WIP: Implementing Project Based Learning: Some Challenges from a Requirements Engineering Perspective

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***Abstract*—Project based learning (PBL) is gaining increasing traction among educational development, scholars and practitioners. The dominant argument suggests that by engaging in real world projects and research, students can acquire valuable critical thinking, team work, problem-solving, and improved communication skills. The aim of this work-in-progress paper is to investigate the effects of PBL on student performance in a requirements engineering (RE) course. Students were divided into 5 project groups; each group carried out a RE project that addresses a real-world problem. The project deliverable for each group is a complete software requirements specification (SRS) document; a user interface design; and software development project management plan. Following the completion of the project, structured feedback was elicited from the students via questionnaires. The results were combined with the final student grades to evaluate the effect of PBL on their combined performance. Preliminary results show that PBL can benefit RE courses, especially by enhancing students performance. Yet, certain challenges, e.g., stakeholders engagement and team cohesion, must be addressed before these benefits can be fully realized.**

I. Introduction

Project-based learning (PBL) is an active learning pedagogical approach wherein students acquire knowledge and develop skills by engaging in real-world projects and research [1]. These projects are usually carried out in groups or teams. Research shows that this approach can be very beneficial to students. For instance, Ruben Gonzalez-Rubi et al [2] report that PBL can help students to acquire skills and competencies such as problem solving and innovative design. Other reported benefits of PBL include supports for experiential learning; closing the gaps between theory and practice; and fostering innovation [3, 1].

On the other hand, Requirements Engineering (RE) is an important course in Software Engineering (SE) and Information Systems Curricular [4, 5]. RE helps in identifying the functional capabilities that should be implemented in software, so that the software can meet the objectives and needs of its owners as well as users [6, 7, 8]. Requirements engineering education (REE) therefore became a resource base for educating and training professionals on how to develop top-quality software products [9, 10].

Project-based learning can also be applied to benefit students in requirements engineering education. However, there are limited number of publications that have investigated the feasibility and use of PBL in REE; particularly if and how PBL can impact student performance in an RE course. If REE is to benefit from the technical and social skills offered through PBL, more empirical research are required to document the opportunities and potential challenges associated with implementing this pedagogical approach. Insights from such empirical studies will contribute to the development of content-specific framework that can support the effective adoption of PBL as a valuable learning technique in RE courses.

As a foundational step towards addressing this gap, this study investigates PBL application to a RE course by analyzing how its implementation affects student aggregate performance, reported challenges, and opportunities for improved practice. The rest of this paper is organized as follows: Section II provides a brief description of our method. This is followed by Section III where we present the preliminary results and findings from the collected data. These results are further discussed in Section IV. Finally, we conclude our research and present direction for future work in Section V.

II. Method

The aim of this research is to evaluate the effect of project-based learning on student performance in our RE course. Additionally, we are interested in knowing how factors such as student interest in PBL and stakeholder availability, affect students' performance in a typical RE course. To achieve these, we experimented on a graduate-level RE course taught in our university. This course is titled '*Requirements and Project Management (GCIS 514)*. The course covers the following learning objectives: (a) Apply tools and techniques to manage requirements from elicitation to validation. (b) Apply review techniques to ensure the quality of requirements and project management work products. (c) Develop and implement a plan for team development of an engineering application. (d) Apply risk management techniques to the development of an engineering project. We implemented project-based learning to help us achieve these objectives.

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For the purpose of PBL, we organized students in groups; the minimum and maximum number students allowed in each group are 3 and 5 respectively. Each team is allowed to decide and select a project of choice. However, the instructor must approve any selected project before students can commence work. To ensure consistency, this approval is based on the following characteristics: (i) Problem: Each project must define and address at least one real-world software requirements development problem or opportunity. (ii) Stakeholders: Each project has stakeholders with a vested interest, and thus willing to engage in the project. (iii) Scope: Each project must demonstrate a clear and defined scope that can be completed within a semester (16 weeks).

At the end of the project, each group is required to submit three main deliverables. These include software requirements specification (SRS) document; software prototype; and project management plan. To comply with the privacy requirements imposed by our institutional review board (IRB), we exclude the title and descriptions of each project. The project deliverables are assessed and graded by the instructor based on the rubrics stated in the course syllabus. In Table I, we show the grade awarded to each project group and the number of students in each group.

