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Developing a Model for the Totality of Designers' Actions in the Architectural Design Process (Aiming for Consensus on Ex-Models)

Javad Goudini^{1*}, Eshagh Rezazadeh², Sadegh Koulivandi³

1. Assistant Professor, Faculty of Technical and Engineering, Razi University, Kermanshah, Iran.

2. Assistant Professor, Faculty of Art and Architecture, University of Mazandaran, Babolsar, Iran.

3. Instructor of Architecture Department, Faculty of Technical and Engineering, Razi University, Kermanshah, Iran.

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Abstract

Problem statement: The design process, one of the common topics among design research, design studies, design thinking, etc. has long been explained by experts using various models. Such divergence necessitates the analysis of opinions to reach a consensus.

Research objective: This study aims to present a totality of designers' actions in the design process to find what designers do to convert the existing situation into a desirable one. Since this aspect of the process has been mainly introduced based on the activities or design stages in the previous models, the extant study also has adopted these components to recognize the totality of designers' actions.

Research Method: This is a review study drawing upon logical reasoning and the comparison of different models of the design process.

Conclusion: The results imply that the totality of designers' actions can be explained in a model composed of subjective stages (within two conscious and unconscious levels) and objective stages (including planning, design, construction, documentation/handover), which convert the existing situation to desirable one based on two ranges of analytic (evaluation, comparison, analysis, test, etc.) and synthetic (genesis, conjecture, image, synthesis, expression, production, etc.) activities. In this model, the totality of designers' actions, not only depends on the specifications of the components mentioned above but also on their relationships. In other words, the totality of designers' actions in the design process is beyond the reduction done in the previous models that consisted of two components of activities and stages.

Keywords: *Design Research, Design Process, Actions of Designers, Stages, Activities.*

Introduction

Design is a term frequently used in recent decades. Despite the various definitions proposed for design, this concept can be further analyzed (Blackler et al., 2021, 42-48). One of the considerable features seen in definitions proposed for design¹ is providing desirable conditions for humans realized through some phrases such as actualization, creation, responsiveness, conversion, conversion, etc. The designer indeed tries to create a consistent condition in

the considered context by providing a solution for the problem. Irregularity in the components of the context is a problem that requires a compatible form. In this case, design is defined as an attempt to achieve compatibility between form and context (Alexander, 2005, 23-55). Therefore, design can be defined as the conversion of an existing (unfavorable) situation to a future (preferred) situation (Goudini et al., 2021, 52). Although this is a simple definition, a noticeable problem exists in it that requires a proper response. This problem is about

*Corresponding author: +989125509521, j.goudini1980@yahoo.com

how designers convert the existing situation to the future situation. It should be indeed determined what designers do in the design process to achieve the desirable conditions through these measures. This problem is scrutinized by reviewing the research background and identifying responses given to this problem. Process researchers have mainly used two terms “activity” and “stage” in this case. A group of process researchers have only described the stages that designers should pass through during a design project. Other researchers have analyzed the required activities in the design. In addition to these models, some samples have determined the design process based on two terms “activity” and “stage.” Reflection on a multiplicity of classifications done by the scholars makes the mind recognize the main stages and activities of the design process; this case helps to create a consensus among these ideas and approaches to causes for these disagreements on the other hand. Therefore, this study tends to answer the following questions to understand the totality of designers’ actions.

- Main question: what kind of relationship can be illustrated between activities and stages of design that represents the totality of designers’ actions in the process of converting existing situations to future ones?

- Secondary questions: what are the main activities of the design process? What are the stages through which the design process is defined?

Research Methodology

This is a review study in terms of nature. In terms of design research, this research is among reflection and theorizing studies. Unlike empirical types of this technique, the researcher considers various dimensions of the design in the theory form in this method (Cross, 2023, 8). On the other hand, logical reasoning is one of the methods used to acquire knowledge in non-experimental fields. This method is consistent with theoretical design research. Accordingly, the extant study has used logical reasoning to answer the questions. In this lieu, this study classifies different models of the design process (e.g., models with two activities, three activities, etc.) and models presented for projects’ life cycle (including the life cycle of design projects, common projects, and building projects), and

then compares them to approach a consensus on opinions based on the deduction of their common aspects.

