a. Students understand the concept of supply chain (SC) development and the problem is based on the level of decision (strategic, tactical, operational) in the 4 (four) cycles of the main activities, namely: customer order, distribution, manufacturing, and procurement.
b. Students understand the basic concepts and are able to use quantitative methods to solve SC problems that are in accordance with the level of decisions and the main activity cycle.
c. Students understand basic concepts and SC system management methods in the information technology era and market uncertainty.
d. Students are able to develop and design an SC system that is efficient and effective for the entire system

In general, students are expected to be able to solve integral system problems involving business processes ranging from suppliers to consumers in providing products efficiently and effectively for the entire system.

LO for Industrial Engineering Undergraduate Degree Program is shown in Table 1. The relevant LO identified for the SCM course are LO3 and LO5. Detailed descriptions of each relevant LO are shown in Table 2.

Table 1. Learning Outcomes (LO) for Industrial Engineering Undergraduate Degree Program in UNS

LO	Description
LO1	Mastering the theoretical concepts of natural science, engineering mathematics applications; engineering principles, and engineering design needed for integrated system analysis and design
LO2	Ability to apply mathematics, science, and engineering principles to solve complex engineering problems in integrated systems (including human, material, equipment, energy, and information)
LO3	Ability to identify, formulate and analyze complex engineering problems in integrated systems based on analytic, computational or experimental approaches
LO4	Ability to formulate solutions for complex engineering problems in integrated systems with regard to economic factors, public health, safety, social and environmental (environmental consideration)
LO5	Mastering system design principles and techniques integrated with the system approach
LO6	Ability to design integrated systems in accordance with applicable technical, safety and health standards by considering aspects of performance and reliability, ease of application and sustainability, as well as paying attention to economic, social, and cultural factors
LO7	Ability to research and investigate complex engineering problems in integrated systems using basic engineering principles and by carrying out research, analysis, interpretation of data and synthesis of information to provide solutions
LO8	Mastering knowledge about communication techniques and the latest and latest technological developments
LO9	Mastering the latest principles and issues in the economy, social, ecology in general
LO10	Ability to choose resources and utilize information technology and computation-based engineering design and analysis tools that are suitable for engineering activities
LO11	Ability to make effective written and oral communication
LO12	Understanding professional responsibilities and ethical aspects of professionalism
LO13	Ability to recognize needs, and manage self-learning for daily life
LO14	Ability to collaborate in a workgroup

Table 2. Detailed descriptions of relevant LO for SCM course

LO	Description
LO3	Ability to formulate deterministic problems into the formulation of linear programming models and derivatives such as transportation, transshipment, and assignment models.
	Ability to model stochastic problems into network analysis formulations, dynamic programs, Markov analysis, queuing theory and game theory (game theory)
	Ability to formulate a simulation model of the integrated system problems provided
	Ability to recognize the symptoms of the problem and damage the problem of designing or repairing a real integrated system
LO5	Ability to formulate a model of the problem formulated
	Ability to formulate steps to find solutions and analysis of the formulation of models formed
	Understand the management cycle and its role in the operation of integrated systems or companies
	Understand basic business concepts, functions in business and business environment that can be utilized in the framework of designing, repairing and installing integrated systems

	Understand the basic concept of organizing a company
	Understand the concept of marketing products both goods and services
	Understand the concept of manufacturing systems
	Understand the concept of the logistics system

3.2 Problem-Based Learning Cycle

Yusof et al. (2012) have developed a PBL framework for an engineering class at a university. The PBL model is shown in Figure 1. The PBL process can be divided into 3 main phases. Phase 1 consists of meeting the problem, problem identification, and analysis. In Phase 2, students do self-directed learning, peer teaching, reporting, synthesis, and application. At this stage, the facilitator must ensure that the coverage of the problem is sufficient, and probes students on the accuracy and validity of the information obtained. This can be an iterative process, where students may need to re-evaluate the analysis of the problem, pursue further learning, reporting, and peer teaching. Upon solving the problem, the students enter the Third Phase, where they do solution presentation and reflection. Later, we adopted this framework to be implemented in the SCM course to enhance students' problem-solving skill.

