CHAPTER II
LITERATURE REVIEW:
REFLECTIONS ON STRUCTURE OF DESIGN INQUIRY AND RESEARCH

This research is involved to the nature of architectural-design inquiry; consequently, it focuses on reviewing literature on the design process and research. The review includes theoretical perspectives of design and creativity, the process of design, design in relation to research, and possible linkage between design and research.

The inherent nature of architectural-design inquiry seeks to find out the integrated solution of the built environment responding to determinate design tasks. In this context, design inquiry relies upon the generative process of problem-solving that are different from a scientific counterpart as a result of solution-oriented creativity toward the end of the design product. An investigation of the design solution in architecture thus depends on the process of design—fundamental acts of problem structuring and design developments toward the design product. To develop design thinking into systematic modes, several models of the design process have been searched for enriching design ideas and specific qualities of architecture. A positivist model has acknowledged more scientific methodology than the others are congruent to how designers think. For design research, the process of design needs to retain a systemic series of constructive, design methodology to allow design investigations to fit into architectural design.

1. Problem-Solving and Architectural Creativity

Although this study does not directly examine design solutions and creativity, it is important to comprehend that design inquiry is considered as the investigative acts of problem-solving through which architectural designers apply design research into the process of design. In the context of design and creativity in any fields including architecture, there are no emerging design solutions without searched problems, tasks, or programs.

Particularly, architectural design needs a program allowing designers for figuring out what an environment might be and how it works in the possible future.[1] In this way, to find out what an appropriate design relies on the investigative relationship between a diversity of design problems and solutions, namely *design problem-solving*. However, this relationship of the design problem-solving process lies not in simply logical thinking and linear sequences of actions to ensure a successful design,[2] but entails creativity and experience so as to modify the procedure that

culminates into the final design product. Design creativity as a discovery of new, integrative solutions to complex problems, in turn, is not merely an event called creative leap; on the other hand, becomes a process of "co-evolution"[3] between finding and solving design problems.

2. The Distinction of Design Problem-Solving

Design problems and solutions prove connected with the design activity and process in that given design tasks are challenging designers' ability and effort to perform ways to resolve problems with an accepted solution. From many observations of design studies, designers embrace a distinctive ability of solving problems different from scientific activities.

As Lawson's design behavior studies demonstrate dissimilarity of problem-solving strategies between architectural students and science students, the scientists employed problem-focused strategy by investigating the rules while architects implemented solution-focused strategy to attain the result. In this respect, a conclusion can be drawn that scientists solve problems by *analysis*; conversely, architects adopt *synthesis* in order to figure out the acceptable outcome to the problems. Designers progressively comprehend the intrinsic nature of the problems as they work out on solutions whereas scientists rather pay attentions on discovering elemental codes of the problems as much as possible before making solutions.[4]

With the nature of design tasks dealing with solution-making, architects collectively learn ill-defined design problems as developing solutions. Therefore, it is impossible to distinguish identification of design problems from solution generation in the step-by-step activities of design; both design problems and solutions are interdependent during the process. In other words, architectural designers use solution-constructive process as mutually researching and redefining focused problems as evolving environmental design.

In the design process, the relationship between design problems and solutions are significantly complex in that there are no truly objective formulations to define design problems and create design solutions. This relationship does not strictly happen in a linear sequence of operations: neither design problems come up first nor design solutions are to pursue objectives of the problems. But, as to Lawson, clarity of design problems begins to emerge when some ideas to create solutions are demonstrated. During the processes, design problems' objectives and primary focuses could be evolved, determined, and revolved as design alternatives begin to suggest possible solutions.[5] This implication is corresponding to the Dorst and

Cross's concept of "co-evolution of problem-solution," in which finding and solving problems are developed and shaped altogether in parallel lines of design thinking. Both problem spaces and solution spaces transact information between the two domains to improve the clarification of a problem and ideas for a solution through a given period of time.[6] Specifically speaking, designers make an attempt to match and evolve problem-solution pairing by means of 1) clustering and strategically checking information to realize defaults of the previous project confronting the current challenge; 2) framing an initial concept and constructing a general image; and 3) reframing simplification of the core problem.[7] This investigative process of matching "a problem-solution pairing" can be considered as an insightfully structuring organization within the process of design inquiry into which research can take place as framing and reframing drives.

