A Study On Analyzing Industrial Design Project Courses As Social Network Structures Through Actor-Network Theory

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Introduction

Background of the Study

The researcher had the opportunity to observe various academicians in the field of industrial design conducting project courses during their undergraduate, master's, and doctoral education at Istanbul Yeditepe University, Mimar Sinan Fine Arts University, and Konya Selçuk University. These observations extended through their tenure as a research assistant and faculty member at the same institutions. While serving as an assistant professor and supervising project courses, the researcher further enriched their previous experiences. Over time, it became evident that project courses were often conducted in a trial-and-error manner. The researcher observed a persistent complexity in these courses, characterized by interdependent projects, a multitude of variables influencing the process, and continuous effects on the project outcomes. Although measures such as segmenting the project development process and preparing structured project briefs to guide students showed partial benefits, these steps were insufficient to reduce the prevailing chaos effectively. The primary aim of this research is to leverage observations and experiences to mitigate the identified complexity in project courses, thereby facilitating a more structured and efficient execution of projects and contributing to improved educational outcomes.

Problem Definition

As a multidisciplinary field, industrial design necessitates diverse intellectual and cognitive skills for both students and instructors in project courses. The coexistence of explicit and implicit aspects within these courses contributes to their inherent complexity. Furthermore, the diverse characteristics of students, instructors, and institutions involved in project courses exacerbate this complexity.

To address this, it is essential to understand the impact of instructors and industrial design curricula on student outcomes, elucidate the processes and stages of project development, enhance students' intellectual capacity and behavioral approaches to the course, and equip them with the skills required by the industrial design discipline. A more structured and controlled approach is needed to manage the chaos observed in project courses effectively.

Research Questions

To guide the study and define its scope, the following research questions have been formulated:

1. Who are the visible actors actively involved in project courses?
2. What are the visible non-human factors influencing project courses?
3. What are the potentially impactful but invisible factors in project courses?
4. How do visible and invisible, human and non-human actors form a network of relationships within project courses conceptualized as a social network?
5. Which actors occupy central positions in the network, and how do they influence design outcomes in project courses?

Industrial Design: A Discipline Rooted in Serial Production

Industrial design is intrinsically connected to serially produced products. Unlike engineering design approaches, the criteria for design in serial production place the designer in an environment dominated not only by problem-solving but also by creativity. This positions the industrial designer to address operational requirements that involve multiple disciplines. Industrial designers reinterpret innovations brought by science and technology to benefit humanity. They often find themselves collaborating with interdisciplinary teams, including those from business and engineering domains.

The Industrial Designers Society of America (IDSA) defines industrial design as follows:

"Industrial design is a professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer" (IDSA).

Industrial design can also be defined as a profession and field of expertise that involves designing the attributes, concepts, forms, and functions of products and systems intended for mass production. This process considers criteria such as product-user interaction, aesthetics, identity, ergonomics, usability, technical aspects, and socio-economic factors (Warell, 1999).Based on the definitions above, industrial designers focus primarily on the following factors:

1. **Product-User Interaction:** Designers aim to optimize the usability and functionality of products while addressing their intended purpose. This involves examining similar products to identify and resolve design problems.

2. **Aesthetics:** Aesthetics not only entails making products visually appealing but also ensuring a semantically accurate visual language aligned with the relationship between form and function. Additionally, aesthetics contributes to how the product conveys its purpose and usability while considering the emotions it evokes in users.

3. **Cost:** Designers are responsible for ensuring the economic feasibility of their products for both consumers and manufacturers. Thus, they must design products that can be produced with minimal materials and time.

4. **Product Identity:** Identity plays a pivotal role in positioning a product strategically in the market and establishing a connection with a brand's other products.

5. **Sustainability:** Designers are tasked with creating products that are safe for both humans and the environment over the long term. This necessitates integrating concepts like ergonomics, sustainability, and green design into the design process.