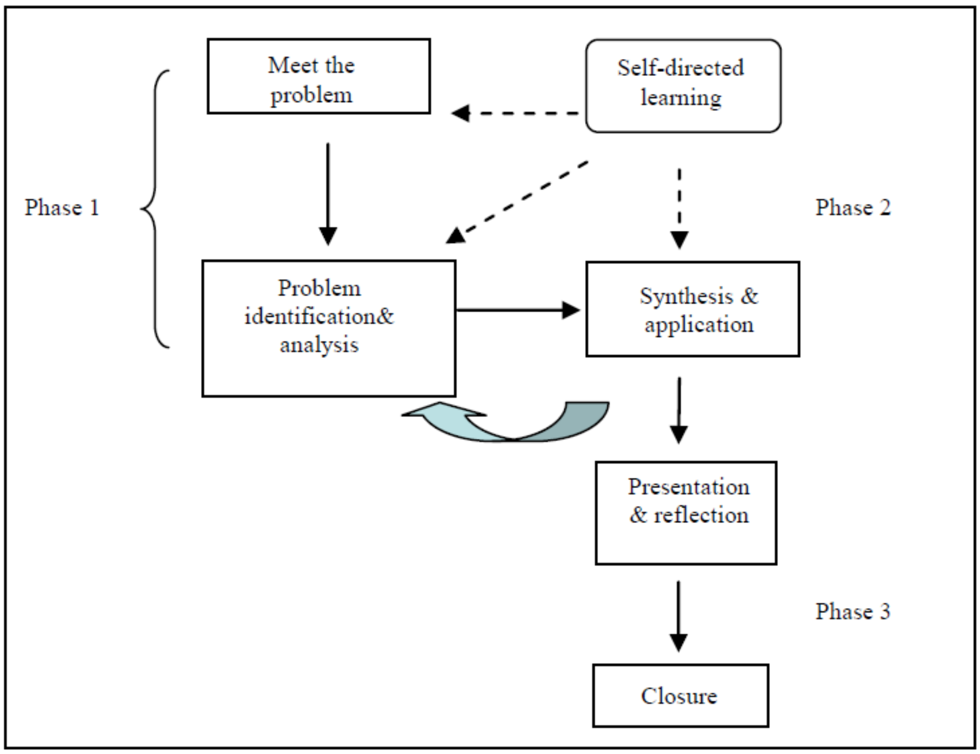

Figure 1. Problem-Based Learning Cycle

3.3 Problem-Based Learning in Supply Chain Management Course

In this paper, we describe the process and results of applying the PBL method to the supply chain management (SCM) course held by the Department of Industrial Engineering at Universitas Sebelas Maret (UNS). We initiated this project since the 2016/2017 academic year. SCM courses are held in a 16 week period for one semester. From a total of 12 students who took this course, they were divided into 6 groups. In the first 2 weeks, the lecturer delivered introductory material about SCM and students were asked to do a literature review of SCM.

In the next 2 weeks, material about the newspaper supply chain was introduced to students. The following week, each group was asked to choose 6 topics that had been provided and students were asked to present a resume about the theory related to the topic chosen. The topics chosen were procurement, production-distribution, customer order cycle, supply chain coordination, distribution, and supply chain risk management.

Then students were given 3 weeks to conduct surveys and observations in the field. Students observe problems in a newspaper producing industry. The students were assigned to follow the real activities in the supply chain processes, identify problems using 5W+1H (What, Who, Where, Why, When and How), and discuss alternative solutions with the problem's owner before the proposed improvements The methods used by students during the survey were in-depth interviews with stakeholders involved in newspaper making and direct observation of the newspaper production process. In this 3-week face-to-face lecture, students submitted reports on the activities and progress that had been made to the lecturer then discuss them for the sake of further observation.