Theoretical Foundations

The totality of all phenomena is examined depending on the adaptation of a holistic approach. The holistic attitudes believe that the totality of a phenomenon is reduced when the whole is divided into parts. Hence, these attitudes put synthesis thinking next to analytic thinking when examining phenomena (Săvoiu et al., 2023, 6). These kinds of thoughts consider the understanding of totality a variable that depends on the relationships and interactions between parts (Kolahi, 2023, 111). Holistic thoughts believe that every phenomenon has a relationship between its parts separated from its components, which makes its totality beyond the algebraic sum of components. Therefore, the relationships between components must be considered in defining the totality of designers’ actions.

Findings

• Determining design process with activities and stage

Reflection on the definition “converting existing situation to future situation” implies that design has a functional, practical, or action aspect. This aspect is mainly based on the fact that the design term is both a verb and a noun. Secondly, this aspect results from the above definition: “converting a situation.” The action aspect is often seen in the definitions presented for the design. For instance, the definition of design by Parsons (2021, 20) who states “Anything we do is design” clearly defines design as an act or action. This action aspect can be seen in the definitions presented for design, design process, or architecture in various ways, including with the term “activity,”² and makes design necessarily a process that requires activity. If “converting existing situation to future situation” requires intermediate situations, the design depends on a collection of activities, and each activity changes the situation of the manufactured product. These points are matched with some models proposed for the design, such as the model by Reymen et al. (2006, 153). In this case, activities are considered as the components of the design project’s activities (PMI, 2004, 350). Moreover, consideration of a procedural nature for design³ would add

some dimensions, such as chain nature, gradualism, and product-orientation⁴ to these activities presenting them as interconnected not separate activities. Since each activity converts an input (or situation) to an output (or another situation), the design process creates an input-output chain that is connected through activities and moves towards the favorable situation. In addition, various chains are created for the design process since each situation may have a subjective or objective nature (Fig. 1.).

The subjective situation of design can be an imagination or fictional one created only in the mind of the designer, and the designer would progress the initial situation through several sketching processes on the situation and finally finish it in their mind. This subjective-subjective chain exists in many imaginations of us. However, designers sometimes try to convert their subjective situation to an objective one on paper through a computer or in the frame of a model, and so forth. In such cases, designers sometimes finish the chain due to many reasons, so that a subjective-objective chain of design is shaped. Nevertheless, most of the time, a designer's mentality is influenced by an objective situation, which considers it a problem or opportunity trying to face it and create other chains, such as objective-subjective or objective-objective chains, by converting it to a better situation (either in mind or in practice). The mentioned chain can be expanded. Regardless of these chains, the designer may not need to mentalize the design situation in real cases due to some reasons such as problem simplicity. In such cases, the designer directly converts the existing objective situation to another objective situation. This case can be presented in the rearrangement of furniture in a house, organizing cabinets, etc. The obtained model (so

far) not only is matched with logical reasonings but also is in line with other models or theories of design experts. For example, the multiplicity of subjective-objective chains indicates that there is no point in finishing the design in the designing itself because another situation can be imagined after any situation. This situation is matched with the opinions of Rittel and Webber about the wicked problems. They believed that no restrictive rule existed for design problems (Rittel & Webber, 1973, 162). This model is in line with those models that link different projects by evaluating them (Goudini et al., 2016, 7). Moreover, this model is also matched with the reflective design theory by Donald Schon (explaining that design is a dialectic between designer and context)⁵. This model is in line with those theories that have examined the differences between design, science, technology, etc.; for instance, the design aims to change the world to reach a better situation, which is distinguished from the descriptive nature of science (Rezaei, 2020, 32). This change is seen in the model mentioned above.