Despite its broad scope, industrial design is only one part of the overall product development process. Other components include planning and preparation for production. The field of product design encompasses both industrial design and engineering design (Warell, 1999). Engineering emphasizes the analytical aspects of design, focusing on technical specifications. These often include areas such as mechanics, structural integrity, aerodynamics, hydraulics, electronics, software, systems, total quality management, economics, and human factors (Warell, 1999).

What sets industrial designers apart from engineers, business professionals, and other disciplines is their ability to synthesize creative and rational methods simultaneously to achieve innovative ideas. While doing so, designers often encounter unforeseen constraints and variables during the process.

As highlighted by Rittel and Weber in their 1973 work on "Wicked Problems," design problems, unlike those in engineering and natural sciences, lack singular, definitive, and ultimate solutions. This complexity also complicates the educational context of project courses, as the answers to design challenges form a rich but ambiguous pool of possibilities. Consequently, design studies do not aim for definitive conclusions but rather strive to identify and refine the most feasible solutions by borrowing from alternative approaches. Designers navigate conflicting values and constraints, ultimately achieving superior solutions through compromise and maneuvering. Yet, even at the end of the design processes, there are no absolute truths (Shön, 1987).

Proposed solutions serve as tools to better comprehend and address the resistance inherent in ill-defined design problems (Cross, 1989). Modern industrial designers must adapt to the complex expectations of both producers and consumers while keeping pace with current technologies and trends. Examples include advancements in computer-aided design and manufacturing, the proliferation of 3D printing, and the integration of artificial intelligence in the design domain.

The Origins of Studio Culture

The emergence of the studio-based education model predates the establishment of industrial design as a profession and discipline, making it worthwhile to explore the historical roots of the studio system. Unlike the traditional amphitheater-style education model, where knowledge is unilaterally transmitted from teacher to many students, early examples resembling studio-based education, characterized by mutual exchange of ideas and discussions, can be traced back to Plato's Academy, founded in 386 BCE. At his academy, Plato spent much of his life debating, developing, and writing his ideas (Pevsner, 1940). These discussions fostered a free and intuitive structure that allowed students to develop both creatively and intellectually (Readers, 1984).

A resurgence of Platonism occurred in late 15th-century Italy, where schools based on humanism—offering free, informal, and open discussions—emerged as alternatives to the universities of the time. Leonardo da Vinci and Michelangelo trained their apprentices in a studio-style education model in the fields of art and sculpture. Their approaches distinguished art from craft and emphasized that painting was not merely a manual skill but also a spiritual form of expression (Pevsner, 1940).

Traces of modern studio culture can be observed in both Plato's informal humanist discourse and the Renaissance's master-apprentice relationship, where creative imagination was emphasized more than logic and analytical thinking (Green, 2005).

The lineage of studio education can be traced through institutions such as the Académie Royale d'Armatür, École des Beaux-Arts, and École Spéciale d'Architecture, which provided training in painting, sculpture, and architecture. These schools were established as part of a deliberate strategy to sustain a consistent flow of skilled designers proficient in drawing and technical representation, laying the foundation of French design philosophy (Heskett, 1997). At École des Beaux-Arts, critiques, discussions, and idea exchanges were integral to studio sessions, while theoretical courses on subjects like mathematics, geometry, mechanics, perspective, and drainage were taught in amphitheaters. Within this framework, the "architectural studio" emerged as a distinctive format of architectural education, blending theoretical curricula with studio sessions.

These studios were modeled after traditional workshops, supported by patrons, and often involved contractual agreements (Bingham, 1993). Notable figures of modern architecture such as Frank Lloyd Wright and Le Corbusier were trained within this system (Proudfoot, 1989).

Industrial Design Studios and Studio Culture

Design studios where project courses are conducted are typically large classrooms equipped with drawing tables and seating to allow students to work independently on their projects. Proper and natural lighting in these spaces is essential for productive work. Additionally, walls in these studio-based classrooms are often designed to display and showcase student work. Unlike traditional amphitheaters, design studios are shaped for presentations and discussions, where the phases and requirements of design projects are explained. The teaching, design, and learning processes in project courses are managed by a design instructor and supporting assistants. These project courses are rooted in an apprenticeship model where values, skills, and knowledge are transferred from instructor to student (Kapkın, 2010). While this relationship has evolved, it remains relevant in current courses, albeit with some differences. In traditional craftsmanship, apprentices could directly observe their mentors practicing their craft. However, in many cases, students today do not have access to such direct observation. Design studios often include workshop equipment, model materials, and computers that enhance students' experiences with form and function. These facilities support "learning by doing," helping students refine and internalize abstract aspects such as a sense of form. Workshops where students can create models of their designs using materials like wood, cardboard, and foam are critical for learning and teaching.

