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Serious Games in Logistics Education – Analysis of Effectiveness and Students' Decision-Making Processes

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Abstract:

Purpose: *The aim of the article is to analyze the application of serious games in logistics education, with particular emphasis on their impact on the development of students' decision-making skills.*
Design/Methodology/Approach: *The study, conducted in an academic setting, utilized simulation games that reflected various logistical challenges, such as supply chain management, production optimization, market strategies, and negotiations. The research methodology was based on a mixed approach, combining quantitative and qualitative methods, including the analysis of game outcomes, interviews, and observations.*
Findings: *The results indicate that serious games are an effective educational tool, enabling the integration of theoretical knowledge with practice and fostering the development of key competencies such as problem analysis, decision-making under uncertainty, and teamwork. At the same time, the study revealed diverse approaches to decision-making processes, including cases of suboptimal decisions arising from insufficient analysis or altruistic motivations. Key success factors were also identified, such as precise game introduction and the provision of support from instructors.*
Practical Implications: *The article highlights the potential of serious games in logistics education and recommends their broader implementation, the enrichment of scenarios with more complex situations, and the use of advanced technologies, such as virtual reality.*
Originality/Value: *The study findings emphasize the need for further research into the long-term effects of this educational method in preparing students for professional roles in the dynamic logistics industry.*

Keywords: *Serious games, logistics, decision making.*

JEL codes: *A29, L91, M53.*

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1. Introduction

Applications defined as games began to be exploited in education as early as 1975. Owen Gaede developed a program called Tenure for the PLATO computer. The software was designed to support teachers in decision-making processes. It aimed to enhance cognitive processes and was used in both short- and long-term memory training. It also promoted motor coordination (Babecki, 2012). In the United States, as early as 1830, board games such as Mansion of Happiness, Game of Life, The Landlord's Game, and Game of the Little Volunteer were available for purchase.

Their creators sought to draw players' attention to the need for continuous moral and spiritual development, advocating altruistic rather than consumerist attitudes. While the dominant perception of board games in the U.S. treated this form of human activity comprehensively, in Europe, it was complemented by other themes. These reflected different historical contexts and emerged in the early 20th century. Just as digital games today are being discovered by activist groups, at that time, board and mechanical games were being explored by individuals engaged in avant-garde artistic movements (Babecki, 2012).

Games have served and continue to serve as a medium for fostering interactions among their users and, more broadly, for facilitating social networking processes. These processes reduce distance in social, group, and organizational relationships. In media studies theories, games, like the press, radio, and television before them, are seen as an abstract, sign-constituted space for public debate, where dynamic responses to historical events occur.

Thematic references in games to real-world events, locations, and figures are one way to elevate their message and separate them from the context of purely children's activities. Among other concepts, some view games, especially online games, as carriers of propagandistic and educational content, tools for social awareness, demystification of reality, instruments for shaping new habits, or acquiring motor skills. The narrative and mechanics of both complex and simple games create opportunities for simulating decision-making, social, political, economic, as well as physical, chemical, and biological processes (Brandl and Schrader, 2024).

In proposed typology, Flanagan identifies several categories: serious games, activist games (by individuals, organizations, or advocacy groups), artist games (for artistic expression), and radical games (also synonymously called games for change). The latter, through hyperbole, draw attention to seemingly unsolvable or challenging problems, particularly when conventional and conformist approaches to addressing these issues are considered (Flanagan, 2009).

According to another approach, educational gamification should not be equated with game-based learning, simulations, or serious games (Glover, 2013). According to this perspective, the latter largely focus on creating applications similar to games, with added value in the form of knowledge transfer. However, their primary aim remains close to that of typical entertainment games.

The potential applications of games for educational purposes include the following (Anderson and Lawton, 2005):

- supporting the dissemination of teaching materials with references to business realities,
- demonstrating managerial networks and their internal interconnections (e.g., marketing, human resources, finance, production),
- developing decision-making skills,
- increasing student engagement during classes through active participation,
- reinforcing acquired knowledge and fostering teamwork skills,
- demonstrating the complexity of seemingly simple tasks (such as creating and implementing a business plan).

