Design Thinking for Fostering Innovation in Logistics

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Abstract - **The increasing complexity of logistics systems requires professionals capable of addressing operational challenges through innovative and collaborative approaches. In this context, Design Thinking has emerged as a human-centered methodology that supports problem structuring and solution development. This study investigated the application of Design Thinking in logistics education through a university-industry collaboration involving two undergraduate logistics classes and a road transport company in Brazil. The research adopted an action research approach in which students applied the stages of empathy, definition, ideation, prototyping, and testing to analyze a real organizational challenge and propose potential solutions. The results indicated that the approach supported the development of transversal competencies and facilitated the generation of practical proposals for logistics improvement. Based on the experience obtained, a practical guide is proposed to support the integration of Design Thinking into logistics education. The findings contribute to discussions on the integration of human-centered innovation approaches into logistics and engineering education.**

Keywords: Supply Chain Management, Production Engineering.

I. INTRODUCTION

In a context where global and national logistics service markets are continuously evolving, efficient logistics management requires highly qualified professionals capable of responding to increasingly complex operational challenges. These professionals must be able to analyze data, adopt emerging technologies, and develop innovative solutions to logistical problems [1]. In addition to traditional technical competencies, logistics professionals are also expected to demonstrate innovative thinking and adaptability in order to address the growing complexity of supply chains and logistics operations, since the capabilities of employees can represent an important barrier to innovation within organizations [2].

In this context, the adoption of Design Thinking (DT) in educational environments can contribute significantly to the development of transversal competencies that are increasingly demanded by the labor market. These competencies are often insufficiently developed in higher education, as traditional teaching approaches tend to prioritize discipline-specific knowledge, particularly technical skills, over broader cognitive and behavioral capabilities [3].

Design Thinking is widely recognized as a human-centered approach that aims to creatively solve problems and promote innovation by focusing on users' needs and experiences [1], [4], [5]. It can also be understood as an approach composed of iterative stages that encourage the reinterpretation of complex problems and the development of alternative solutions, rather than following rigid and predetermined procedures [5]. In this study, Design Thinking is considered as a methodological approach as presented in the literature [4]. This perspective emphasizes that educational institutions still lag behind in the adoption and systematic investigation of DT, despite its potential to promote significant transformations in traditional academic structures by strengthening the connection between theory and practice [7].

Although Design Thinking has gradually expanded across different sectors and disciplines, studies investigating its incorporation into logistics education remain limited. Most existing research focuses on engineering and design programs, leaving a gap regarding the use of DT as a pedagogical tool within logistics curricula [8]. Logistics encompasses the management of the entire supply chain, from the acquisition of raw materials to the final delivery of products to customers. This field includes activities related to transportation, storage, distribution, and inventory management, aiming to ensure the efficient and coordinated flow of products and information across various sectors of industry and commerce [9], [11].

In Brazil, the road freight transport sector plays a central role in logistics operations. According to the Technical Bulletin of the National Confederation of Transport, published in January 2023, the country has approximately 295,000 companies dedicated to freight transportation [12]. In such a competitive environment, transport companies must continuously seek innovative ways to meet customer demands and improve service quality in order to remain competitive [2].

The increasing complexity of logistics systems requires structured approaches to support decision making. In this context, Design Thinking can be interpreted as a problem structuring and decision support methodology that facilitates the identification of user needs, the generation of solution alternatives, and the evaluation of potential improvements in logistics processes.

In light of this context, the present study aims to evaluate the contribution of Design Thinking to the development of soft skills and to the generation of practical solutions in the logistics field. Specifically, the study analyzes the implementation of a DT activity conducted with two logistics classes in partnership with a road transport company, focusing on the mobilization of transversal competencies among students. Additionally, based on the

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experience obtained, the research proposes a practical guide to support the integration of DT into logistics education. Unlike purely analytical optimization models, this work focuses on the front-end phase of problem solving, where DT helps structure ill-defined problems and generate innovative solution spaces. The study contributes to the literature by demonstrating how DT can be applied in logistics education through university-industry collaboration, supporting both the development of transversal competencies and the generation of practical solutions to organizational challenges.