Models represent objects, and modeling signifies the process. Ultimately, creating models is a process that provides answers (Giard, 1999). In contemporary industrial design curricula, project courses are central because they teach students how to visualize and present a product, a problem, or a solution as a design. Emphasis in the design studio is placed on creativity, drawing, problem-solving, and communication. Project courses provide an environment where values, skills, and knowledge are conveyed in a spirit of open inquiry, allowing students to learn to "think like designers" (Maitland, 1991).

Thinking like a designer involves perceiving and addressing essential, often overlooked aspects of design. It encompasses discussion, assumption, imagination, and defining boundaries. The supported thinking style in design studios is often described as random, intuitive, holistic, synthetic, and subjective. This thinking style ties into concepts of talent, creativity, and art, all associated with imagination and synthesis.

The teaching and learning approaches in industrial design studios differ from those in natural sciences and engineering disciplines, which are based on principles, rules, methods, and formulas applicable to rational problems. This difference stems from the nature of design problems encountered in the real world, which are not rational like those in the sciences. Studies describe these design problems as ill-defined, resistant to straightforward solutions, and difficult to analyze (Rittel, 1973).

The industrial design studio project may encompass the design of visual, auditory, and tactile interfaces that influence the overall quality of product design, functionality, and appeal. These interfaces serve as formal extensions that establish a connection between the user and the product, fostering an emotional bond. Additionally, industrial designers work with materials and structural elements that must be suitable for manufacturability, assembly, use, and environmentally safe disposal at the end of their lifecycle. As a result, addressing ill-defined industrial design problems requires simultaneous consideration of numerous factors and constraints (Talbot, 1999).

Such design problems are typically resistant to resolution and are often described as ill-defined or poorly articulated. Rowe provides a summary of the characteristics of these "wicked problems," first defined by Rittel, which can be interpreted as resistant to solution. First, Rowe highlights that these problems lack specific formulas or clear pathways for resolution, requiring iterative refinement through continuous questioning. Second, these problems lack a clear foundation and terminology necessary for initiating problem-solving actions, and there are no definitive indications of reaching a final solution. In other words, the problem-solving process cannot be abruptly halted after arriving at relatively good solutions; there is always room for improvement and the possibility of a better solution. Third, the formulations of these problems lead to alternative solutions, allowing for diverse interpretations. These formulations and solutions can span a wide spectrum, offering various paths to address the issue. Finally, none of the proposed solutions can be deemed right or wrong. Proposing solutions to design problems is merely a tool for understanding and addressing resistant and ill-defined challenges (Cross, 1984).

Therefore, recognizing and addressing these resistant and ambiguous design problems is essential. Teaching students how to identify and tackle such challenges forms the backbone of education in the design studio. Recognizing and addressing such problems, as well as teaching students how to find and manage them, form the backbone of education in design studios. Critiques of student work by instructors lie at the heart of studio education. Critiques aim to identify logical or visual errors in a student's work and guide its evolution into a more accurate and aesthetically pleasing outcome. Project courses typically begin with the identification of a project topic. Students then explore various solutions and sub-solutions throughout the design process, which includes searching for and synthesizing relevant information. The synthesis of information helps clarify design problems and facilitate the development of alternative solutions.The design studio's natural environment fosters the emergence of diverse ideas and perspectives through discussion, critique, defense, and exchange of ideas. Students in the studio experience its natural setting, characteristics, and requirements. For example, adding aesthetic or semantic attributes, assigning identity, and integrating regional, cultural, or emotional characteristics into a product is integral to studio education.