The mentioned explanations indicate the design process, like any other process, requires determination through appropriate activities. This situation has made many individuals consider activity as the base for describing the design process, and or use the title of activities when naming the procedural models. However, the design process is moving due to its product-orientation nature and activities; therefore, activities are subject to their situations or places in the process. These situations indicate the activities' distance from or proximity to the favorable situation and are known as stages in the design field. Because activities are subject to stages, the process is not reduced to these parts. Therefore, actions

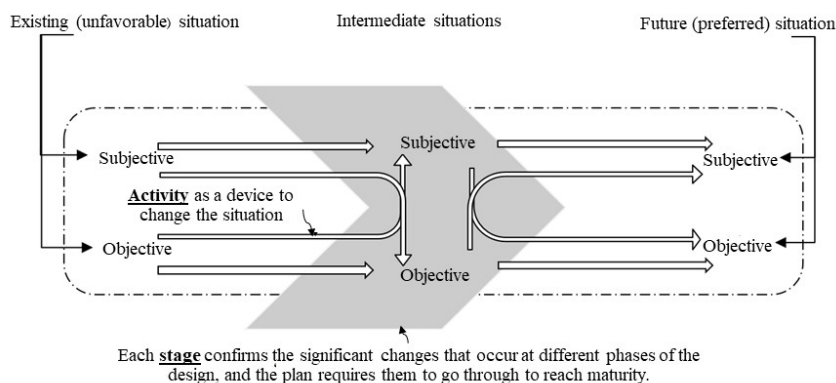


Fig. 1. Explaining the design process with multiple paths that link different situations. Source: Authors.

of the design process are essentially obtained from the simultaneous consolidation of activities in the stages (or situation conversion positions).

• Main activities of the design process

Explanation of the process with activities has been done within various models. The simplest ones are the models presented by Alexander (2005, 102), DVI 2221 (Dubberly, 2004, 23), Le Corbusier (Mahmoodi, 2001, 62), Foreman (Dubberly, 2004, 15), Pena-Parshall (1969, 18-22), and the model proposed by Krauss et al. (1970, 11) that only consist of two main activities (Table 1). Regardless of the differences between these models, the designer would analyze and examine the problem in all five first models (analysis), then solve it based on the obtained understanding (synthesis). Since the whole is converted to parts or details in problem analysis, the designer will have a divergent action in the analysis process. In contrast, the designer does a convergent action by aggregating details under the synthesis operations. According to these explanations, the activities of these models confirm two spectra of analysis/synthesis. In the sixth model, the designer frequently does two activities making a form (synthesis) and evaluating it within a repetitive format. Since the form evaluation requires matching it with various criteria, the designer would evaluate the problem in this activity (like analysis) by pursuing a divergent and analytic process. This situation would place the evaluation action within the analysis action. Therefore, the difference between the sixth model and other models is the priority of activities and the practical scope of this model not to type of activities mentioned for the model⁶. In addition to the models mentioned above, other theories confirm that problem-understanding and solution-providing are simultaneously developed as two main activities in the design process (Cross, 2019, 154). The main activities of the design process still imply two analysis-synthesis spectra in this viewpoint.

Design process explanation has occurred with three activities in the models proposed by Laugier (Lang, 2002, 41), March (1984, 266-269), Jones (1984, 26), Lawson (2008, 57), Zeisel (Heath, 2010, 10), Nasser Khaki & Noorian (2011, 61), Darke (1984, 179-181) and Doblin (1987, 8). The three-activity model by Laugier is similar to the Alexander and VDI 2221 ones and is

