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Theory Building in Multi-Paradigmatic Discipline of Industrial Design

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Abstract

The complex and multidimensional nature of industrial design activity requires the consideration of multiple perspectives in its exploration. Therefore, design theories have often been developed using various perspectives from various disciplines. While this has facilitated the expansion of knowledge in the field, the expansion is often comprised of singular theories that claim universality despite their limited scope, resulting in conflicting and contradictory theories. As a result, the inability to establish communication between different theories appear as a significant barrier to cumulative knowledge building in the discipline. The study explores the discipline of industrial design in terms of paradigm conceptualization, a criterion for distinguishing what is considered scientific or not, in the philosophy of science of the 20th century. Since a nomothetic theory cannot be built in multi-paradigmatic disciplines, a research strategy for industrial design has been proposed, suggesting the hybrid use of activity theory and grounded theory. This strategy aims to construct partial theories that facilitate communication among different paradigms and support the cumulative knowledge in the discipline.

1. INTRODUCTION

In the capitalist mode of production, where the needs of individuals are represented and satisfied through a social need concept and products, industrial design emerges as a creative activity. Taking place within a complex hierarchical system, this activity is executed in various ways in alignment with organizational strategies. Industrial design, involving numerous decisions made under uncertainty, inherently carries a certain amount of subjectivity. The uncertainty and subjectivity inherent in industrial design practice are perceived as risk factors for the commercial success of products. Since industrial design is primarily a commercial activity, this perception prompts theorists to seek ways to mitigate uncertainty and impose universal rules on design practice to make it rational and systematic. The effort to apply criteria of objectivity and universality, exclusive to natural sciences, to industrial design and to develop a nomothetic theory while ignoring the complexity and diversity of the discipline has persisted to this day, deepening the gap between theory and practice. The absence of a practice-based theory has been a recurring concern in the literature [1], [2], [3], [4], [5] with critiques directed at studies attempting to develop theory in the field but often becoming disconnected from practical applications. The diversity in objectives, tools, methods, and outcomes within the versatile and complex design field renders each activity unique. This uniqueness leads to a tension between practice and traditional methods of theory generation, posing a significant challenge in design research - specifically, the difficulty in developing a theory grounded in the practice of the discipline [2].

To establish a comprehensive body of knowledge and theory in design fields, it is essential to understand the relationships between the independent elements [6]. Understanding these relationships requires clarity on the boundaries between main disciplines, sub-disciplines, singular frameworks, and contexts shaping the construction of design theories [6]. Current design theories strive to comprehend design as a unified phenomenon, aiming to identify the fundamental steps common to all design processes or the essential

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elements all designed products must possess [7]. However, an existing theoretical framework can only partially integrate such diversity [7]. The absence of such a theoretical framework leads to contradictions and conflicts among theories built in the discipline. While each theory may be scientifically sound and internally consistent, the inability to establish communication among these theories which are based on various paradigms impedes the cumulative knowledge building. Although studies that propose recommendations for improving design practice or suggest that certain types of activities are more valid than others by solely focusing on specific elements of the activity contribute to the expansion of knowledge in the field, they do not necessarily contribute to knowledge accumulation. Design theories should generate cumulative knowledge [8]. Consequently, one of the significant problems in design theories is the inability to establish communication among different studies. The lack of communication among different studies in design theories stems from the multi-paradigmatic nature of design and the absence of a theoretical framework to analyze various paradigms together.

Therefore, in this study, the multiparadigmality in industrial design has been justified based on the dynamics of the practice, and a research strategy proposing the hybrid use of grounded theory and activity theory has been suggested for theory building through practice. The proposed research strategy is also believed to lead to the development of a theoretical framework that supports the cumulative knowledge building since it enables the analysis and interpretation of the diversity in design practices and elements of design activities and facilitates communication between different paradigms.

2. KNOWLEDGE PROBLEM

The questions of what knowledge is and how actual knowledge can be achieved belong to the specialized branch of philosophy known as epistemology until the 17th century and have been among the fundamental issues discussed in the history of thought since ancient times—meanwhile, sciences such as mathematics and geometry act as intermediaries for philosophers trying to understand the universe. However, in the 17th century, with the emergence of empirical sciences, science became an institutionalized activity independent of philosophy [9]. The debates on distinguishing between science and non-science also began in the 17th century, with positivists excluding forms of knowledge not based on observation and experimentation, non-quantitative, non-inductive, and unverifiable, from science.
In positivist thought, knowledge is relegated to an instrumental role, with its sole criterion being the function it serves in establishing dominance over nature [10]. The remarkable success of natural sciences in transforming nature for human purposes provides the basis for natural scientists to reject different modes of knowledge that follow methods different from theirs. Positivists reduce science to the rules and procedures applied in physics and its various branches, withholding the label of 'science' from any theoretical effort that does not align with the principles they abstract from physics [10]. Thus, embracing positivist thought and asserting their status as sciences, humanities, and social sciences begin to imitate the natural sciences. On the other hand, Dilthey [11] argues that positivists' attempts to explain social reality using the concepts and methods of natural sciences are distorting and falsifying reality. According to Dilthey [11], the initial step is to reject the idea of a universal reality. Nevertheless, humanities and social sciences developed in the shadow of natural sciences throughout the 19th century and a significant portion of the 20th century [12]. Bauman [12] notes that, during this period, the dark corners of doubt go almost unnoticed amidst the dazzling magnificence of technological success originating from the natural sciences. These apparent successes prove too persistent and insidious for those tempted to waste time contemplating or challenging the sustainability of natural scientists' approaches to studying social life [12].

Industrial design also arises as a consequence of the Industrial Revolution, representing one of the most prominent achievements of natural sciences. As Western science is rooted in positivism, emphasizing experimentation and rationality, and Western capitalism thrives on the technical application of this scientific knowledge, the advancement of these sciences is economically incentivized [13]. The notion that the continuity of growth relies on the principle of calculability, coupled with the increasing societal significance of machines, sets the stage for the emergence of applied knowledge types as scientific categories [14]. In the early 19th century, the term "applied sciences" referred to the utilization of scientific knowledge in technological advancements, as evidenced by conceptualizations such as

"angewandte wissenschaft" or "*science appliquee aux arts"* [15]. Primarily, these terms were used to describe fields such as engineering and health sciences [15]. However, until the 20th century, the concept of applied sciences was not a research category but a subset of positive science proposed for dissemination through teaching [15]. The 19th century witnessed not only the emergence of new scientific fields under the influence of modernism but also radical transformations in professions that had existed for centuries. Changes in the mode of production laid the groundwork for the emergence of new activities. One such example, industrial design, is perceived merely as an activity involving the application of art to machine products in its early stages [16]. In the 20th century recognizing industrial design activity's distinctive thinking and practices, it gradually establishes itself as a distinct profession [17].