The following week, each group presented the findings and problems from the survey results and proposed a method for problem-solving. In this case, the lecturer has a role to provide opinions and input on the proposed method. At this stage, 2 students who choose the same topic are required to give different proposals. Here, students analyzed the existing problems and make alternative improvements to give recommendations to problem's owner and then evaluate them. The consultation process between lecturers and students last for the next 2 weeks.

Then students were given 3 weeks to write scientific articles based on case studies that have been carried out according to their respective topics. At week 15, students presented the results of their case studies to the newspaper industry to obtain feedback on the proposed alternative improvements. In the last week, there was an evaluation of SCM courses by lecturers to students. Figure 2 shows the PBL timeline which was implemented to this SCM course.

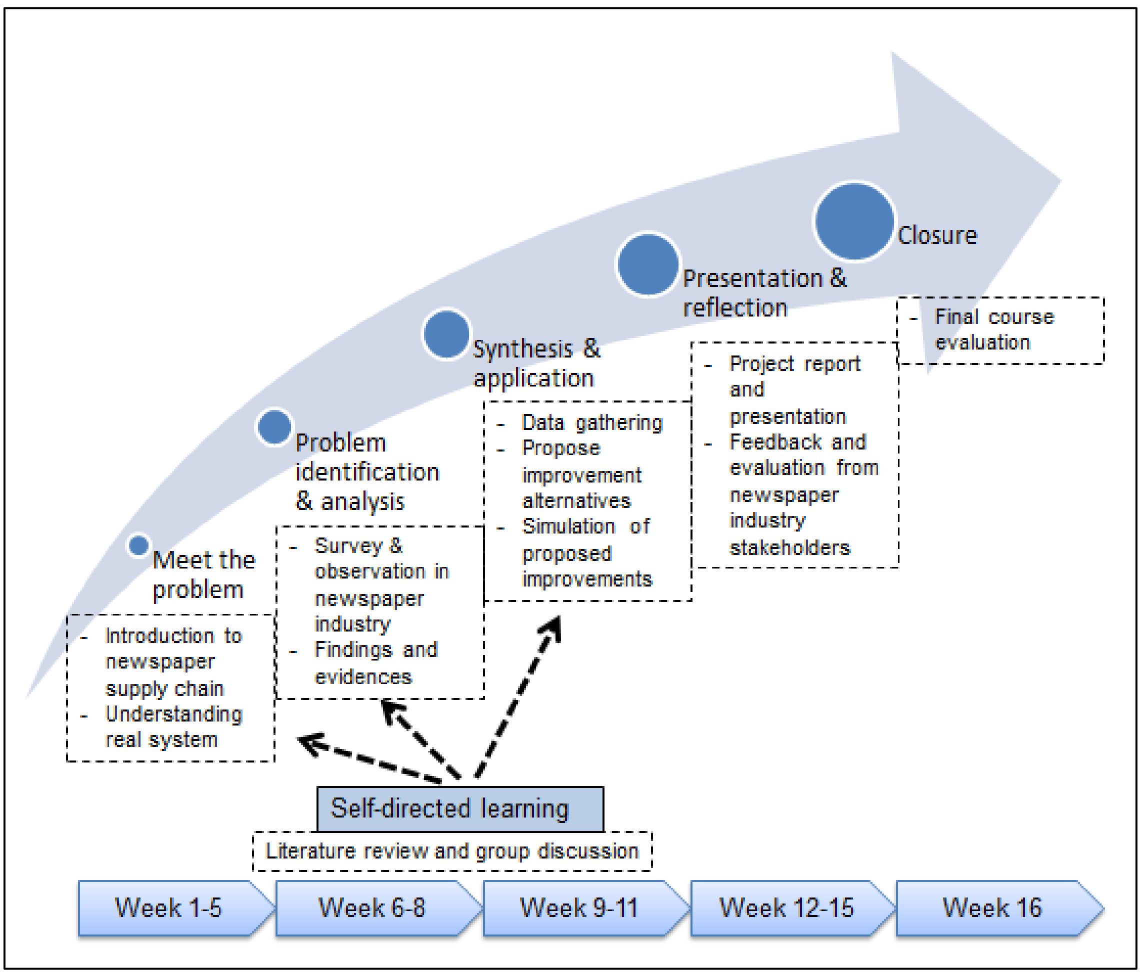

Figure 2. Problem-Based Learning Approach in SCM Course

In order to get a clearer picture, here we presented the newspaper supply chain cycle by adopting the green supply chain concept, which is shown in Figure 3. In this supply chain, it is important to integrate environmental thinking into supply chain management, including product design, material sourcing, and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.