divided into three parts. March believes in three types of logic, including productive, inductive, and deductive logic in the design. March assumes that deduction activity has an analytic nature, and production and induction activities have a synthetic nature. Accordingly, March's model is indeed the developed form of dual analysis/synthesis spectrum. In Jones's model, these dual activities are followed by an evaluation activity. This activity tends to discover the inefficiencies of the solution to correct them before selecting or completing the solution. In other words, evaluation tends to assess and measure the rate of design compliance with the problem's demands. Contrary to induction, which has a synthetic nature, evaluation has an analytic nature; therefore, Jones's model is based on the dual analysis/synthesis spectrum like March's model. Lawson's model is also composed of the triple activities of Jones's model with the difference in the order of activities; hence, this model can also be converted to those two spectra. In Zeisel's model, the main activities of the design process include the image, present, and test. In his opinion, the image created in the mind of the designer has some limitations; for instance, it cannot be tested or corrected. Hence, the mental image is unable to progress the design in practice. Hence, the representation or expression of the mental image as a sketch or map is an essential case. According to the mentioned points, the present is the continuation of the previous synthesis activity that converts internal syntheses to external shapes. On the other hand, like evaluation, the test has an analytic nature. Hence, the activities of Zeisel's model also follow that two-spectrum model. The three-part model by Nasser Khaki & Noorian (2016), which includes synthesis/performance, interpretation/representation, and analysis/evaluation is highly similar to Zeisel's model. Hence, the activities of this model are not beyond the analysis and synthesis spectra. Reflection on the three-part Darke's model, which includes generator, conjecture, and analysis indicates that initial generators are devices for reaching one or a set of conjectures, so provide the introduction to the second activity in practice. On the other hand, the conjecture's nature is similar to the image; hence, the two first parts of Darke's model would have a synthetic nature. Therefore, the activities included in Darke's model are composed of those two spectra. In Doblin's model,

genesis is also in the synthesis range; hence, this model is also composed of those two activities (analysis/synthesis). Cross’s model (2000, 30), Maver’s model (1970, 97), Asimow’s model (Rowe, 1991, 47), Watts’s model (1996, 85), 4Ds model (Dubberly, 2004, 6 & 61), and Polya’s model (Tabesh, 2021, 10) are the most important models with four activities. According to explanations given by Cross about the four activities in this model, (i.e., exploration, generation, evaluation, communication) exploration, and evaluation have an analytic nature, while generation and communication are synthetic. Asimow’s and Watts’s models are completely similar, and they are created by adding communication activity to the end of Jones’s model. Accordingly, communication would complete the previous activity; hence, these models rely on the analysis/synthesis based on Jones’s model. In Maver’s model, appraisal and decision activities exist after two activities of analysis and synthesis. Since the decision is the continuity of the previous activity and appraisal has an analytic nature, Maver’s model also follows this dual spectrum. In the 4D model, the problem definition is considered under the analysis and other activities in this spectrum. According to Polya’s model, understanding the problem and devising a plan is in the analysis spectrum,

and carrying out a plan and looking back exist in the synthesis spectrum. Similarly, it can be argued that the five-activity THEOC model (Dubberly, 2004, 38). Six-activity Archer’s model (1984, 64), and Koberg & Bagnall’s model (1974, 17-21) with seven activities even Archer’s model (Dubberly, 2004, 98-113) with 229 activities can be reduced to dual analysis/synthesis spectrum.

Reflection on the design definition indicates that the totality of “converting the existing situation to a future situation” implies an action resulting from aggregation of all activities of the process. Since this aggregative action is done to create a favorable situation, the totality of the design is based on an aggregative action that has a synthetic nature. On the other hand, the product orientation of the design indicates that synthesis is the purpose and destination of the design. Therefore, design not only is composed of a synthesized activity, but also its product is a synthesis. In this case, the dual analysis/synthesis spectrum can be aggregated in a synthetic activity. Convergence of design activities towards the product or favorable situation indeed puts the analysis in the background of the synthesis. In this mode, design is defined as a synthesis activity that itself is composed of a dual analysis/synthesis spectrum. According to the mentioned cases, the reason

Table 1. Classification of models introduced for activities. Source: Authors.

