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Original Research Article

A Methodological Comparison of the Processes of Product Design and Architectural Design*

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Abstract

Problem Statement: In design methodology studies, it has been assumed that designing is a unique cognitive action that is used in various professional fields. The generality of this matter is not rejected, but after nearly seventy years of design methodology studies and relying on common general knowledge of design, we can now address the question: What are the differences in design methods in various fields? And what is the reason for these differences?

Research Question: More specifically, this research has limited the research problem to comparing the design method used in product design and architectural design and raised the following question: "What are the differences in design method in the fields of product design and architectural design?" To find the answer, this preliminary question had to be answered: What is the design method in product design and architectural design?

Research Objective: To find the methodological differences between the process of product design and architectural design.

Research Method: According to the criticism that was accomplished in the literature review regarding the problem and experiment method of similar research, this research method is a qualitative case study, and in terms of method, it is an experimental-descriptive one. Experiments and unstructured interviews were conducted to collect information, and the grounded theory method (GTM) was used to refine and classify the information. The theoretical framework of this research is design methodology with the approach of "design cognition".

Conclusion: After collecting the data through testing and categorizing it, there have been discussions on the findings that showed seventeen general cases. In conclusion, it can be said that the method in product design is similar to the method in architectural design in some dimensions, but in others, these two groups have evidently different behaviors. In the common aspects, the inherent dimensions and nature of the design can be seen, but in the different aspects, the role of the environment and education is evident.

Keywords: *Design, Design Cognition, Product Design, Architectural Design, Methodology.*

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Introduction and the Problem Statement

The design methodology is a science that examines what and how the mind works during design. These studies are carried out with many fundamental and practical goals. In the fundamental dimension, methodology aims to describe the mental action of design, and in the practical dimension, the prescription of methods and tools for the professional work of designers is the methodology's main goal. Until today, the design methodology has stood on the assumption that the act of designing is a fundamental act of the human mind. This act is very specific and complex, but it is not rare; on the contrary, it is very frequent and the mind uses it many times when facing daily problems. This act of the mind plays a central role in some human activities. The importance of the act of designing has been such that in the division of social work, some design-based activities have become a profession. In industrialized societies, these professions are increasingly developed. The professional and educational needs of these disciplines have made design methodological research increasingly important.

The research on design methods and design thinking started very late. The history of this research reaches the 1950s at most. Although these studies grew very well compared to other fields, they did not have much quantity and even still they don't. On the other hand, according to the practical and educational needs in the field of design, there has been a constant rush to summarize and conclude from the descriptive studies and prescribe practical methods. Anyhow, after nearly seven decades, today these studies have provided an acceptable understanding of the totality of design action and can describe deeper dimensions of this action. but this is the beginning of a new level of design methodology. From now on we can explore more subtle dimensions of the design, and more importantly, research strategies and frameworks can also change and expand. One of these strategies is that "the action of design is the same in all public and professional design activities".

Until today, the main assumption in design methodology is that all activities and jobs based on design have a common core and the nature of design is the same in different fields of design and planning. This opinion is generally accepted, but the argument is that we have reached a point where we can pay attention to the differences in the design method in different fields of design. By identifying the differences, a much more accurate understanding of the design can be obtained, and this is what we meant when talking about starting a new level of design methodology. Searching for differences in the fields of design is the strategy that this research has followed. To begin with, this research has focused on a comparative study of two main and old design-based disciplines and fields, namely "product design" and "architectural design". The question is: "What are the differences in the design method in the fields of product design and architectural design?" To find the answer, this preliminary question must be answered: What is the design method in product design and architectural design?

Literature Review

It was pointed out that design studies are in their infancy, and despite this, good and responsive research has been done in this field, but concerning the question of this research, it can almost be said that there has been no similar research. The few existing ones that partly overlap with this research, generally have faced the following criticism:

1. In most cases, the problem presented to the examinees was a very general, one-dimensional, and puzzle-like problem, for which there is often an answer. Most of these problems are similar to the ones that are prevalent in the psychology of creativity (such as the nine-dot problem, or Charlie's puzzle). Whereas design issues are real issues that have various dimensions and are related to very deep levels of the designer's experiences. Brian Lawson's research (1980) is one of the most noted studies in this field.

2. In studies similar to protocol studies, a short time is usually considered for conducting the test, which is between forty and one hundred and fifty minutes, and as Nathan Crilly has shown, they were done in a complete laboratory condition (Crilly, 2019). Even the highly referenced research of Dorst and Cross (Dorst & Cross, 2001), which was later extended in important research such as the study of (Kruger & Cross, 2006) and was a model for subsequent research, has been conducted in the same time and laboratory conditions. But design issues in the real world have much longer time frames. Design issues take at least a few weeks. So, a few minutes of experiments, with one-dimensional problems, cannot simulate the nature of a design project with a highly uncertain problem.

