these concerns, we plan to incorporate several team building exercises during the initial joint meeting between classes to enhance team building and establish expectations for each member of the team based on the Seven Competencies that were identified in this paper. We hope these exercises will provide students with a common foundation for which majors and non-majors can enhance their knowledge of collaborative learning. We look forward to providing additional interdisciplinary, innovative and challenging learning opportunities for our students.

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APPENDIX

Team Competency	Description	# Students	Percent
Communcation	Students effectively used written or verbal communications to interact, ask questions, and convey information with faculty and students during all phases of the project.	27	100.00%
Commitment	Students were dedicated to completing the project and showed a strong work ethic via active participation during course and team meetings.	24	88.89%
Cooperation	Students worked together as a team to solve problems and implement solutions.	19	70.37%
Comprehension	Students shared and demonstrated their knowledge and understanding of related subject material and concepts.	18	66.67%
Contract	Students were prepared for team meetings, completed assigned tasks by specified deadlines, earned trust of team members, held accountable for actions, and performed in a professional manner.	16	59.26%
Command	Students demonstrated leadership qualities by keeping team members motivated and focused by creating a positive team environment while moving the project forward.	15	55.56%
Creativity	Students shared original and innovative ideas, various perspectives and possibilities, and solutions that were a result of "thinking outside of the box".	14	51.85%

Table 2. The Seven C's (Competencies) for Collaborative Learning in Interdisciplinary Projects