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Problem-Based Learning in Marketing Engineer Course: A Case Study from Industrial Engineering Curriculum

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Abstract. Problem-Based Learning (PBL) is an innovative and practical teaching approach in which students participate in real-world problems, which are complex and demanding. This approach offers a unique learning opportunity in an engineering curriculum and helps students apply their knowledge, develop critical-thinking and problem-solving skills, and work collaboratively. In a Marketing Engineer course, students can work on real-world marketing projects as part of PBL, where they apply the theories and concepts learned in the course to address a specific marketing challenge. The problem case study focuses on analyzing customer purchasing behavior based on student group selections. The students collect and analyze data, identify key segments, and design marketing strategies for a specific product or service through surveys and questionnaires. This practical learning approach allows students to understand the concept of customer loyalty programs while improving their critical-thinking, problem-solving, and teamwork abilities. The poster presentation provides a platform for students to showcase their learning and understanding of marketing engineering in practice that shows to analyze customer purchase behavior data, identify key segments, and marketing strategies. The effectiveness of PBL as a teaching approach in the Marketing Engineer course is analyzed using various data analytics methods. The results show that PBL can be a valuable approach for teaching marketing engineering and can lead to positive outcomes for students. The hands-on learning experience and the real-world projects provide students with a practical and engaging learning environment, which can have a lasting impact on their understanding of the subject. In conclusion, PBL is a valuable approach for teaching marketing engineering and can result in positive outcomes for students.

Keywords. Problem-based learning (PBL), Marketing engineering, Industrial engineering curriculum, Engineering education

Introduction

Problem-Based Learning (PBL) is a progressive and pragmatic pedagogical method that involves students in intricate and challenging real-life problems. PBL is a globally implemented instructional method where students engage in discussions of professionally relevant problems to enhance the integration and application of knowledge. This is believed to encourage students towards a deep learning approach, where they are inherently motivated and strive to gain a thorough understanding of the subject matter [1]. Higher Education Institutions (HEIs) play a critical role in promoting

and implementing PBL as a teaching approach. By incorporating PBL into their curricula, providing faculty development opportunities, and supporting students and faculty, HEIs can help prepare students for success in their careers and contribute to the advancement of knowledge in their respective fields. The PBL is an important approach to education that can help students develop critical thinking skills, prepare them for the real world, foster teamwork and communication, and increase motivation and engagement. This approach presents a distinctive educational prospect in an engineering syllabus, enabling students to employ their understanding, enhance their critical thinking and problem-solving aptitudes, and collaborate effectively. Especially, It is extremely important in engineering courses because students can analyze complex problems and apply their theoretical knowledge to practical situations. Also, teamwork is essential for success, as projects often involve multiple engineers working together to solve complex problems.

In a selective course in the industrial engineering curriculum from Khon Kaen University Thailand. A Marketing Engineer course is a specialized course that combines marketing principles and quantitative analysis to help students develop skills in designing and implementing effective marketing strategies. The course focuses on the use of data and quantitative methods to understand customer behavior, evaluate marketing performance, and develop marketing campaigns. Students will learn how to use various quantitative methods and tools, such as data mining, regression analysis, and machine learning, to analyze customer data and apply these methods to various marketing problems including customer segmentation, pricing strategies, and product positioning. The goal of a marketing engineering course is to provide students with the skills and knowledge they need to design and implement effective marketing strategies that drive business success. This includes understanding customer needs, analyzing market trends, developing pricing strategies, and creating effective advertising and promotional campaigns. In this course, students can work on real-world marketing projects as part of PBL, where they apply the theories and concepts learned in the course to address a specific marketing challenge. It was moved away from the lecture-style approach used in the past to PBL for this course.

This study was conducted to examine the effectiveness of PBL as a teaching approach in the Marketing Engineer course. The problem case study focuses on analyzing customer purchasing behavior based on the case selected by each student group. Students collect and analyze data, identify key segments, and design marketing strategies for a specific product or service through surveys and questionnaires. To compare student outcomes in the traditional teaching model with the PBL model.

