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GAME-BASED LEARNING FOR SUPPLY CHAIN MANAGEMENT: DESIGN AND IMPLEMENTATION OF PRODUCTION AND DISTRIBUTION GAME

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Abstract

Supply chain management is one of the most complex systems, requiring deep understanding of interconnected processes, decision-making, and dynamic interactions. This study presents the design and evaluation of game-based learning to enhance higher education students' comprehension of supply chain management. The proposed production and distribution game is an extension of traditional Beer-Game, designed as an interactive simulation that incorporates key supply chain elements such as material and information flows, costing, and coordination among users. The study involves 40 undergraduate Industrial Engineering students enrolled in a logistics and supply chain management course between 2025-2026. Following the session, a survey that based on six points Likert-scale was given to evaluate the engagement and effectiveness of the game. The results revealed a positive mean-scores ranging from 4.025 to 4.975 indicating positive student perception towards the learning activity. The findings demonstrate that game-based learning can improve student engagement, motivation, and conceptual comprehension. In additional, the game-based learning approach also provides a more interactive and experiential learning environment for logistics and supply chain education.

Keywords : *Supply Chain Management, Game-Based Learning, Logistics Education, Industrial Engineering*

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I. Introduction

Supply Chain has been one of the most interesting and complex system in which nowadays the use is extensive and important in global economic (Alhawari et al., 2021; Xu et al., 2022). Consequently, effective supply chain management is crucial for organizational success, yet its dynamic nature often presents significant pedagogical challenges especially for younger generation (Kavota et al., 2024). To address this problem, a game-based learning approach has emerged as a compelling pedagogical strategy, offering an interactive and experiential platform for students to grasp complex supply chain concepts (Deghedi, 2023; Loaiza-Velez et al., 2021). This approach leverages serious games to simulate real-world supply chain scenarios, enabling learners to develop practical operational skills and understand dynamic interdependencies within the system (Romagnoli, Galli, Mezzogori, & Reverberi, 2022; Sato et al., 2023). Such educational games facilitate continuous learning, enhance comprehension, improve retention, and increase participation and engagement in logistics and supply chain management curricula (Pacheco-Velazquez, Rodés, et al., 2024).

The experiential learning principle, deeply rooted in engineering education, is particularly salient in disciplines like production and supply chain management, where students must grasp the complex interplay of decision-making and contextual impacts (Baalsrud Hauge & Kalverkamp, 2023). Higher education students in industrial engineering generally need exposure to topics such as production planning, inventory management, distribution flows, and demand variability, despite their relevance to everyday consumer experiences (Terkaj et al., 2024). Early introduction of supply chain literacy has been shown to enhance systems thinking, problem-solving skills, and economic awareness among students, preparing them for future academic and career pathways in business, engineering, and logistics-related fields

Gamified learning refers to the use of game elements such as competition, rules, feedback, and simulation in non-game educational contexts to increase engagement and motivation. Numerous studies have demonstrated that gamification can improve student participation, conceptual understanding, and learning retention, particularly in complex, process-oriented subjects (Jun & Lucas, 2025). For higher education learners, game-based learning aligns well with experiential and constructivist learning theories, where knowledge is actively constructed through interaction, experimentation, and reflection rather than passive instruction (Situmorang et al., 2024).

Simulation games have been widely used in higher education to teach supply chain and operations management concepts. One of the most prominent examples is the Beer Game, which illustrates demand fluctuation, information delays, and the bullwhip effect (Roser et al., 2021). Research shows that such games significantly enhance learners' understanding of dynamic systems, coordination challenges, and decision-making under uncertainty. Although most studies focus on university students or professionals, recent literature suggests that simplified production and distribution games can be effectively adapted for younger learners by reducing mathematical complexity while maintaining core system dynamics (Turner et al., 2020).