3. These studies emphasize the uniformity of design in different areas and do not pay attention to the differences in design between them. In other words, a methodological comparison of two design-based fields has not been done so far. A few similar studies such as (Asefi & Barani, 2014) focused on comparing external features and even design outputs (form) and did not deal with mental-methodological performance. Researchers like (Daalhuizen & Cash, 2021) paid attention to the effect of the context on the method, but highlighted the general aspect of design and consider the context in general. Similar to (Luck, 2019), they discussed the similarities and differences between design methodology and studies of a specific field (especially architectural design and engineering design).

4. Some researchers have also compared approaches to the design phenomenon itself and theoretical and practical rotations within the design system. Such researchers, such as (Price & Straker, 2017) and (Ferrari, 2017), have emphasized these developments and "transdisciplinary" aspects of design. Like (Dean & Loy, 2020), they paid attention to the differences and the need for a turn in the cognitive horizons of design.

In the current research, the research question, the problem, and the method of conducting the test are completely different. As a result, we can expect that new results will be obtained at the end.

Research Method

According to the criticism raised in the literature review, it is required that the research examinees do real and specific problems of their specialized field in longer periods (close to real-time). In this regard, several students who were on the threshold of graduation in industrial design and architectural design and were among the students with a higher average score in the design courses were selected. At the end of each group, four people fully and acceptably completed the test (the remaining cases were excluded from the test due to the unreliability of the data). The reason for choosing these people was that they were at the "novice" stage and reached the "beginner"[1] stage due to university training and academic design experience and were ready to carry out a design project in the market as an expert. These people were not novices, but they were not professionals (i.e., someone who has his/her own set of schemas, preconceptions, and experimental tricks and is at the stage of action or insight) either. So, their work and design methods were good criteria for recognizing their similarities and differences.

In this research, the participants in the test have been asked to complete real design problems related to their field of study. The subject for industrial design students was "designing a desk made of wood and/or MDF, for young couples", and the subject for architecture students was "designing a kindergarten for employees' children in a historical context; for a maximum of ten children aged between two and six years old."

The time given for this test was "six" days. At the end of each day, the researchers contacted the participants and conducted unstructured interviews with them. The data were collected through the participants' self-reports and then coded through the foundational data method. Due to the role of open coding in educational ethnography, text-

driven concepts (in vivo codes) were used to record the quality of active problem solving in design. To abstract the first round is concepts, in the second and third rounds (central and selective coding), the coding was set in categories and classes relative to the concepts of design methodology in each sample.

One of the differences between this research plan and a classical foundation data research in social sciences is that in this research, due to the nature of the design methodology and commitment to the theoretical framework of the research, instead of moving towards the canonical code, selected categories extracted from each case study were identified and analyzed over time.

In terms of nature, this research is a qualitative case study, and the method is empirical-descriptive. To collect the data from unguided (unstructured) tests and interviews, and to refine and classify the information, the grounded data method was used, and according to the qualitative method, the level of explanation is focused on the description of the designer's individual process.

Theoretical foundations

The theoretical framework of this research is "Design Perception" studies with the "Design Expertise" approach. These studies are generally in the study field of "design methodology", but on the other hand, they are in an interdisciplinary domain related to the field of cognitive sciences. In the 1960s, the first generation of design methodology considered design as a science and prescribed engineered methods by focusing on the design model of "design as problem-solving". In the 1970s, this approach gave way to the second-generation methodology, in which design was considered an independent mental discipline, by which a set of special features of the mental performance of design were emphasized. These features can be categorized into three groups: 1. Specificity of design thinking 2. The specificity of the design problem and 3. The specificity of problem-solving in design (Tondi & Amraei, 2018). Among the most important characteristics of design, emphasized in the second generation, were acquisitive problem-solving through a solution-driven strategy, wicked design problems, abductive reasoning, and the creative leap. In a prominent and seminal study, Brian Lawson found out that designers, unlike scientists, start to produce solutions from the very beginning of facing a problem, and they even collect information and analyze the problem based on the solution. In other words, the mental method and strategy of the designer are to solve the problem by relying on the solution, and this is an acquisitive strategy (Lawson, 1980). Completing this view, and examining the work and design methods of several famous architects, "Jane Darke" showed that designers are not only solution-oriented, but they focus on one solution with a set of concepts and policies from the very beginning. He called these images "primary generative" (Darke, 1979). Lionel March's research also confirmed the existence of abductive logic in design (March 1984, 268). This logic supports the existence of a "creative leap" in design. Another cited research in the second generation of design methodology was Rittel and Weber's research, which showed that design problems, or as they say "wicked problems", are special and rare (Rittel & Webber, 1973, 160).