1. Literature review

In recent years, PBL has become increasingly popular in engineering education. This teaching approach involves presenting students with authentic, real-world problems and tasking them with applying their knowledge and skills to develop solutions. PBL emphasizes active learning, critical thinking, and collaboration, and aims to prepare students for the dynamic and ever-changing demands of the engineering industry. The effectiveness of PBL in engineering courses has been studied extensively, with a focus on its impact on student learning, engagement, and retention. Amaya Chávez *et al.* (2020) [2] presented a study that investigated the impact of PBL on the academic performance and perceptions of engineering students in computer sciences. The study involved two groups of students, one taught using a traditional lecture-based approach and the other

using a PBL approach. Both groups were evaluated based on their academic performance and perceptions of the teaching method. They found that students in the PBL group had significantly higher academic performance than those in the traditional group. Furthermore, students in the PBL group reported more positive perceptions of their learning experience, including increased motivation, engagement, and collaboration with their peers. Joshi *et al.* (2020) [3] presented a framework for measuring the effectiveness of problem-based learning (PBL) in engineering education using learning analytics. The various data sources were proposed, such as learning management systems, online discussion forums, and student performance data, to track students' engagement, performance, and progress throughout the PBL process. Also, The paper included a case study of the framework's implementation in an engineering course, providing practical examples of how the framework can be used to support PBL in engineering education. This framework can provide valuable insights into the effectiveness of PBL in engineering education and help teachers to monitor and support their students' learning. Moreover, Dolmans *et al.* (2016) [4] found that PBL can encourage both deep and surface learning, depending on how it is implemented. Specifically, they identified several factors that can influence whether students engage in deep or surface learning in a PBL environment, such as the design of the problem, the quality of the facilitation, and the motivation of the students. Learning analytics is an important field that involves using data and analytics techniques to gain insights into learners' behaviors and preferences in order to improve educational outcomes [5]. Also, the potential benefits of learning analytics interventions, such as improving student performance and reducing attrition rates. It also identifies the challenges and limitations of these interventions, such as ethical concerns, data privacy issues, and the need for effective communication and collaboration between stakeholders [6]. Suchithra *et al.* (2015) [7] provided valuable insights into the various purposes and techniques of learning analytics to improve student performance, and highlights the potential benefits and challenges of using learning analytics in educational settings. Few studies have focused the PBL in industrial engineering curriculum. Tortorella and Cauchick-Miguel (2017) [8] discussed an initiative to incorporate problem-based learning into a lean manufacturing course within an industrial engineering graduate program. They emphasized the benefits of this approach in enhancing students' problem-solving skills and understanding of lean manufacturing principles. And Lutsenko (2018) [9] presented a case study of a PBL course focused on project management for senior engineering students. The author examined the effectiveness of this approach in developing students' project management skills. The findings highlight the positive impact of problem-based learning on students' knowledge acquisition, problem-solving abilities, and engagement in the course. For this paper, “PBL” which stands for Problem-Based Learning, is a teaching and learning method in which students learn by solving complex, open-ended problems. PBL emphasizes student-centered learning, where students work in groups to identify and solve problems together. The role of the teacher for this course is to facilitate the learning process, provide guidance, and support students' learning. Thus, this study shows the effectiveness of PBL as a teaching approach in the Marketing Engineer course is analyzed using various data analytics methods.

2. Research Methodology

2.1. Participants and Data

The study was conducted on a batch of 3rd year BE 29 students studying Industrial Engineering at Khon Kaen University, Thailand. Data from the academic year 2021 and 2022 were compared. In the 2021 academic year, the teaching style adopted was traditional, featuring lectures without any activities during teaching. In contrast, the teaching approach for the 2022 academic year involves integrating problem-based learning (PBL) and various activities into the course.

2.2. PBL unit delivery

In the selective Marketing Engineer course students are given the opportunity to work on real-world marketing projects as part of a PBL session where they can apply the theories and concepts learned in the course to address a specific marketing challenge. The methodology used for the research comprises of three main components, namely: 1) Pre-assessment, 2) PBL Midterm and Final exams, and 3) Post-assessment for the purpose of comparison.

2.2.1. Pre-assessment

Pre-assessment is done to understand a student's knowledge in marketing engineering context before conduction of PBL session. Students are asked to work in a team of 7 to 8, as a result, 4 teams were formed in the course. The problem case study focuses on analyzing customer purchasing behavior based on student group selections. At the end of the activity and exam, a feedback is taken from the students with various questionnaires to understand their pre - knowledge in testing. This activity helped to understand their analytical capacity for a given problem.