We collected both quantitative and qualitative data. For quantitative data, we focus on the grade for each project group, as shown in Table I. Note that these grades exclude exams, assignment, and test, since these are not directly related to project-based learning. For the qualitative data, we designed a survey with the Survey Monkey Software and made this available to the students. The response rate is 90% i.e. eighteen (18) out of twenty (20) students. The questions in the survey focus on five (5) key factors that can affect student performance in RE-project-based learning. The survey asked students to *agree* or *disgree* on whether each of these factors affected their project. These factors were identified from existing publications [11, 12], and include the following:

(a) Student interest in group projects.
(b) Students attitude towards PBL (like or dislike)
(c) Student team-interactions.
(d) Stakeholder availability.
(e) Student-stakeholder communication.

TABLE I: Students Grade Per Project

Project Groups	Grade in Percentage (%)
Group 1: 4 Students	90.6
Group 2: 4 Students	89.6
Group 3: 5 Students	82
Group 4: 3 Students	89
Group 5: 4 Students	89.3

III. Finding

In Figure 1, we present two different charts plotted from the collected data. The first chart, i.e., Figure 1a, shows students' response to the five factors listed in the last paragraph of Section II. Each of these factors corresponds to a question in our survey. For instance, the first factor above (i.e., (a): student interest in group projects), corresponds to the following question: *"I have little interest in group projects"*. For each question, students are expected to select one of the two options–*"agree" or "disagree"*. Figure 1a, shows the percentage of students that selected 'agree' and 'disagree' for each question. According to this chart, 33% of the students agree that they have little interest in group projects, but 67% did not agree to this.

Similarly, 33% of the students agree that stakeholders were not always available for meetings, while 67% do not agree. Half or 50% of the students found it difficult to communicate with stakeholders. Nonetheless, the other half say they did not find it difficult to communicate with the stakeholder. 94% of the students agree that they like project based learning and also had excellent interaction with their team members. This is a relatively large number when compared to the other 6% that do not agree that they like project-based learning and had excellent interaction with their team members.

In order to find out if or how these factors affect students' performance, we grouped the five factors by project groups and plotted these in another chart in Figure 1b. At the bottom of this chart is a Table that shows the percentage grade for each project group alongside the percentage of the students in the group that agree or disagree with each question (factor). For example, the grade for 'Group 3' project group is 82%, as seen next below the grade. 50% of the students in this project group say (agree) that have little interest in group project, while the remaining 50% do not agree, and so on.