In the last two decades, various studies have distorted the approach of the second generation of design methodology. For example, the studies of Maher and his colleagues showed that designers also pay attention to the level of the problem (Maher, Poon & Boulanger, 1996). Next, Kruger and Cross showed that in addition to the solution-oriented strategy, designers also use three problem-oriented, information-oriented, and knowledge-oriented strategies (Kruger & Cross, 2006). Another range of researchers, such as Farrell and Hooker, investigated the "design problem" or the "wicked problem" and found that design problems are not specific and rare but special and rare (Rittel & Webber, 1973, 160).

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Parallel to these studies, the achievements of cognitive science and creativity psychology influenced the leading design studies. An instance of this influence is that design methodology has moved beyond romantic creativity paradigms and rather emphasizes creativity as a perceptual and experiential process. As creativity is the result of continuity of thought, accumulation of information, and experience in the subject (Weisberg, 2006), the higher the level of experience of a person, the higher will be the value of his designs. The outcomes of these findings and impressions formed the new model of "design as learning". According to this model, design is a perceptual act strongly influenced by the designer's level of experience. The application of the "cognitive perception" approach to design was developed under the title of "expertise[2] in design". In this approach, there is a belief that professional designers use different paths and methods than novice designers. These different methods are the result of their different levels of experience (Lawson, 2004). In his/her professional path, from the beginning of education (which usually starts with entering the university), and through experience, the designer continuously develops his/her perception schemata of the design situation, precedents, and gambits; and achieves a deep knowledge of his profession, to the extent that he/she gains the ability to change professional definitions and strategies. Based on the level of experience, Lawson and Dorst place designers in four levels: 1. project level, 2. process level, 3. practice level, and 4. profession level (lawson & Dorst, 2009, 61). It is necessary to remember that design exists in the mind foundations of all humans; in other words, all humans are designers at the "novice" level, but the levels of expertise starting from then on. The project level is the level at which a designer can accomplish a design agenda (project). At this level, the design has "reflection-in-action". The Process level is the level where the designer can manage and guide his work process. At this level, the design has "reflection-on-action". At the practice level, the designer uses a set of strategies, guiding principles, and precedents that improve the quality and efficiency of his design. At the fourth level, the designer has the necessary competency for basic defining and redefining, social guidance, and modifying the formal language.

Findings

After conducting the tests and collecting the data, the analytical propositions extracted from the unguided (unstructured) in-depth interviews were first coded. In the next step, open codings were re-categorized using concepts and components of theoretical foundations, and central and selective codings were determined. We used the method of controlling the validity of the categories themselves to assure the reliability of the research. This was achieved by checking and studying the results by the research team members and a group of scientific peers with expertise in the subject.

Due to the theoretical framework of the methodology and the goal of the research, the process of categorization was stopped in this section. There was no attempt to reach a single focal category, but axial and selective categories

have been placed in the timeline to extract an image of the mental process for each case study.

To achieve reliable results, 716 text-based open codes (in vivo codes) were extracted in the first round. After peer control, in the second round, succeeding several times in coding by the group's researchers, 344 core codes were identified, which emphasized the characteristics and orientation of the categories, with sensitivity to design perception. To shed light on the process, an example of the codings is shown in Table 1.

In the stage of final categorization and post-coding, content analysis was used to achieve the goal of the research by using selected categories. Since the aim of the current research was not to present a single theory, the categories were extracted using the designer's action analysis in the form of selected design categories and their results (Table 2).

Finally, the summary of the process of two groups of architectural design and industrial design has been extracted as described in Table 3.

Discussion

In the next step, the findings went through more detailed discussions and investigations, and the results were again compared with the extracted data. The summary of these discussions is as follows:

1. In both processes, the designer has made perceptual mistakes about the problem. Both the architectural and the industrial design case studies were oblivious to the key information contained in the problem and focused on early associations instead. That is, the cause of the perceptual error was mental associations. In the very early stages, designers get an idea of the problem in terms of associations, and this idea is completely stabilized in the following days. This association is the result of focusing on a familiar aspect of the design process. That is, the designer's mind has left the unfamiliar data and focused on familiar data that is related to his/her mental images. Of course, this neglect is more prominent among industrial designers.

Table 1. An example of open and axial coding done in three stages of the interview with an examinee. Source: Authors.