Design research can be fit into the structure of design investigation as strategic methods; however, conducting design research in the process of "co-evolution of problem-solution"[8] is not recognizably concentrated on analysis. What possible design research could lend itself to improve inquiries of finding and solving problems arises in the core of the study. It is thus crucial to review the nature of design problems and design creativity in relation to design inquiry.

3. Design Problems

Theoretical development of design inquiry seeks to interpret creative problem-solving to understand design bounded rationality that settles the possible, accepted solution, which Simon indicates as "satisficing," to a critical problem in limited time.[9] If architectural design is not merely simple problem-solving, it must address the nature and characteristics of design problems.

The term *design problem* connotes an explorative challenge that is worthwhile to be resolved and activates a primary interest. However, a design problem is not instantly apparent from design assignment or program by its nature; it needs the actions to (re)search for problems within the process.[10] As Rowe notes in *Design Thinking*, architectural problems can be categorized into three types as follows:

1. *Well-defined problems* indicate the missions inclusive of project goals are obviously stated: their design solution must offer suitable modes of the space-planning problem—functional requirements and spatial relationships—in which assembles a site and contexts. The purpose of the well-defined problems is to seek a satisfactory compositional arrangement and a building

integration with the environment. These types of problems must be further elucidated and redefined in way that is concrete enough for a design proposal.[11]

2. *Ill-defined problems*, in contrast, refer to which both outcomes and modes of the design solutions lie not in illumination at the beginning of the process. Ill-defined types of problems become the most significant obligations that architectural designers concentrate on dealing with framing and reframing during the creative problem-solving process.[12]
3. *Wicked problems*, as sub-classified in ill-defined problems as Rowe observes, are considerably difficult to be established because there is an indeterminate formulation of these problems. (Re)framing wicked problems depends on the continual process of evolving tension between proposed solutions and redefined problems.[13] Moreover, different strategies of approaches toward the wicked problems lead to a diversity of design solutions. Therefore, the research for wicked problems involves preoccupied interpretation—subjective ideas for solving them—with originating initial alternatives that enable for design reconsideration and the possibility of problem reformulation in an organized, pragmatic level.[14]

In this way, design problems are likely to be evolved or revolved during the continuing process as much as alternatives of the solution are developed, regarded as *co-progression of problem-solving*. However, the relationship between finding and resolving problems is not just straightforward logical in terms of operations (means) and the outcomes (ends) because architectural design manifests itself as the multi-dimensional synthesis of form, thereby inevitably requiring creativity at the culmination. Thus, how architectural creativity is engaged with the process of design turns into a relevant review.

4. Creativity as a Process

Architectural design is more or less pertinent to creativity because environmental designers aim to discharge their missions to generate environmental novelty that never exists in a specific location. In this sense, the term imagination emerges out of design thinking and ability as a visualizing foresight of what an environment could be in the future.

According to Dorst and Cross's creativity research in the process, the term *creativity* demonstrates itself as "the evolution of a unique solution" to complex

problems and focuses on a comprehensive quality of the design product rather than exclusive discussion of the originality.[15] As Lawson quotes Hertzberger to introduce creativity in relation to the process of problem-solving, that is, not merely making something original without assessing it to comply with its requirements.

> "For me creativity is, you know, finding solutions for all these things that are contrary, and the wrong type of creativity is that you just forget about the fact that sometimes it rains, you forget that sometimes there are many people, and you just make beautiful stairs from the one idea you have in your head. This is not creativity, it is fake creativity"[16]

In an era of modern design research, creativity is the synthetic process rather than talent; it operates with skills, abilities, and practices of imagery visualization of the idea and novel reality: concrete matters, objects, and environments.[17] *Creativity as process* raises design ability and research against an orthodox belief that creativity has been the "eureka" moment,[18] namely "creative leap" by Cross, as the new perspective and idea instantaneously appears to deal with the situation.[19]