Particularly after the 1960s, the increasing significance of the industrial design profession for companies' competitiveness reveals the motivation to harness its inherently creative and often implicit nature under the efficiency principle of capitalism. According to Taylor, tacit knowledge is not ideal; knowledge about objects and production methods should be acquired and objectified through scientific reasoning [18]. This perspective propels contemporary industrial design researchers, inspired by the natural sciences, to seek an ideal form of activity devoid of subjectivity, thus unveiling the first primary paradigm defined in the field, the modern paradigm. The *Design Methods Movement* began in 1962 with a grand narrative, driven by the belief that science-based advancement in design would contribute to creating a better world [19]. The movement had a significant impact on the growth of academic attention towards design leading to the establishment of design studies [20]. But Christopher Alexander [21] one of the pioneers of the movement, expresses regret in the preface of his book *Notes on The Synthesis of Form*, highlighting the futility of separating design research from design practice.

Especially in the twentieth century, as the fragility of the foundations of natural sciences became evident, scientists' attitudes toward epistemological problems transformed. Old questions, once considered answered definitively, resurface [22]. Categorical distinctions such as knowledge, artistic knowledge, scientific knowledge, philosophical knowledge, scientific method, etc., and the divisions between natural sciences and human sciences are reconsidered, leading to a restructuring of their relationships [22]. Discussions about the nature of science and the methods for attaining scientific knowledge intensify. This process makes distinctions between natural sciences, humanities, and social sciences more apparent. Various branches of science scrutinize their ontological and epistemological assumptions, developing research methodologies tailored to their specific subjects. The dominance of modern thought, prevailing from the 17th century to the 20th century, gives way to postmodern thought, characterized by its critical stance.

The interpretivist tradition brings about a profound transformation, distinguishing 20th-century thinkers from their predecessors, as they abandon the pursuit of an objective reality. Scientific theories, akin to language games, construct frameworks of meaning; therefore, understanding—ensuring comprehensibility within a particular framework of meaning—involves presenting an explanation that solves a puzzle in the most suitable manner [23]. Social phenomena create an immaterial world beyond the scope of natural laws, and their comprehension relies solely on the framework of purpose-action relations [24]. In analyzing these phenomena, deterministic laws of nature should yield to an interpretive approach that takes into account the purposeful actions of individuals [24].
Design researchers tend to pursue their work from within one of these two paradigms: positivist and interpretivist [25]. The ontological, epistemological, and methodological differences between positivism and interpretivism, the two major research paradigms relevant within the scope of the discussion in the study, are illustrated in Table 1.

Table 1. *Research Paradigms* [26].

Research Paradigm	*Ontology*	*Epistemology*	*Methodology*
Positivism	Objective reality	Reality can be measured	Quantitative
Interpretivism	Multiple realities created by individuals	Reality needs to be interpreted	Qualitative

The criteria set forth by the positivist approach to science, which defines objectivity as confronting the research object devoid of values, beliefs, interests, and emotions, cannot be applied because this criterion does not align with human nature [27]. Historical, social, and cultural conditioning shape our perspective on objects, making knowledge relative under these conditions. Therefore, it cannot be asserted that it is the method that distinguishes science from non-science [27]. In the interpretivist approach, the demarcation problem holds a significant place. The question of what distinguishes science from non-science, if not the method, shifts the focus of 20th-century philosophy of science debates. In this context, Kuhn's paradigm conceptualization is observed to be in harmony with the interpretivist approach to science.

During the post-modern period, it became evident that design problems resisted scientific methods [28]. The roots of this resistance were analyzed by Rittel, who characterized the nature of design problems as 'wicked' problems, while the issues tackled by the scientific method are 'tamed' [28]. The lack of practical response to the modernist design discourse [29], especially after the 1970s, prompted industrial design theorists to search within the realm of post-modernist thought. The transformation in the mode of production during the post-modern period, transitioning from a supply-side economy to a demand-side economy, lays the economic foundation for recognizing the human factor in industrial design. Emphasizing the human factor, post-modern paradigms cannot transcend modernist thinking since they derive from the traditional distinction of modern epistemology that divides reality into subjective and objective realms [30]. Despite being contradictory to the pluralism of postmodernism, it is observed that the human-centered paradigm elaborated by Krippendorff [31] still claims to be the dominant paradigm. However, industrial design's complex and multidimensional nature requires multiple perspectives in its exploration. The requirement becomes evident in design research as it borrows theories from other fields through analogy. The absence of established paradigms essential for conducting scientific studies results in multiparadigmality, even if theories are borrowed from different fields, and facilitates the development of specific theories. However, this multiparadigmality is not questioned as an indication of multiple realities within the discipline; it arises from design researchers seeking a paradigm in other fields to provide a solid foundation for their research.

3. PARADIGM

The concept of paradigm refers to the accepted and unquestioned presuppositions shared by the scientific community [23]. Thomas Kuhn, in his 1962 book "The Structure of Scientific Revolutions," introduced the term that addresses the challenge of delineating the boundaries of science and responds to the demarcation problem. Kuhn [32] illustrates that by examining specific historical processes in more established sciences like physics, for instance, before the establishment of the first universally accepted scientific paradigm (Newton's paradigm), there were as many electrical theories as there were scientists investigating it. Spending a year with a community mainly consisting of social scientists allowed Kuhn to observe the differences between natural scientists and social scientists [32]. As a physicist, Kuhn expressed that he found it challenging to comprehend their profound disagreements regarding scientific problems and methods during his collaboration with social scientists. Kuhn [32], initially assuming that similar disagreements were not present in natural sciences, sought to identify the source of this difference and came to realize that the concept he called "paradigm" played a crucial role in science [32]. The absence of a paradigm hinders the initiation and, more crucially, the advancement of fundamental research in a field, as foundational assumptions need to be redefined with each attempt. Kuhn [32] illustrates that by examining specific historical processes in more established sciences like physics. For instance, before the establishment of the first universally accepted scientific paradigm (Newton's paradigm) existed as many electrical theories as scientists investigating it. Despite being scientific, there must be a universally agreed-upon framework to ensure in-depth exploration beyond basic assumptions. However, once a paradigm is adopted, a scientist no longer needs to reconstruct the entire field from scratch and justify every concept introduced based on the initial principles during their most significant studies [32].

