Interdisciplinary Collaborative Teaching in Project-Based Learning Approach

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CONTEXT

It is common for Engineering and Technology programs to nurture interdisciplinary courses when aspirant graduates need comprehensive knowledge and skills to start working even before their graduation. These hybrid courses usually demand collaborative teaching to ensure high expertise of educators to provide for requirements of different disciplines. The Bachelor of Information Technology and the Bachelor of Electrical and Electronic Engineering are two disciplines with close bonds between hardware and software. The course design, implementation and evaluation should be reported to reflect good practice from collaborative teaching in an interdisciplinary environment.

PURPOSE

The study details the process of designing and implementing an interdisciplinary collaborative teaching in Project Based Learning (PBL) approach, and reflects on its benefits and drawbacks for both educators and students.

APPROACH

A reflection was done on the teaching practice for course alignment, preparation and delivery based on teaching journals. As for students' evaluation of the course, a post-course survey and focus group interviews were conducted. Also, an analysis of the results of students' learning outcomes (acquired course learning objectives, students' perception of the course, and their product showcase) was carried out to present the advantages and disadvantages of the course.

RESULTS

The alignment of course learning outcomes, course structure, and assessment were demonstrated. The findings showed that students succeeded in achieving the course objectives and felt positive about the course as a whole. Although, students' interviews revealed some drawbacks of the collaboration, it did not significantly impact the students' learning. Besides, the collaboration of lecturers was generally a success, but still recommendations were given for the improvement of the course delivery.

CONCLUSIONS

As regards the course design and delivery, more attention is needed in aligning and communicating to students about learning outcomes and assessment of different disciplines. As for the course benefits, authentic project work was facilitated with interdisciplinary group formation encouraging more engagement and self-learning among students.

KEYWORDS

Interdisciplinary learning, project-based learning, collaborative learning, collaborative teaching

Introduction

Project-Based Learning (PBL) enables industry authentic projects and increasing students' exposure to real-world working environment (Johns-Boast & Flint, 2009). Although PBL approach was introduced in education in early 70's (de Graaff & Kolmos, 2007), when it involves different disciplines, challenges arises in designing collaborative interdisciplinary activities, and most importantly aligning the learning outcomes and assessments for groups of students in different majors. An endeavour was conducted at RMIT University Vietnam in 2015 in PBL courses for the Bachelor of Information Technology (BIT) and the Bachelor of Electrical and Electronic Engineering (BEEE). The goals of these two courses were to provide students with knowledge and skills in working with the two closely related parts of a technological project: hardware and software, as well as learning project management. The affinity in the learning outcomes (CLOs) of two courses as stipulated by the school program and no requirement of prerequisites for these two courses allowed their integration into one class.

Background theories

To lay the foundation for understanding the PBL courses delivered to interdisciplinary class with collaborative teaching, relevant theoretical points will be reviewed below.

Interdisciplinary learning

Interdisciplinary collaborations in education are more and more common not only in closely related majors (e.g. arts and humanities or IT and engineering) but also between courses from different disciplines that hardly share any expertise like medical and legal (Morton, Taras, & Reznik, 2009), or even medicine and architecture (Mason & Pirnie, 1986)

The benefits of interdisciplinary learning are shown by a study of Abdulhalim, Sammarco, Jayasekera, and Ogbonna (2011) which describes how students from different majors benefited in sharing and learning from different perspectives, complementing each other's expertise, bridging the gap between research and practice, enhancing communication skills, and exploring knowledge and experience outside the course. Moreover Davies, Devlin, and Tight (2010) argue that higher education which "acknowledges the challenges and possibilities in interdisciplinary ways of thinking learning, knowing and being" aims at producing graduates with the ability to "recognize, reflect on and negotiate different forms of knowledge" (p. 24). Meanwhile, Borg and Borg (2001) assert that critical thinking skills are promoted when students involved in working out the differences between two disciplines to collaborate with each other. Beyond that understanding, students are believed to develop their leadership and communication skills, presentation skills and confidence, to make their learning purposeful and thus to succeed at university and later in life (Anderson, 2010).

Generally, due to the discrepancies in different disciplines, interdisciplinary courses require instructors to master different expertise; therefore, the necessity of collaborative teaching is manifested.