	First Stage		
	Proposition	**open coding**	**Axial coding**
1	It was mostly the form of space that kept my mind engaged due to the university site.	thinking about form and space issues	Episodic thinking
2	I was inspired by the stone, due to the structure of the university (brick and cube-like texture)	getting ideas from the environment and material	Episodic and semantic thinking about material and historical context
3	…	…	…
	Second Stage		
10	I have read all kindergarten materials from one site	Study	Searching for information through the study of available samples
11	I have read in some resources: Generally, children do not like corridors	Study results	opportunism turning data into a principle/
12	The plan should be designed not to have many corridors.	A principle for the design	
…	…	…	…
	Third Stage		
…	…	…	…
19	The rest is the interior layout, which is related to interior architecture	The distinction between architecture and interior architecture	Distinguishing the generics and the details and limiting self duties

Table 2. Selected categories and points extracted from the methods of architectural design and industrial design case studies.Source: Authors.

	Selected Categories and Points Extracted From the Methods of Architectural Design and Industrial Design Case Studies
	Case study no.1 Architectural Design
Selective coding	Semantic and visual thinking about the problem with a focus on a policy, Consolidation of assimilation policy, Continuity of verbal, metaphorical[3], and visual thinking around the policy, Retrieval of semantic and visual information from memory (long-term and event-based) and successive leap from Verbal-metaphorical thinking to visual precedents, Searching for problems and solutions through existing examples, Continuity of semantic and visual thinking around the policy by determining the guiding principles of the components, Jumping between other dimensions of the problem and component solutions
Points	He/she started the work with verbal and visual thinking, and a package of information was associated with these thoughts (the vocabulary of the historical context is related to the assimilation scheme, and from there this mentality was formed. This package led to a policy From the very beginning, it has established a policy, that the form is in a historical context and must be assimilated with it. This policy has been repeated in all the following cases and it seems to be related to the training provided in the university environment. We witness successive jumps between verbal, metaphorical, and visual thinking and different levels of memory and types of reserves. Deductive reasoning and the association of signs are prominent in this process. The designer has easily referred to the existing samples and paid careful attention to them. At the same time, he/she did not pay much attention to direct observation or search for written information. During these searches he/she has easily formed guiding principles, behind this acceptance there is a mechanism of judgment. In addition, these guiding principles are not only general but also a component (detail). After reaching a level of satisfaction with the policy and guiding principles, the designer has expanded the dimensions of the problem and regularly jumps between dimensions, partial solution, and memory. In the final stage, he/she has tried to organize and link the parts into a whole, by developing the plan. This case did not rely on drawing and used drawing mostly for analyzing the plan.
	Case study no.2 Architectural Design
Selective coding	Emphasis on determining the policy, verbal and semantic thinking with oneself, in line with the intention, he/she has designated the user-centered approach (the guiding principle) but has not relied on observations in any way, searching for the problem through existing examples and association (also from existing examples) both from own words) and as a result of determining the policy of guiding principles and reference fragments, starting to draw, confusion and jumping between parts and solutions, focusing on the policy and integrating and transforming the segments around it
Points	This case has acknowledged from the beginning that he/she must have a policy (procedure). This can be a result of training. That is, he/she has learned from the professors and the educational environment that to achieve a good plan, he/she must have a policy from the beginning. In this case, we have gone to the existing examples in the initial stages to identify the problem-solution. The person is not embarrassed to express this point, so the social fields in which he/she operates (including the educational space) do not consider this act bad. The primary generator appeared on the second day and is not very primary, but rather a combination of several policies, precedents, and reference pieces that are consciously (targeted) or unconsciously placed in the working memory. Drawing started on the second day and is relatively very faint. That is, this case did not advance thinking and searching by relying on drawing and relying on verbal thinking, and searching for existing examples. It seems that this person has little or no skill in formal work and drawing, and this issue has affected his/her work. The thoughts of this case are not based on observations or information documents, but are completely subjective and are the result of personal analysis of existing samples. Compared to product design students, there is much less intellectual leap (to other dimensions of the problem). Instead, the dimensions of the problem are very limited, that is, the problem domain has not been expanded. The final design is the result of combining and transforming common and floating forms in one's educational space. In other words, it is personal(p) creativity.
	Case study no.3 Architectural Design
Selective coding	Searching for problems and solutions through existing examples, determining and developing the initial generator, continuity of thinking with successive jumps between problem dimensions, existing examples, and memory information (especially previous experiences) (gradually uses drawing), postponement of decision making, continuity of thinking around Primary generator with the jump between components and review, course from structural whole to form (from plan to form)
Points	This person is one of the two cases that realized one of the limitations of the problem (ten children), but on the second day, and as a result of analyzing a solution (outside yard). The effect of successive associations is outstanding in the design. It seems that the person has had many visions. That is, he/she has visualized the process of using the design. During this incarnation, he has regularly jumped to different dimensions. From the third day, we see parts that are fixed in the design (especially the central courtyard and the tree). This item also emphasizes the spatial concept of entrance and corridor. At the same time, some parts are considered by default and without importance, such as kitchens and bathrooms. This case also has very little drawing skills, but he/she had more courage to draw, and his drawings rely on his visualization power[4].