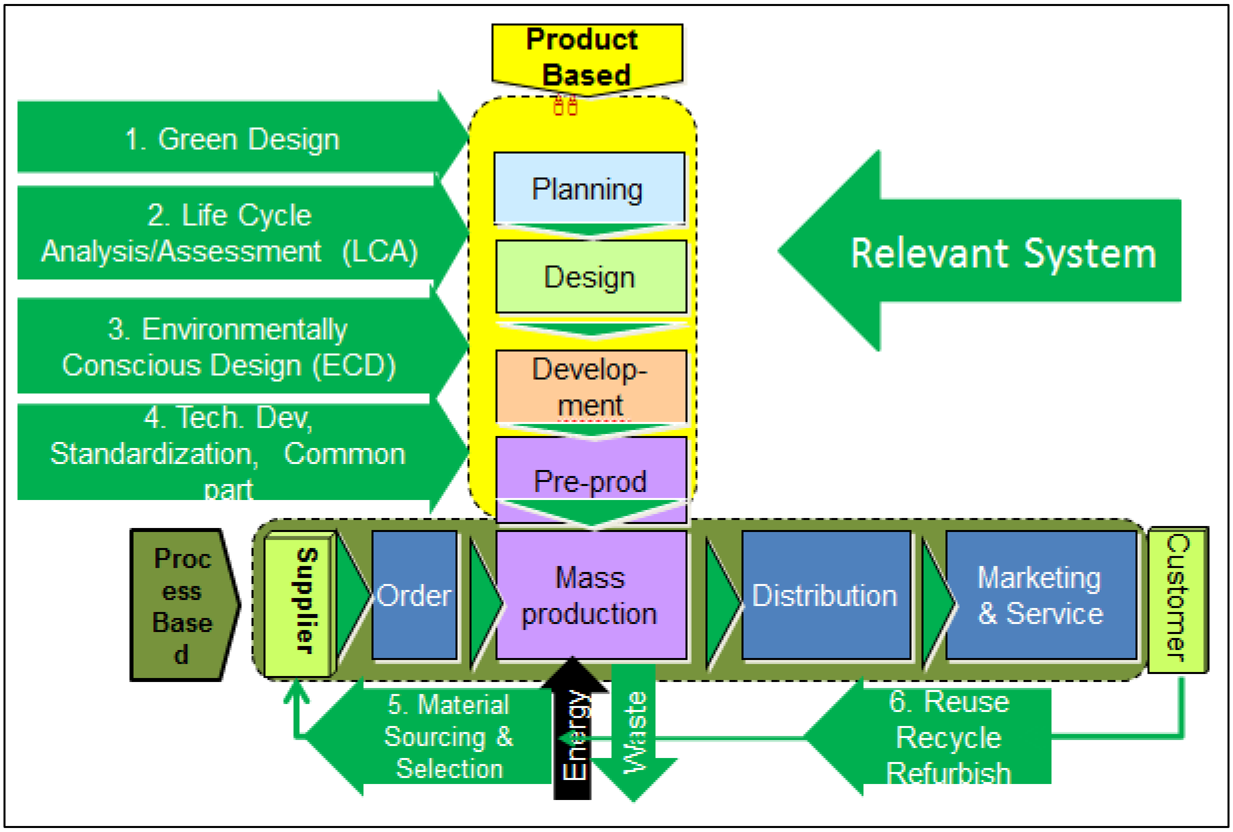

Figure 3. Green Supply Chain Cycle in General

Based on this model, it is known that there are 4 main cycles in the supply chain, namely customer order cycle, distribution cycle, manufacturing cycle, and procurement cycle. Regarding the PBL approach, students were assigned to observe the real activities in each cycle and then did the problem definition, synthesize the findings and collected data in order to propose recommendations to solve the problems. Table 3 shows the project outcomes, highlighting the papers resulted from students' article writing activities based on the case study. Based on the table, it can be known the SCM cycle and the level of problem-solving decision in which each paper is categorized.

Table 3. The project outcomes, highlighting the papers resulted from students' article writing activities based on the case study

No.	Paper title	SCM cycle				Level of decision		
		Customer order	Distribution	Manufacturing	Procurement	Strategic	Tactical	Operational
1	Sales forecasting newspaper with ARIMA: A case study	√				√		
2	Order Optimization for Perishable Products: Case Study	√				√		
3	Solving Capacitated Vehicle Routing Problem Using Sweep Algorithm For Determining Newspaper Distribution Routes: Case Study		√					√

4	Optimization of Distribution Channel Vehicle Routing Problem with Time Windows using Differential Evolution Algorithm A Case Study in Newspaper Industry		√					√
5	The Integration of Production-Distribution on Newspapers Supply Chain for Cost Minimization using Analytic Models: Case Study		√	√			√	√
6	Multi Times Direct Shipment Method for Synchronizing Production and Distribution Planning Newspapers: A Case Study		√	√			√	√
7	Supply chain risk management in newspaper company: House of risk approach	√	√	√	√	√		
8	Supply Chain Risk Management of Newspaper Industry: A Quantitative Study	√	√	√	√	√		
9	Supply Chain Coordination with Revenue Sharing Contracts: Case Study of Newspaper Industry	√	√	√	√	√		
10	Supply Chain Collaboration Optimization based on the Agreement of Relations between Suppliers and Network Design Problems	√	√	√	√	√		
11	Supply Chain Coordination Mechanism with Buyback Contract: Case Study in Newspaper Industry	√	√	√	√	√		
12	Multi-Objective Optimization Model for Multi Inventory Planning of Supplier Using ABC Method: Case Study				√		√	