The inherent structure of industrial design studios enables the identification of design problems before they arise, ensuring healthier project progression and better outcomes through iterative processes. Students' imagination and creativity are crucial for both functional solutions and achieving formal richness. These qualities are often nurtured by students' prior experiences and intellectual accumulation.To meet the requirements of design projects, students often rely on prior coursework, typically derived from other disciplines.

Courses such as technical drawing, computer-aided design, ergonomics, material knowledge, manufacturing methods, and advanced drawing techniques support project courses when tailored to the character of industrial design and integrated into studio culture. A curriculum focused on anticipated design problems encourages professional practices more effectively than academic courses disconnected from practical applications.

The foundation of studio-based learning lies in students discovering clues and puzzles related to design problems they wish to solve. The need for organized knowledge clusters borrowed from other disciplines arises only when such knowledge is required to solve design problems (Boud, 1985). Problem-based studio learning relies on students' ability to understand, experience, and conceptualize the world around them. This approach reflects the expertise of industrial design, encompassing its methods, experiences, and concepts (Ramsden, 1992).Project-based learning in design courses requires students to work more independently than in other disciplines.

While experienced design instructors and assistants provide guidance, responsibility for maintaining design processes, identifying problems, developing solutions, making decisions, accessing resources and information, and adapting these to project designs ultimately falls on the students. This alignment with the "learning by doing" model, frequently discussed in education literature, underscores its widespread use in project courses (Green, 2005).

In design studios, learning by doing involves activities where students develop a deep understanding of problems related to real-world or simulated products (Morgan, 1983). The immersive, active learning environment fosters creativity, problem-solving, and the integration of theoretical and practical knowledge essential to industrial design.

Actor-Network Theory

Actor-network theory (ANT) was developed in the 1980s by Bruno Latour, Michael

Callon, and John Law as a framework to analyze and decipher complex social networks consisting of multiple variables and their subcomponents, all of which continuously influence one another and the system as a whole. One of ANT's defining features is its structuralist perspective. Rather than relying on essentialist explanations such as "what is true is inherently correct, and what is not proven as correct is inherently false," ANT accepts entities and phenomena as they are, seeking to objectify and equalize them for analytical purposes to explore the outcomes of their interactions (Latour, 1999).

ANT challenges previous theories like "social analysis theory," which focus solely on human agency while disregarding non-human elements (e.g., objects, technologies, systems) and invisible actors (agents), deeming these theories inadequate for explaining complex social networks. ANT considers humans and non-human entities as equal participants in their capacity to influence systems and one another. Objects and phenomena are viewed as co-constructors of social structures (Latour, 2008). Humans are defined as "actors," while non-human entities are termed "actants," signifying their capacity to act (Fallan, 2010). Latour emphasized that "nothing can be reduced to something else, but everything can relate to everything else," rejecting reductionist approaches and focusing instead on the relationships among entities (Latour, 1984).

In ANT, non-human actants are not passive "objects" under human control but active participants that shape and constrain human actions. This approach critiques modern epistemology for sidelining the formative influence of non-human actors while privileging human agency (Harman, 2009). ANT highlights that non-human entities are not merely shaped objects or planned stages; rather, they actively influence human actions (Çelikel, 2013).

Latour's objection to separating humans and objects stems from his goal of bridging the gap between material (world) and conceptual (word) realms, represented by the terms "actor" and "actant." Latour argued that neither humans nor objects have inherent superiority over the other in their capacity to act (Latour, 2008). Similarly, Appadurai's concept of the "social life of things" posits that objects, like humans, have a lifecycle, biography, and social existence (Appadurai, 1986). Beyond the core concepts of actors, actants, and agents, ANT introduces "intermediaries" and "mediators." Intermediaries facilitate interactions within the social network by enabling and accelerating the spread of relationships but remain unaffected by those interactions themselves. Mediators, by contrast, actively influence and shape the interactions they facilitate (Latour, 2008).

Another key concept in ANT is "translations," referring to the delegation or transfer of tasks and authority from one actor or actant to another. This process involves four key stages, as outlined by Latour (1995):

Problematisation: Defining the source and structure of the issue among the actors and actants.