The purpose of this research is to design and develop a game for enhancing student's experience in learning a complex system like supply chain management by providing an immersive and interactive environment for understanding production and distribution dynamics. The game was developed based on the existing renowned supply chain game which is the "beer game". The beer game itself was developed by Jay Forrester at MIT Sloan School of Management in the 1960s, illustrating coordination challenges and the bullwhip effect in distribution systems (Pacheco-Velazquez, Rodes-Paragarino, et al., 2024). In the beer game, there are two main variables that used as the foundation of cost calculation which are holding costs for inventory and backorder costs for unfulfilled demand. However, this seminal simulation has since been expanded upon and adapted in various forms to address a broader spectrum of supply chain complexities, including incorporating elements like transportation, production planning, and supplier relationships to offer a more holistic learning experience (Romagnoli, Galli, Mezzogori, & Zammori, 2022). Thus, the production and distribution game offers a more comprehensive simulation by integrating production decisions, transportation logistics (ordering cost), and multiple demand scenarios in addition to the beer-game two main variables which are holding and backorder penalties, thereby fostering a deeper understanding of integrated supply chain operations (Gigante & Abreu Lopes Ramos, 2025).

The structure of the paper written as follows: chapter 1 gives an introduction and background of the research, chapter 2 details the methodology and the design of the production & distribution game. Chapter 3 presents the results of the game's implementation and evaluation, followed by a discussion of the findings. Finally, Chapter 4 concludes the paper by summarizing the key contributions and outlining future research directions to further enhance game-based learning methodologies in supply chain education.

II. Methodology

Research Subject

This study was conducted between 2025 – 2026 comprising 40 students (aged 17 – 22 years) enrolled in logistics and supply chain management class within an industrial engineering undergraduate program. The industrial engineering department conducted this course using an onsite approach. After the game-based learning was conducted, the students were filling the survey feedback form. To promote judgment free environment, students' responses were handled anonymously. The objective of the feedback survey was to obtain insight regarding whether gamification can help students understand

Study Design

Figure 1. elaborate the research methodology that been used in this research. The Preliminary Phase focuses on establishing a strong foundation for the community service program. The first step is to determine problem and objective. At this stage, the main problems related to limited supply chain literacy among students are identified. Program objectives are clearly defined, focusing on improving students' understanding of production and distribution processes through gamified learning. The second step is literature review. Relevant literature on supply chain education, gamified learning, and simulation-based instruction is reviewed. This process ensures that the program design is grounded in academic research and best practices, and helps identify suitable learning strategies and evaluation methods.