Models	Examples of models
Models with 2 activities	<ul style="list-style-type: none"> - Alexander (breaking a problem into pieces which means “decomposing” it, solving each sub-piece, and finally knitting all the pieces back together which means “recombining” the pieces) - VDI 2221 (decomposition, recombination) - Le Corbusier (decomposition, composition) - Foreman (establishing needs, satisfying needs) - Pena-Parshall (programming which is analysis. design which is synthesis) - Kraus, Myer, Danielson, and Lewis (making special forms relating to the pertinent data and analysis, reevaluating the problem and possible solutions)
Models with 3 activities	<ul style="list-style-type: none"> - Laugier (decomposing a problem, solving the components, and then synthesizing the partial solutions into whole ones) - March (production, deduction, induction) - Jones (analysis, synthesis, evaluation) - Lawson (analysis, synthesis, evaluation) - Darke (generator, conjecture, analysis) - Doblin (analysis, genesis, synthesis) - Zeisel (image, present, test) - Nasser Khaki and Noorian (synthesis/performance, interpretation/representation, analysis/evaluation)
Models with 4 activities	<ul style="list-style-type: none"> - Cross (exploration, generation, evaluation, communication) - Maver (analysis, synthesis, appraisal, decision) - Asimow (analysis, synthesis, evaluation, communication) - Watts (analysis, synthesis, evaluation, communication) - 4Ds: (define, design, develop, deploy) - Polya (understanding the problem, devising a plan, carrying out a plan, looking back)
Models with 5 activities	<ul style="list-style-type: none"> - THEOC (theory, hypothesis, experiment, observation, conclusion) - d.school (empathy, define, ideate, prototype, test)
Models with 6 activities	<ul style="list-style-type: none"> - Archer (programming, data collection, analysis, synthesis, development, communication)
Models with 7 activities	<ul style="list-style-type: none"> - Koberg and Bagnal (accept situation, analyze, define, ideate, select, implementation, evaluate)

for the difference between these models may be related to the aggregation or separation rate of design activities.

• Design process stages

The dynamism of the design process requires some stages through which, the design can pass to reach its favorable situation. According to Lang (2002, 49), each stage has its specific character and results. On the other hand, multiple chains of subjective and objective situations indicate that design stages include both spectra depending on their favorable trajectory. Subjective stages indicate some situations of design that are in the minds of designers without any external presentation. In contrast, objective stages mainly have tangible and external presentations, so that the designer, owner, or employer can see the outcomes of the design⁷. Contrary to objective stages that have different formats in the opinion of process researchers, subjective stages are less introduced in the design process models. However, a brief review of the five-stage Lawson's model that comprises first insight (formulation of the problem in mind), preparation (conscious attempt of mind at solution), the incubation (the conscious mind is replaced with the unconscious mind to direct the creation action), illumination (sudden emergence of the idea in mind), and verification (conscious development with a scientific or technical review of solution) (Lawson, 2008, 175; Torabi & Islami, 2013, 40) indicates that two conscious and unconscious parts of the mind are involved in this process. In other words, it is concluded that the design process can be determined based on two related conscious and unconscious parts within subjective stages. However, this subjective process can have some objective representations too. Since objective stages have an inseparable relationship with lifecycle theory⁸, three categories of models related to the life cycle of common projects, building projects, and design projects are compared to reach a consensus.

Many models have determined the process of common projects, including PMI (2000, 18), Stuckenbruck (1981, 1), Westland (2006, 5-15), and Wideman (2004, 28-30) (Table 2). In the PMI's model, the life cycle comprises three initial, intermediate, and final phases. The initial and final phases of a project result from one stage, while the intermediate phase may include several stages; for instance, this phase is divided into two

growth and production stages in Stuckenbruck's model, as well as planning and execution stages in Westland's model. Wideman's model introduces four general stages, including conceiving (or understanding the idea), developing (or transferring the idea to a practical plan), executing (or operationalizing the plan), and finishing the project activities. A comparison of these models provides several considerable points. First, the separation lines between these stages are hypothetical indicating the change in activities. It means that similar activities are put in one stage. Second, these models follow the idea of "Plan Before Doing." Therefore, the first stage can be called planning, and the next one can be considered as plan operationalization. Third, some (hypothetical) stages can be imagined under the title of initial and finish phases at the first and end of the life cycle.