Interessement: Inviting other actors or actants to join the social network and delegating authority to them.

Enrollment: Establishing procedures and relationships among the participating actors and actants.

Mobilization: Encouraging passive actors to take action through the facilitation of privileged actors acting as mediators.

Black Box Theory

The systems analyzed using ANT often involve highly complex social or technical networks, which can become even more convoluted when subcomponents of actors and actants are considered. This complexity may contradict ANT's goal of simplifying and deciphering these networks, potentially diverting focus from critical points of analysis. To address this, ANT is frequently used alongside Black Box Theory.

The Black Box Theory, employed across disciplines such as psychology, marketing, politics, software engineering, and other engineering fields, conceptualizes systems as "black boxes." It focuses on the system's inputs and outputs rather than its internal structure. This theory was developed in the 1960s by Norbert Wiener and Mario Bunge, building on earlier guidelines proposed by Wilhelm Cauer for analyzing electronic circuits (Bunge, 1963).

The Black Box Theory examines how a given entity interacts with external macro-environments, emphasizing that these interactions are influenced by the nature of the entity or the actors that designed it (Harman, 2009). In the context of industrial design project courses, unless a problem emerges from the actors or actants within the social network, the internal mechanisms remain closed, focusing solely on the communication networks. If an issue arises, the internal structures are reanalyzed and redesigned to resolve the problem and generate new inputs and outputs.

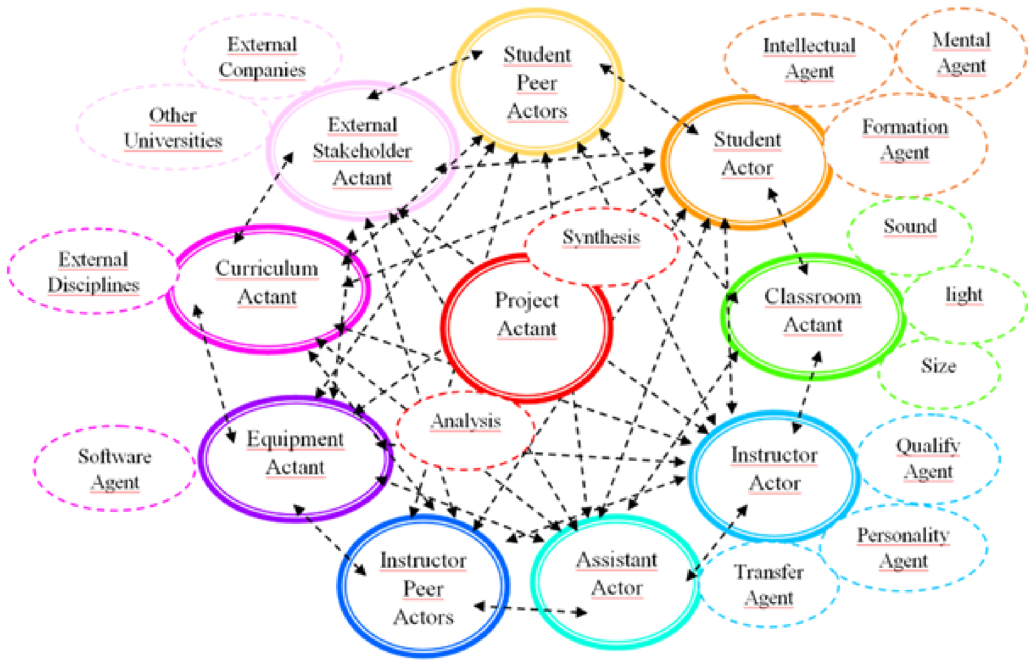
Project courses, forming the backbone of industrial design education and simulating professional design studios, are characterized by their complex, multi-component social and cultural networks.

To analyze the explicit and implicit aspects of these courses and their interrelations, ANT serves as a structural framework, while Black Box Theory offers a methodological lens for focusing on key variables.In the design studio, human variables are designated as actors; visible, non-human variables as actants; and hidden but influential variables—revealed through the Black Box approach—as "agents."