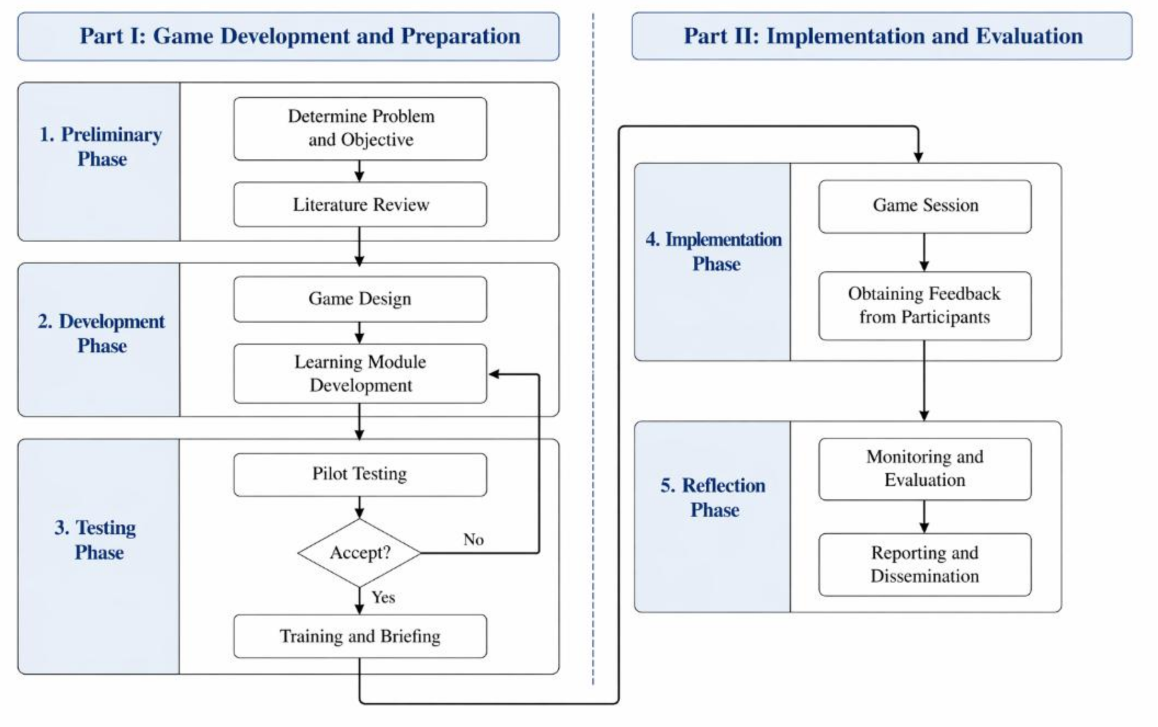


Figure 1. Research Methodology

The second phase is development phase. The Development Phase translates the identified objectives into practical learning tools. In this phase the game design was conducted. A Production and Distribution Game is designed to simulate real-world supply chain operations. The game structure includes defined roles (retailer, wholesaler, distributor, and manufacturer), demand flows, inventory management, lead times, and cost components. The design emphasizes experiential learning and systems thinking and the game developed in a board game format. Supporting learning modules are developed to guide facilitators and participants as well in this phase. These modules include game rules, learning objectives, worksheets, reflection questions, and assessment instruments. The learning module is aligned with the game mechanics to ensure clarity and instructional effectiveness.

The third phase is the testing phase. This phase ensures the quality and feasibility of the developed game and learning materials. In this phase, the game and learning modules are tested on a small group of participants. This pilot implementation evaluates the clarity of instructions, engagement level, time allocation, and achievement of learning objectives. Following pilot testing, an acceptance evaluation is conducted. If the game and modules do not meet the expected standards, revisions are made to the game design and learning materials before re-testing. If accepted, the program proceeds to the next stage. Once accepted, facilitators and lecturers receive training and briefing sessions. This step ensures consistent understanding of the game mechanics, learning objectives, and facilitation techniques prior to full implementation.

The fourth phase, implementation phase involves direct engagement with the target research subject. The Production and Distribution Game was conducted with higher education students in a structured session. Participants actively play their assigned roles, make weekly ordering decisions, manage inventory, and respond to demand fluctuations under information constraints. After the game session, feedback is collected from participants through discussions, questionnaires, or reflection forms. This feedback captures students' learning experiences, engagement levels, and perceived understanding of supply chain concepts.

The last phase was the reflection phase. Program outcomes are evaluated using observation, post assessments, and participant feedback. This step measures improvements in supply chain literacy, engagement, and learning effectiveness.