Collaborative teaching

Collaborative teaching and co-teaching are distinguished by Friend, Cook, Hurley-Chamberlain, and Shamberger (2010) in that the latter is under the umbrella of the former. However, these two terms are used interchangeably in many studies (Gerber & Popp, 2000; Speer & Ryan, 1998; Waters & Burcroff, 2007). In this study, collaborative teaching is understood as co-planning, co-assessing, and mixed delivery between individual lectures and joint managements of tutorials and students' presentations.

Collaborative teaching presents indisputable benefits. Besides the advantages of shared expertise, insights, new approaches, perspectives, and peer-feedback, lecturers can combine strengths and reduce weaknesses (Buckley, 1999). Also, when sharing the teaching task for a class, collaborative lecturers can be satisfied with increased students' academic achievement, improvement of teaching skills as well as collegial relationships (Walther-Thomas, 1997), and understand the position of the subject in reciprocal relation with others (Zhou, Kim, & Kerekes, 2011).

However, collaborative teaching is also loaded with different challenges such as the coordination of lecturers' schedule for co-planning, the heterogeneity of students in each class, and the provision of specialists' support, heavier administrative support, and sponsor for staff development (Walther-Thomas, 1997), the lack of time for class preparation (Goldstein, 1967), the inconsistency of emphasis on learning materials and assessment components (Carter, Barrett, & Park, 2011), and students' confusions of different lecturers' expectations (Dugan & Letterman, 2008). Therefore, endeavouring collaborative teaching can be a challenging mission for both novices and veterans.

Project-based learning

Project-based learning is the instructional approach emphasizing the learners' autonomy in a learner-centered environment where they realize ideas in projects (Krajcik, Czerniak, & Berger, 1999). In PBL courses, students' personal interests are encouraged (Wurdinger & Qureshi, 2015), so they are motivated to be greatly engaged in the learning process and thus make use of their strengths, and overcome their weaknesses in the effort to jointly create authentic products. Moreover, learner-centeredness embedded in PBL entrusts the lecturer as a facilitator, coach, advisor, and motivator besides his traditional role of a lecturer of the class (Chua, 2014; Montequín, Fernández, Balsera, & Nieto, 2013). Also, because project-based learning approach does not only teach students academic knowledge but also trains them a variety of soft skills (Chua, 2014), assessing a PBL course often requires the weighing of the following skills: individual work versus group work, cognitive skills versus metacognitive skills, knowledge versus soft skills and done as formative assessments scattered during the course and filled with the teachers' feedback for improvement. Students were assessed through presentations, observations, reflective journals, weekly reports, discussions, self-assessment, group assessment, and final product evaluation, some of which are combined in a portfolio for each student (Bell, 2010; Chu, Minasian, & Yi, 2012; Jaeger & Adair, 2015). This reflects the spirit of formative assessment, which is assessing for learning (Bell, 2010; Montequín et al., 2013; Strijbos & Sluijsmans, 2010).

Research Methodology

Action research was conducted in a class where a single instruction was given to two interdisciplinary courses namely *Software Engineering Project Management* (SEPM) for IT major and *Engineering Management* (EM) for Engineering major. The study aimed at demonstrating the implementation of interdisciplinary courses in PBL approach and reporting experiences of collaborative delivery from both lecturers' as well as students' general evaluation of the course. There were 30 IT students in the SEPM mainly at their final years while the 8 Engineering students were doing their first year. A reflection was done on the teaching practice to detail course alignment, preparation and delivery based on teaching journals of two lecturers instructing the course. As for students' evaluation of the course, a post-course survey for 38 students and 3 focus group interviews were conducted and analysed to reveal emerging themes. Also, students' learning outcomes shown in the achievement of course learning objectives, students' perception of the course, and their product showcase were analysed to expose the advantages and disadvantages of the course result.

Findings

Contributions of the study revolve around elaboration of the joint construction of the courses, the influences of the courses on students' learning, and the lessons learned from collaborative teaching.

Course Learning Outcomes and Contents

The two courses had different learning outcomes, yet the two lecturers reviewed them together and determined that they were compatible to enable collaborative delivery and common assessments as endorsed by their Program Manager. In particular the following learning outcomes can be summarized as: students' Teamwork, Collaboration, Communication skills, Human Management, Project Planning, Project Execution, Risk Management through which, the demonstration of critical analysis, problem identification, problem solving, decision making and team facilitation skills in managing Engineering projects.