It is worth noting that Julian Alvarez and Olivier Rampnoux propose dividing serious games into five categories: Advergaming, Edutainment, Edumarket games, Diverted games, and Simulation games (Alvarez and Michaud, 2008).

2. Literature Review

Research has shown that students attending lecture-based classes can focus their attention for only about 40% of the class time (Pollio, 1984). Other studies indicate that while listeners absorb approximately 70% of what the lecturer says during the first 10 minutes of a lecture, this percentage drops to 20% during the final 10 minutes. According to D.W. Johnson, R.T. Johnson, and K. Smith (1991), the low effectiveness of lectures stems from the following factors:

- listeners' attention decreases over time,
- long and cyclical lectures appeal mainly to "auditory learners,"
- the lecture format favors the assimilation of information at a basic level,
- the lecture format assumes that all listeners need to learn exactly the same content and absorb information at the same pace,

- it is not a particularly popular format among listeners.

According to constructivist principles, learning occurs when (Pritchard, 2009):

- new information is integrated into existing cognitive structures, becoming part of the learner's knowledge, skills, and understanding of the world;
- learners actively construct knowledge;
- learners activate their prior knowledge;
- learners use various information sources during the process of understanding or solving a cognitive task;
- authentic tasks are presented in meaningful contexts for the learner;
- reflection is encouraged on prior knowledge and new learning situations;
- learners engage in social interaction and learn from one another;
- autonomy and independence are fostered.

Educational constructivism, although primarily a theory of learning and cognition, serves as a framework for designing the teaching process. It specifies student activities and, to some extent, defines the roles and responsibilities of teachers, who, by planning appropriate educational situations, can help students achieve their learning objectives (Biggs and Tang, 2009).

Thus, in this theoretical context, teaching is not understood as the transmission of information but as the creation of cognitively engaging learning situations in which learners, through appropriate activities and tasks, construct knowledge and develop new skills. The teacher is not merely considered a source of information but, above all, a designer and coordinator of students' cognitive activities.

Experiments using functional magnetic resonance imaging (fMRI) have identified several brain areas that are intensely engaged during gameplay. These include structures associated with attention and working memory (e.g., the cingulate gyrus and orbitofrontal cortex), highlighting the high complexity of cognitive tasks performed during gameplay.

Recent studies suggest that in tasks engaging cognitive functions relevant to gaming, the observed activation strength is negatively correlated with the expertise of the player. Such effects have been independently observed in several experiments, including those examining the neural costs of filtering out distractors in the visual field.

These findings suggest that gamers have greater resource reserves, making certain tasks relatively less demanding for them compared to control groups. Similar conclusions have been drawn from electrophysiological studies using steady-state visually evoked potential (SSVEP) analysis. These studies have shown that gamers are more effective than control groups at filtering irrelevant information in the visual

field, reflected in both better task performance and lower signal amplitude related to distracting information that needed to be ignored.

A second significant line of research on gamers focuses on measuring structural changes in the brain. This research uses techniques such as voxel-based morphometry (VBM), which has demonstrated greater gray matter volume in areas involved in memory and spatial navigation (e.g., the hippocampus and dorsolateral prefrontal cortex). It also employs diffusion tensor imaging (DTI), which can detect changes in nerve fiber structure and the degree of their myelination.

Although studies using this method are still relatively few, they appear highly promising due to its exceptional sensitivity and ability to detect even subtle changes in brain microstructure. For instance, recently published studies using DTI have demonstrated statistically significant changes in the hippocampus and its associated nerve fibers after just a single two-hour training session using games (Bielecki, 2015).