Creativity can be considered as the imagination process of thinking and making, generative drives from conception toward reality in a perspective of inclusivity.[20] Creative accomplishment seems to progress into three insightful steps: initial awareness and inquiry of the problem, blueprint visualization of the solution as a key concept, and developing phases of elaboration and verification.[21] Lawson furthermore expands that the process of creative problem-solving comprises of a series of five sequences: first insight, preparation, incubation, illumination, and verification.[22] The stage of "first insight" begins to realize a scope of problems in design tasks and broadly formulate them to encourage the search for an innovative idea. This implies that the creative impetus arises from imposed problems. The "preparation" period leads designers to consciously embark on seeking out a holistic solution to problems. The "preparation" and "first insight" periods always move back and forth: designers reformulate or redefine problems as investigating the possibility of solutions. This "co-evolution of problem-solution"[23] is a deliberately intensive course of the design process before incubation. The "incubation" refers to the calming stage of developing on which designers have generated either an alternative solution or parallel lines of thought to carry on through design inquiry. The "illumination" stage is a vital moment as an integrative import that the core concept emerges after which designers restructure and reexamine all absorbed data, problems, and anticipated solutions during the incubation period. Finally, the period

of "verification" is involved with developing design and testing both problems and the solution in order to criticize how robust the design development and the central concept prevail. All of these recognized creative sequences go on continuously throughout the design process.[24]

In addition, architectural creativity exhibits a matter of the integrated form between tangible and intangible of design elements. As to Jean Labatut, tangible elements respond to rationality of design considerations such as well-defined problems. On the other hand, the intangibles will build the whole, distinctive design, which reveals meaningful symbols of humanity to be served, as a unique, excelled environmental form compared to its contemporaries.[25] As a result, architectural creativity presents itself as an exploration that assimilates the competency to think critically, to process information strategically, and to construct imagery of the future during the process into the making an environmental reality.

5. Architectural Design Process

Once a design assignment has been posted, design thinking is intuitively getting operated: the quests of what could be, what evidences need to know, what key problems come up. Since nineteen-sixties, design theorists have made an attempt to decode and delineate the mysterious way designers work out to achieve their missions. This is so called *design process* to establish design methodology as a discipline of creativity.

The design process involved with formulation of controlling data, design strategies, and design decision intends to help designers make clear of problem structuring and modes of solution-making.[26] Design methodologists, since early sixties, have initiated three major models of the design process: an analysis-synthesis-evaluation model, a conjecture-analysis model, and a generator-conjecture-analysis model.

5.1 The Analysis/ Synthesis/ Evaluation Model

Design theorists formulate processes of designing based on inductive reasoning and scientific methods of the positivist stance as traditional design process has no basis on scientific facts and much relies on the designer's experience and preoccupied interests applying information to creating a form responsive to design tasks. Design thus seems deprived of validity of ideas regarding a variety of complex issues of involved environments and people's needs. It requires empirical investigation for which reliability could be established.

The *analysis/ synthesis/ evaluation* model focuses on processing as much information as possible. Analysis is viewed to be the initial step to gather valid facts for the problem and sub-problems by means of scientific, quantifiable methods to realize design situations and set up design criteria. Analysis would lead to synthesis of finding out sub-solutions much dependent on computer modeling.[27] Then, evaluation takes place to test, select, and integrate suitable sub-solutions into the overall solution.[28] This model is identified as system theory in design practice.

If the process of design lies much more in solution-based thinking as previously mentioned in design problem-solving, this model of the design process seems opposed to the nature of architectural-design thinking that incorporates analytical facts with environmental symbol-making. Designers need to spend a plenty of time to research and verify empirical facts, but the beginning of research is prerequisite to the generated, main inquiry—a focus of deductive idea to control conducted research. In this view, design research during the creative process and acts must call for which to be searched for, an initial scope of problems in design situations in the real environments rather than rational procedures in controlled settings to build environmental patterns.

5.2 The Conjecture/ Analysis Model

As an analysis-synthesis-evaluation model was fallen down against difficulties of changing designers' innate thinking processes, design theorists better understood designers' intuition in the creative process and developed a new model of the design process, a *conjecture-analysis* model. This model aims to cooperate with a combination between subjective intellectual as solution drives and objective accounts for programming and solution assessment.

Hillier, Musgrove, and O'Sullivan propose that an appropriate model of the process encompasses generating a solution conjecture that is followed by analysis. Conjecture indicates building up intellectual capacity of problem and solution relationships; at the same time as, analysis suggests operating and applying principles discovered in the conjectured solutions to agree with design assignment. The *conjecture-analysis* model draws subjective experiences in parallel with a wide range of spatial, formal, and ordering principles. Problem structuring, on an emphasis at the beginning, is more likely to be successful and natural to the process for design, by means of highlighting hidden, relevant knowledge such as solution-based modes, figural precedent studies, and possible methods of construction.[29]

The *conjecture-analysis* model accepts utilizing designers' intuitive experience as solution-impetus for generating future places. Architectural programming is initiated as initial responsibility of the designers through research, gathering, and evaluation. After the program and its criteria are formed, design conjectures are generated as possible solutions with regard to what might succeed in specific design situations. The *conjecture-analysis* model employs a process of "variety reduction" to minimize possible solutions by assessing an alternative solution against project constraints, social and cultural factors, and designers' cognitive structuring. This model allows design research to incorporate with both program-building and design assessment within the whole design process.