Game Design and Instruction Design

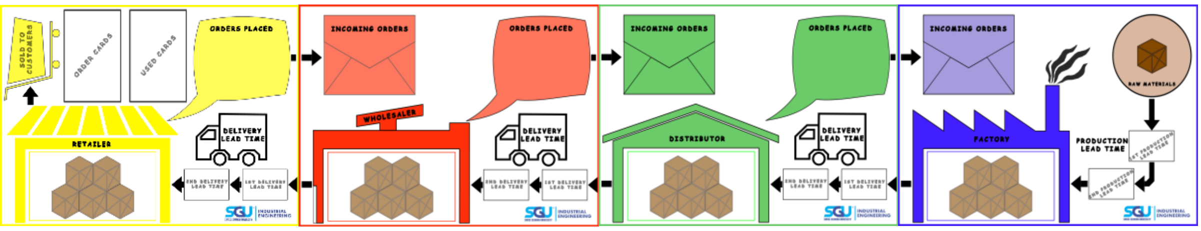


Figure 3. Game Board Design

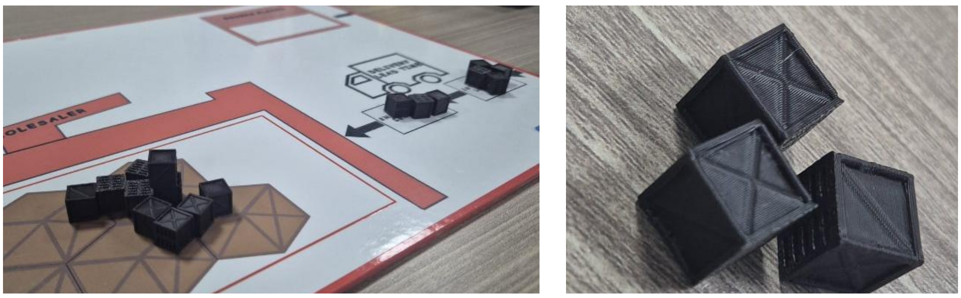
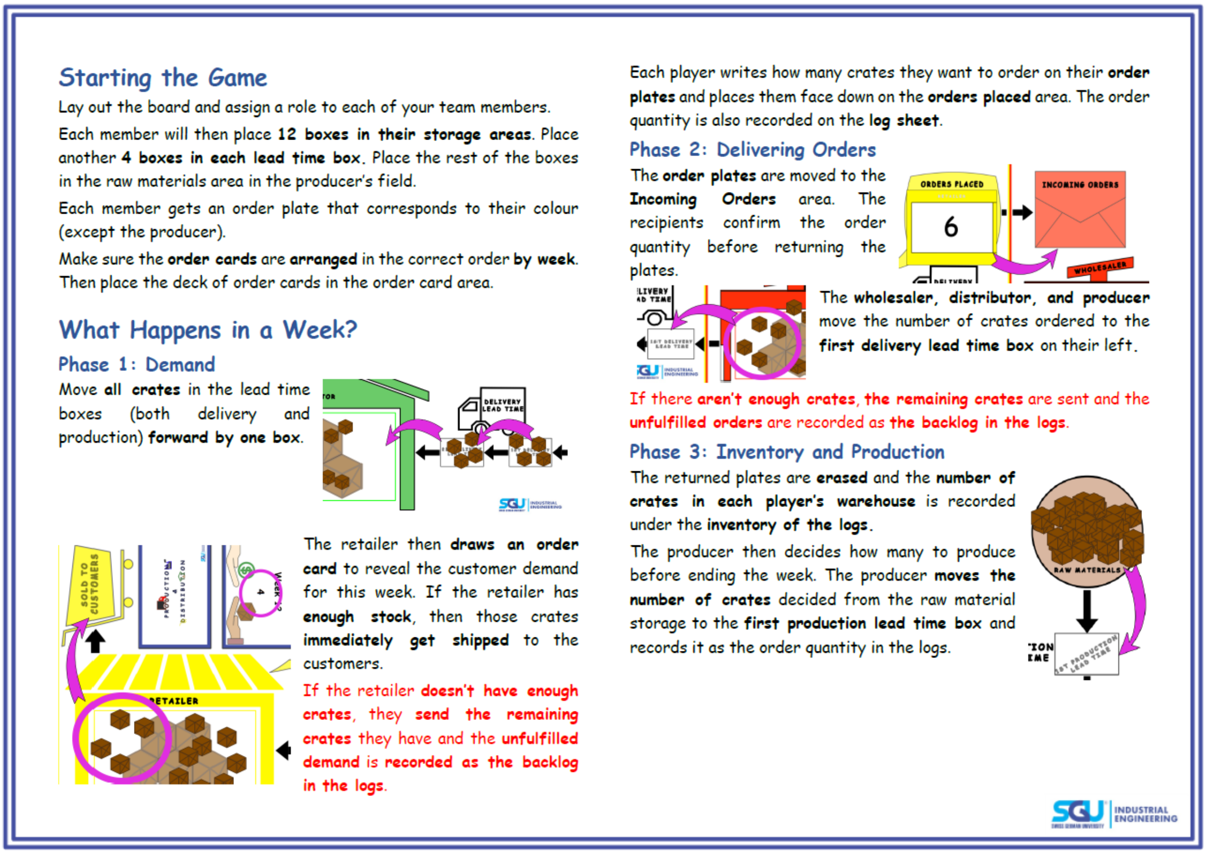


