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Work-In-Progress: Using research-focused PBL to support computer engineering students' learning engagement in a systemic PBL environment

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Summary

Problem-Based Learning (PBL) anchors learning to special problems and enables effective teaching. The systemic PBL model which has been implemented at Aalborg university provides students with the opportunity to solve problems of a given field in a team. In this work, by applying the experience of research-based learning to PBL teaching, we explore PBL and propose a research-focused PBL framework, which integrates three focuses: research-focused project through research proposal design, enhancing student's learning engagement through research, and co-creation of mutual learning with the project supervisor. The framework was piloted through a one-semester long project with initial feedback from students collected through a survey. The preliminary results demonstrated their positive reaction to the pilot and willingness to engage to further similar practices. Practical implications are provided based on the initial results.

Keywords: effective teaching, senior students' enthusiasm, research integration, problem-based learning

Type of contribution: Best practice extended abstracts

1 Introduction

Problem-Based Learning (PBL), defined as “an instructional learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem” (Savery, 2015), is one of the latest innovations in active learning for which a wide range of positive outcomes for students are claimed. Such an innovation facilitates deep learning through better understanding of concepts and the development of skills, as well as fostering student engagement and enthusing classes (Du et al., 2019). In PBL, students tend to use a more in-depth approach of learning and understand the meaning of materials being studied, which increases deep learning and decreases surface learning for students especially in practical courses (Du et al., 2019), e.g., computer science and software engineering. In PBL, the teaching goal is to create an interesting environment that is conducive to active, engaged learning study and allows for supervised exploration. The most important learning occurs in situations that are both meaningful and practical, and student-centred teaching promotes purposeful and continuous learning.

In such an environment, the exchange of ideas between teachers and students can collide with some valuable and creative ideas. In addition to playing the role of knowledge disseminator, teachers also play other roles like discipline enforcers, students' friends, and team leaders. University students have a variety of personality characteristics and particularities. They are not as profound as their teachers in terms of specific professional

knowledge and knowledge, but they also have their own ideas and dignity. When teachers get along with students, they must respect the personality and individuality of students and learn with students modestly. It is also an important role for teachers to understand who the students (i.e., learners) are, what knowledge and experience they have, and what they want to achieve, so that they can customize the teaching activities meeting students' needs. Accordingly, in a PBL environment, teacher-student relationships play a key role in the teacher-student experience and have been found to be related to learning. Teacher-student communication is an educational process where teachers influence students purposefully according to a predetermined direction (Savery, 2015). When teachers have an influence on students, students will inevitably influence teachers. The field of literature on PBL in engineering education has reported PBL's effectiveness regarding students' improvement of deep approach to learning (Du et al., 2019), learning engagement (Naji et al., 2020), diverse professional competencies such as problem solving and teamwork (Du et al., 2020). Nevertheless, most of the current literature were embedded in PBL implementation at a course level, while the PBL implementation at a curriculum level is little practiced and researched.

Aalborg University (AAU) has been over decades practiced a systemic PBL approach, namely the AAU PBL model, integrating a problem-based and a project-organized teamwork approaches (Kolmos et al., 2004). Within the systemic PBL model, students' learning process is guided by problems as a start of the learning, and students work together in team to solve the problem through a process organized in a format of project, within a timeline of the whole semester (five months) which accounts for half of their semester credits. Within the AAU PBL model, the problems can be developed in various ways ranging from discipline knowledge focused and well-structured problems to ill-defined real-life problems from industry (Kolmos, 2017). While students develop their engagement to learning at different levels depending on the ways PBL is implemented (Naji et al., 2020), there is a need for more research on impact of diverse practices on student engagement within a systemic PBL approach like AAU PBL model. To address such a need, this paper reports a pilot study of designing and implementing a research-focused approach to PBL involving students to work on research in the field as the 'problem' of their team-based project work.

2 Concepts and design of the study

The objective of PBL includes two sub-problems: 1) how to improve on the learning experience for junior students; and 2) how to improve on the learning experience for senior students. Student bias related to age, with younger students preferring younger supervisors and older students preferring older supervisors (Sprinkle, 2008). Compared with junior students that have a sense of freshness and passion for university environment and the knowledge they learn, senior students are no longer interested in them and may just study for exams. Besides, senior students are faced with different pressures, e.g., academics, employment, and self-development. These pressures suppress the students, causing them to lose interest in studies. If the pressures cannot be transformed into positive motivation, it affects senior students' ability to judge and learn. More seriously, it affects the personal development of senior students. Therefore, it is difficult and necessary to motivate senior students. To tackle this issue, this study was guided by the research question: In which ways engineering students may develop learning engagement in a research-focused PBL setting?