II. Literature Review

A. Logistics

Logistics involves the management of the entire supply chain, encompassing activities from the acquisition of raw materials to the final delivery of products to customers. This field includes processes related to transportation, storage, distribution, and inventory management, aiming to ensure the efficient and coordinated flow of products and information throughout the supply chain [9], [11].

Supply chain management (SCM) can be understood as the planning and integration of material, financial, product, and information flows both within organizations and between companies. These flows extend from primary suppliers to final consumers, with the objective of creating value for customers through the efficient delivery of products and services [9], [10].

Transportation represents a fundamental component of logistics operations, responsible for the physical movement and geographical distribution of goods within the supply chain [11]. Different transportation modes are available, each presenting specific characteristics that influence their selection depending on factors such as cargo type, operational performance, and associated costs. The main transport modes include road, rail, air, waterway, and pipeline transport systems [13].

In Brazil, road transportation plays a particularly significant role in logistics activities due to the country's large territorial extension and the predominance of highway infrastructure for freight movement. Despite its importance, the sector faces several challenges, including infrastructure limitations, regulatory constraints, and the influence of economic and political dynamics that directly affect logistics efficiency and operational performance [14].

B. Design Thinking Methodology

The concept of Design Thinking (DT) gained prominence through its dissemination by innovation and design organizations and has become widely adopted in different organizational and educational contexts [15]. Although its roots can be traced back to design research from the 1980s, DT has progressively evolved into a structured approach for addressing complex problems and fostering innovation [16].

The definition of Design Thinking is not uniform in the literature. Several authors describe DT as a mindset, an approach, a discipline, or a problem-solving framework [4], [15], [17], [18]. In general, Design Thinking can be understood as a human-centered methodology that focuses on understanding users' needs and developing creative solutions to complex challenges [5].

Despite the diversity of conceptual perspectives, DT reflects the characteristic way designers approach problem solving, emphasizing empathy with users, experimentation, and iterative learning processes. This approach seeks to establish connections between human needs, available technological resources, and the practical constraints of business environments [4].

Design Thinking is often applied in the development of innovative products, services, and processes. In this sense, the solutions generated through DT are typically evaluated based on three fundamental dimensions: desirability from the users' perspective, technical feasibility, and business viability [15]. When applied to projects, these three dimensions guide the identification and validation of innovative solutions that are both practical and sustainable.

The DT process is generally structured into stages that guide individuals in observing problems, gathering information, generating ideas, and testing potential solutions [17], [18]. Although different models exist in the literature, most share similar underlying principles and emphasize iterative cycles of divergent and convergent thinking. These cycles allow participants to explore multiple alternatives before converging on the most promising solutions [4], [15], [19].

Among the various Design Thinking frameworks, the model proposed by the Hasso Plattner Institute of Design at Stanford University, also known as the D. School model, is one of the most widely referenced in the literature [17]. This model offers a structured and didactic representation of the DT process and is frequently applied in both educational and organizational settings [7], [8]. The structure of this model is presented in Figure 1.