Figure 2. Item Pieces by using 3D Printing

The game design begins with preparing the board design that inspired from the original beer game. Figure 2 shows the game board design for this study. The design still followed the four roles occurs in the traditional beer game which consists of manufacturer, whole seller, distributor, and retailer. The demand from the customer generated based on the demand card that prepared in the game. There were several assumptions occurs in the game design:

- One period of game is accounted as one week
- Flow of goods lead time between roles are two weeks
- Each game will have 3 options of duration (24 weeks, 35 weeks, and 50 weeks)
- Holding inventory cost is \$1, Backlog cost is \$4, and ordering cost is \$10

Every single game package consists of one playing board, 200 pcs of item pieces (Figure 3), 50 order cards, three order plates, and one rulebook (Figure 4). Figure 5. is a sample of the role from the game illustrates the wholesaler's role. In this role there are four main components that must be monitored. Component 1 in the figure 5 represents the inventory on hand during the current period. Component 2 in the figure 5 represents the incoming delivery order which is separated into two phases to emulate the two weeks of lead-time delivery. Component 3 in figure 5 represents the incoming orders from upstream that need to be fulfilled during the period. Component 4 in figure 5 represents the order that the wholesaler is going to order to the downstream.



Starting the Game

Lay out the board and assign a role to each of your team members.

Each member will then place **12 boxes in their storage areas**. Place another **4 boxes in each lead time box**. Place the rest of the boxes in the raw materials area in the producer's field.

Each member gets an order plate that corresponds to their colour (except the producer).

Make sure the **order cards** are **arranged** in the correct order **by week**. Then place the deck of order cards in the order card area.

What Happens in a Week?

Phase 1: Demand

Move **all crates** in the lead time boxes (both delivery and production) **forward by one box**.

The retailer then **draws an order card** to reveal the customer demand for this week. If the retailer has **enough stock**, then those crates **immediately get shipped** to the customers.

If the retailer **doesn't have enough crates**, they **send the remaining crates** they have and the **unfulfilled demand** is **recorded as the backlog in the logs**.

Each player writes how many crates they want to order on their **order plates** and places them face down on the **orders placed** area. The order quantity is also recorded on the **log sheet**.

Phase 2: Delivering Orders

The **order plates** are moved to the **Incoming Orders** area. The recipients confirm the order quantity before returning the plates.

The **wholesaler, distributor, and producer** move the number of crates ordered to the **first delivery lead time box** on their left.

If there **aren't enough crates, the remaining crates** are sent and the **unfulfilled orders** are recorded as **the backlog in the logs**.

Phase 3: Inventory and Production

The returned plates are **erased** and the **number of crates in each player's warehouse** is recorded under the **inventory of the logs**.

The producer then decides how many to produce before ending the week. The producer **moves the number of crates** decided from the raw material storage to the **first production lead time box** and records it as the order quantity in the logs.