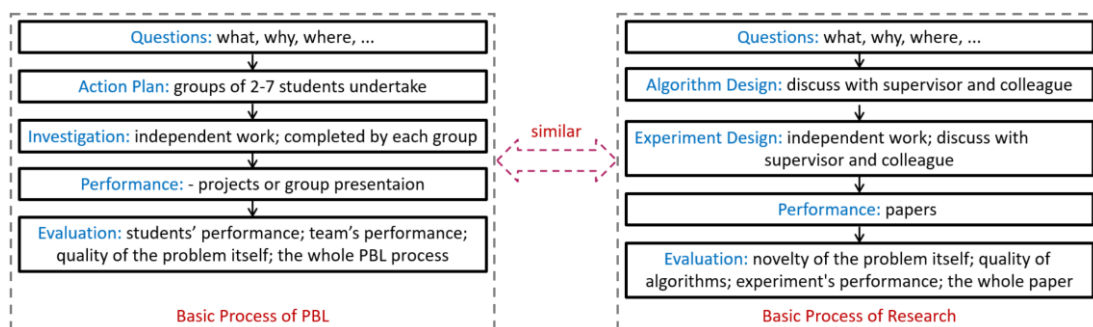


Figure 1: PBL vs. Doing Research

The study assumes that involving senior students to conduct research work as the supervisors do in their academic work. Figure 1 illustrates a connection between a PBL approach to a typical research process. PBL includes raising questions, making action plans and investigation by students, and finally evaluating the performance of students, teams, the proposed problem, and the whole PBL process. The process is similar with that of research-based learning, which also includes raising questions, designing algorithms, conducting experiments, writing papers, and evaluating the novelty of the problem, the quality of algorithms, the experimental performance, and the whole paper. To enhance supervisor-student relation and motivate students' engagement, the study designed a pilot initiative of involving students to work on ongoing academic research as their semester project work. The remaining of the study reports the design, process of implementation as a pilot, and initial evaluation of student feedback.

3 Methodology and implementation

In this section, a framework for research-focused PBL is proposed with three dimensions: research-focused project through research proposal design, enhancing student's learning engagement through research, and co-creation of mutual learning with the project supervisor.

3.1 Research-focused project through research proposal design

Research-focused proposal. A proposal is a document creating a plan for a designed project, and a solid proposal acts as a source of truth for students, where supervisors can provide advice and integrate their research and PBL. The most suitable advice means that the supervisor can assist students with what needs to be done. Therefore, a good proposal should clearly focus on the semester topic and explain the problem. However, it is also important to be clear that proposals do not have to exist purely for the benefit of students. It needs to contribute to the work and development of the supervisor. To achieve this, a good solution is to integrate the research of supervisors and PBL into proposals. Besides, a good proposal should meet PBL objectives, e.g., improving the self-directed learning and problem solving of students. A well-written research-focused proposal allows the supervisor to demonstrate the value provided and show that the supervisor is the right person for the project.

Practice. The first author of the study, who served as the project supervisor of students proposed an initial design of research topics. To integrate research, objectives of PBL, and the project of DAT5 students as well as to achieve the semester goal/topic (i.e., Experimental Data Analysis and Modelling or Theory-Driven Data Analysis and Modelling), the first author proposed two proposals, i.e., Effective and Efficient Task Assignment in Spatial Crowdsourcing and Unsupervised Time Series Anomaly Detection. These two proposals are based on the research fields of the first author, where the first author has published several papers. Students in group DAT-05-03 selected the first proposal and defined a novel problem, namely Heart Runner AI, in spatial crowdsourcing. They explore and develop a new method combining reinforcement learning and genetic evolutionary, achieving the PBL objectives and inspiring the first author to find new problems and solutions.

3.2 Enhancing student's learning engagement through research

Students' research awareness. Students' research awareness also plays a crucial role in research-teaching integration. Claims that teaching is research-led are not credible if students have negative or no idea about the university as a research environment (Brew, 2020). Research on the student perspectives shows the extent to which students see themselves as part of the research community. Geography students, for example, feel that research is most visible 'in the field' and is done by lecturers and students. However, physics majors indicate that research is visible in the presence of laboratories and machinery, which is believed to be done by lecturers 'over there' (Brew, 2020). There is evidence showing that many of a university's initiatives in research-led teaching are initially teacher-centred. An interesting aspect of development is the constant awareness that the concept of research-led teaching is not well defined and requires evolving understanding.

Practice. A good way to enhance students' awareness of research in their project is to encourage students to present their project and results in public (e.g., uploading reports and codes to GitHub), which is beneficial for them to broadcast the project results. During the supervision for group DAT-05-03, the first author suggests students to submit their report and codes to GitHub and stresses the necessity, e.g., it is helpful to pursue higher education and find a satisfied job. The students show great interest about it, which enhances their awareness of research to a certain extent.