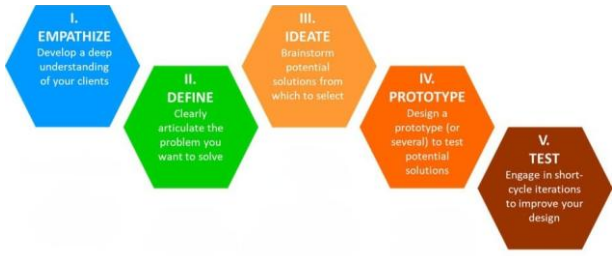

Figure 1. Design Thinking stages according to the D. School model

The D. School model consists of five main stages: empathy, definition, ideation, prototyping, and testing. The empathy stage focuses on understanding users' experiences and needs through techniques such as observation and interviews [7], [17]. In the definition stage, the information collected is analyzed in order to clearly define the problem to be addressed. The ideation stage encourages the generation of creative solutions through collaborative brainstorming and other idea-generation techniques. Subsequently, in the prototyping stage, selected ideas are transformed into tangible representations that allow preliminary evaluation of the proposed solutions [4], [7]. Finally, the testing stage involves the evaluation of prototypes by users, enabling feedback and continuous refinement of the proposed solution [7].

C. Transversal skills or soft skills

The concept of competence encompasses a broad range of meanings and has been widely discussed in the literature. In general terms, competencies can be understood as a set of individual attributes that integrate knowledge, skills, and attitudes, which together contribute to improved professional performance [20], [21]. These elements interact to enable individuals to effectively perform tasks and respond to the demands of organizational environments.

Transversal competencies, often referred to as soft skills, represent a dynamic combination of cognitive, metacognitive,

socio-emotional, behavioral, and ethical abilities that support individuals in adapting to the challenges of personal, social, and professional life [22]. Unlike technical skills, which are typically associated with specific professional tasks, soft skills are transferable across different contexts and professional fields.

From an economic and organizational perspective, competencies play a fundamental role in improving productivity and competitiveness. The development of these skills contributes to creating environments that are more conducive to innovation, particularly in contexts characterized by rapid technological change and global competition. Consequently, the development of both technical competencies (hard skills) and transversal competencies (soft skills) has become essential for effective professional performance.

According to the World Economic Forum's Future of Jobs Report, transversal competencies such as analytical thinking, creative thinking, leadership, empathy, and active listening are increasingly valued by employers as essential attributes for professional success in a rapidly changing global economy [23]. These competencies enable professionals to adapt to new challenges, collaborate effectively within teams, and contribute to innovative problem-solving processes.

III. Methodology

The study was carried out at a Technological Education Institution located in the municipality of Guarulhos, Brazil, in partnership with a company operating in the road transportation sector. The research involved the participation of 37 students enrolled in the fifth semester of the logistics program, attending both afternoon and evening classes.

The partner company participating in the research is located in the Metropolitan Region of São Paulo, Brazil. In addition to its headquarters, the company operates two branches in the cities of Americana (SP) and Nova Serrana (MG). The organization has been operating in the logistics market for 22 years, specializing in cargo collection and distribution across the São Paulo-Minas Gerais corridor, transporting both raw materials and finished products. The company has a total workforce of 21 employees. Most employees perform operational assistant roles, totaling eight professionals. Other areas include four assistants distributed between the commercial (two) and financial (two) departments, in addition to two operational coordinators. The remaining positions are occupied by a single employee each.

The research followed the principles of action research, structured as a four-stage cycle focused on empirical investigation. The stages included planning, implementation, description, and evaluation of the application of Design Thinking in logistics education. Action research facilitates collaboration between universities and companies, as it establishes relationships between researchers and professionals and contributes to learning processes [24]. It is characterized as a type of empirical research conducted in close association with a specific action or with the resolution of a collective problem, in which researchers and participants cooperate throughout the process [25]. According to Tripp, action research emerges from the broader field of action inquiry [26].

As an investigative approach, action research is understood as a continuous and cyclical process in which each cycle generates improvements that serve as the basis for subsequent developments [27]. The model adopted consists of four stages: (i) planning the improvements to be implemented; (ii) implementation of the planned improvements; (iii) monitoring, recording, and describing the effects of the action; and (iv) evaluation of the results obtained. In the present study, these stages encompassed the planning of the Design Thinking activity, the practical implementation of the methodology, the recording and description of the execution process, and the evaluation of the results generated during the activity.