Nevertheless, the lecturers had to align some of the courses' CLOs which were not equivalent. After analysis and comparison, apart from incompatible outcomes exclusively intended for each discipline, some were kept as shared outcomes as they were very beneficial for all students. For instance, "Software Development Methodologies", a part of the IT knowledge was introduced to BEEE students whereas the "Communication Barrier" (language, perception, environment and ambiguity) from EM was also kept for IT counterparts because those two topics were important to meet the CLOs.

For better achievement of those CLOs, the lecturers announced and emphasized them together with the course content in the first week and continuously reinforced these requirements after that.

Course delivery

With the course learning outcomes review and course content alignment above, the course structure was designed for the 12-week course, with 6 hours of face-to-face sessions per week as shown in Figure 1 below.

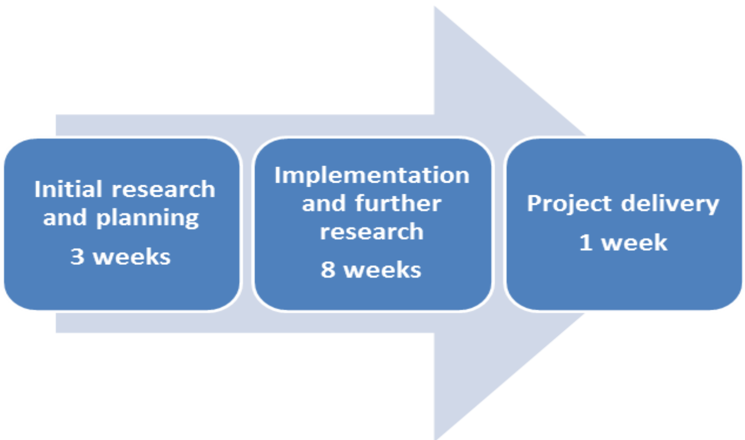

Figure 1: Course delivery structure

Each lecturer took turn to give jointly developed lectures to the combined class in a manner that encouraged students' critical thinking for working on the projects. However, both held weekly tutorials together to solve situational problems based on the project and actively managed to engage students in collaborative learning exercises. There were eight projects, namely: Gas Leakage Risk Management system, Room Temperature Management system, Smart Parking System, Refrigerator Light Management System, Online Parking system, Media Centre system, Smart Home Security and Maze Robot Solver. All of these projects required the design and implementation of complex systems including both hardware and software, which exposed the students to engineering/IT authentic situations. The final products had been designed by the lecturers and introduced to students, but the design, planning, implementation, and overall organization were figured out by each student team. However, team formation and project assignment were done by the lecturers based on the students higher education background and demonstrated strengths in their academic records in order to enhance the teams' chances for success.

In terms of group formation, mixed academic backgrounds was organized for the teams. IT students enrolling into SEPM were doing their capstone projects whereas Engineering students were conducting their first higher education projects. Each project team was constituted of 5 students with 3 or 4 third-year IT students, and 1 or 2 Engineering freshmen. The IT students, with their programming experience and skills, were carefully selected to balance the technical competency level for each group while Engineering students were expected to bring to the team their experience in working with electronic hardware. Such diversity in the background of team members was a crucial factor to which the teams must pay attention for task management where the role and responsibilities of each individual had to be specified to mitigate overlapping and conflict among the members.

Course Assessment

As these courses were the first PBL experience for both IT and Engineering students in this study, the lecturers agreed that the assessment had to be mostly formative in order to scaffold students' project management (planning, implementation and delivery) skills. The assessment scheme (see Table 1) comprised three phases; each subsequent phase built up on the previous one by having similar format and content, yet with higher complexity, providing a formative structure.

Table 1: Assessment structure

Phase	Task	Group/Individual	%	When (week)
Initial research, project proposal and planning	Report	Group	10	Week 4
	Report (individual section)	Individual	5	
	Presentation	Group	7.5	
	Presentation	Individual	7.5	
Implementation (and further research)	Report (progress update)	Group	12	Week 8
	Presentation	Individual	7.5	
	Presentation	Group	7.5	
	Peer performance evaluation	Individual	3	
Project Delivery	Report	Group	12	Week 12
	Peer performance evaluation	Individual	6	
	Presentation (Product and Showcase)	Group	22	