3.3 Co-creation of mutual learning with the project supervisor

Co-creation of mutual learning. Working on a student's project is a period of inspiration and learning, but it can also be chronic stress and concern about unfinished reports. The primary task of the supervisor is to help students work through the project and understand what has been learned from the relevant courses. Rather than offering support and advice, supervisors should encourage students to actively organize information. By doing so, supervisors can also learn more about what happens during supervision and how to encourage mutual learning. It is necessary to learn from students, creating an environment where supervisors understand that they do not have a wealth of knowledge in every field. Harnessing the wisdom of students not only helps supervisors grow but often inspires students to learn further and share their expertise.

Practice. When supervising DAT-05-03 students, they explore a new problem, Heart Runner AI, which is a three-party task assignment problem including workers (i.e., runners), tasks (i.e., patients), and defibrillators. Besides, they explore the combination between reinforcement learning and genetic evolutionary. While the supervisor has broad knowledge in spatial crowdsourcing, the supervisor admits that the knowledge about these techniques is limited. The supervisor often asks students to share their knowledge and expertise, or to help the supervisor when getting stuck. They build relationships that enable them to learn from each other.

4 Data for piloting

In the 2022 fall semester, the first author conducted student evaluations in the DAT5-03 supervision. Six students returned the questionnaire, where the questions are shown below.

Table 1: The questionnaire and its statistical results, where Q denotes Question.

Q1. Do you prefer a research-related proposal or a course-related proposal?	Q9. Do you think it enhances your interest of research by a research-related project?
Q2. How much benefit by a research-related proposal?	Q10. Which way do you think is the best to present and broadcast the project results?
Q3. What do you think of a research-related proposal?	Q11. Do you think it is helpful for knowledge sharing among group member by a research-related project?
Q4. Do you think it is helpful if the project is related to the research field of your supervisor?	Q12. Do you feel better if the teachers/supervisors can give you feedback on time?
Q5. Do you think a research-related project is helpful for finding a job in industry?	Q13. Do you feel better if the teachers/supervisors share related publications to you?
Q6. Do you think a research-related project is helpful for pursuing higher education?	Q14. Which way do you prefer to find a suitable solution to your problem in the project?
Q7. Do you feel stressful when conducting a research-related project?	Q15. Do you believe your project/report can help the supervisors to improve or inspire their research?
Q8. Do you think it enhances your awareness of research by a research-related project?	

5 Analysis and initial results

Based on the questionnaire results, the following analysis can be summarized:

1) *Evaluation for research-focused project through research proposal design (Q1-Q3).* Most students (66.67%) prefer a research-based proposal. 50% of the students think they can benefit a lot from a research-based proposal, which is a good way for learning knowledge.

2) *Evaluation for enhancing student's learning engagement through research (Q4-Q10)*. All students believe it is helpful if the project is related to the research field of the supervisor, and 83.33% believe that a research-based project can help them for pursuing higher education. As expected, only 33.33% of the students think a research-related project is useful for finding a job in industry. Most students (83.33%) feel stress-free to conduct a research-based project, which means that it is easy for them to deal with it. Half of the students think a research-based project enhances their awareness of research, and 83.33% claim that such a project enhances their research interest, which demonstrates the superiority of a research-based project. In terms of the way to present and broadcast project results, 66.67% of the students tend to use a project report and share their codes by GitHub. It shows that they promote the dissemination of research results actively.

3) *Evaluation for co-creation of mutual learning with the project supervisor (Q11-Q15)*. A majority (66.67%) of the students believe it is helpful for knowledge sharing among group members by a research-based project. All students feel better if supervisors give feedback on time, which means that the feedbacks from supervisors are helpful and valuable. 83.33% of them hope that supervisors could share related publications to them, from which they can explore the solution by themselves. 66.67% of the students believe that their project/report can improve or inspire the research of supervisors.

6 Reflection and future work

In AAU, the pedagogical learning goal is to develop teaching skills to engage students in teaching process (Kolmos, 2017). In this work, a new problem aiming to integrate research and teaching for improving the enthusiasm of senior students on learning is proposed. To solve it, a theoretical analysis and an empirical study are given. The results show that the proposed methodology can integrate research and teaching, thus enhancing the enthusiasm and interest of senior students on learning to maximize the teaching and supervising effect (Kolmos et al., 2004). The paper reports the initial results of the piloting approach using research-focused PBL to support student learning engagement. The approach shall be further revised, and more data are needed in the future including both qualitative and quantitative sources to provide a comprehensive understanding of students' learning. Based on the preliminary results, it can be suggested that future design of such an approach shall focus on some research-driven practical applications that benefit students for finding a job in industry and enhance their awareness of research more effectively.

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