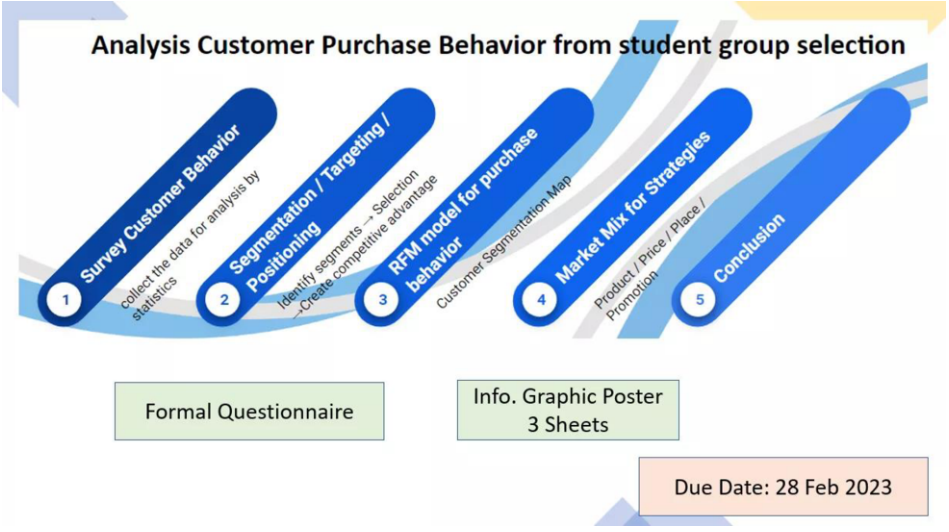

Figure 1. Problem-Based Learning case study in Marketing Engineer course.

2.2.2. PBL Midterm and Final exams

A Problem-Based Learning session is followed by a workshop on analyzing customer purchasing behavior for a given problem scenario. The session is organized for a month and includes a four-step format that involves brainstorming, information gathering, listing out the objectives and requirements, and writing the test plan for a problem statement [3]. The activity is conducted in four phases: 1) Surveying customer behavior through data analysis, 2) Identifying and selecting segments using the Segmentation, Targeting, and Positioning (STP) model, 3) Creating a customer segmentation map using the RFM model, and 4) Developing marketing strategies using the Marketing Mix (4P) as shown in Figure 1. Moreover, the midterm exam covers marketing concepts, market planning, and the STP model, while the final exam covers forecasting, new product and service design, and the Marketing Mix.

2.2.3. Post-assessment

Following the workshop, students will engage in a reflection activity. The instructor will begin by summarizing the experience, highlighting the root causes of common variability observed during the workshop. Subsequently, students will be asked to provide their reflections on the learning outcomes and workshop activities. This will involve using post-it notes and a whiteboard to share their thoughts. After the completion of the Problem-Based Learning session, a post-assessment is conducted to analyze the students' improvement in performance and their problem-solving and critical thinking skills. To gather feedback, a set of questionnaires on the PBL session is designed and administered at both the midterm and final chapters.

2.3. Instruments

To determine the effectiveness of workshop activities, a pairwise t-test was carried out to compare the students' overall understanding of Marketing Engineering before and after participating in the workshop.

3. Results and Discussion

For achieving the learning outcome of a Marketing Engineers course, students can apply the marketing concepts and skills they have learned in a real-world context, which can increase their motivation and engagement in the learning process. This will require students to collect and analyze data through surveys by questionnaire and present their findings in a poster presentation. Students will understand customer loyalty programs for a specific product or service. This will require them to analyze customer purchase behavior data, identify key segments, and marketing strategies. Analysis of data is done by collecting data concerning activity of students and teachers in the PBL session. Taking feedback from students and teachers with respect to the pre-assessment and post-assessment activities. The PBL activity consist of context in chapter 2, 3 and 6 that covers the overall Marketing Engineering course as shown in Table 1.

Table 1. Contents for each session.

Contents	Midterm	Final	PBL Project
Chapter 1 Marketing concepts	√		
Chapter 2 Market planning	√		√
Chapter 3 Segmentation, Targeting and Positioning framework	√		√
Chapter 4 Forecasting		√	
Chapter 5 New product and service design		√	
Chapter 6 Market mix		√	√

The teaching approach for the 2022 academic year involves integrating PBL and various activities into the course. Figure 2 presents the results of comparing the scores and Table 2 shows the average score in the academic years 2021 and 2022. Analysis of the midterm and final exam scores of students over the past two years revealed an improvement, with the midterm exam score being 5.7% higher and the final exam score being 2.4% higher than before. Furthermore, students' project scores have also shown improvement, being 3.5% better than the previous year, likely due to the incorporation of activities that facilitate collaborative learning.