According to Kuhn [32], the main feature of the first stages in the development of most sciences is the constant competition of many different views. He characterizes this period as the pre-scientific phase,

marked by the coexistence of various paradigms. As a significant scientific achievement emerges, the number of competing schools typically diminishes to a single one, marking the commencement of an adequate scientific practice. This allows community members to embrace a field-specific foundation readily. When the new science discourse supersedes the old one and suppresses alternative views, it is defined as a paradigm shift. Kuhn suggests that multiple paradigms in a field indicate its immaturity or lack of scientific status.

Taking this into consideration, industrial design researchers label any emerging paradigms in design as a "paradigm shift" [28], [29], [31], [33], [34], [35], [36], [37], [38], [39]. Pursuing a nomothetic theory in the field overlooks the multiple realities inherent in design. Aside from industrial design, which is a relatively new and developing discipline, it is worth noting that according to Turner [40], even in the broader context of social sciences, there has never been a theory that approaches the level of comprehensive and explanatory power seen in Newton's or Darwin's theories. Although theories such as those of Marx and Freud have emerged in the historical process, it is seen that these theories still need to produce results or become a dominant paradigm [40]. For this reason, the theories in question are described as "pseudo-scientific" by philosophers of science such as Popper and Lakatos [40].

The disciplines that include human factor/subjectivity, which Bhaskar defines as conceptually dependent where reality is socially constructed, there is no reality; instead, there are semi-realities [41]. In contrast to natural sciences, which typically adopt an explanatory approach towards objects and do not encompass the category of purpose/reason [11], [12] these sciences need to be understood in a manner distinct from a mere explanatory form. The term "paradigm shift" disregards all other forms of design and asserts that the entire reality in the field can be unveiled with a single theory. Design approaches, described as paradigm shifts in the literature [28], [29], [31], [33], [34], [35], [36], [37], [38], [39] can be classified as partial theories as they reveal only one of the existing approaches to design, or as prescriptive theories since they introduce new suggestions to the field. However, they must catch up to the comprehensiveness a dominant theory claims.

With the advent of the pluralistic world of post-modernity, producing justifications to defend the superiority of one paradigm over another has become challenging [42]. Moreover, the assertion of a single paradigm in design fields is meaningless because even Kuhn [32] distinguishes applied fields. He suggests that disciplines whose raison d'être is based on a social necessity external to themselves may not necessarily need to agree on a paradigm to become a branch of knowledge and may be sufficient for them to adopt a particular paradigm. While industrial design has dramatically benefited from borrowing theories from more established disciplines, advancing design research requires a departure from the notion of a universal reality. It is essential to acknowledge and embrace the multiparadigmality of the field. Adapting to the existing paradigms, as observed in practical applications, is crucial for defining the direction of design research.

4. DESIGN RESEARCH AND THEORY CONSTRUCTION IN DESIGN

Design research is categorized into three types based on the problem being addressed: clinical research, applied research, and basic research [17]. Clinical research involves case studies with a focus on action. Case studies typically gather data that provides insights into problems beyond individual cases[17]. On the other hand, applied research concentrates on issues within a specific product class or particular situations[17]. The goal is not to develop a general principle to explain problems but to discover principles and operational modes explaining a specific set of phenomena[17]. A common aspect of applied research in design is the attempt to gather hypotheses from multiple cases, demonstrating the forms of reasoning effective in designing for that class [17]. Moreover, since applied research falls between clinical and basic research, it is generally mindful of applying fundamental principles to investigate a class of products and activities [17]. Using a general principle involves many other factors governed by additional principles [17]. Applied research focuses on the process, aiming for designers to work more efficiently through research [17]. Thirdly, basic research seeks to comprehend the principles governing and explaining phenomena. In general, this type of research is associated with design theory, aiming to provide a foundation for all other activities in the discipline of design [17].

On the other hand, design research can be defined across various scales, ranging from cognition to the overall functioning of the design process [43]. Micro-scale studies delve into the cognitive and mental models influencing design performance, whereas macro-scale studies take a broader perspective to outline the general characteristics of design activity [43]. Since basic research aims to produce theory, the research object is approached on a macro scale to make specific reductions. Medium-scale data also supports basic research to make sense of the information. On the macro scale, the research should emphasize information coordination, seeking, sharing, and representation within the design activity [43]. Design studies are related according to their purpose and scale, as in Figure 1. Figure 1, adapted from [17] and [43], highlights the strategy proposed for theory building in terms of objectives and scales.