Rest of table 2.

	Selected Categories and Points Extracted From the Methods of Architectural Design and Industrial Design Case Studies
	Case study no.4 Architectural Design
Selective coding	Searching for problems and solutions through the examination of existing examples, determining the guiding principle of assimilation and determining the formal-metaphoric policy, continuing thinking in line with the policy and completing details by relying on the recovery of the objects, completing the details, especially by relying on visual metaphors
Points	This case has paid little attention to the information documents and direct observation. He/she has not developed the dimensions of the problem, but rather the behavior of project management and scheduling is more prominent in this case. He/she has been more successful in developing the form than in other cases.
	Case study no.5 Industrial Design
Selective coding	Searching for information in memory, Developing the breadth of the problem and its dimensions, Determining guiding principles and a reference, Direct search for information, Targeted search in existing examples, Continuity of thinking centered on policy, reference pieces and common tricks - along with graphic-thinking and successive jumps between Solutions, Formation of primary generator with high emotional excitement, Increasing the complexity of primary generator, Searching for solutions to solve component problems with the help of information, reference parts, consultation, successive jumps at different levels of the problem, solutions and verbal-visual thinking
Points	Graphical thinking is very noticeable. Some precedents and tricks to make the form attractive are evident; the P creations. Establishing the policy of creativity makes a person try to avoid existing examples. It is a constraint, and at the same time, a psychological struggle. Two understandings of the problem have given direction to the work: 1. Being a couple. 2. Being young. These two have led to less space and therefore collapsible mechanisms. The designer has ignored various aspects of the subject, which are especially related to the realization of a part of the design. The final design is a brief synthesis and transformation of the existing examples and is a personal creation (P).).
	Case study no.6 Industrial Design
Selective coding	Searching for information in memory and verbal-semantic thinking, Development of the dimensions of the problem, which is done with extreme jumps and through the visualization of solutions, Determination and successive emphasis on the policy of being specific and stylish, Searching for existing examples based on policies, Formal ideation - A drawing with a policy to reach a specific design, method: combination of main volumes (on paper and computer), development of solutions with increasing complexity and irregular successive jumps, continuity of thought with thematic search for online information, self-talk and jumping between problem dimensions and ideas, Increasing complexity in line with policies, Critical thinking with fear and feeling of pressure that has led to referring to existing examples, Searching for solutions in existing examples, Confusion, Jumping to other solutions and irregular online searches, Critical thinking of ideas with event visualization, Development of main plan through dialogue (guessing and falsification) with self, replica and 3D, inordinate increase in complexity
Points	In the initial stages, jumping to different dimensions of the problem was very intense, far from each other, and actually based on existing solutions. In fact, these jumps were the result of retrieving packets of information and pieces of reference from memory, not divergent creativity. Because all the pieces and solutions are there and one has already absorbed them. But these information packages are apparently very different from each other and there is no uniform process to recover them. That is, the packages that are expressed consecutively are of very different dimensions, so one package did not trigger the association of another package, and the memory processing quickly recovered all of them. This case emphasized the specificity policy, but from day one, it referred to existing examples. It seems that he/she is consciously trying to hide this issue even from himself/herself. For example, he/she justifies that this work was not aimed at imitating or finding a solution, but simply a control of the originality of his own design. It can be concluded that one of the methods of the designer's mind is to refer to existing examples. The mind knows that there is a way out of the existing examples. This case moves very easily to complexity. In general, the consecutive and irregular jumps between all levels are very intense. This item does not refer to the real world and real users. He/she even considered himself/herself a hypothetical user. This case placed great emphasis on the specificity of the result, even when he/she realized that he/she could not create an original form. This emphasis itself can show that some mental processes are criticizing the policies and showing the designer that his thinking and policies are wrong, but its reflection is in the form of confirming these policies. Naturally, with that strong creative genius policy can't find forms interesting to him/her, so he/she continues to search divergently, his searches seem to be even more random and aimless, and highly personalized than before. His/her sensitivity to being specific is more about generalities and he/she easily refers to existing examples about components. his item has spent too much time on the chair when it was not on the agenda at all. That is, it has been associated with him/her during his/her work. In the face of the criticism that the plot is not attractive at all, it complicates it. At the end of the project, this case had doubts about its methods and policies, and as a result, it showed stressful behaviors. He/she even seemed ready to accept defeat. But at the same time, a kind of experimental growth was also seen in him/her. Because in the last few days, he/she easily referred to the existing designs and talked about using them in future projects.
	Case study no.7 Industrial Design

Rest of table 2.