Table 2. Average score in academic year 2021 and 2022.

Activities	Average score in academic year (% Full score) = % Average score			
	2021		2022	
	Score	Normalization score (100%)	Score	Normalization score (100%)
Midterm	(30%) = 19.4	64.7	(25%) = 17.1	68.4
Final	(30%) = 22.5	75.0	(25%) = 19.2	76.8
Project	(20%) = 17.7	88.5	(25%) = 22.9	91.6

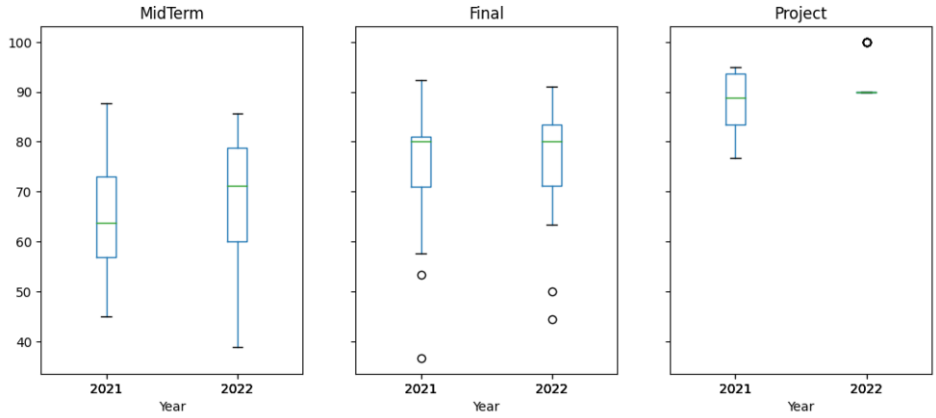

Figure 2. Score in academic year 2021 and 2022.

The pairwise t-test result of the project score (Table 3), $t(28)=0.001920832$, $p<0.05$, for the conceptual evaluation, showing that students performed significantly better after PBL workshop activites.

Table 3. Pairwise t-test result of the project score in academic year 2021 and 2022.

	Mean	Variance	df	t Stat	P(T<=t) two-tail
2021	88.35	23.0611	27	-3.4368	0.0019
2022	92.14	17.4603			

Evaluation from students is important as it provides valuable feedback, helps to ensure accountability, empowers students, and improves satisfaction. After the completion of the PBL session, a post-assessment is conducted to analyze the students' improvement in performance. Table 4 shows the scores for students' comprehension of each chapter in the Marketing Engineering course. The assessment score of 5 points for the 2021 academic year does not evaluate students' comprehension of each chapter individually, but rather assesses their overall understanding of the subject. However, in the 2022 academic year, both pre- and post-learning assessments were conducted. The results revealed that active learning and PBL methodologies were more effective in helping students comprehend the subject matter, owing to the advantages offered by PBL. Students can understand and develop a deeper understanding of the concepts and techniques. They are learning by applying them to the analysis of customer purchase behavior projects. Students practice teamwork and communication skills. Many marketing engineering contents involve collaboration and communication with other team members, and PBL allows students to practice these skills in a simulated work environment. Also, PBL can also help students develop their creativity and new product or service innovation. Marketing engineering requires the ability to think outside the box such as market mix (final part) and term project (analysis customer purchase behavior project), and PBL allows students to explore new ideas and provide new strategies and approaches to meet market demand. We use post-it notes for their reflections every week. These notes are separated into two colors: pink for students to reflect on their own learning and become more aware of their perceptions, and yellow to reflect on the teacher's performance. This process helps teachers identify areas for improvement in the next teaching and learning sessions as shown in Figure 3.

Table 4. Evaluation score from students with PBL.