All types of games (including logistics games) share the following characteristics (Puszko, 2016):

- Participants in games are individuals seeking to achieve their changing goals and fulfill various needs during gameplay; this variability arises from an undefined preference system that evolves over successive game sessions.
- Every game takes place under changing conditions shaped by its interactions with institutional, social, economic, ecological, and technical environments. The nature of these interactions varies over time and may be known to participants to differing degrees.
- The rules of the game are relatively stable but are not equally mastered by all players.
- The value of the game's outcome is unpredictable for all participants, and its significance varies among them.
- Participants engage psychologically in the game with varying intensity, which is a function of the game system and the players' individual psychological predispositions.
- Game participants can form alliances that change over time.
- The proper progression of the game depends on a shared language among participants; however, this language is not equally understood by all and may evolve during gameplay.
- Every game includes the potential for rule-breaking.

J. Juul proposed six elements that, when present simultaneously, define a product as a game. These are: rules, measurable outcomes, values assigned to individual outcomes, player effort, emotional attachment to the outcome, and negotiable consequences. According to his definition, a game is a formal system bound by rules, featuring variable and measurable outcomes, where certain variables are

assigned specific results. The player must exert effort to influence the outcome, and the consequences of their actions can be optional and negotiable (Juul, 2003).

Game design refers to the process of creating the rules and foundations of a specific game (Fullerton, 2008), as well as, in a broader sense, the production of a finished product in the form of a program, application, or simulation. Game design involves defining goals that motivate the player to achieve a specific outcome.

The player voluntarily follows the scenario and makes decisions within defined rules to reach their goal. It is widely believed that effective game design is largely focused on the audience and their experience of the gameplay (Oksanen and Hämäläinen, 2014). Players must work together to achieve better results, but the game structure fosters distrust among players while providing greater satisfaction from cooperation than from competing against others.

To create an effective game, whether for entertainment or educational purposes, regardless of its form or genre, the design process can be divided into the following components (Brathwaite and Schreiber, 2009):

- World Design – Developing the foundations, defining the setting of the gameplay environment, scenario, laws, and storyline. Depending on whether the project aims to simulate reality or create an abstract world, the designer decides the extent to which the game should imitate reality.
- System Design – Choosing the appropriate mechanics, mathematical patterns, algorithms, and decision paths. This process is fundamental to designing any type of game, establishing the most basic rules and regulations.
- Content Design – Determining the available items, tools, tasks, characters, cards, etc. This stage involves deciding how players can influence the game rules through items and how they operate them.
- Gamewriting – Developing dialogues, in-game context, notifications, and instructions for players throughout gameplay. This step involves creating all the information needed for players to interact with and understand the game at every stage.
- Level Design – Designing maps, boards, and game stages. Whether this involves increasing difficulty levels or following the game's storyline, proper level design significantly impacts player motivation.
- User Interface – Typically defining the graphic design and the degree of interaction between the participant and the game mechanics.

In 2002, Sawyer redefined the concept of serious games, basing his definition on the idea of integrating the purpose of serious games with the knowledge and technologies of the video game industry (Sawyer, 2002). Building on Sawyer's considerations, Chen and Michael (2005) and Zyda (2005) pointed out that the primary purpose of serious games is neither fun nor entertainment.

The term "serious" can be applied to emphasize that games can be used to enhance media literacy during educational processes, highlighting that games can include "serious" content aimed not only at entertainment but also at learning.

Although various authors' definitions of "serious games" refer to a similar scope, the boundaries of these games can be interpreted and defined differently. Moreover, various types of games can fall into this category. In serious games, the primary goal is teaching. Serious games have a clear and carefully thought-out educational purpose and are not primarily played for entertainment.

Today's generation of students has grown up in a digital environment; they are familiar with the operation of computer applications and navigate the virtual world with ease. Providing such games can be one way to meet students' needs while also supporting traditional teaching methods. This suggests that traditional methods of teaching certain modules may not be effective.

Therefore, incorporating these solutions as a didactic element aligns with the expectations of the younger generation, particularly in terms of tailoring to their preferences and incorporating electronic media into educational processes. Serious games combine learning, typical gameplay (fun), and the use of simulations. A graphical representation of the connections between these three areas is presented in Figure 1.