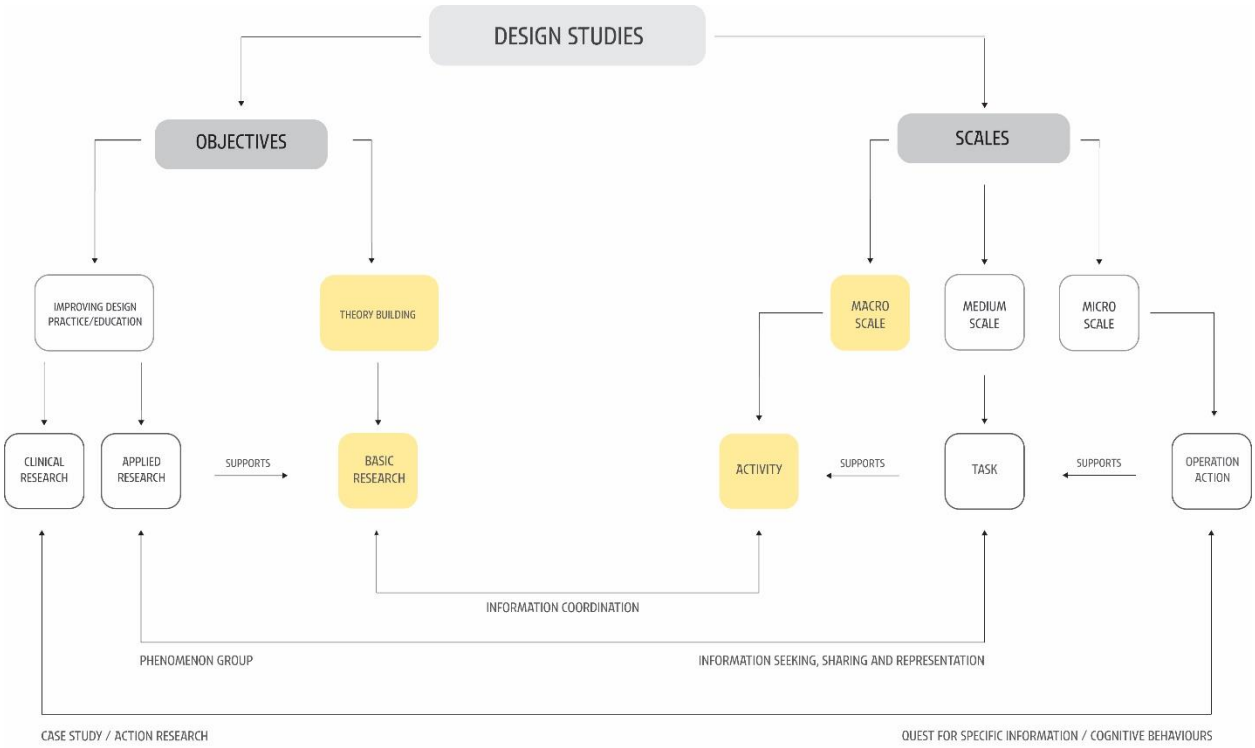

Figure 1. *Classification of Design Studies According to Their Objectives and Scales (Adapted from [17] and [43])*

Design theory differs from theories in other fields because it has to satisfy the requirements of two worlds: academic and professional [44]. In such disciplines based on human activity, 'making' knowledge is constructed rather than discovered and is expected to meet academic requirements and compatibility with practice [44].

Herbert Simon [45] also draws attention to the difference between design sciences and natural sciences in his book "The Science of Artificial." He explains how design activity occurs at the center of design sciences. Although he identifies the difference between natural sciences and design as "what things are" or "how things are," Simon [45] suggests focusing solely on the formalizable and explainable facets of design theory to ensure its acceptability in the academy, believing that the uncertainty inherent in design can be managed. Formalizing design by imposing specific rules implies neglecting the distinctive dynamics inherent in the design process. Simon's reduction of design to a rational decision-making process needs to be revised, as rational problem-solving represents just one facet of designing [31]. According to Krippendorff [31], since theory cannot be derived solely from invariances in design, conditions that can change through design should be considered when developing theory. Research that emerges from observations of designers' actions needs to consider how the theory can be redesigned [31]. In this context, Krippendorff seeks a solution to developing prescriptive theory. Both Simon and Krippendorff share the presupposition that considering the unique dynamics of design makes it challenging to reach universal generalizations. While Simon proposes a solution by concentrating solely

on the formalizable aspects of design practice, Krippendorff, somewhat disconnected from practice, suggests establishing rules for design through design theory. While Krippendorff [31] characterizing his paradigm as post-modern, both researchers maintain a modernist approach by not relinquishing the aspiration to construct a broad-scale theory.

A theory provides the most comprehensive, consistent, and simple model for connecting diverse and seemingly unrelated facts functionally and pragmatically. It is a way of revealing explicit, implicit, hidden, or unknown knowledge [46]. Theories provide a coherent description, explanation, and representation of observed or experienced phenomena [47]. Design is too complex and diverse to reveal all its realities with a single theory. Therefore, a gradual approach supporting the accumulation of knowledge in the field is needed to achieve consensus in design theories [7]. Therefore, theory building in design should be partial, focusing on theories that explain specific aspects of design practice through causal processes. Subsequently, more comprehensive theories can be constructed by integrating different elements from various partial theories [4].

5. PROPOSED RESEARCH STRATEGY

The positivist approach is characterized by believing that truth exists outside and is singular and definite. This epistemological assumption guides the researcher, aiming for absolute knowledge, towards an experiment-based methodology [38]. In the post-modern era, natural sciences' unassailable and uncontested power in the knowledge world began to diminish due to the criticism directed towards binding generalizations, universal explanations, grand narratives, and all forms of totalizing structures [22]. Contrary to the positivist approach, which places the known object against the knowing subject, qualitative research is an activity that repositions the observer in the world and adopts an interpretive approach to the world [49]. The constructivist/interpretivist paradigm defined by Denzin and Lincoln includes a relativistic ontology (multiple realities) and several different methodological procedures, where the main aim is to understand the relationship between people, their activities, and their physical environments [50].

Located within the constructivist/interpretive approach, grounded theory is a theory-building strategy that embodies the close relationship between theory and practice [51]. The difference distinguishing grounded theory from other types of research is its focus on building theory but on partial theories rather than grand theories that address more universal issues [52]. On the other hand, activity theory provides a holistic and contextual discovery method that supports qualitative and interpretive research in disciplines centered around human activity [53]. While grounded theory equips the industrial design field with analytical tools for constructing a partial and articulate theory based on practice, activity theory offers a qualitative framework for comprehending the variables within the entirety of industrial design activity.

5.1. Grounded Theory and Activity Theory

Grounded theory was initially developed by sociologists Glaser and Strauss [54]. Later, Glaser embraced the positivist approach to the theory, whereas Strauss [55] and Charmaz [56] represented distinct constructivist approaches. Coming from the positivist tradition, Glaser develops a purely inductive qualitative research method based on the ontological acceptance that social reality is the same as natural reality. In the Straussian approach to grounded theory, there is a rejection of positivist claims that an objective reality can be attained through pure induction. Strauss revisits the methodology from a pragmatist perspective, asserting that individuals construct knowledge by interpreting shared meanings [51]. This perspective assumes that reality is inherently dynamic and interpretive, exploring how individuals create meanings and take actions [56]. Thus, Strauss includes human agency, subjective and social meanings, and problem-solving practices within the scope of grounded theory [56]. In his constructivist approach, Charmaz [56] adds to Strauss's constructivist approach the discourse that the constructed reality is also built under existing structural conditions, that is, hermeneutic analysis and ethnographic methods. Grounded theory is a research strategy adopted to develop a theory on a topic neglected or superficially addressed in the literature [57], implying that the theory is grounded in data. While in other methods, analysis begins after data collection is completed, in grounded theory, the

researcher initiates the search for meaning by questioning the data in the early stages of data collection [54], [55].