To guide the practical application of Design Thinking, the five-stage model proposed by the Hasso Plattner Institute of Design at Stanford, known as the D. School model, was adopted. This model includes the following stages: empathy, definition, ideation, prototyping, and testing. During the empathy stage, students visited the partner company during a scheduled visit. The purpose of the visit was to allow students to observe the operational environment, listen to the company manager, and ask questions regarding the organization's practices, enabling them to understand the challenges faced in the company's daily logistics operations [28].

During the definition phase, students met with their respective groups to share the information collected during the company visit with members who were unable to attend. Subsequently, the groups were instructed to synthesize the information and clearly identify the central problem to be addressed. To support this process, the facilitator recommended the use of analytical tools such as the empathy map, SWOT analysis, and the CSD matrix. The empathy map was used to record perceptions related to the needs expressed by the company manager. The SWOT analysis enabled the identification of internal strengths and weaknesses, as well as external opportunities and threats related to the company's context. The CSD matrix (Certainties, Suppositions, and Doubts) was applied to register the certainties, assumptions, and uncertainties that emerged during the problem definition stage. Based on the information consolidated through these tools, the students defined and delimited the specific problem that would guide the development of solutions during the DT process.

In the ideation stage, students generated ideas both individually and collectively using techniques such as brainwriting and brainstorming. Following the idea generation process, the groups conducted a voting procedure to select the most promising solution to be developed during the prototyping stage.

During the prototyping phase, students transformed their ideas into more structured proposals through the development of spreadsheets in Microsoft Excel, conceptual illustrations, and descriptions of implementation steps. In total, the students developed eight prototypes addressing the logistical challenges presented by the partner company. The development of these prototypes involved analytical approaches such as benchmarking, desk research through online sources, and the application of the 5W2H method.

Data were collected through observation of student activities, analysis of the materials produced, and a Likert-scale questionnaire (1 = totally disagree to 5 = totally agree) applied to 25 students to assess their perceptions of the DT process. The prototypes developed by the students are presented and analyzed in the results section.

IV. Results and Discussion

A. Prototypes Developed

Most students reported that solving the proposed problem contributed to the development of analytical thinking, creative thinking, and prototyping skills. This result indicates that the participants were able to experience the Design Thinking process in practice and understand the fundamental principles of the methodology as a tool for generating innovative solutions.

During the Design Thinking activity, students actively engaged in collaborative discussions and analytical exercises aimed at structuring the logistics problem presented by the partner company. The use of tools such as the empathy map, SWOT analysis, and the CSD matrix supported the identification of operational constraints and opportunities for improvement. These activities facilitated the generation of structured proposals that were later translated into the prototypes developed by the student groups.

The Design Thinking process resulted in the development of several prototypes addressing different aspects of the logistics challenges identified during the company visit. These prototypes represent the solutions proposed by the student groups and illustrate how the ideas generated during the ideation phase were translated into preliminary models during the prototyping stage. A summary of the prototypes developed during the activity is presented in Table I.

TABLE I. PROTOTYPES DEVELOPED DURING THE DESIGN THINKING ACTIVITY

Proposed logistics solutions developed by student group
Form for driver registration and preventive vehicle inspection
Steps for implementing the 5S methodology
Fleet expansion analysis suggesting the acquisition of one additional truck
Draper-type conveyor belt model for product loading and unloading
Dashboard created using a Microsoft Excel spreadsheet to visualize order indicators
Implementation steps for a strategic plan recommending the hiring of an analyst
Analysis of vehicle capacity based on volume and trip frequency suggesting the acquisition of van-type vehicles
Spreadsheet developed in Microsoft Excel based on benchmarking data from companies in the same sector to demonstrate the feasibility of acquiring a new truck and improving route distribution

The diversity of the proposed solutions reflects the exploratory and collaborative nature of the Design Thinking process, in which different analytical perspectives are mobilized to address complex logistics problems.