At first glance, the design studio appears as a physical classroom with a design instructor ("lead actor"), a teaching assistant ("assistant actor") bridging the gap between the instructor and students, a design student ("student actor"), other students ("peer actors"), and the equipment used in the project, such as laptops, drawing tools, and presentation boards ("equipment actants"). Hidden variables discovered through the Black Box approach are labeled as agents. Figure 1 illustrates the network of actors, actants, and their communication channels within the design studio, viewed as a social network structure. In industrial design studios, all actors, actants, and agents continuously influence each other and the system as a whole. These interactions occur through "communication networks," a term more aligned with ANT terminology. Before exploring these networks, the necessary actors and actants are identified and analyzed using the Black Box Theory to uncover hidden agents. This combined approach ensures that problems within the design studio are identified, analyzed, and addressed effectively while maintaining focus on the interplay of explicit and implicit factors within the studio environment.

Figure 1

A diagram illustrating the actors and actants that constitute the social network structure in a project-based course.



Project Actant: In design education, project-based courses are conducted around a defined topic. Each student actor begins the project process by selecting a specific sub-project topic in collaboration with the directing actors.

At this point, whether the sub-project topic aligns with or diverges from the inclinations of the student actor and the directing actors can influence the project process. As mentioned earlier, the intellectual background and experiences accumulated by both actors up to that point are considered to significantly impact the process. Here, as an actant, the topics and project briefs that design students work on, as well as the complex and interrelated processes from the presentation of these topics to the defense and evaluation of completed design projects before a jury, are examined. Figure 2 demonstrates the product development processes in industrial design project courses, with design processes deciphered through the black box methodology by gradually unveiling the black boxes and reaching the sub-black boxes.

Figure 2

A diagram illustrating the actors and actants that constitute the social network structure in a project-based course.

Student Actor: During the course, the student actor engages with the project they are working on, receiving critiques from the instructor. They bring to the table all their accumulated experience, skills, and intellectual capital. Since the student actor builds all cognitive and creative actions in the project processes on their pre-university intellectual foundation, it is understood that intellectual richness significantly influences creativity. The environment in which the student actor was raised, the quality of their previous education, their interests, accumulated knowledge, skills, and tools collectively impact their perceptual capacities, including imagination and creativity, during the project course. If it is assumed that all the intellectual accumulation the student gathered before their undergraduate education is reflected in the design studio, this phenomenon can be considered as an "intellectual capital agent." In industrial design departments, support courses are offered before project courses to equip student actors with the knowledge and skills required for their projects.

When these courses, often borrowed from external disciplines, are revised according to the characteristics of industrial design and delivered using examples from the field, it is believed that assimilating this knowledge and skillset through "learning by doing" principles will support student creativity during the execution of project courses. This observation of transformation in student actors during the process can be evaluated as a "formation agent." The different mental structures of students manifest at various stages of the project process, resulting in either stagnation or adept problem-solving, referred to as the "mental agent." Due to differences in the prior knowledge and skills of student actors, their starting levels in the studio vary, leading to differing rates of acquiring design skills as semesters progress. These differences, observable as varying levels of design skill acquisition among students in the same studio, act as agents influencing the entire system.

Instructor Actor: In shaping the cultural environment of the design studio, the instructor actor, present as the design studio instructor, plays a key role. Like student actors, instructor actors are not homogeneous among their peers. Each instructor carries unique characteristics that distinguish them, forming the "personal trait agent." These traits can be categorized into "skill agent," "transfer agent," and "character agent." The instructor actor's behavior typologies emerge during the project processes and impact other actors and actants, earning them the title of "behavior agent." These behaviors, whether directly or indirectly, can influence the morale and motivation of student actors within the reciprocal and continuous interaction of the studio culture. Beyond teaching and learning, instructor actors undertake the crucial role of fostering creative thinking and promoting lifelong learning among students. The ability of instructor actors to fulfill these roles depends on their capacity to create an environment of dialogue and consultation that sparks curiosity and encourages creative and critical thinking in student actors.