Referring to Kuhn's puzzle analogy, Charmaz [56] states that, unlike quantitative research, in qualitative research, researchers add pieces to the puzzle during the research. At the end of the study, they create a brand new puzzle. In grounded theory, the landscape is viewed from a wide angle, like a camera with multiple lenses. The lens is changed several times to zoom in on scenes, creating a new landscape [56]. The researcher realizes that certain classifications are possible during data analysis and discovers patterns [58]. Repetitive regularities in the data should be a process of first dividing the data into parts and classifying them based on similarities [52]. Merriam [52] exemplifies this classification process: "Consider sorting two hundred food items in a grocery store. These two hundred items can be considered pieces of information that form the groundwork for analysis. By comparing one item with another, these two hundred items can be divided into categories. For example, if you start with a cereal with the second ingredient, orange, it will be discussed whether it is similar to the first. If they are not similar, this time, there are two categories in which the third item can be placed. If the third item is also different, we have three categories..."

When it comes to human activity, this process naturally becomes complicated. Analysis and description of human activity must consider the inherent uncertainty and nonlinear dynamics (chaos) in activity regulation [59]. When analyzing design activity, data can be studied at numerous scales and frameworks, from cognition to consciousness, from intuition to material conditions, sectoral requirements to organizational structures, design processes, and the designer's relationships with other actors. Since it is impossible to classify and make sense of all these data using only grounded theory tools, getting support from activity theory is proposed to create a qualitative framework in the theory-building process.

In the broadest terms, activity is the purposeful, goal-oriented modification of the environment; it is a form of human-specific agency [60]. What makes the activity human-specific, unlike other entities that contribute to the transformation of the environment, is that the activity is goal-oriented; the goal is consciously determined [60]. When designing an activity, the subject considers one’s knowledge, one’s goal, the ways and means of achieving the goal, that is, the harmony between ones will and the laws of nature, and designs one’s actions accordingly. Nikiforov's starting point is to develop an approach that empirically reveals different aspects of human activity. He proposes focusing on three essential elements in the activity analysis: the conditions under which action is taken, the goal, and the means to achieve this goal [60]. Activity theory examines the unique dynamics of each activity. It enables the holistic analysis of the relationship between the variables in question by placing them in a specific framework.

Like all known modes of operation, design is a problem-solving activity that requires organizing information into a specific representation [61]. Design problems are searched for a few objects that offer satisfactory or optimal solutions, in which a design strategy radically reduces potential objects in a wide area [62]. The design output results from processing information about the object's characteristics, such as appearance, material composition, production methods, functionality, etc. [63]. Design information can be defined as data acquired, used, and transformed during the product development process [63].

The design space is already constrained by other dynamics that affect the activity before the cognitive decisions of the designer. According to Mostow [64], a comprehensive design model should address the following aspects of the design process: design conditions, the object (the object describes not the properties of the object but how these properties are manipulated), design decisions, management of the design process, and the role of information in design (how it is acquired, processed and used). In this context, studies, on the one hand, aim to understand the tools required by designers for specific tasks, the integration of tools into the design process, information flow, and the environment created by design support systems, and on the other hand, investigates how design processes can be restructured for optimal utilization of tools [62].

Depending on the purposes of the study, utterly independent research topics can be derived from the same activity, and different representations of the same activity can be created [65]. Dividing the activity into

various components and conducting the analysis from part to the whole by establishing necessary relationships is a crucial part of the systemic-structural analysis of the activity. The hierarchical activity scheme includes four levels: activity, task, action, and operation [66]. A task, which plays a crucial role in the analysis of activity, is understood as a part of the activity directed towards achieving a specific goal, constrained by a certain time frame, and it is a logical system containing cognitive and behavioral actions [67]. In activity theory, cognition is understood as a process and a structured system of actions [68]. When cognition is considered a process regulating human behavior, the activity becomes the research subject and is depicted as a hierarchically organized structure consisting of conscious, goal-directed actions. When understood as a structured system of actions, activity is the object of research; it is not based on operations and actions but draws attention to the general characteristics of activity on a macro scale. According to Vygotsky, activity is an object of research, and units of analysis are components divided and integrated into a dynamic whole [67]. Such an understanding of activity makes it possible to classify different human activities and develop theories about these activities [68].

The research strategy proposed for theory building in design, derived from the hybrid use of certain approaches of grounded theory and activity theory, both of which are belong to the interpretive research paradigm, is summarized in Figure 2.