Impacts of the interdisciplinary PBL course on students' learning

The authentic requirements derived from PBL projects created favourable conditions for students to develop the skills intended for them through their achievement of CLOs. In particular, the majority of CLOs assessed the ability of students on project management skills through presentation, reports, peer evaluation and showcase that met requirements stated in the rubrics. According to the assessment results, students' performances provided solid evidences that they were able to meet the CLOs stated earlier. For specific CLOs related to the SEPM course, IT students were able to apply appropriate methods to their projects, which were at operational level. Moreover, the teachers' teaching journals revealed that Engineering students' communication-related CLOs were also met as they successfully coordinated teamwork, and presented their projects to the industries and other students at the product showcase. The online survey showed that both group of students (IT and Engineering) expressed overall positive learning experience. The students reported that they were intellectually stimulated during the course, which proved to support students' cognitive processes and thus enhanced self-learning and responsibility. This motivation created opportunities for students to actively search and process new information and connect it to their current understanding of the subject matter (Behizadeh, 2014; Chua, 2014; Musa, Mufti, Latiff, & Amin, 2012) rather than "passively receiving" knowledge**.** Moreover, learning from peers was highly appreciated in the interview where junior Engineering students showed interest in gaining knowledge of various programming languages, and developed complex software systems with the assistance of their IT partners. On the other hand, senior IT students, with the consultancy of their Engineering peers, explored the integration of multiple hardware components, developed software for these and had opportunities to practice leadership skills thanks to the PBL environment. Finally, in the course reflection, the lecturers supported this course setting as they confirmed that the students seemed to inquire much on the details of materials and effectively used lecturers' feedback in assessment items for improving their performance.

Lessons from interdisciplinary coordination

Despite general success of the course, a number of challenges were observed and reported from the interdisciplinary environment. The students rated the collaborative teaching lower than lecturers' expectation. It was only because students experienced confusion when they received significantly different feedback for their work from each lecturer. This problem is also reported by Dugan and Letterman (2008). It could be explained by the fact that the two lecturers had different individual expectations for the quality of work and for the student's performance in two disciplines. This confusion was acknowledged by the lecturers after some discussions with the students regarding the second assessment in week 8 and later was addressed during the delivery by clarifying and aligning expectations for students' work around the middle of the semester. To avoid similar problems, course coordinators should have reached consensus on the similarities and differences of their expectations for students of each discipline before conveying them to students. In case there are unique requirements for different courses, lecturers should split them when announcing their expectations to avoid confusion in the mixed-major class. This information should not only be dispensed at the beginning of the course but also be reiterated and emphasized throughout the course duration.

Even though it was well considered during the course development, the difference between student's levels in groups still raised many challenges to the course delivery. It has been justified that in collaborative groups, to realize their common goals as well as actions, individuals are expected to hold joint authority, responsibility, and acceptance of each other's strengths and weaknesses (Laal & Ghodsi, 2012). However, discomfort was instilled in senior team members because it was brought to the lecturers' attention later during the course delivery and tutorials that there were incidents when junior Engineering students in some groups were not able to carry out their discipline-specific tasks. Their IT teammates, therefore, had to cover the undone hardware-related tasks left by their less capable teammates. As a result, senior students commented that having junior team members hindered the team progress and considered it a challenge difficult to cope with. This happened even when the lecturers constantly gave feedback on students' performance and guidance to assist them in solving their problems. Fortunately, that experience did not discourage most students from expressing their interest in participating in such mixed projects in the future. However, to ensure a more successful course, it is advised for lecturers to organize cross team exchanges, or even a technical tutor to help the first-time PBL learners troubleshoot their obstacles to better catch up with the common pace of the whole team of mixed disciplines and capabilities.

Conclusions

The study has demonstrated CLOs alignment, course structure, and assessment scheme of the PBL interdisciplinary courses for students of IT and Electrical Electronic Engineering majors with collaborative teaching. It also proved positive attitudes from students who asserted their stimulation to learn and overall satisfaction with the course. The formation of students teams comprising students of year 1 and year 3 also showed the motivation for learning from teammates and peer-support; however, it also created trouble to somehow ensure the even performance of team members with different background knowledge. The solution to this problem may be assigning technical tutors to help poor performers or encouraged cross-team support through the class online forums. Besides, the study also pointed out the importance of the clear, and if possible, separate announcements of lecturers' expectations to students of different majors to avoid confusion in an interdisciplinary class.

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