	Selected Categories and Points Extracted From the Methods of Architectural Design and Industrial Design Case Studies
Selective coding	Searching for information in memory and semantic verbal thinking, Searching for problems and solutions in online examples, Determining policies based on a wrong understanding of the design brief, Relating new experience to the project, Searching for existing examples and graphical thinking, Jumping between problem levels and partial solutions from the pre-existing ones that are based on policies. Temporarily abandoning the primary generator by referring to a common gambit: adding light to the design, Systematic disorder in the work, Continuity of thought around the combination and transformation of the pieces of the observed examples based on the primary policies.
Points	This case repeats the same misconceptions about the issue. Industrial design emphasizes smallness and space, while architects were not like that at all. In the agenda that was given to the architects, there was much more space to think about the issue of space. Because the number of children was very few and there is very little empty ground in the campus area, they did not pay attention to this at all. At the same time, he/she is working on the main plan, and he/she is also thinking of other solutions. That is, he/she has kept option B for himself/herself, neither abandoning the first option nor fully relying on it. This case was aware of design fixation and falling into a creative track. The method of solving and developing the design is completely the same, first determining a series of policies, based on perceptions of the problem (which are easily wrong), then finding parts in the memory, such as mechanism, collapsibility, and lighting, easily these parts They enter the working memory and the person has no limits to increase the complexity. This case obviously lacks order and management and simultaneously or consecutively deals with other tasks. This behavior is not just a simple disorder. In other cases, it was observed that whether they wanted to or not, in parallel with the project, they also do other work and are not afraid of suspending the work (especially in the initial stages).
	Case study no.8 Industrial Design
Selective Coding	Searching for information in memory and verbal-semantic thinking, The policy of being specific by avoiding existing examples, Searching for information in memory and verbal-semantic thinking, Visualizing the problem through event and image memory, Jumping from framing the issue to a policy that is a framework It is a solution, Continuity of thinking in the policy: creative track, parallel thought in details; Dialogue with hand drawings; Continuity of thinking in the groove of creativity; Slight jumps in details and combining details of precedents in the design, Continuity of thinking and dialogue with oneself and with the drawings: expanding the scope of divergence in the same policies, Decision making and justifying the design
Points	This case explains its method very simply: first, he/she tries to analyze the problem. Second, he/she makes a sketch, and third, he/she searches in the existing examples to see if the obtained design exists in the existing examples or not. However, he/she has repeated the same wrong perception of the problem. In all the cases where the metaphor of being a couple is emphasized, the only way to show the couple was to double the table, while there were other ways, for example, to bring a double color combination or to have motifs on the table. In addition, the final design is a transformation of the existing examples that were at the top of Pinterest pages at the time of the test, that is, the final design is a simple creation. The person seems to rely entirely on episodic and visual memory to analyze the problem

An important point is that each of these groups had the same misconception. That is, they all followed the same perceptual paths that led to cognitive error. In other words, the perceptual paths of the problem (whether right or wrong) were acquisitional. In architectural design, the information about the historical context formed a range of associations, and this range evoked a central policy for the designer.This policy was founded on the belief that assimilating historical form and texture was essential. This policy is quite common among architectural designers and architectural educational environments in Iran. Industrial designers also quickly ignored an important part of the data. Instead, some information on the issue evoked two specific perceptions of it: “The space of this couple’s home is very small, so this product must be “small” and “These two will use the table together (at the same time).”. While these restrictions are not true at all.

2. Architectural designers did not try to change the level of the problem at all. However, based on the data on the problem (the number of ten children), it was even possible to reduce the level of the problem. Still, except for two cases, others did not pay much attention to this point and considered the problem at the same level. Comparatively, the industrial designers completely raised the level of the problem and tried to make it too complicated.

3. Both architectural designers and industrial designers rarely referred to direct observation or even written information to obtain information. Most of them relied on looking at existing examples and retrieving information from memory (through

Table 3. An abstract of the process of the two groups of architectural design and industrial design. Source: Authors.