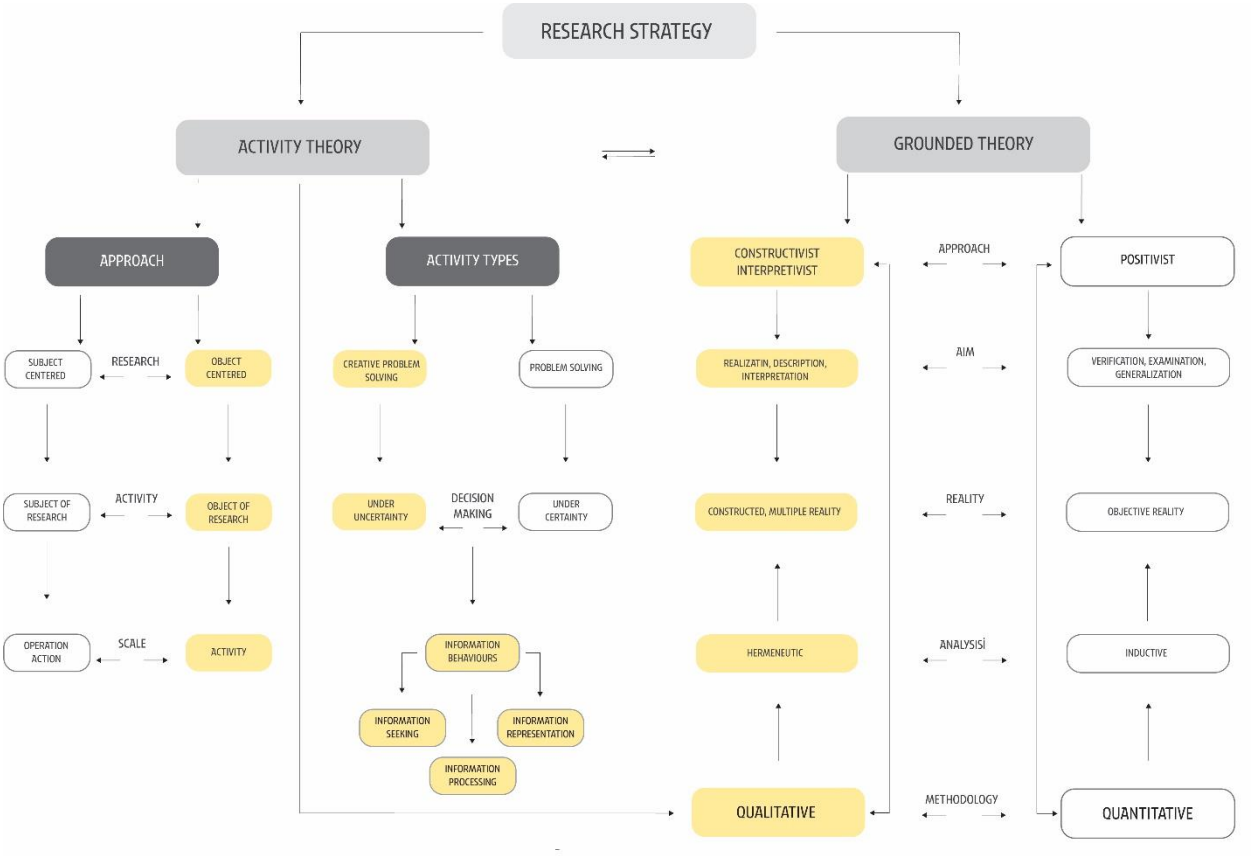

Figure 2. *Research Strategy Proposal / Grounded Theory and Activity Theory (Authors)*

Activity theory is identified as being used in two ways in the field of design: as a qualitative research framework to understand and explain design tools and processes, and as a basis for micro-level clinical research aimed at understanding or improving the design process [69]. When used as a qualitative framework, activity theory's contribution is primarily to examine and understand different variables that may have affected the design process, the designers' choices, or the design outcome of a project [69]. The review of the literature on activity theory's application in industrial design ([69], [70], [71], [72], [73], [74]) indicates that activity theory is mostly used in micro-scale clinical research to understand or develop the design process. These may have been used as a tool for developing design practice or as a qualitative research framework, but in both cases, there is an orientation towards the internal dynamics of design. In other words, in these studies, design is not the subject of research but rather the object. So far, no research

aimed at understanding the activity in terms of its holistic dynamics or aimed at theory building has been found. However, in activity theory, depending on the research objective, activity can be approached at different scales. When design activity is considered as the object of research, the aim is to improve the design process, and cognitive processes of activity are taken into account. Such research is conducted in the form of case studies. But theory building becomes feasible only when the research is object oriented and conducted on a macro scale, as depicted in Figure 1, i.e., at the level of activity, and design activity is regarded as the object of research.

In the proposed research strategy depicted in Figure 2, the activity theory is highlighted in terms of its potential applicability to theory building in industrial design for theory development depending on the nature of the activity and the scale of research. The interpretive, qualitative research strategy of grounded theory, which is considered suitable for multi-paradigmatic theory building in design, is also highlighted. While the constructivist/interpretive approach of grounded theory, recommended for partial theory building, offers analytical tools to capture various activity patterns, the object-oriented approach of activity theory supports the interpretation of similarities and differences within these patterns.

6. CONCLUSION

Conventional methods of constructing theories in industrial design have often yielded valuable yet partial perspectives on design knowledge. This is primarily due to their reliance on the principles of a single dominant paradigm, as outlined by Kuhn, or a particular way of comprehending design phenomena. The reality is that the majority of practitioners, despite discipline's assertions, do not adhere to a single paradigm. Instead, they utilize a combination of paradigms and participate in a diverse array of activities, incorporating both positivist and interpretivist approaches depending on the circumstances they encounter. They pragmatically adopt whichever tool or approach they deem necessary in any given situation.

The issue lies not in whether the current paradigms provide enough categories to encompass the wide range of design practices, but rather in the limitation of this type of theorizing to fully accommodate such diversity on its own. There cannot be a single paradigm of design, but rather, there could be numerous paradigms that are empirically verifiable through practice. The existence of such a vast array of theories makes the idea of a unified theory impractical. However, when the complexity and multiplicity of reality require plurality in paradigms, it does not preclude communication among them.

Ignoring the multiplicity of realities in design practice to build a comprehensive theory assumes viewing design not as a discipline, but rather as a research field independent of its academic structure; education, profession and research. However, as Wang and Ilhan stated, design knowledge isn't a distinct "third area" of knowledge apart from the sciences and humanities, as proposed by Cross [75]. Instead, the central challenge in defining design as a discipline lies in understanding not the content of its knowledge, but its creative act, including any general knowledge that aids in the creative process, as it shapes its identity within the larger cultural context [75].

In the multi-paradigm perspective, theory building aims not to reach a reality but to reach the scope of reality [47]. Considering that each design process is unique and unrepeatable [76], it seems that it is not possible to reach a universal pattern in a design theory based on practice. To get the scope of reality in the discipline, various paradigms of the practice must be evaluated on the same basis that the proposed research strategy offers. Grounded theory facilitates the development of a qualitative research matrix, which is adept at identifying common and distinguishing parameters influencing design activities, regardless of whether they belong to the same paradigm or not, and it permits the application of the constant comparative method. Meanwhile, activity theory aids in interpreting the meanings of these parameters specific to the activity and the various relationships among these factors. However, the inevitable limitation in every scientific research is the number of activities from which the researcher can access data in design research based on practice that focuses on theory development. It is believed that the model created for analyzing industrial design activities through the hybrid use of grounded theory and activity theory can overcome this limitation due to its openness to articulation.

REFERENCES

[1] Redström, J. (2017). *Making Design Theory*. Cambridge: MIT Press, 94.