Figure 4. Rule Book Sample

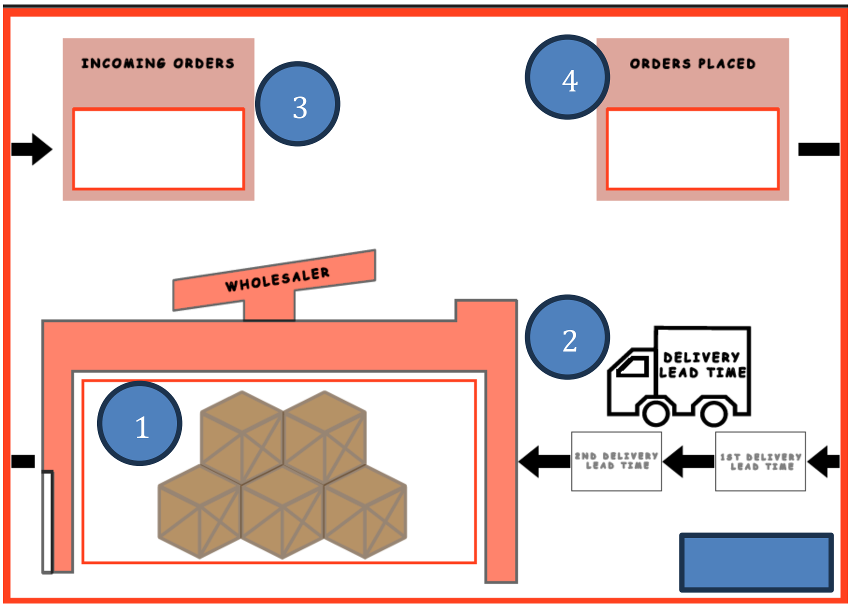


Figure 5. Game Description (Wholesaler)

The challenges added in this game include additional of ordering cost, unexpected demand surges (which can be set for the scenario by shuffling the demand card) that compelling participants to apply advanced inventory control and forecasting strategies in a dynamic, multi-echelon environment. This design choice aims to elicit deeper critical thinking and adaptive decision-making skills among students, mirroring real-world supply chain complexities (Pacheco-Velázquez et al., 2023).

III. Results and Discussion

The results from the game are related to the students' satisfaction and opinions regarding how the game was able to enhance their understanding of logistics and supply chain. To achieve the objective of this research, a survey was administered to the students attending this activity. In the data collection step, the number of participants determined for the inclusion in this survey was 40 university students in the Industrial Engineering Department. The survey utilized a 6-point Likert scale, as shown in Table 1. The survey was conducted during the period of September 2025 – March 2026.

Table 1. Likert Scale Questions

	Notation	Strongly Agree	Agree	Slightly Agree	Slightly Disagree	Disagree	Strongly Disagree
The session was engaging	Q1	6	5	4	3	2	1
The session was fun and exiting	Q2	6	5	4	3	2	1

	Notation	Strongly Agree	Agree	Slightly Agree	Slightly Disagree	Disagree	Strongly Disagree
A new concept was learned during the session	Q3	6	5	4	3	2	1
There is no trouble on following the instruction from the speakers	Q4	6	5	4	3	2	1
The session is helpful	Q5	6	5	4	3	2	1

Table 2. Responses given by the participants on a Likert scale

	Q1	Q2	Q3	Q4	Q5
Strongly Disagree (1)	0	0	0	1	0
Disagree (2)	0	0	0	7	1
Slightly Disagree (3)	4	5	2	6	2
Slightly Agree (4)	8	10	12	9	11
Agree (5)	18	13	13	10	9
Strongly Agree (6)	10	12	13	7	17

Table 2 specifically compiles student responses to a series of questions designed to gauge the efficacy of the game-based learning intervention in improving comprehension of logistics and supply chain principles and fostering greater engagement. For Question 1 (Q1 – The session was engaging) the majority of responses were between slightly agree to strongly agree which represented 36 students or 90% of total participants. For Question 2 (Q2 – The session was fun and exciting) the majority of responses also fell between slightly agree to strongly agree (35 students or 87.5% of the total participants). For Question 3 (Q3 – New concepts were learned during the session) aligns strongly with 'slightly agree' and 'strongly agree' responses (38 students or 95% of participants). For Question 4 (Q4 - 'There was no trouble following the instructions from the speakers') showed a more varied distribution: 14 students (35% of participants) selected responses from 'strongly disagree' to 'slightly disagree,' while 26 students (65% of participants) selected 'slightly agree' to 'strongly agree.' For the last question (Q5 - 'The session is helpful'), the majority of responses (37 students, or an overwhelming 92.5% of total participants) indicated 'slightly agree' to 'strongly agree.'