Many design models have determined the design process based on the stages. Models presented by Salvadori (Lang, 2002, 43), Lang (*ibid.*, 50), French (Cross, 2000, 31), Pahl & Beitz (Cross, 2000, 37), Maver (1970, 197), RIBA: The Royal Institute of British Architects (*ibid.*), and AIA: American Institute of Architects (Mahmoodi, 2001, 69) are some of these models. Salvadori's model comprises five main stages of programming, schematic, preliminary design, working document, and construction phases. In models proposed by French or by Pahl & Beitz, the second, third, and fourth stages include conceptual design, embodiment design, and detail design. However, the explanation of stages indicates that the difference between them is only in the title of stages. Accordingly, the similarity between activities mentioned in these three stages allows for classifying them in a single design title. On the other hand, a stage with a planning nature exists before design in all three models. The different point is seen in the fifth stage of Salvador's model (construction phase), which is absent in other models. According to the comparison and aggregation of these three models, three stages of programming, design, and implementation are obtained. The same stages are found in Lang's Model when reflecting on it. The difference is seen in the implementation phase which is divided into two parts contractor selection and implementation, which are considered as implementation stages due to the relative similarity of activities. In Lang's model, the evaluation

stage has made it novel since it may refer to another stage. The four stages mentioned above (programming, design, implementation, and evaluation) are divided into five stages in Maver’s model, so the same model is obtained if similar stages are aggregated. RIBA’s model also comprises the same stages mentioned in Maver’s model. The AIA’s model is highly similar to the Lang’s model. According to the comparison between models provided for design projects and common projects, the design stage has been introduced more accurately in the first models.

By review of the models for building projects life cycle, including presented by Stuckenbruck (1981, 4), Morris (1983, 19-22), Webster & Knutson (2011, 2-5), Wideman (2004, 10), Archibald (1976, 25-29), Alan Stretton (Wideman, 2003, 9-10), Badiru & Osisanya (2013, 299), evaluation stage has been replaced with two stages of commissioning, documentation/handover after being executed. A comparison of these three categories of models indicates that common models only include the totality of stages, but design projects concentrate on sub-stages of design, and building projects emphasize the execution, commissioning, and documentation stages. The aggregation of the mentioned stages in these models introduces programming, design, construction, commissioning, and documentation/handover as the

main five stages for a process that can be initiated and terminated within two symbolic stages.

Discussion

Reflection on the dual analysis/synthesis spectrum confirms that genesis, conjecture, image, synthesis, expression, induction, production, etc. are all based on creative thinking because this kind of thinking creates new facilities, unconventional probabilities, and improves or promotes facilities (Treffinger & Isaksen, 2013, 88). There are other definitions that emphasize generating ideas beyond conventional solutions (Lansing-Stoeffler & Daley, 2023, 21). Another definition expresses a fluent presentation of ideas for solving a problem as creating thinking (Malik et al., 2023, 91). On the other hand, reflection on the dual analysis/synthesis spectrum indicates that evaluation, deduction, analysis, testing, and other activities are based on critical thinking because critical thinking includes the following activities: defining and formulating proper questions; collecting relevant data; evaluating information; testing solutions based on the appropriate measures; recognizing implications; controlling and supervising this process to eliminate self-centeredness, etc. (Paul & Elder, 2022, 2). Other definitions of critical thinking also indicate that analysis, organization, prioritization, and selection of ideas

Table 2. Classification of models introduced for stages of various projects. Source: Authors.