5.3 The Generator/ Conjecture/ Analysis Model

Later, Jane Darke observes that architects not only employ conjectures or a prospective-solution focus in articulating their strategies and methods to design situations, but also convey a "hidden agenda," namely termed *primary generator*. Darke's research introduces a *generator-conjecture-analysis* model, and concurrently disproved an *analysis-synthesis-evaluation* model.[30]

The *generator-conjecture-analysis* model reveals a set of values—a vital characteristic of the problem—reflected in original conjectures of what an anticipated place might be, and then inquires design conjectures and development to uncover other aspects of the problem. Especially, designers emphasize high values of inferences on the subject of the specific contexts in the site because environmental designers investigate their design upon a perspective of the relationship to the site and of visualizing initial conjectures.[31] Lawson moreover notes that the primary generator might be derived from three sources: a program, external constraints or site contexts, and individual interests. The primary generator in each project usually includes worldviews: cultural, societal, philosophical, and experiential drives of design, which influence the direction of the primary generator. On the one hand, architectural students tend to bring about the primary generator out of the problems such as essential functions, user constraints, and external conditions of the site. On the other hand, experienced architects mainly take on their own sets of steering attitudes. When these focused principles are posited against local external constraints, design issues are likely to emerge collectively and lead to speculate the principal solution toward the central concept or *parti* as a major idea dominating design schemes and development.[32]

While the *generator-conjecture-analysis* model confines significant considerations that need to be addressed, designers encounter a number of project conditions that are mostly manipulated by a worldview and the creation of concrete images as solution conjectures. In this sense, both the *conjecture-analysis* and the *generator-conjecture-analysis* models depend upon a process of solution-focus that enables for organizing the main core of design strategies, methods, and research. These collaborative models of the design process can contribute design research to be inclusive part of design understanding, enhancement, and challenges in an integrative worldview of the design nature. It is thus imperative that how design research be involved with the process.

6 Design Research as Investigative Modes in the Process

Designing is creative performance of non-propositional reasoning of the synthetic formative process, but research embodies a propositional inquiry of *what pertinent topics are to be investigated and examined* based upon reviewing literature, defining hypotheses, gathering and analyzing data. In this light, design problems and conjectures reflecting the primary generator need to be primarily constructed before design research will be carried on through the process. Design research, in this view, can perform itself as *investigative methods* that help a designer systematize a design framework[33] to (re)define problems, and also (re)evaluate design alternatives and schemes, including decision-making shaping creative development.

Groat and Wang indicate that generative design and analytical research hold different philosophical modes of inquiry; however, these spheres of investigation can coexist. The former is a subjectively constructive-based process to create figural products, the latter lies in a rule-based framework to deeply understand contingent factors established.[34] Groat and Wang furthermore propose the possibilities of creative design cooperating with research: programming and post-occupancy evaluation, design as action research, design as learned skill, and design collaboration. These design frameworks allow designers to conduct "episodic research" into design process.[35]

As design activity flows, architectural programming and post-occupancy evaluation entail analytical research collaborating with a design domain at the beginning and the end of the process, respectively.[36] Programming is "problem-seeking" by means of scientific methods to identify design questions, design hypotheses, and data organization and interpretation as understanding of a wide range of the project data and criteria for which a design concept and product need to

be responsive.[37] At the other end, post-occupancy evaluations offer analytical insights of the existing environments that enlighten criteria for the next design.

On another view, design research can integrate with the design process if design activity is performed as "action research" to investigate concrete design situations and reflective factors of the project. Action research turns out design to be a systematic inquiry through pragmatic operations so that theoretical and empirical knowledge can enlighten each other and lead to a reflective design product suitable to a particular context. According to Susman, action research runs into an iterative process as the following stages:

1. Diagnosing to identify or define a key problem
2. Action planning to generate alternatives of action for problem-solving
3. Action taking to examine and select a course of action
4. Evaluating to explore the consequences of an action, and
5. Specifying to identify findings: new information, concept, and constructive form.[38]

These steps describe what designers move through the process of action research. Design response and decision-making will reflect upon another attempt of the next design cyclical process. This iterative design process can continue on until an appropriate design product suggests the insightful solution, that is, dependent on given project conditions.