	An abstract of the process of the two groups of architectural design and industrial design
Architectural Design Process	Verbal and visual thinking about the problem, Searching for the problem and solution by examining existing examples, Determining and consolidating policies and guiding principles, Retrieving information from memory and jumping between different levels, solutions, and components, Continuity of verbal-metaphorical and visual thinking in line with policies And the guiding principles/course from the structural whole (plan) to the form and components
Industrial Design Process	Searching for information in memory, Developing the breadth and dimensions of the problem, Determining and consolidating the policy, guiding principles, and in some cases a reference, Targeted search for information and pieces of reference, in existing examples with a little direct reference to the information, Continuity of policy-oriented thinking, guiding principles and reference pieces, along with graphic thinking, at the same time successive jumps between different levels (problem, solution, and references), which is accompanied by an unlimited increase in the complexity of the basic plan [5], continuity of thinking at the same time successive jumps at different levels, based on Policy and principles in the form of integration and transformation of reference parts in the basic plan

self-talk). Architects even referred to existing examples to identify users and their needs. Meanwhile, in the higher education environments of these disciplines, the scientific performance of information-gathering steps is emphasized. So, it can be said that "referring to existing examples is a mental method". The mind knows that there is a lot of information and even solutions hidden in the existing examples, and by referring to them, it can have optimal efficiency and "satisfactory processing".

4. In this respect, a critical behavioral difference was noticed between the two groups. Architectural designers would quickly refer to existing examples to understand the problem and even the solution. This was without any restrictions. But industrial designers consciously tried not to refer to existing examples so that their creativity would not be affected. There are many points in this regard, including Industrial designers sooner or later referred to existing examples, but felt that this was not the right thing to do. According to our evidence, they justified their actions in some cases by claiming that their goal was not to imitate but rather to ensure the originality of their design. Second: the designs of industrial designers are even more influenced by the existing examples than their architectural counterparts.

5. Following the previous point, industrial designers felt far more psychological pressure to be creative than architects. In most cases, the designer's policy was that it should be a specific design. "Policy of being specific" caused them not to have a correct understanding of the problem and focus on data from the problem, which they thought was opportunistic information. All industrial designers emphasized the design being "collectible". Every one of these designers with this perception of the problem felt that this particular perception would lead them to a specific design. Whereas that perception was only "associative data". In the analysis, this policy caused them to not use the knowledge accumulated in the existing samples in a timely and correct manner and to have very low efficiency throughout the design period. In the final decisions, they preferred having a specific design to having a good, logical, and efficient plan. In other words, having a specific policy or being a creative psychological driver distorts the entire work of an industrial designer, while an architectural designer is far less prone to this problem. The existence of this psychological drive is not due to the nature of the fields or their subjects, but it is the result of their social, educational, and professional fields. The social field of the industrial design profession strongly emphasizes formal creativity. While the social fields of architects pay attention to other dimensions such as "having a philosophy" or "symbolic and metaphorical expressions". Architects used to show these forms more mildly. Although the architects also emphasized some data and form parts (for example, corridor or assimilation), they showed more diversity in

understanding the problem, solution, and work method.

6. In both groups, parallel thinking is quite evident on various dimensions of the problem, and so are, irregular jumps between the dimensions of the problem and the solution. These jumps are not only at different levels of problem and solution, but we see successive jumps between verbal, metaphorical, and visual thinking and different types of memory. Deductive reasoning and symbolic associations play a central role in these jumps. An observer feels that these jumps are random and scattered, but there is a reason why the brain is moving between these levels, to say the least, the mind does not consider these levels to be irrelevant, or it has not classified them in separate sections, so "dimensions of the problem" are concepts created by design methodology and have no originality in the mind.

7. It seems that architectural designers use verbal thinking and verbal metaphors much more than industrial designers, both in problem analysis and form creation.

8. Concerning the discussion of parallel thinking and jumps, another point is that at the beginning of the process, the designers have behaved in a completely convergent manner, which means that they have tried to reach a framework through the selection of some data and dimensions of the problem. Then, in line with that, they have retrieved from memory a coherent framework, policies, and guiding principles. When they reached a satisfactory point, then they proceeded to develop the dimensions of the problem and it is from there that the mental leaps started. Interestingly, these jumps have not stopped even in the final stages. In other words, the "divergent-convergent" work pattern is not seen here.

9. Even in the work of architecture students, the primary generator is not very prominent. What is more common is the existence of a set of policies, guiding principles, and general or partial pieces of reference. A notable point is that designers use reference pieces a lot. The reference pieces are mostly in the components, for example, the central courtyard, the facade, and brickwork of the buildings on the site, the folding mechanism, or the wall table. Even industrial designers who follow a much more specific policy are comfortable using reference parts.

10. Architectural designers used drawings for problem analysis much less than industrial designers. This could be because of their university education or even because of their primary and secondary education because architectural designers in Iran are recruited through the math entrance exam and are less used to drawing and doodling.

11. In most cases, the final design is the result of the transformation and combination of common and floating forms in the educational space. Most of the final designs are personal creativity[3] and there are similar precedents for them.

12. Designers have decided from the outset that parts of the problem's data are important and opportunistic. Also, based on the selected data, policies and guiding principles have been recovered and stabilized from memory. Such cases show that the design judgment mechanism is active from the very beginning of the design process. Of course, these judgments are associated with associations and perceptual errors, and both groups of designers are equally affected by these errors in judgment.