Figure 1. *The connection of areas in Serious Games*

Source: *Frederick J.F. (2024), Defining Serious Games, https://flowleadership.org/serious-games/.*

Serious games enable the simulation of events or processes occurring in the real world, designed to achieve a specific goal, such as solving a given problem. All

activities are based on clear and well-defined rules. Educational games surpass other forms of learning in terms of functionality. This is linked to the opportunity for more active participation in the educational process, making it easier to understand the issues at hand and to enhance skills.

3. Research Methodology

The methodology of the study on the use of serious games in education was based on an analysis of the teaching process and the results achieved by students during simulation gameplay. A mixed-methods approach was employed, combining quantitative and qualitative methods to gain a comprehensive understanding of the educational outcomes and decision-making processes of the participants.

The use of decision-making games in teaching aimed to determine whether games serve as an effective educational tool for modeling competencies under conditions of competition and uncertainty, which are not easily replicated by other teaching methods. Additionally, it examined the decision-making processes of students participating in supply chain management games.

The study was conducted in an academic setting among undergraduate and graduate logistics students. Serious games were selected based on their alignment with the curriculum and educational objectives, such as developing skills in analyzing logistics processes, making decisions under resource constraints, and managing risks in dynamic systems.

Each game session was part of practical classes and lasted between 1.5 to 3 hours, depending on the game's complexity. To ensure adequate preparation, the introductory process included:

- Presentation of the game's objective and rules – an explanation of the game's mechanics, scenario, and key logistics challenges.
- Role assignment – each participant was assigned a specific task or role reflecting typical functions within a logistics system (e.g., supply chain manager, transport specialist, analyst).
- Test round of the game – a brief exercise allowing participants to familiarize themselves with the game's mechanics.

Data collection involved questionnaires assessing students' theoretical knowledge, practical skills, and perceptions of the game; an analysis of decisions made during the game (documenting key choices and their impacts on outcomes); and observations of the gameplay to analyze team strategies and participant interactions.

Group interviews were conducted post-game to understand the motivations and thought processes behind decisions. Quantitative methods were applied to analyze game outcomes, such as process efficiency, achieved logistics goals, resource

utilization, and scores. Qualitative methods were used to analyze interviews and observations, identifying patterns in decision-making, communication styles, and strategies.

Students' performance was evaluated based on the effectiveness of solutions (e.g., cost minimization, delivery time optimization), creativity in problem-solving, teamwork skills, and alignment of actions with the game's scenario objectives. Results were analyzed by grouping participants based on different levels of advancement (e.g., first-year undergraduates vs. master's students) and considering participants' prior skills.

This approach allowed the identification of differences in decision-making approaches and action effectiveness. To ensure the reliability of the results, data triangulation was employed, combining findings from questionnaires, observations, and interviews. This provided a coherent picture of the educational process and its outcomes.

The study's methodology enables the evaluation of both the effectiveness of serious games as an educational tool and the decision-making processes of students in complex logistics scenarios, offering valuable insights for educational practice.

4. Research Results and Discussion

Conducting educational games with logistics students represents an innovative approach to teaching, aimed not only at imparting theoretical knowledge but also, and most importantly, at developing practical skills essential for future professional careers. Simulation games allow students to experience real-world logistics challenges in a safe, controlled environment, enabling them to apply acquired knowledge in practice. The objective of these activities is to foster competencies such as problem analysis and resolution, decision-making, teamwork, and time and resource management in dynamically changing conditions.

Introducing students to educational games required careful preparation and the creation of appropriate learning conditions. This process included several key steps:

- Defining the game's objective precisely – Each game was designed to align with specific educational goals and support the academic curriculum. The game's purpose was clearly communicated to students, helping them understand the skills they would develop and the outcomes they were expected to achieve.
- Explaining the rules and scenario – Before starting the game, the instructor thoroughly discussed the participation rules, the simulation scenario, and the tasks students needed to complete. Particular emphasis was placed on explaining the decision-making mechanisms and their impact on the game's progression.