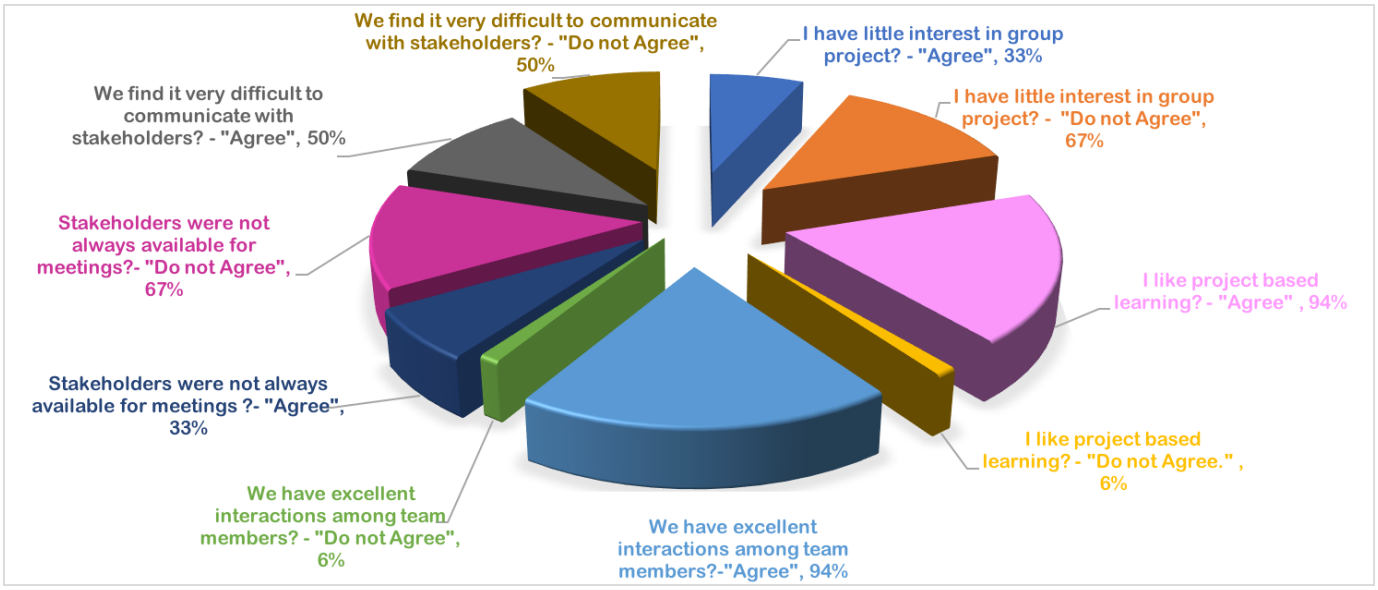
The chart in Figure 1b shows that Group 1 has the highest grade, i.e., 90.6% while Group 3 has the lowest grade of 82%. Notice that all students in the group with the highest grade, i.e., Group 1, have affirmative responses to all five questions. For the first question, *"I have little interest in group project?"*, 100% of students in this group do not agree. This means that they all have more than a little interest in group project. Similarly, 100% of these (Group 1) students also agree that they like project-based learning, had excellent interaction among team members, and did not find it very difficult to communicate with stakeholders. For the penultimate question i.e., *"stakeholders were not always available for meeting?"*, the response is the same; 100% of the students in this (Group 1) group do not agree, meaning that stakeholders were always available.

On the other hand, the Group 3 had the lowest grade of 82%. From Figure 1b, one can easily see that half or 50% of the students in this group had little interest in group projects, while 25% agree that stakeholders were not available for meeting.

IV. Discussion

Looking at the overall grades for each group, one can say that students performed very well in project-based learning. To sustain and improve on student-performance in PBL, certain challenges need to be addressed. Using the preliminary results of our data collection and analysis, we highlight and discuss these challenges in the proceeding paragraphs.

(a) Student-Stakeholder communication is a major challenge



(a) Factors that Affect Students in RE-PBL

	STEM-TSS	TREC-VMS	ATS	CSRA	GUEx
I have little interest in group project - Agree	50	66.67	0	50	33.33
I have little interest in group project - Donot Agree	50	33.33	100	50	66.67
I like project based learning - Agree	100	66.67	100	100	100
I like project based learning - Donot Agree	0	33.33	0	0	0
We have excellent interactions among team members - Agree	100	100	100	75	100
We have excellent interactions among team members - Donot Agree	0	0	0	25	0
Stakeholders were not always available for meetings - Agree	25	100	0	75	66.67
Stakeholders were not always available for meetings - Donot Agree	75	0	100	25	33.33
We find it very difficult to communicate with stakeholders - Agree	0	33.33	0	75	33.33
We find it very difficult to communicate with stakeholders - Donot Agree	100	66.67	100	25	66.67

(b) A Comparison of Students' Performance with Factors that Affect RE-PBL

Fig. 1: Charts for Data Analysis

of implementing project-based learning in requirements engineering. This finding is supported by the Chart in Figure 1a where half or 50% of the students agree that they find it difficult to communicate with stakeholders. Further research is needed to investigate the cause and exact nature of this difficulty in communication. Yet, we believe that cultural and language barriers might be key causes of this challenge. The vast majority of the students that registered for this course are foreign and non-English speaking students. For such students, communicating with English speaking stakeholders might present a sizable challenge. Nonetheless, further research is needed to investigate this.