Period	Contents	Average evaluation score in academic year		
		2021	2022 (Full score = 5)	
			Pre-assessment	Post-assessment
Midterm	Chapter 1 Marketing concepts	-	1.9	4.2
	Chapter 2 Market planning	-	1.8	4.3
	Chapter 3 Segmentation, Targeting and Positioning framework	-	2.0	3.9
Final	Chapter 4 Forecasting	-	2.0	4.5
	Chapter 5 New product and service design	-	1.7	3.9
	Chapter 6 Market mix	-	1.8	4.0
	Average	-	1.9	4.1

Evaluation Throughout the course, student engagement was monitored both individually and collaboratively as a group. Individual engagement was assessed by tracking (1) the total time spent on activities, which included reviewing and reading provided materials, and (2) the time spent viewing and reviewing notes when using the brainstorming board. Collaborative participation was evaluated by aggregating data on (1) the total time spent on the board, (2) the time spent brainstorming, and (3) the number of votes for each marketing strategy. These measures provided insights into how much time each group spent discussing ideas and the factors that may have sparked these strategy discussions. Higher time spent on discussion suggested that students were more actively engaged in strategy conversations, while lower time spent may indicate that students reached a consensus more quickly.

Figure 3. Example of students' reflection.

It should be noted that prolonged discussions among students about various strategies can sometimes hinder their group activities. While such debates can be beneficial, instructors must ensure that groups remain focused and complete their plans within a reasonable timeframe. Moreover, during group activities, it is crucial to encourage teams to thoroughly analyze collected data and promptly develop marketing strategies. Adapting original strategies based on updated data is also essential for eventual success.

In a marketing engineering course, comparison of two teaching styles are lecture-based and PBL. The lecture style typically involves an instructor presenting information to students in a structured manner, while PBL focuses on students working collaboratively to solve real-world problems. However, lecture-based teaching may not be as effective for helping students develop problem-solving skills. Without opportunities to apply their knowledge, students may struggle to fully grasp the complexities of customer purchasing behavior. Lecture-based teaching may also be less engaging for some students, as it can be passive and one-sided. On the other hand, PBL can be effective for helping students develop problem-solving skills related to customer purchasing behavior. By working collaboratively on real-world problems, students can apply their knowledge to complex situations and develop a deeper understanding of how customer behavior works. PBL can also be more engaging for students, as it allows them to actively participate in their learning. However, PBL requires significant effort from students, as they must work collaboratively to solve problems, which may not be appealing to all students. This approach differentiates from classical teaching methods by providing a practical and hands-on learning experience. Unlike traditional approaches that focus primarily on theoretical concepts, PBL immerses students in real-world problems where they actively engage in solving authentic marketing challenges. Through data collection, analysis, and the design of marketing strategies, students develop critical-thinking, problem-solving, and teamwork abilities. PBL also promotes collaboration among students as they work together to address the multifaceted aspects of the project.

4. Conclusion

The proposed PBL and practical learning approach aim to achieve multiple objectives, including enhancing students' comprehension of customer loyalty programs and fostering their critical-thinking, problem-solving, and teamwork skills. Furthermore, this approach is expected to meet individual educational needs and enhance the overall competitiveness of the educational institution. On the other hand, lecture-based teaching can provide students with foundational knowledge, but may not be as effective for developing problem-solving skills. PBL, on the other hand, can help students develop problem-solving skills by allowing them to apply their knowledge to real-world situations, but may not be as effective for ensuring all students have a basic understanding of the subject matter. Therefore, a combination of both approaches may be the most effective way to teach about customer purchasing behavior in a marketing engineering course. By providing a structured lecture component and opportunities for students to work collaboratively on real-world problems, students can develop both foundational knowledge and problem-solving skills, resulting in a well-rounded education. The success of this case study suggests that PBL can be an effective pedagogical approach in other engineering and business-related courses. As such, further research and exploration of PBL in different disciplines are warranted to promote student-centered and active learning.

In our study, the results suggesting that PBL can increase student engagement and understanding in the subject. Overall, students showed a positive attitude towards the PBL. The student reflection indicated that the learning of Marketing engineer is more enjoyable and interactive as they could learn physics through workshop activities.

Finally, The success of this case study suggests that PBL can be an effective pedagogical approach in other engineering and business-related courses. This finding opens up opportunities for further research and exploration of PBL in different disciplines to promote student-centered and active learning. We plan to study the implementation of PBL in engineering education further. Future work includes the integration of Learning Analytics (LA) framework and usage together with problem- and project-based learning models to assess its effectiveness in the engineering education area.

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