- Preparing the game environment – Depending on the type of game, the instructor prepared appropriate materials, tools (e.g., boards, cards, computer simulations), and instructions to help students navigate the gameplay. Planning the game's structure, including team divisions and participant roles, was also an essential element.
- Introducing the logistics context – To ensure students fully understood and engaged with the game, the instructor presented the logistics context and realities on which the simulation was based. This allowed participants to analyze the problem in a manner similar to real-world industry approaches.
- Providing support during the game – The instructor monitored the gameplay, answered students' questions, clarified uncertainties, and offered guidance when necessary. Their role also involved encouraging participants to be active and collaborate.

This approach enabled students not only to acquire new skills but also to learn from their mistakes, analyze the consequences of their decisions, and enhance competencies required in the dynamic logistics industry.

The analysis utilized several types of games. The first was the Service Game, where participants take on the roles of members of the management board of a service company. Each team's task is to build a company with the highest possible value for shareholders, calculated using a predetermined formula. To achieve this, they must compete in a market created by the trainers, planning strategies to outperform other teams, acquiring customers, reducing costs, and maintaining quality.

All activities occur within a structured simulation framework that dictates the workshop's progression but leaves strategy and tactics to the participants. Every action results in costs or revenues, allowing participants to experience how a company operates in a market, what market and competitive strategy entails, how money circulates within a service company, sources of costs, key financial categories (e.g., investments, fixed and variable costs, profits, cash flow), and what considerations are crucial for strategic and operational decisions.

Between four and eight service companies compete in the market. Each offers similar services but can target slightly different market segments. At the start, every team receives specific financial, material, and human resources. The goal is to achieve the highest profits over several years while competing with others, even though they may cater to different customer groups. To win, participants must define their service range and pricing, determine spending on marketing, human resources, customer service, and logistics.

The second game was the Production Simulation, where participants become managers of manufacturing plants within a large enterprise. They are responsible for organizing the production floor, deciding on productivity, modernity, and reliability of the technologies used. Participants must also plan the purchase of materials, semi-

finished products, and machinery.

Managing storage costs for raw materials and finished products becomes a critical cost element in the simulation. In this production simulation, several teams compete against each other. Participants experience the principles of production organization (e.g., dependencies between workstations, changeover planning, dealing with delays), how production costs affect overall operational costs, how to rationally reduce production expenses and plan spending, and how to make decisions regarding purchases of materials, machines, and parts. They also learn to plan raw material and finished goods inventory.

The game scenario involves several manufacturing plants within a large company, where management has announced a productivity improvement project. The plant that best improves its operations will receive a reward. The evaluation criteria include low production costs, high quality (low defect rates), timeliness (no delays), and flexibility in adapting to new orders. Over four months, plant managers work to reduce costs, shorten downtimes, improve work organization, and enhance quality. Monthly performance reports allow managers to analyze results and make better decisions for the subsequent month.

The third game was the Supply Chain Game, in which participants become CEOs of companies offering products in a supply chain operating in a highly competitive market. They are responsible for setting and achieving sales targets and ensuring their company's profitability. Participants experience the principles of building commercial and market strategies for companies within a supply chain, operationally managing sales teams, planning production and sales (including budgets, targets, and pricing), and understanding the impact of promotional activities and customer loyalty programs.

Several supply chains compete in the market, aiming to serve the same customer groups. These chains offer identical products (two from different market segments). The participants' task is to develop strategies to acquire and retain as many customers as possible while meeting quantitative and value-based sales targets. They must craft a comprehensive sales strategy, make "make or buy" decisions, organize the sales team, develop offers, pricing, and discount policies, and undertake promotional activities. They also manage the revenue (planning income and targets) and expense budgets.

