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Multidisciplinary Collaboration on Mobile Game Development for Engineering Education

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Abstract: Traditional engineering education focuses heavily on scientific knowledge and technological training. Previous studies realized modern engineering education need to include multidisciplinary collaboration and experiences of product development cycle in this fast changing world. This paper reports an empirical study of how to run an engineering course in which students collaborated with students from the design departments of another college and anther university. Students evaluated the course favorably and the results revealed some benefits and problems.

Keywords: Engineering education, multidisciplinary collaboration, mobile games, product development, communication

1. Introduction

Traditional engineering education stresses on the technical knowledge of engineering and produces highly technically trained engineers (Jørgensen et al., 2011). But it becomes increasingly clear that consideration of social and environmental concerns, in addition to technological issues, would bring more innovation in consumer products. A product development team should involve all concerned parties of a product starting from the planning stage. Hence, Jorgensen et al. suggested a multidisciplinary approach to design and innovate education by building three basic knowledge and skills components: reflective technological engineering competences, creative synthesis oriented competences, and innovative socio-technical competences. Researchers in other countries share similar concerns, e.g., Sweden (Bergström, et al., 2007), U.K. (Baxter and Somerville, 2011), and the U.S.A. (Shah, et al., 2004).

According to a National Science Foundation report (2007) of the U.S. on engineering education, *"The context of engineering education is changing. Markets have become more international. Other countries have a competitive advantage in low cost manufacturing and services. In some countries, excellent engineers are available at one-fifth of the cost of a U.S.-educated engineer. Supply chains are increasingly integrated across companies and nations, requiring a different set of communication and cultural skills. Other countries ... have greatly increased their production of engineers. Conventional engineering work from conceptual design through manufacturing is increasingly outsourced to lower cost countries. The speed of change means that any set of technical skills may quickly become obsolete. To prosper, U.S. engineers need to provide high value and excel at high-level design, systems integration, innovation, and leadership."*

Addressing the issues raised above, the authors submitted a proposal to transform an engineering course on mobile application development by adding elements of inter-university, multidisciplinary collaboration on mobile game development. This proposal was well received and funded by the Ministry of Science and Technology, Taiwan. In spring 2013, a traditional engineering course on app programming on mobile devices, taught by one of the authors, focused on programming skills. In order to increase the motivations of students to learn more actively, most of whom like playing mobile games, the course content shifted to focus on the design of games on mobile devices. However, a successful game on mobile devices should include attractive graphics, sound effects, game story, game levels, marketing strategies, etc. Lacking these elements, the final projects of engineering students in such a course often produce boring games. On the other hand, design students can produce stunning graphic designs but might not be very skillful on programming. Hence, it is natural to put engineering students and design students to work together in a team to produce an attractive game on mobile devices.

This study involved three instructors at three different departments of two universities, namely, the Department of Electronic Engineering and the Department of Digital Media Design at National Yunlin University of Science and Technology, and the Department of Digital Design at Mingdao University. Another researcher was responsible for evaluating the issues of student collaboration. Each instructor was teaching a course at his department in spring 2015 and in spring 2016. In addition, a number of weekend workshops were scheduled for the students of these three courses throughout the semester. The students formed multidisciplinary teams to produce games for mobile devices with Unity, a popular and free game engine, as their semester projects.

This study aims to study how the engineering students felt about the multidisciplinary approach in the game design course, what benefits and problems might arise from the collaboration among students from different disciplines, and what implications the findings would have for engineering education.

2. Literature Review

2.1 Concerns of Funding Agencies

Traditional engineering training of universities pays attention almost entirely to the technical skills and knowledge of engineering. In 2004, "**Engineering Design in 2030: A Strategic Planning Workshop"** was held in Arizona and its results recommended to National Science Foundation showed that engineering training should be transformed fundamentally. Quoting from the report of the workshop (Shah et al., 2004), "Scientific needs and social importance not only drive the needs to elucidate and apply the process of design to new *products* throughout the economy, and new *processes and services* that increasingly drive the economy, but also the *organizations* that create and are the economy." Social-technical aspects should also be stressed in addition to engineering innovation and design informatics. These aspects refer to the "basic knowledge regarding how humans and social dynamics influence design that involves multiple stakeholders with wide societal roles."

In a later workshop reported by National Science Board (2007) with theme "Engineering Workshop Issues and Engineering Education: What are the Linkages", some innovative approaches to engineering education were discussed. Examples included "providing first year students with hands-on engineering and integrative experiences that involve design, imagination, and communication", "emphasizing social relevance, collaboration, and problem solving in the curriculum", "putting students on multidisciplinary and even multinational project teams". Our proposed course followed the above recommendations closely.