Action research could be integrated with the design process if design activity is considered as "learned skills," rather than mysterious "black box."[39] As Groat and Wang cite Lawson, the design process arises from accumulative approaches on connected design constraints: generators, functions, and domain categories, all of which must be searched for developing a comprehensive network of design criteria and features. This framework of collaboration prospects for design as the process of uniting collective demands into a synthetic solution.[40] In this way, a complex framework of the *conjecture-analysis* model between generative thoughts of symbolic concepts and schemas and research conducted for analysis and refinement of design rationales is possible to be co-evolved in the collaborative process of design.

In addition, research operations can occur in collaborative design that accentuates the process focusing on stakeholders' participations, interdisciplinary design, and socio-cultural settings. Its ultimate aim of the collaborative framework is constructive for the sake of environments obliged to communal contexts. By promoting participatory design namely an "integrative process," Boecker and colleagues recommend that the design process be repetitively run through an

interchangeable pattern of *research/analysis* and *team workshops*.[41] Research/ analysis phases refer that design team members intend to develop issues, identify design assumptions and design conjectures, and analyze alternatives to originate common understanding of the project. Team workshop afterwards brings design members and participants to join their cross-disciplinary ideas related to the whole system, thereby contributing to a more comprehensive, incorporative outcome. These alternate processes will keeps on progressively until a design solution reaches to the aims.[42] In a view of this methodology, research/analysis stages consider design to be action research, which holds binary activities of generative inquiry of concepts and formal design as well as analytical validation of design, altogether. Team workshop, in the meantime, results in exploratory opportunities in collaborative forms such as an interdisciplinary design charrette that allows for raising new searches.

These previously mentioned design approaches make an attempt to draw analytical research into the larger domain of design. With these frameworks, research is recognized as *investigative modes* available for delivering design inquiry. According to Zeisel, Augustin and Coleman, design research begins when design questions and issues are imposed and addressed in design situations. It affords critical methods for designers to structure wicked problems and to form a framework for the design process that concentrates on main issues and design objectives.[43] Zeisel, Augustin and Coleman suggest research approaches for design; qualitative and quantitative, both of which introduce designers to realms of the insightfully experimental inquiry in terms of environment-behavior design. Both qualitative and quantitative methods offer a diversity of research tactics: literature archive, case studies, observations, interviews, behavioral mapping, and questionnaires. The appropriate ways to use all these research tools rely on design situations.[44]

Initial conjectures can advance the design strategies, problems and rationales: hypotheses, frameworks, problems, and research questions so as to begin to conduct environmental-design inquiry. Design research, in turn, articulates investigative accounts on refining subjective, design conjectures. However, these frameworks only present gateways of research collaboration in design activity rather than clarify how designers pragmatically systematize the complex design inquiry between the process of design and research. This interwoven ramification between design and research causes the quest on understanding of design rationality.

7 Dialectic of Design Rationality

"Architecture is a synthetic phenomenon covering practically all fields of human activity."[45]

Alvar Aalto quoted in *Poetics of Architecture*

As mentioned previously in design problem-solving and in Alvar Aalto's statement, the ways designers act rely upon integrative performance so as to construct the new possibility of the future environment. Architectural design combines with pertinent propositional concepts and knowledge, other than to purely analyze problems to reach out the solution.

It is undoubtedly that architectural-design thinking might be inspired by subjective perspectives: collective experience, tacit knowledge, and individual intuitions, but architecture serves for the appropriateness of environmental understanding and public utilities that call for new integrative facts. According to Zeisel, environmental design includes two types of information; first for imaging design conjecture by heuristic understanding and second a body of knowledge for examining design alternatives.[46] Thus, environmental designers utilize dialectical modes of reasoning: abductive logic and inductive logic, both of which embody the acts of synthesis and analysis, respectively.