Assistant Actor: Graduate students pursuing advanced degrees in industrial design and participating in courses to gain teaching experience as prospective instructors are referred to as assistant actors. Assistant actors share the teaching load of instructor actors and provide support to both instructor and student actors.

While the characteristics described for instructor actors are also applicable to assistant actors, assistant actors often lack the teaching and instructional experience of instructor actors due to their relatively young age. However, their close age proximity to student actors can facilitate communication, turning this into an advantage. Having recently been in the role of student actors themselves, assistant actors may exhibit greater empathy, bridging the gap between instructor and student actors.

Instructor Peer Actors: These actors vary across institutions and are involved in project processes in different capacities. In some institutions, various instructor actors rotate within a classroom system to contribute to student projects, while in others, each instructor oversees the project processes of their group within a group system. Regardless, peer instructor actors influence the entire system by playing roles in defining project topics and educational strategies at the beginning of the process and serving as jurors evaluating projects—including those outside their groups—at the end.

Student Peer Actors*:* During project courses, student actors receive critiques from instructor and assistant actors as the project processes unfold. Meanwhile, other students participate as student peer actors, either actively or passively listening within the studio organization. Collaboration or competition among these actors influences the overall system and its components.

Classroom Actant: The physical spaces where courses are conducted are referred to as classroom actants. The characteristics of classrooms, including acoustic, thermal, lighting, and spatial ergonomic compatibility, as well as access to resources like food, rest, computers, the internet, and necessary equipment, impact all actors, actants, and the overall system. The conditions of this actant affect educational, scientific, and social activities, including collaborative group work, jury arrangements, and the presentation, defense, and evaluation of projects.

Equipment Actant: The tools and materials used by student actors during the research, visualization, and presentation stages of project processes, such as computers, tablets, smartphones, drawing boards, rulers, and coloring tools, are considered equipment actants. Hidden elements like computer-aided design software, artificial intelligence applications, and internet tools, which emerge to influence all components and outputs within the system, can be seen as “software agents” embedded within equipment actants.

External Stakeholder Actant: Institutions outside the physical boundaries of the design education institution, yet capable of infiltrating and influencing the social network structure of project courses through their actions, are defined as external stakeholder actants. Though they involve human actors when unpacked, they are treated as actants due to their corporate nature. Examples include other universities’ industrial design departments. In Turkey, department heads and vice-chairs of all universities offering industrial design convene annually to discuss national design education, curricula, professional organizations, and relationships with companies, forming various strategies. These meetings, where they observe each other's educational environments and student outputs, indirectly influence project courses.

Therefore, such interactions with external stakeholders are referred to as "institutional education agents." Additionally, companies involved in commercial activities often engage with project courses, especially in the final semesters, by contributing topics for product design. This collaborative interaction, also termed "university-industry cooperation," directly influences the actors and the overall education, enhancing the previously mentioned simulation characteristics of the course. These institutions are identified as "external company agents."

Analysis of Communication Networks Between Actors, Actants, and Agents in Project Courses Using the Actor-Network Theory Approach

Student Actors' Interaction with Themselves: In project development processes, the healthy interaction of the student actors with themselves is considered to positively influence all actors, actants, and the overall system. To establish a solid foundation in their self-relationship, student actors are expected to possess or develop the following skills: time management, adaptability to various conditions, openness to constructive criticism, self-reflection, the ability to identify weaknesses in their design skills, and development strategies to strengthen them, recognition of their strengths to establish a unique design style, self-monitoring of personal growth, enjoyment of learning and self-improvement throughout the educational stages, logical risk-taking, and self-motivation. Actors with high intrapersonal intelligence are more likely to build healthy relationship with themselves, enabling proper self-consultation, decision-making, and self-regulation. Therefore, this interaction can be defined as a "self-regulation network."

Student Actor's Interaction with Instructor and Assistant Actor: The guidance of instructors and assistants, who themselves are industrial designers, plays a pivotal role in transforming student actors into industrial designers during project courses. The understanding, process mastery, skills, and competencies required by the industrial design profession are often assimilated through years of experience by instructor actors, becoming implicit and embedded knowledge.