2.2 Similar Courses in Other Universities

Pirker, Economou & Gutl (2016) reported a pilot study that involved 24 students studying different subjects, such as computer science, law, or biology, in United Kingdom and Austria, who collaborated in a game project. Game development provides learners opportunities in going through an entire development cycle, to learn how to do team work, and to learn new skills to produce games. Preliminary results show that such programs are highly engaging for students, can improve their employability, have a good learning outcome, and increase their motivations in doing international collaborations. Our study was similar but did not involve international collaborations so the collaborating students in our study had more face-to-face meetings than the subjects in the international collaboration between UK and Austria. Our study was done at a lower cost, which was an important consideration.

Bourdreaux at al. (2011) reported a game development class offered by the Computer Science department at the University of Louisiana at Lafayette (ULL). Multidisciplinary students in the course teamed up to develop 3D video games for personal computers as term projects. Depending on their background and interest, they served as programmers, artists, and musicians in the teams. A rendering machine called Ogre was used as the game engine. The characters used in the games were created with modeling software such as Maya, Blender, and Milkshape. Each team chose a leader, who assigned tasks to members and dealt with conflicts, and monitored tasks to meet the deadlines. Another member of each team was appointed as an artist liaison, who was responsible for spelling out the requirements of art or music assets needed by the programmers. Students' evaluation of the course was very positive.

There are several differences between our study and that at ULL. Our students worked with Unity for mobile devices while the ULL projects were done with Ogre for personal computers. In addition, our students were taking one of the three collaborating courses so there were a sufficient number of programmers (two to three) and graphic designers (two to three) in each team and there were about a dozen teams providing an atmosphere of in-class competition. Moreover, our students came from two universities about 30 km apart and they generally chose to chat online with social media such as Facebook instead of traveling to meet face to face. The group dynamics were different from those of face-to-face communication in the ULL course. Nevertheless, there were several weekend workshops providing face-to-face meetings for all students throughout the semester. In order to encourage good collaboration among students, the instructors had to work closely with each other.

3. Empirical Study

An empirical study of the three courses were done in spring 2015 and spring 2016. It involved three courses taught at three departments of two difference universities for this spring semester. The first course was "programming for mobile apps" offered by the department of electronic engineering with 17 students in spring 2015 and 32 students in spring 2016 at NYUST. There were three instructors for the course. In the first four weeks, game designs on PC and mobile devices were discussed and students learned some basic concepts and terminology of video games. In the next nine weeks, they learned the user interfaces and assets of Unity and writing animation and interaction scripts with JavaScript. In the last five weeks, they learned about android programming in spring 2015 and WebGL programming, which provided more training with JavaScript programming in spring 2016.

The second course was "game planning" offered by the department of digital media design, College of Design, NYUST with 23 students both in spring 2015 and 23 students in spring 2016. These students were generally well trained in graphics design, e.g., 3D models in Maya, but they had little knowledge of Unity. The third course was "game plan and marketing" offered by the department of digital design with 25 students in spring 2015 and 20 students in spring 2016 at MingDao University, which was about 30 km away from NYUST. They were well trained in graphics design and game planning with some experiences of Unity from previous courses. The students taking these three courses were asked to form teams of four to six members from at least two of the three courses. Each team was asked to design and implement a game using Unity for mobile devices such as smartphones or tablets by the end of the course.

In addition, four monthly workshops were held for all students in both semesters from March to June. In the first workshop in spring 2015, students became acquainted with each other by playing group games and chose their team members for the term project. In the second workshop, students did one page design by changing the rules of a board games. In the third workshop, each team reported the progress of the term project. In the final workshop, they presented their projects.

In the first workshop in spring 2016, students formed teams just for the workshop to design a board game with paper. Then the students were asked to form teams for the term project within two weeks and each team started to design a mobile game. In the second workshop, each team presented their game proposals and the course instructors commented on their proposals so that they could improve their design and implementation. In the third workshop, all teams reported their progress while in the last workshop, students presented their projects. At the end of each workshop, students filled in questionnaires about their team dynamics, e.g., trust, responsibility and communication.

In order to let students form teams earlier, a winter workshop was offered in 2016 before the semester began. Candidate students of the three courses were asked to take part in a 3-day winter workshop in January 2016 that involved training on game design and collaboration to design and implement a game prototype using Construct 2. The rules for team formation in the workshop was similar to the rules used for the semester project. About two thirds of the students of the courses participated in the winter workshop.