[2] Friedman, K. (2003). Theory Construction in Design Research: Criteria: Approaches, and Methods. *Design Studies*, *24*(6), 507-522.

[3] Findeli, A. (1998). A Quest for Credibility: Doctoral Education and Research in Design at the University of Montreal. *Doctoral Education in Design*, *1*.

[4] Chakrabarti, A., & Blessing, L. T. (2014). *Anthology of Theories and Models of Design*. London, UK: Springer London Limited.

[5] Kaptelinin, V. ve Nardi, B. A. (2006). *Acting with Technology: Activity Theory and Interaction Design*. Cambridge: MIT Press, 333.

[6] Love, T. (2002). Constructing a coherent cross-disciplinary body of theory about designing and designs: some philosophical issues. *Design studies*, *23*(3), 345-361.

[7] Jones, D., & Gregor, S. (2007). The Anatomy of a Design Theory. *Journal of the Association for Information Systems*, *8*(5), 1.

[8] Eckert, C. M., & Stacey, M. K. (2014). Constraints and Conditions: Drivers for Design Processes. In *An Anthology of Theories and Models of Design: Philosophy, Approaches and Empirical Explorations* (pp. 395-415). London: Springer London.

[9] Lektorski, V. A. (2016). *Özne, Nesne, Biliş 1. Ed*. İstanbul: Yordam Kitap.

[10] Horkheimer, M. (2018). *Akıl Tutulması 3. Ed.* İstanbul: Metis Yayınları.

[11] Dilthey, W. (1999). *Hermeneutik ve Tin Bilimleri 1. Ed.* İstanbul: Paradigma Yayınları.

[12] Bauman, Z. (2017). *Hermenötik ve Sosyal Bilimler 1. Ed.* İstanbul: Ayrıntı Yayınları.

[13] Weber, M. (1999). *Protestan Ahlakı ve Kapitalizmin Ruhu*. Ankara: Ayraç Yayınevi.

[14] Wallerstein, I. (2003). Bildiğimiz Dünyanın Sonu: Yirmi Birinci Yüzyıl İçin Sosyal Bilim,(çev. Tuncay Birkan). *Metis Yayınları, İstanbul*.

[15] Bud, R. (2012). "Applied science": a phrase in search of a meaning. *Isis*, *103*(3), 537-545

[16] Read, H. (1961). Art and industry. Bloomington: Indiana University Press.

[17] Buchanan, R. (1998). Education and Professional Practice in Design. *Design Issues*, *14*(2), 63-66.

[18] Engeström Y, Miettinen R, Punamäki R-L (1999). *Perspectives on Activity Theory*. Cambridge: Cambridge University Press.

[19] Langrish, J. Z. (2016). The Design Methods Movement from Optimism to Darwinism.

[20] Bayazit, N. (2004). Investigating design: A review of forty years of design research. *Design issues*, *20*(1), 16-29.

[21] Alexander, C. (1973). *Notes on the Synthesis of Form* (Vol. 7). Harvard University Press.

[22] Winch, P. (2007). *Sosyal Bilim Düşüncesi ve Felsefe 2. Ed*. Ankara: Vadi Yayınları.

[23] Giddens, A. (2003). *Sosyolojik Yöntemin Kuralları: Yorumcu Sosyolojilerin Pozitif Eleştirisi 1. Ed.* İstanbul: Paradigma Yayınları.

[24] Şimşek, L. (2007). Felsefe açısından sosyal bilimlerde nitelik ve anlam sorunu tartışması. *Doktora Tezi. İstanbul Üniversitesi, İstanbul*.

[25] Malek, K. M. (2001). *Analytical and interpretive practices in design and new product development: Evidence from the automobile industry* (Doctoral dissertation, Massachusetts Institute of Technology).

[26] Clemente, V., Tschimmel, K., & Pombo, F. (2018). Methodologies in doctoral research in design: the role of research paradigms. In *Back to the future. The future in the past: ICDHS 10th+ 1 Barcelona 2018: conference proceedings book* (pp. 694-698). Edicions de la Universitat de Barcelona.

[27] Özlem, D. (1999). Felsefi Hemeneutiğe Geçiş Yolu Olarak Tarihselcilik. *A.Ü. İlahiyat Fakültesi Dergisi*, *1*(40), 127-145.

[28] Cross, N. (1981). The Coming of Post-Industrial Design. *Design studies*, *2*(1), 3-7.

[29] Cross, N. (2001). Designerly Ways of Knowing: Design Discipline versus Design Science. *Design Issues*, *17*(3), 49–55.

[30] Çelikel, S. B. (2015). *Endüstriyel Tasarımda Paradigma Kaymaları: Bruno Latour'a Özel Bir İlgiyle*. Ankara: Nobel Akademik Yayıncılık

[31] Krippendorff, K. (2005). *The Semantic Turn: A New Foundation for Design*. New York: Taylor and Francis Group, 349.

[32] Kuhn, T. S. (2019*). Bilimsel Devrimlerin Yapısı 10. Ed.* İstanbul: Kırmızı Yayınları.

[33] Krippendorff, K. (2004). Intrinsic Motivation and Human-Centred Design. *Theoretical Issues in Ergonomics Science*, *5*(1), 43-72.

[34] Birkeland, J. (2002). *Design for Sustainability: A Sourcebook of Integrated, Eco-Logical Solutions*. Earthscan

[35] Gane, V. (2004). *Parametric Design: a Paradigm Shift?* (Doctoral dissertation, Massachusetts Institute of Technology).

[36] Speer, L. E. (2006). Paradigm Shift: The Next Decade in Design. *Innovation*, 31-35.

[37] Fiorentino, C., & Hoyos, C. M. (2014). The Emerging Discipline of Biomimicry as a Paradigm Shift towards Design for Resilience. *The International Journal of Designed Objects*, *8*(1), 1-15

[38] Muratovski, G. (2015). Paradigm shift: Report on the New Role of Design in Business and Society. *She Ji: The Journal of Design, Economics, and Innovation*, *1*(2), 118-139.

[39] Schneider, R. O. (2021). Extended Reality: The Next Frontier of Design. *International Journal of Design Management & Professional Practice*, *15*(1).

[40] Turner, J. H. (1990). "The Misuse and Use of Metatheory." In *Sociological Forum*, vol. 5, pp. 37-53. Kluwer Academic Publishers-Plenum Publishers.