4. Discussion

In this section, we discuss the benefits of PBL approach in teaching and learning process for the SCM course. The teaching and learning process using PBL approach that was carried out during the SCM course able to encourage and train the students to develop critical thinking, to actively participate in the classroom/meetings and to be effective team members. In engineering education, apart from producing engineers who possess in-depth technical knowledge, it is also important for the engineers to be able to work effectively as a team member. Team working requires skills such as organizing meetings; negotiating, discussing and arguing; solving problems creatively; willingness to give ideas and opinions; leadership; communication (listening, talking and visual presentation) and others relevant skills (Andersen, 2003). Team working played an important role in the overall success of projects. The learning process also enhanced the students' skills to interact and communicate orally with each other. The student's awareness of newspaper supply chain issues was at the same time improved by having the PBL activities. Newspaper sustainability awareness was enhanced through the PBL approach, whereby students were actively involved in gathering relevant information and data from a survey and observations in solving the problems. Furthermore, students' problem-solving skill was enhanced through the understanding of a real system, problem synthesis, and simulation of proposed improvements.

5. Conclusion

This study illustrates the applications of problem-based learning in a Supply Chain Management (SCM) course for Industrial Engineering Students. An active methodology for teaching and collaborative learning was proposed through case studies in the newspaper industry. Problem-based learning approach was used in the course to improve students' capabilities, including problem identification and analysis, data collection and analysis, proposed improvements and recommendation and its simulation. A team project report was presented to show how to design, improve, and install of integrated systems has been developed in a semester of SCM Courses. Particularly, this study was implemented successfully in an undergraduate course of SCM.

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