The final game was the Negotiation Game, where participants take on the roles of company boards operating in the real estate market. Their goal is to grow their real estate portfolios, requiring them to form consortiums and negotiate with others. Participants experience the principles of negotiation planning, analyzing the other party's position and interests, conducting team negotiations as well as three-way and consortium negotiations, and navigating situations where shared interests clash with conflicting positions. They also learn to avoid letting emotions dictate their actions.

In the game, five companies operate in a large city, specializing in constructing and acquiring properties such as houses, shopping centers, office buildings, industrial areas, and rental warehouses. These companies compete and simultaneously cooperate by selling land and buildings to one another, forming bidding consortiums, and renting equipment. Each negotiation balances competing priorities: offering a larger discount might reduce profits, but failing to do so could lead to losing a bid to competitors. The game provides the sensation of constantly balancing on the edge of strategic decision-making.

The described games allowed for the analysis of numerous decision-making situations related to logistics activities. To illustrate the decision-making process of students participating in the games, several of these situations were presented.

The first decision-making situation involved the make or buy problem. Students had to decide not only whether to produce a product themselves but also, in the case of purchasing, which supplier to buy from. The first scenario offered virtually the same profits in each situation: both self-production and purchasing from two suppliers guaranteed a profit of 6 million. Only choosing the second supplier was entirely irrational due to lower payouts for both players.

Among the participants, 30.3% chose to manufacture the product themselves to maintain control over the process, 30.3% purchased the product from the first supplier with a profit split of 6:2, and 23.5% chose the third supplier with a split of 6:3. In post-game discussions, students indicated they opted for purchasing to focus on other aspects of their operations without losing profits.

Some also cited a desire to "let others earn," reflecting a degree of altruism rather than economic rationality, particularly among those choosing the third supplier who earned more. A total of 15.9% made entirely irrational decisions by selecting the second supplier. When asked about the determinants of this choice, these students demonstrated a complete misunderstanding of the situation and the consequences of their decision.

In the second round of the game, the profit distribution was altered. While self-production remained profitable, only purchasing from the first supplier yielded an equivalent level of profit. Changes in decisions during the second round highlighted difficulties in understanding market mechanisms.

Specifically, the number of players choosing self-production decreased by 3 percentage points, despite it still being profitable. More notably, the number of players choosing an irrational 5:3 split increased to 21.2%. Fully justified decisions to select the first supplier were made by 47.7% of participants. The number of quasi-altruists significantly declined to 3.8%, as they prioritized higher personal profits. In the third round, participants in the make-or-buy situation were allowed to propose their own profit distribution between the supplier and their company, aiming for a

more satisfactory outcome than in the second round.

Here, economic rationality suffered the most. Only 20 participants (15.5%) believed they could propose a better solution, and only 12 (9.1%) actually did so, opting for a profit ratio of 8:1.

In the supply chain game, players had to decide how to handle a partner who breached a contract by taking advantage of another market opportunity. In the subsequent stage, as managers, they faced the possibility of achieving significant profits, which required breaking existing agreements. For most players, the inconvenience of a partner breaching a contract did not constitute a definitive end to collaboration.

Specifically, 65.2% of participants would terminate the contract, 54.5% would impose penalties, and 24.3% would reduce the scale of collaboration. For 12.1% of participants, the situation did not require any consequences beyond contract termination, and 3% would not even terminate the contract.

When faced with reversed circumstances—taking advantage of a market opportunity themselves—63.4% decided to breach the contract. If the opportunistic contract involved a 50% risk, 24.2% were willing to take this step. This result indicates some consistency in behavior but may be flawed due to the inclusion of both scenarios in a single study.

Another scenario concerned cost distribution systems and the perception of fairness in such distributions. Players acted as decision-makers in a supply chain where transferring all inventory to a single link was possible without significantly affecting service quality. This reduced inventory maintenance costs across the chain by 50%, but one link (out of four) bore all the costs. The task was to determine a fair distribution of these costs across the supply chain. Statistical measures describing the payout distribution among the supply chain links are presented in Table 1.