B. Student Perceptions: Quantitative Assessment

In addition to the qualitative observations, a Likert-scale questionnaire (1 = totally disagree to 5 = totally agree) was administered to 25 students from two classes. The results show high levels of agreement regarding the competencies mobilized during the activity (see Table II).

TABLE II. STUDENT AGREEMENT WITH DT LEARNING OUTCOMES

Statement	Agreement (Class A)	Agreement (Class B)
The DT process allowed me to reflect on the problem from the manager's perspective (empathy)	100%	73%
Problem understanding facilitated analytical thinking	91.7%	100%
My ideas for the problem were creative	91.7%	92.2%
I could express my ideas without fear of being judged	91.7%	92.3%
Working in teams facilitated knowledge construction	66.7%	92.3%
I felt engaged during the DT activity	91.7%	84.6%
I would recommend DT for logistics problem solving	91.7%	96.0%

Regarding difficulties, 50% of Class A students agreed that "solutions related to services are difficult to prototype", compared to 38.4% in Class B. While Class A had more prior professional experience in logistics, the difference between the two groups was modest. The main challenges identified by students overall were time constraints for iteration and the abstract nature of service prototyping.

C. Manager Evaluation of Prototypes

The prototypes developed by the students were evaluated by the manager of the partner company, who indicated that the proposed solutions were aligned with the organization's operational needs. Regarding the feasibility of implementation, the manager explained that investments related to fleet expansion are usually carried out directly by the company. In relation to the proposed dashboard solution, the manager reported that the company already uses Microsoft's business intelligence tool, Power BI, for data analysis. However, the current system does not include a specific mechanism to evaluate vehicle utilization during transportation operations. For this reason, the proposed dashboard was considered relevant and may be evaluated for future implementation, as illustrated in the following statement:

"We already use a BI tool on the dashboard that our system provides, but it does not address the concept of vehicle utilization for travel; therefore, we will evaluate its applicability."

Regarding the level of innovation and originality present in the students' proposals, the manager emphasized that the solutions were practical, coherent, and grounded in a clear understanding of the company's operational challenges. When reflecting on the competencies mobilized during the Design Thinking activity, the manager highlighted critical thinking, analytical reasoning, and emotional intelligence as key skills demonstrated by the students. He also emphasized that these competencies, together with resilience, organization, empathy, and professional attitude, are highly valued when hiring logistics professionals, particularly in roles that require interpersonal interaction and management capabilities.

With regard to the application of Design Thinking in the logistics field, the manager indicated that the methodology can support the development of effective solutions aligned with the operational, strategic, and financial realities of the organization. According to the manager, the approach allowed the development of proposals that were not purely theoretical but rather based on insights derived from understanding the company's context and operational constraints. This perception is reflected in the following statement:

"The DT approach understands the company's reality and adapts pragmatically, finding solutions within the company's capabilities without significantly altering its course (including financially)."

Despite recognizing the potential benefits of the methodology, the manager identified budget constraints as one of the main barriers to the implementation of proposals that require financial investment. According to him, financial limitations can represent a significant challenge to the adoption of some solutions generated through the Design Thinking process.

D. Practical Guide for DT Integration in Logistics Education

The results obtained also highlight broader implications for the use of Design Thinking in educational contexts. Planning and implementing a practical Design Thinking process in collaboration with companies requires considerable effort and coordination between academic and organizational actors. Nevertheless, the results of such initiatives can be highly beneficial for both students and partner organizations. On the one hand, companies may benefit from innovative ideas generated during the collaborative process. On the other hand, students have the opportunity to engage with

real-world problems and develop solutions that address challenges commonly faced in professional environments. Despite these potential benefits, one of the difficulties encountered during the development of this study was identifying a company willing to participate in the initiative and share its operational challenges with university students.