Models	Examples of models
Presented models for common projects’ life cycle	<ul style="list-style-type: none"> - PMI (initial phase, intermediate phases, final phase) - Stuckenbruck (initiation, growth, production, shut-down) - Westland (initiation, planning, execution, closure) - Wideman (conceive, develop, execute, finish)
Models for design projects	<ul style="list-style-type: none"> - Salvadori (programming, schematic, preliminary design, working document, construction phases) - Lang (understanding the situation, design, selection, implementation, Post-operational evaluation) <ul style="list-style-type: none"> - French (analysis of the problem, conceptual design, embodiment of schemes, detailing) - Pahl and Beitz (clarification, conceptual design, embodiment design, detail design) - Maver (inception, design including feasibility/outline proposals/scheme design/detail design, implementation including production information/bills of quantities/tender action/project planning/operation on-site/completion, feedback) - RIBA (inception, feasibility, outline proposals, scheme design, detail design, production information, bills of quantities, tender action, project planning, operation on site, completion, feedback) - AIA (pre-design, including programming, feasibility studies, master planning, and developing prototypes, schematic design, developing preliminary design ideas and concepts, design development, providing architectural drawings and identifying architectural organization, construction documents, including shop drawings, specification writings, and construction details, construction administration, supervising construction and making revisions, post-design, including post-occupancy evaluation, user’s manuals, and evaluation research.
Models for building projects’ life cycles	<ul style="list-style-type: none"> - Stuckenbruck (feasibility, design, execution, implementation) - Morris (feasibility, basic design, execution, handover) - Webster: (concept, development, implementation, termination). - Wideman (concept and economics, functional design, working drawings and specifications, tender and award, construction, commission) - Archibald (concept, definition, design, manufacture, installation) - Stretton (concept, development, execution, finishing) - Badiru & Osisanya (conceptual design, preliminary design, detailed design, construction, testing/commissioning/handover)

(Treffinger & Isaksen, 2013, 88), search, scrutinizing, discussing, and judging ideas (Kahlke & Eva, 2018, 158) are in line with the activities introduced in the analysis spectrum. Therefore, design activities originate from both creative and critical thinking. These two thinking types are both required in the design process because this process simultaneously depends on two analysis and synthesis activities. Progress in these activities or ways of thinking occurs in the presence of both types (Sharif, 2012, 59–62). In this case, dual analysis/synthesis or creative-critical spectra complement each other, so the process cannot be developed in the absence of one element. The considered interaction is matched with the abilities of two hemispheres of the brain⁹, and these two hemispheres participate in the process depending on the design process needed for dealing with analysis and synthesis activities. Also, the previous topics indicate the relationship between the type of activity and the design stage.

Conclusion

As mentioned at the beginning of the paper, this study tends to find a model for the relationship between design activities and stages to indicate the totality of designers’ actions in the process of converting an existing situation into a future situation. It has been attempted to determine the main stages and activities of the design process. Regarding the secondary questions, the main activities of the design process occur within two analyses and synthesis spectra based on the research findings (Fig. 2). Design stages include two subjective and objective categories:

- Synthetic activities, such as genesis, conjecture, image,

synthesis, expression, induction, production, etc. are based on creative thinking.

- Analytic activities, such as evaluation, deduction, analysis, testing, etc. are based on critical thinking.

- Conscious and unconscious involvement are two subjective phases of a process that are outlined with two symbolic initiation and termination or finish stages.

- Planning, design, construction, commissioning, and documentation/handover are five objective stages of a process. These stages can be divided into sub-stages and specified with two symbolic initiation and finish stages.

On the other hand, it can be stated in response to the totality of designers’ actions based on the findings that these actions are not just reduced to the activities and stages mentioned above because this totality results from aggregating the analytic-synthetic activities within subjective-objective stages. Consideration of two subjective and objective natures for existing, intermediate, and future situations would provide multiple chains of design process confirming that design is not necessarily an abstract/real chain, but can comprise real-real, abstract/abstract, real/abstract, and other chains. Design passes through these multiple chains based on the activities that originate from two creative and critical thinking spectra and complement each other. Interaction and constraints indicate the design trajectory is not a constant and certain path, so some experts have considered an exploratory aspect for it¹⁰. Hence, this process requires active exploration of the designer, and its definition depends on this trajectory. Therefore, designers’ action in converting an unfavorable situation to a preferred situation is beyond