The transfer of tacit knowledge in creative disciplines like design differs significantly from the explicit knowledge transfer in fields like engineering. Furthermore, the contrasting nature of engineering problems—structured and solvable through systematic formulas—and the complex, ill-defined design problems necessitate different educational approaches.This distinct educational dynamic necessitates closer collaboration between instructor and student actors compared to the traditional teacher-student relationship in engineering education. The communication channel between them resembles a highway where work is presented, defended, critiqued, appreciated, approved, rejected, or redefined with new suggestions. A wide and smooth highway indicates efficient communication and information flow, while a narrow and congested one signifies slow or blocked communication. The instructor actor's ability to maintain a balance of humility and dignity, communicate positively and moderately, provide feedback without undue stress, calm anxious students, act fairly, honor achievements, and behave consistently and respectfully can broaden this communication channel. Consequently, it is predicted that high social intelligence in both actors positively influences this relationship and the system as a whole.

Instructor Actor's Interaction with Student Peer Actors: Although design critiques in project courses primarily occur one-on-one, other students, identified as peer student actors, participate in the class as active or passive observers while waiting for their turn. Thus, a project group can be considered a social, cultural, and public space. Even though critiques are directed at the students presenting their project, the instructor actor expects peer actors to listen, understand, and apply general and specific feedback to their projects.

Student Actor's Interaction with Peer Student Actors: In project groups, knowledge and skills often circulate among students, becoming fluid and sometimes tacit, effectively transforming students into instructors for one another. After receiving feedback from the instructor, a student actor may also seek additional critiques from their peer student actors. This interaction enriches the student actor's understanding of the instructor's feedback through the perspectives of their peers. In some institutions, educators cluster project groups for collaborative work. This approach aims to prepare designers for interdisciplinary collaboration by fostering habits of working with diverse individuals and disciplines. However, it has been observed that student actors working with self-selected peer actors often achieve more productive results than those grouped by instructor actors.

Instructor Actor's Interaction with Peer Instructor and Assistant Actors: In project courses, alongside instructor actors, assistant actors and peer instructors managing other project groups collaborate within institutions. However, peer instructors work more closely together during the initial discussion of project topics, department meetings, and end-of-semester project juries. During this intense collaboration, the behavior of instructors and assistants toward one another is observed by student actors. Negative interactions among colleagues can adversely affect student motivation, undermining their respect for and trust in the instructors and the institution. Therefore, respectful communication between instructor actors, peer instructors, and assistant actors is deemed critical for positively influencing all actors and the system.

Conclusion

This study aimed to shed light on the complex network of visible and invisible factors within project courses, which simulate the product development processes of professional industrial design services and serve as the cornerstone of industrial design education. By revealing and analyzing these factors, the study sought to provide a clear and detailed picture of the perceived chaos in project courses, contributing to future efforts aimed at improving structure and organization. Actor-network theory (ANT) and Black Box Theory, along with their terminologies, were utilized as tools to decipher and structure these intricate social networks.

The study captured the relationships among actors, actants, and agents—typically unnoticed during smooth system operation but only visible when significant problems arise—through a real-time snapshot of the functioning system. This analysis revealed parallels between the logic patterns observed in this research and the findings of ANT and Black Box Theory applications in other disciplines, such as sociology, politics, biology, electronics, and the internet. These alignments suggest that the study successfully achieved its objectives.

By adapting a well-established observational methodology from other disciplines to industrial design education—specifically project courses—this research offers significant contributions to the literature. It highlights unseen factors linked to ongoing or potential process issues, thereby enriching the understanding of project courses. As with any academic study, this research has limitations. Chief among them is the reliance on the researcher’s personal experiences and observations, informal discussions with colleagues at different institutions, and past academic activities not conducted explicitly for this study due to time constraints. Future research encompassing a broader sample set, including industrial design departments in universities across different countries, could provide a richer conceptual framework by exploring how diverse contexts, sociologies, and cultures reflect in design studios. In this regard, this study is expected to make a valuable contribution to the literature on industrial design education and inspire future research.

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