(b) Stakeholder availability and student interest in project-based learning are two other prevailing challenges. As shown in Figure 1a, 33% of the students agree that stakeholders were not always available for meeting. Stakeholders are the owners and users of the requirements being elicited and the software being developed. Without their availability and involvement, the software will most likely be unsuccessful. RE instructors implementing or planning to adopt PBL must develop strategies to ensure that stakeholders are involved in the requirements and software development projects. Supports from instructors such as sending reminders to the stakeholders, or even attending student-stakeholder meetings can boost the morale of both students and stakeholders.

(c) Furthermore, Figure 1a also shows that another 33% of the students have little interest in group projects; this challenge needs to be addressed as 33% is a material amount of students. In practice, software requirements development is normally done in groups. Thus, its success requires a significant amount of group work and team cohesion. For students to derive the full benefits of applying PBL to RE, they need to work in groups. Only when students work in groups can they learn and acquire social skills expected from RE professionals. Further research should be carried out to investigate why a significant number of students have little interest in group projects. RE

instructors should make concerted efforts to device strategies for improving student interest in group projects.

(d) One of the challenges faced by RE instructors, perhaps in other fields as well, is how best to structure PBL to stimulate student interest in a contemporary culture that emphasizes individual merit and independent show of brilliance. Traditionally, as affirmed by responses from the least performing group, individual merits are often masked by group synergy (or lack of it). Although, better performance can be fostered if explicitly recognized at the course design phase. A key insight for RE instructors is that providing structure such as making team performance evaluation as a distinct component of individual grades can serve as an incentive for better team synergy and overall performance.

The legitimacy of scholarly claims on Project-Based Learning can only be affirmed through application and feedback gathered from participants. The overall picture from the analysis suggests perception varies across groups but that a well-designed PBL has direct correlation with student final grades in the class. In order words, the group with the highest score reports stronger internal synergy than groups with comparatively lower scores. What implications, then, do the results have for PBL implementation in RE? First, it is important to acknowledge at the outset that much of the intended benefits of PBL are premised on acquisition of soft skills relevant to the professional work environment and career development rather than technical skills and scientific knowledge derived from such technique.

Similarly, any discussion of a better implementation of PBL in RE must never lose sight of individual learning preferences and the wider issue of socio-cognitive development of individual learners. The idea that a single learning technique such as the PBL can bridge social skills misunderstands the intersectionality of individuals as unique learners. Along with the question of how instructors can support student ability to maximize PBL technique, insights into student learning preferences using existing classifications such as the Kolbs Inventory or traditional visual-auditory-tactile classification may be valuable for adapting PBL to individual class context. In addition, what is needed is a much robust dialogue of how tertiary institutions can create a peer support network atmosphere. This may involve training instructors who are considered to possess a strong skill sets for implementing PBL or who are genuinely interested in implementing PBL in a more deliberate, accountable, and student-centered way as demonstrated in our study.

V. Conclusion and Future Work

The challenges faced with implementing PBL in RE result from a significant shift in intellectual culture that promotes individual merit and a student-centered learning process grounded in constructivism. In order for PBL to remain a viable tool in RE, instructors need to create a stimulating approach that engages student interests in acquisition of the intended soft skills while also providing explicit structure that emphasizes individual contributions within a group. At least at the course design phase, attention to group dynamics must be integrated in the grading rubrics. The challenge is also whether the implementation of the course design can be maximized in practice. This suggests the need for a more institutional approach that emphasizes peer networking and state-of-the-art training in PBL design and implementation for instructors.

All these ideas, be they peer networking, administering learning preference tools or instructors training, are pointing towards a more holistic approach to PBL application in RE. These are however based on the inert acceptance of the intended benefits of PBL to REE and the observable challenges from our experience implementing the technique. Although our empirical approach is focused on a single-semester, course-based context with limited scope, the study does lay a groundwork for conceptualizing current challenges to PBL implementation in the RE context.

In the future, we intend to further investigate the preliminary results obtained from this work-in-progress. Accordingly, we will design and carry out a more robust experiment; which will include a larger sample size or number of students. This is achievable since this course is taught every semester with the expectation of increasing enrollment in subsequent semesters. We will also conduct further studies adopting a multi-year data benchmarked against non-PBL-based techniques, as this is likely to offer a much more robust engagement with the topic.

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