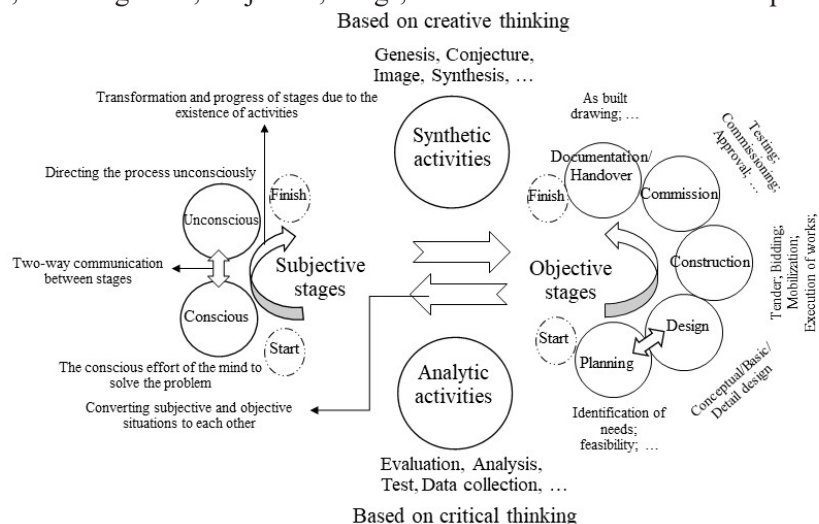


Fig. 2. A conceptual model for the totality of designers’ actions to reach a consensus on previous theories and models. Source: Authors.

the parts, and cannot be reduced to activities or stages of situation conversion but many interactions occur in this action in addition to activities and stages.

Endnotes

1. For example, Cross defines design as a human capability that does not exist in other creatures, and even machines (Cross, 1999, 5). Design refers to an operation that creates a complete collection of documents- from a need or idea to a product- to realize that product and satisfy the perceived needs of the operator or other stakeholders (Blessing & Chakrabarti, 2009, 1). Initial meaning of design implies the action of creating a physical meaningful sign on an object (Costanza-Chock, 2020, 12).
2. For instance, Heath introduces architecture as a type of activity shaped by individuals and believes that architecture is the action of a master constructor (Heath, 1984, 1).
3. Like what architecture theorists explain about the design. For instance, Friedman believes that action "Design" describes a process of thinking and programming. This meaning is the dominant aspect of design before its other meanings (Friedman, 2003, 507). Lawson believes that design emphasizes both the final product and its realization process. it means that design simultaneously refers to two nominal and practical aspects (Lawson, 2008, 3).
4. These dimensions are presented based on the meanings proposed for the term "process" in Cambridge, Oxford, and Meriam Webster Dictionaries.
5. Schon believes that design is nothing, but a continuous dialogue between the designer and context (Schon, 1983, 76-79). This continuity allows expanding the chain.
6. The priority of convergent action in the fourth model has given a solution-oriented nature, which is different from the problem-oriented approach in other models.
7. As explained by Lawson, objective stages indicate the work schedule of designers. The work schedule reveals the products of the process instead of talking about the design activities. The most important functions of these schedules include measuring design fees, determining how to pay costs, outlining the services of designers, and determining the outputs of each design situation (Lawson, 2008, 40-42).
8. Life cycle indicates the periods through which, the project reaches its maturity. Accordingly, each stage of the life cycle indicates a change in the nature, activities, complexities, and resources allocated to each project (Smith, 2002, 4; Badiru & Osisanya, 2013, 53).
9. Two hemispheres of the brain have different specifications. The right hemisphere of the brain mainly deals with images, feelings, etc., but another hemisphere pays attention to logic, language, and computations (Cross, 2019, 54).
10. For instance, Cross (2019, 76) believes that design is an exploratory process.

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