13. In most cases, designers did not have proper management behaviors. In particular, they have had problems with scheduling and have not been able to give enough time to each stage. In other words, there is no balance between expanding the scope and dimensions of the work and the time limit. In addition, the designers, willingly or unwillingly, have done other works in parallel with the project and are not afraid of suspending the work (especially in the initial cases). This is a systematic disorder, meaning designers are used to it. Of course, in some cases, this has been

done well. That is, the designer has avoided the development of the dimensions due to the time limit, in this case, the architects have performed better.

14. Industrial design cases easily move towards complexity. They have limited guidelines and guidelines, but many reference pieces are retrieved from memory and existing examples and put into working memory. Interestingly, one of the guiding principles they put forward from the beginning is "minimalism", but in practice, they seek complexity indefinitely. It seems that this is not just a problem of problem management, but a trick to make the plot special and interesting.

15. Architectural designers seem to use much more long-term informational memory, while industrial designers use more episodic and visual memory and retrieve little information. The reason for this difference is in the educational environments of both. In the classrooms of architects, there is much more verbal discussion about the topic and problem, while industrial design professors discuss more designs. An interesting point is that designers (especially industrial designers) recovered some information in the following days, but the person did not understand and considered a design that is on the front page of virtual networks as his creative idea.

16. The stages of analysis and creativity are not separate, but completely intertwined. In this regard, observations do not show that architectural designers are holistic and industrial designers are partial. Both of these are completely dependent on the policies and principles that are set in the early stages. With these policies, one examines existing targeted samples. Examining the available samples is simultaneously accompanied by the search for information and solutions.

Conclusion

Many points and cases can be extracted from the analysis of the central and selective categories of the examinees, of which 17 general cases were introduced in the previous section. In general, it can be said that the two groups of product design (industrial) and architectural design are similar in some aspects and behave differently in others. In common aspects, both groups are close to the inherent methods of the mind, and in different aspects, the role of environment and education is evident, but the effect of the difference in the types of subjects (buildings and industrial products) cannot be proven. That is, it cannot be said that the reason for the differences is that the subjects of these two are very different from each other, instead, the impact of education and social fields of these two fields is visible. This research completely changes or develops some of our previous information regarding the descriptive cognition of design, including that:

1. The design process is a continuous process of thinking. From the very early stages of the policies, principles and reference pieces are used as a basis for comparison and move in comparison with them. All coded examples show this.

Policies: procedures, intentions, and desires that generally define the nature of design actions.

Guiding principles: are packets of information that are retrieved from information storage or identified during searches. Designers value these packages based on the principle of opportunism.

Reference pieces: These are parts of designs that have already been realized or have been evaluated as valuable in ongoing searches. These parts may be a shape or a structure. Sometimes an entire design may be based on imitation.

That is, design is more dependent on policies, preconceptions, and individual perceptual information than it is dependent on observations and research. An interesting point is that even beginner designers have a policy and guiding principles (as this was evident in three samples of the examinees), this is contrary to those hypotheses that focus on being solution-oriented, the existence of a primary generator and they emphasize abductive thinking. Also, divergent-

convergent thinking patterns cannot be seen in the way they were thought until now (first divergence, then convergence). In this mental performance, individual-psychological drives and tensions also have a great impact.

2. The design process in both architecture and industrial design relies heavily on reference to existing examples. Although industrial designers try to avoid existing examples, they refer to them in practice and are strongly influenced by them. Analogy and association play a very colorful role in this process (referring to existing evidence and existing examples).

3. Training greatly affects design performance, but (even in designers who are at the implementation level) the design method cannot be reduced to training only, and much more attention should be paid to common mental-perceptual structures in this process. One of these very important structures is the "imitation" of existing examples. The duality of the "inherent method - acquired method" sometimes leads to a behavioral duality in designers. It means that the designer tries to remain faithful to the values and methods he has learned, but in parallel, he follows a different mental path. This duality can both waste a lot of energy and lead to stress and psychological suffering for a person.

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The authors declare that there is no conflict of interest in conducting this research.

Endnotes

1. Definitions are given in the theoretical foundation part.
2. The word implicitly expresses proficiency based on experienceand skills.
3. Verbal is talking to yourself. Metaphor is the result of signs associations, or in other words, consecutive mental meanings.
4. It seems that architecture students can be divided into two groups that are two ends of the same spectrum, those who have more visualization and drawing skills and vice versa. It can be hypothesized that the second group works more with plans and goes to computer modeling sooner.
5. Its difference from the primary generator is that it is not primary, and it is not very certain, but it is a basis for measuring thoughts and a modular structure for combining and transforming parts.

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