Another relevant aspect concerns the methodological preparation required to implement Design Thinking in educational contexts. Although prior experience with DT is not necessarily required, it is essential for participants to understand the methods and tools that can be applied during each stage of the process, according to the characteristics of the problem being addressed. Furthermore, the flexibility of the methodology allows it to be adapted to the specific needs of different contexts and challenges. This adaptability enables students to apply Design Thinking across a variety of professional situations and in different fields of engineering and management.

The application of Design Thinking in logistics education enabled the development of proposals that were considered satisfactory by the manager of the partner company, particularly in terms of their potential to improve operational practices. In this context, the prototypes developed by the students played an important role by allowing the visualization and structuring of the proposed ideas. This process demonstrates how Design Thinking can support the development of practical and user-oriented solutions in the logistics field and in other areas of organizational activity.

Overall, the results indicate that the use of Design Thinking can contribute to addressing logistical challenges by promoting solutions that are aligned with the operational, strategic, and financial realities of organizations.

Based on the experience obtained during the activity and the lessons learned from the implementation of Design Thinking in the educational context, a practical guide was developed to support the integration of the methodology in higher education institutions through partnerships with organizations.

Figure 2. DT practical guide cover

Based on the lessons learned from this action research, a practical guide was developed to support educators in implementing DT through university-industry partnerships. The guide details the five stages of the D.School model and suggests specific tools for each stage, as summarized in Table III.

TABLE III. SYNTHESIS OF THE PRACTICAL GUIDE: DT STAGES AND RECOMMENDED TOOLS

DT Stage	Key Tools and Techniques (from the guide)
Empathy	Company visit, semi-structured interviews, observation, questionnaire, active listening
Definition	Empathy map, SWOT analysis, CSD matrix (Certainties, Suppositions, Doubts), persona, user journey, blueprint
Ideation	Brainwriting, brainstorming, desk research, benchmarking, affinity diagram
Prototyping	Spreadsheets (Excel), conceptual illustrations, 5W2H method, low-fidelity mockups
Testing	In-class presentations, peer feedback, evaluation questionnaire for company manager, iteration planning

The guide presents the five fundamental stages of the Design Thinking process: empathy, definition, ideation, prototyping, and testing. Each stage is described in detail and includes a set of tools and techniques that can support the development of innovative solutions. The guide also provides practical suggestions for the application of these tools in educational activities, aiming to stimulate creativity, encourage collaboration, and support the development of user centered solutions. In addition, representative images from the study were included in order to illustrate how the stages of the methodology can be applied in real educational contexts.

V. CONCLUSION

This study investigated the application of Design Thinking in logistics education through a university-industry collaboration involving undergraduate students and a road transport company. The results indicate that the Design Thinking activity facilitated the development of transversal competencies such as collaboration, creativity, and problem solving, while also enabling students to engage with a real logistics challenge. Quantitative student feedback revealed high levels of agreement: over 91% of participants would recommend DT for logistics problem solving, and more than 90% agreed that the approach fostered analytical thinking and creative confidence.

The findings suggest that Design Thinking can provide a structured environment that encourages students to explore complex problems and develop innovative solutions in collaboration with stakeholders. The approach contributed not only to learning outcomes but also to the generation of practical proposals aimed at improving logistics processes.

The results also suggest that Design Thinking can function as a structured approach to support decision making in complex logistics contexts, particularly during the early stages of problem analysis and solution generation. In addition to its pedagogical benefits, the methodology contributed to the structuring of real logistics problems and facilitated the exploration of alternative solutions through collaboration between students and industry partners.

Based on the experience obtained during the activity, a practical guide was developed to support educators interested in implementing Design Thinking in logistics education. The guide presents the stages of the methodology and suggests tools that can be applied in educational activities aimed at addressing real organizational challenges.

This study is limited to a single case with a relatively small sample, and the evaluation is primarily qualitative, which restricts generalizability. Future studies may expand this approach by integrating Design Thinking with analytical or optimization methods in order to further support decision making in logistics and supply chain systems. Such integration could strengthen the

connection between creative problem structuring approaches and analytical decision support tools.

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