[41] Sayer, A. (2019). *Sosyal Bilimde Yöntem: Realist Bir Yaklaşım 2. Ed.* İstanbul: Küre Yayınları.

[42] Tekeli, İ. (2006). *Çok Paradigmalı Bir Sosyal Bilim Alanında Yaşamak*. Felsefe ve Sosyal Bilimler–Muğla Üniversitesi Felsefe ve Sosyal Bilimler Sempozyumu Bildirileri, 145-157.

[43] Cash, P., Hicks, B., & Culley, S. (2015). Activity Theory as a Means for Multi-Scale Analysis of the Engineering Design Process: A Protocol Study of Design in Practice. *Design Studies*, *38*, 1-32.

[44] Dunin-Woyseth, H., & Michl, J. (2001). Towards a Disciplinary Identity of the Making Professions. *The Oslo Millennium Reader*, *4*.

[45] Simon, H. A. (1996). *The Sciences of the Artificial*. MIT Press.

[46] Goulding, C. (1998). *Grounded Theory: The Missing Methodology on the Interpretivist Agenda*. Qualitative Market Research: An International Journal.

[47] Gioia, D. A., & Pitre, E. (1990). Multiparadigm Perspectives on Theory Building. *Academy of Management Review*, *15*(4), 584-602.

[48] Cohen, L., Manion, L., & Morrison, K. (2002). *Research Methods in Education*. Routledge.

[49] Denzin, N. K. (2008). *Strategies of Qualitative Inquiry* 2. Ed. Sage.

[50] Frankel, L., & Racine, M. (2010). *The Complex Field of Research: For Design, Through Design, and About Design.* Design and Complexity - DRS International Conference 2010, 7-9 July, Montreal, Canada

[51] Oliver, C. (2012). Critical Realist Grounded Theory: A New Approach for Social Work Research. *British Journal of Social Work, 42(2),* 371-387.

[52] Merriam, S. B. (2018). *Nitel Araştırma: Desen ve Uygulama için Bir Rehber 3. Ed.* Ankara: Nobel Yayın.

[53] Hashim, N. H., & Jones, M. L. (2007). *Activity Theory: A Framework for Qualitative Analysis*. https://ro.uow.edu.au/commpapers/408

[54] Glaser, B., Strauss, A., 1967. *The Discovery of Grounded Theory.* New York: Aldine Publishing Company.

[55] Strauss, A., Corbin, J. (1994). "*Grounded Theory Methodology: An Overview*," in Denzin, N. and Lincoln, Y. (Eds), Handbook of Qualitative Research, Sage Publications, Newbury Park, CA.

[56] Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. Sage.

[57] Goulding, C. (2002). *Grounded Theory: A Practical Guide for Management, Business and Market Researchers.* Sage Handbook of Qualitative Research.

[58] Strauss A., Corbin J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage Publications, Thousand Oaks, CA

[59] Karwowski, W. (2000, July). Cognitive Ergonomics; Requisite Compatibility, Fuzziness and Nonlinear Dynamics. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 44, No. 6, pp. 580-583). Sage CA: Los Angeles, CA: SAGE Publications.

[60] Nikiforov, A. L. (1990). *Activity, Behavior and Creativity*. In V. P. Lektorsky (Ed.), Activity: The Theories, Methodology & Problems (pp. 23-31). Paul M. Deutsch Press, Inc.

[61] Eastman, C. M. (1972). Toward a Theory of Automated Design. *In* Brinkers, H. S. (1972). *Decision-making: Creativity, Judgment and Systems*. The Ohio State University Press.

[62] Horvath, I. (2004). A Treatise on Order in Engineering Design Research. *Research in Engineering Design*, *15*, 155-181.

[63] Shooter, S. B., Keirouz, W. T., Szykman, S., & Fenves, S. J. (2000). A Model for the Flow of Design Information in Product Development. *Engineering With Computers*, *16*, 178-194.

[64] Mostow, J. (1985). Toward Better Models of the Design Process. *AI Magazine*, *6*(1), 44-44.

[65] Bedny, G. Z., & Karwowski, W. (2004). Activity Theory as a Basis for the Study of Work. *Ergonomics*, *47*(2), 134-153.

[66] Bedny, G., & Meister, D. (1997, October). The Factor of Significance in the Operator's Activity. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 41, No. 2, pp. 1075-1078). Sage CA: Los Angeles, CA: SAGE Publications.

[67] Bedny, G. Z., & Chebykin, O. Y. (2013). Application of the basic terminology in Activity Theory. *IIE Transactions on Occupational Ergonomics and Human Factors*, *1*(1), 82-92.

[68] Bedny, G. Z., & Harris, S. R. (2005). The Systemic-Structural Theory of Activity: Applications to the Study of Human Work. *Mind, Culture, and Activity*, *12*(2), 128-147.

[69] Zahedi, M., Tessier, V., & Hawey, D. (2017). Understanding Collaborative Design Through Activity Theory. *The Design Journal*, *20*(sup1), S4611-S4620.

[70] Blumenthal, B. (1995, July). Industrial design and activity theory: A new direction for designing computer-based artifacts. In *International Conference on Human-Computer Interaction* (pp. 1-16). Springer, Berlin, Heidelberg.

[71] Jonassen, D. H., Tessmer, M., & Hannum, W. H. (1998). *Task analysis methods for instructional design*. Routledge.

[72] Mwanza, D. (2000, April). Mind the gap: Activity theory and design. In *Conference on Computer Supported Cooperative Work*.

[73] Fjeld, M., Lauche, K., Bichsel, M., Voorhorst, F., Krueger, H., & Rauterberg, M. (2002). Physical and virtual tools: Activity theory applied to the design of groupware. *Computer Supported Cooperative Work (CSCW)*, *11*(1), 153-180

[74] Desai, G. (2008). An activity theory framework for industrial design. *Journal of Design Research*, *7*(3), 304-316.

[75] Wang, D., & Ilhan, A. O. (2009). Holding creativity together: A sociological theory of the design professions. *Design Issues*, *25*(1), 5-21.

[76] Gidel, T., Gautier, R. ve Duchamp, R. (2005). Decision-making Framework Methodology: An Original Approach to Project Risk Management in New Product Design. *Journal of Engineering Design*, *16*(1), 1-23.