According to (Koo & Yang, 2025), the analysis of Likert scale can be based on descriptive statistics, especially for composite scales such as mean and standard deviation. The descriptive statistics presented in Table Q1–Q5 indicate that respondents generally provided positive evaluations across all questionnaire items on a six-point Likert scale. The mean scores for Q1, Q2, Q3, and Q5 range from 4.80 to 4.98, demonstrating that respondents tended to express strong agreement toward these aspects. Among the variables, Q5 obtained the highest mean score (4.975), followed by Q3 (4.925), indicating that these dimensions received the most favorable perceptions. In comparison, Q4 recorded the lowest mean score (4.025), although the value still reflects a moderately positive assessment considering the maximum scale value of 6.

The median values reinforce these findings, with Q1, Q2, Q3, and Q5 each achieving a median score of 5, suggesting that most respondents selected responses within the upper range of the scale. Meanwhile, Q4 had a median value of 4, indicating relatively lower agreement compared to the other questionnaire items. Regarding response dispersion, the standard deviation values indicate varying levels of consistency among respondents. Q3 demonstrated the lowest standard deviation (0.905), implying that respondents showed the highest level of agreement and consistency in their responses to this item. Conversely, Q4 exhibited the highest standard deviation (1.423), suggesting more diverse perceptions among respondents. Overall, the relatively low standard deviation values across most variables indicate that respondents' opinions were generally concentrated around the higher end of the six-point scale, reflecting a consistent and favorable evaluation pattern.

Table 3. Descriptive Statistics for Survey Result

	Q1	**Q2**	**Q3**	**Q4**	**Q5**
Mean	4.85	4.8	4.925	4.025	4.975
Median	5	5	5	4	5
standard deviation	0.92	1.005	0.905	1.423	1.060

These findings provide strong empirical evidence that the game-based learning approach was successfully implemented and well received by students. The consistently high mean and median score demonstrate that the game effectively facilitated students’ understanding of logistics and supply chain concepts while simultaneously increasing engagement during the learning process. Furthermore, the low variability in responses across most questionnaire items indicates that positive perceptions were shared broadly among participants rather than being limited to a small subgroup of students. This suggests that the learning game was not only engaging but also pedagogically effective in supporting conceptual comprehension and interactive learning experiences.

The results also confirm the potential of game-based learning as an effective instructional strategy for logistic and supply chain education. The overwhelmingly positive evaluation from respondents also indicates that the developed game successfully transformed abstract logistics and supply chain concepts into to more interactive, practical, and accessible learning experience. Therefore, the survey findings strongly support the conclusion that the implementation of game-based learning achieved its intended educational objective and contributed positively to students' learning outcome.

IV. Conclusion

In conclusion, this study demonstrates that game-based learning is an effective pedagogical approach for enhancing student' understanding of logistics and supply chain management concepts. By adapting and expanding the traditional Beer Game into a more comprehensive production and distribution simulation, the developed learning game successfully introduced students to the complex supply chain dynamics, including inventory management, transportation decision, demand fluctuations, and coordination challenges.

The survey results further confirm the success of the developed game-based learning intervention. Most students expressed strong agreement with the session. The descriptive statistical analysis showed high mean and median scores across nearly all questionnaire items, accompanied by relatively low standard deviation values. This indicates both positive perceptions and consistent responses among participants. These findings provide strong empirical evidence that the learning game not only increased student engagement and motivation but also significantly support students' comprehension of logistics and supply chain principles in a more accessible and interactive manner.

Overall, this research highlights the substantial potential of game-based learning as an instructional strategy in industrial engineering and supply chain education. The developed game simulation successfully transformed the abstract concept into a practical and immersive learning experience. Therefore, the implementation of production and distribution game can be considered successful in achieving its education objective. Future studies may further enhance the game by incorporating digital platforms, more advanced supply chain scenarios, and broader participant groups to strengthen its applicability and education impact across different learning environment.

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