Abductive reasoning is innately implanted into designers' thinking different from other modes of logical forms of problem-solving.[47] Abductive reasoning proposes that what a form *may be* suitable for given problems and conditions: it is the way to build a design hypothesis as Roger Martin notes:

> "Abductive logic...[is] that it is not possible to prove any new thought, concept, or idea in advance: all new ideas can be validated only through the unfolding of future events. To advance knowledge, we must turn away from our standard definitions of proof—and from certainty of the past—and instead stare into a mystery to ask what could be. The answer...[will] come through making a "logical leap of the mind" or an "inference to the best explanation" to imagine a heuristic for understanding the mystery."[48]

The rising realization of abductive reasoning becomes centrally immersed in the design rationality of speculating forms, objects, or environments based on cumulative experience. The term abductive reasoning could be substituted by either "productive reasoning" because of the fact that designers commit themselves to creating the product or "appositional reasoning" by reason of design making a solution as an

appropriate response to the problem.[49] Abductive logic, in this view, indicates the act of generating design conjectures as initial imagination of any form.

The operation of design conjectures of images is akin to creative, deductive constructs, which primary assumptions are made to advance knowledge in any discipline as Downing and Zeisel propose based on Karl Popper.[50] Popper argued that deductive conjectures would need to be set up as a leading concept as a point of view for what was to be searched and observed in scientific progress. *Deductive conjecture-building* is significantly fundamental to the guiding concept with respect to the nature of intentional phenomena. The guiding concept through deductive constructs must be thus launched prior to an inductive process to be conducted in any inquiry.[51] In parallel with scientific progress, envisaging design conjectures of a solution in the early development of the design process is corresponding to working investigative hypotheses. Working hypotheses are developed during scientific progress: design conjectures are refined during the design process.[52] In design context, abductive reasoning functioning with design conjectures, like the guiding concepts mandatory to scientific inquiry, cooperates with deductive logic to construct initially visualized forms for identifying the framework of the design problem and piloting further design investigation.

If architecture is worthwhile to sustain human living situated in the given physical environment, design conjectures must be balanced by objectively concrete searches for contextual knowledge and collaboration through the process. Abductive thinking of design, in other words, is utilized to visualize possibilities of creative forms as well as to operate with novel knowledge through the inductive process to inquire design conditions and specifics. Inductive thinking functions as discovery for what is, in reality, *operative* in a particular circumstance;[53] it draws on evaluative skills to strategically make the environmental design more unprejudiced, meaningful, and tangible in the contexts. Because design thinking deals with pragmatic, interactive activity, environmental designers combine their thinking with acting within circumstantial models of the design phenomena in order to *project* the future environment. In this way, designers employ a range of design tools—sketching, modeling, perspective scenarios, prototyping, virtual simulating, and criticism—lending themselves to "a set of situating strategies" as Gedenrd mentions.[54] As Ganshirt supports, all of these design tools become the mediums to develop design ideas.[55] Designers make use of these design techniques that allow for propelling a design inquiry into the future state of events, thereby giving a design solution explanatory power toward constructive creativity handling contextual challenges.

This inductive line of thought is to progressively converge on the contingency design of the acceptable solution in specifically contextual conditions.

Within the larger domain of abductive thinking, deductive and inductive reasoning plays important roles in design activity and processes into different modes. Deductive thinking works for generating of figural conjectures and decision-making, depending on skills, experience, and collected knowledge. Inductive reasoning, in succession, continues on investigating complex, contextual collaboration through design rationality. Designers, as a result, can draw an acceptable prospect of the design solution from known facts and/or virtual situations. This integrative operation of design thinking delineates design discipline as skill-building and learning, and more importantly, can be a generative platform to interweave between the design process and research. But, how these two folds of design thinking affect integrative approaches between design inquiry and research is raised.

8 An Overview of Reviews toward Design Inquiry

From theoretical stances and research in design, the cooperative gateway between the design process and research can emerge if environmental designing is recognized as the *accumulative process* of skills and knowledge rather than solely dependent on subjective cognition. The understanding of design inquiry as an evolving course of actions enables designers to continue an investigation on a complex association between finding problems and generating an acceptable solution. This dialectic process of design inquiry can be evolved on the "co-evolution of problem-solution," that is, contributing to creativity. The process of design combines skills and experience with the systematic inquiry to resolve any critical challenges. In this view, design research can collaborate with the creative process if design conjectures are initially originated for operational problems that provide channels for design research to redefine issues and enhance design solutions.