Table 1. *Statistical measures describing the payout distribution among the supply chain links*

Variable	Arithmetic Mean	Mode	Mode Frequency	Min	Max.	Variance	Standard Deviation	Coefficient of Variation	Standard Error
Company 1	2647,73	4000	57	1000	4000	1739766	1319,00	49,82	114,80
Company 2	528,03	0	57	0	1500	265850	515,61	97,65	44,88
Company 3	447,73	0	65	0	1300	220376	469,44	104,85	40,86
Company 4	376,52	0	69	0	1100	189902	435,78	115,74	37,93

Source: *Own elaboration.*

From the perspective of theory, a fair distribution of costs would be proportional to the benefits gained from the lack of inventory and would amount to 1000, 1500, 1000, and 500 units, respectively, for each company. Despite the fact that achieving this outcome did not require complex calculations, only a few students proposed such a distribution. The vast majority decided that the first link in the chain should bear all the costs. The justification given was that allowing the transfer of all inventory to this link was a sign of market weakness, and it should face the consequences.

The information available to participants allowed for another cost distribution that could be considered logical and fair: equal costs of 1000 units for all links. Other proposed distributions were illogical, as they assigned higher costs to the third and fourth links, which benefited less from the inventory transfer than the second link.

During the simulation-based negotiation game in the supply chain, students had to decide in a very short amount of time which of the offered contracts to accept (based on transport rates, volume, and distance). The game was played sequentially and repeated four times, with time constraints for each round. In the fourth round, the time available was 10 times shorter than in the first. The offers also varied across rounds. It turned out that in the fourth round, decisions were made before the time ran out, whereas in the first round, time expired before all offers were allocated.

This outcome was influenced by changes in how the game and offers were perceived. In subsequent rounds, decision-makers focused less on each individual offer. Instead, they searched for expected offers or opportunities, deciding based solely on rates (which could lead to irrational decisions due to transport volume). A tendency to ignore competition and avoid fighting for customer segments was also observed. Most often, the procedure involved ranking offers and selecting from those not yet taken by competitors.

5. Conclusions, Proposals, Recommendations

Simulation games have proven to be an effective educational tool, enabling students to develop analytical skills, decision-making abilities, and management capabilities in complex and dynamic conditions. Participants had the opportunity to apply theoretical knowledge in practice, fostering a better understanding of logistics processes and improving their competencies.

The decision-making processes demonstrated by students revealed a variety of approaches and levels of understanding. Not all decisions were economically rational—some were motivated by altruism or insufficient analysis of the situation. These results highlight the need for further improvement in participants' decision-making skills.

The effectiveness of the games was strongly influenced by carefully designed

scenarios that provided participants with diverse challenges, such as cost optimization, negotiations, and risk management. The games allowed students to gain knowledge and experience in logistics areas such as supply chain management, production optimization, and market strategy. This enabled participants to grasp the specifics and challenges associated with various aspects of logistics.

Another critical element was the preparation of participants and the support provided by instructors. Explaining the rules, assigning roles, and conducting test rounds significantly impacted student engagement and outcomes. During the simulations, it was crucial for instructors to monitor the process and provide guidance, which helped students better understand their actions.

Based on the study results, several recommendations can be made. First, the scope of serious games should be expanded to include more complex scenarios, such as crisis management or long-term strategic decision-making. Second, serious games should complement theoretical lectures and case studies to provide a holistic approach to logistics education. Third, it is advisable to conduct research on the long-term effects of using games to assess their impact on graduates' professional effectiveness.

Finally, introducing more technologically advanced simulations, such as virtual reality games, could enhance realism and participant engagement.

Serious games demonstrate significant educational potential in logistics education, offering students the opportunity to gain practical experience and develop essential professional competencies. The study results indicate that this teaching method can greatly enrich traditional educational approaches and should continue to be developed.

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