4. Results

The course was offered in three semesters in 2013 spring, 2015 spring and 2016 spring. In the last two semesters, multidisciplinary collaboration was adopted and the instructors were experts from engineering and game design. The statistics of the official course evaluation for the three courses were shown in Table 1. Each item of the evaluation provided five choices depending on how a student agree with the item. The choices correspond to the scores of 5 (strongly agree), 4 (somewhat agree), 3 (it is ok), 2 (somewhat disagree), and 1 (strongly disagree). Each item showed a rating averaged over all students who filled in the evaluation. The results showed that the re-designed course offered with multidisciplinary collaboration and multidisciplinary instructors, where the average scores of 4.47 (2015S) and 4.56 (2016S) compared to 4.01 (2013S), was much better received by the students.

Table 1: Summary of course evaluation of the app course in three semesters.

Semester	***2013S***	***2015S***	***2016S***
No. of students	19	17	32
Multidisciplinary collaboration	No	Yes	Yes
Multidisciplinary instructors	No	Yes	Yes
Questionnaire items (Max score = 5)	***Score***	***Score***	***Score***
Good quality of instruction materials	3.89	4.50	4.56
Good clarity of instruction	3.89	4.56	4.5
Smart pedagogy	3.74	4.56	4.53
Good progress monitoring	3.79	4.44	4.47
Good fitness of assignments	3.89	4.50	4.44
Good fitness of grading	4.16	4.50	4.53
Good attitude of instruction	4.21	4.50	4.56
Good quality of instructor-student interaction	4.26	4.50	4.59
Good promotion of learners' motivation	4.05	4.38	4.56
Instruction tailors to the background of students	3.79	4.38	4.53
Respecting students responses	4.05	4.50	4.53
Enthusiastic in answering student questions	4.21	4.56	4.63
Good after-class assistance to students	4.21	4.38	4.56
Course benefits students	4.05	4.44	4.56
Good overall quality of this course	4.00	4.31	4.56
Average	4.01	4.47	4.54

5. Discussion and Conclusion

With years of experiences of teaching an engineering course on mobile application development, we learn some important lessons for how engineering education can be done and should be done. From the results of the course evaluations, the course was much better received by students when offered with multidisciplinary collaboration and multidisciplinary instructors in 2015S and 2016S. Items as "smart pedagogy" and "fitness of assignments" were about 4.5 compared to about 3.8 in 2013S when no multidisciplinary approach was used in the course.

Comparing the two semesters 2015S and 2016S, the course scored slightly higher in 2016S than in 2015S. There were two possible factors. The first was that the instructors of the course became more experienced so that the course was better organized in 2016S. The second factor was possibly the extra pre-course winter workshop before the course began in 2016S. The winter workshop helped the students from different colleges and different universities got acquainted with each other before they chose the partners of their project teams. This helped some teams to form earlier and got a head start in their projects. The projects produced by these teams were generally more interesting than those produced by the teams which were formed later and less active in working on their projects.

There were other more qualitative results from this study. From students' responses, their collaboration in a team improved their self-efficacy, which should help innovation. This worked even for average engineering students who thought their programming skills ordinary before doing the team project, since they felt their programming skills made a difference in team work. In collaboration, they felt some pressure, but not too much of it, and they trusted their partners, which could lead to better performance.

Since it might not be convenient to meet face to face due to distance or schedule conflict, students generally relied on online tools such as Facebook to discuss their projects. However, they still preferred to meet face to face if possible. Students confessed there were misunderstandings and arguments during discussion, but most of these problems were finally resolved. When asked to weigh two factors in their success in completing their team project, they thought collaboration was more important than their expertise.

Inspired by the findings of this study, several directions are suggested to enhance engineering education. First, in their collaboration, students need to solve problems not only from a programmer's perspective but also to consider the graphics designer's perspective. Such multidisciplinary thinking, lacking in traditional engineering education, is needed badly. Second, creativity and innovation are also called for in order to solve complex problems by considering multiple viewpoints. Game design trains engineering students to design, build, test a game repeatedly until a set of criteria are met. This is in accord with the current maker movement that is believed to cultivate creativity and innovation (e.g., Hagel et al., 2014; Martin, 2015). Third, engineers must learn to explain difficult concepts to audiences from different disciplines who might have biases and misconceptions. By collaborating with designers, engineering students learn to communicate and collaborate with people outside the engineering circle. To summarize, engineering education should include more training on multidisciplinary collaboration, creativity and innovation, and communication by providing students more opportunities in doing projects such as the ones exemplified in this study. For example, collaboration projects can also be done on machine designs that involve mechanical engineering and industrial designs, or on maker projects that involve electronic engineering and physical therapists to help patients with physical disabilities.

Several directions are suggested for future studies. First, the progress of the term projects can be monitored more closely by the instructors so that problems can be identified and resolved in time. Second, experienced professionals can involve in the term projects from the beginning and provide more feedback to students. This would make the projects more realistic and similar to authentic product development in industry. Finally, international collaboration can be considered.

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