9 Notes

1. Bryan Lawson, *How Designers Think: The Design Process Demystified*, 4th ed. (Hungary: Architectural Press, 2006), p. 125.
2. Ibid., 124.
3. Kees Dorst and Nigel Cross, "Creativity in the Design Process: Co-Evolution of Problem-Solution," *Design Studies*, Vol. 22, No. 5, 2001, pp. 425-37.
4. Nigel Cross, *Designerly Ways of Knowing* (Germany: Birkhauser Verlag AG), 2007, pp. 22-23.

5. Bryan Lawson, p. 120.
6. See Kees Dorst and Nigel Cross.
7. Ibid.
8. Nigel Cross, p. 114.
9. Peter Rowe, *Design Thinking*, 3rd ed. (US: MIT Press), 1991, p. 39.
10. Ibid. Also, see Bryan Lawson, p. 120; and Kees Dorst and Nigel Cross.
11. Peter Rowe, p. 40.
12. Ibid., p. 40-41.
13. Ibid., p. 41. Also, see Kees Dorst and Nigel Cross.
14. See Bryan Lawson, p. 120; and Peter Rowe, p. 41.
15. Kees Dorst and Nigel Cross.
16. As cited in Bryan Lawson, p. 153.
17. Anthony Antoniades, *Poetics of Architecture: Theory of Design* (US: John Wiley & Sons, 1992), pp. 9-26. Also, see Kees Dorst and Nigel Cross; and Bryan Lawson, pp. 147-150.
18. See John Zeisel, *Inquiry by Design: Environmental/ Behavior/ Neuroscience in Architecture, Interior, Landscape, and Planning* (US: W.W. Norton & Company, 2006), p. 23.
19. Nigel Cross, p. 65.
20. Anthony Antoniades, p. 13.
21. Bryan Lawson, p. 147.
22. Ibid., pp. 148-150.
23. Nigel Cross, p. 114.
24. Bryan Lawson, pp. 148-50.
25. Anthony Antoniades, pp. 19-20.
26. Bryan Lawson, *What Designers know* (China: Elsevier), 2004, pp. 14-15.
27. Frances Downing, *Image Banks: The Purpose, Function, and Meaning of Environmental Imagery for Architectural Designers*, Dissertation (Ann Arbor: UMI), 1989, pp. 28-30.
28. Nigel Cross, *Design Thinking* (UK: BERG, 2011), p. 27.
29. Ibid., pp. 31-32.
30. Jane Darke, "The Primary Generator and the Design Process" *Design Studies*, Vol. 1 Issue 1, 1979, pp. 30-44.
31. Ibid.
32. Bryan Lawson, *How Designers Think: The Design Process Demystified*, pp. 188-89.

33. Sally Augustin and Cindy Coleman, *The Designer's Guide to Doing Research: Applying Knowledge to Inform Design* (US: John Wiley & Sons), 2012, p. xxvii.
34. See Linda Groat and David Wang, *Architectural Research Methods* (US: John Willey & Sons, Inc.), 2002, pp. 104-18.
35. Ibid., p. 108.
36. See John Zeisel.
37. William Pena and Steven Parshall, *Problem Seeking: An Architectural Programming Primer*, 4thed. (US: John Willey & Sons, 2001).
38. As cited in Linda Groat and David Wang, pp. 112-13.
39. Linda Groat and David Wang, pp. 114-15.
40. Ibid. p. 114.
41. Jonh Boecker, et al., *The Integrative Design Guide to Green Building: Refining the Practice of Sustainability* (US: John Willey & Sons, 2009), pp. 103-105.
42. Ibid.
43. Sally Augustin and Cindy Coleman, p. 22.
44. See John Zeisel. Also, see Sally Augustin and Cindy Coleman.
45. As quoted in Anthony Antoniades, p. 15.
46. John Zeisel, pp. 25-26.
47. Nigel Cross, *Design Thinking*, p. 27.
48. As quoted in Sally Augustin and Cindy Coleman, p. 2.
49. See Nigel Cross, *Design Thinking*, p. 28.
50. See Frances Downing, p. 35. And, see John Zeisel, p. 23.
51. Frances Downing, p. 35.
52. John Zeisel, p. 23.
53. Nigel Cross, *Design Thinking*, p. 27.
54. As cited in Nigel Cross, *Design Thinking*, p. 28.
55. See Christian Ganshirt, *Tools for Ideas: An Introduction to Architectural Design* (Germany: Birkhauser Verlag AG), 2007.