

# PERSPECTIVES OF **DESIGN RESEARCH:** IN DESIGN

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Collective views for forming the foundation of design research

## ABSTRACT:

Based on a wide-ranging discussion of design research that sought to establish its nature, controversies and types, this paper uncovers some ongoing difficulties in understanding ways to structure and communicate about variations in design research. Two basic types of design research are defined in order to establish greater clarity for what follows: research that advances design project development — this is particular in its nature; and research that provides theory, principle, method or tool — this is academic and more general in its nature. The discussion stresses the second area of research. Participants brought in research cases to anchor the discussion; these are presented as snapshots and are referred to in the larger discussion. Also Ph.D. dissertation models are presented as yet another way to define research variation. The paper concludes with unresolved issues that impede access and use of research.

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“What is Design Research?” was the general question throughout the two-day meeting to discuss “Design Research.” The intention of the session was to explore the nature of design research from different viewpoints and derive models of design research that the design community can share as a foundation for further development of research practice and advanced education.

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Research in design has a short history – it would be safe to say it is no longer than fifty years. This history might be relatively long compared with some new research areas that emerged from established areas of science and engineering. The difference between those areas and design research comes from the degree of inheritance from existing models of research. New research areas usually inherit basic resources to establish their own system from related areas of research. Research in design, on the other hand, does not have much default asset inherited from other areas. There have even been skeptical views about the legitimacy and usefulness of developing design research in the sense other areas of research exist as a system of scientific inquiry or an intellectual foundation for practical pursuit. The skepticism relates to several reasons. One is the diversity of the areas and cross-domain nature of its concern, since design is a practice that deals with diverse types of artifacts. Another is the complexity of human cognition involved in various aspects of design. For example, to understand design practice itself requires one to know how designers understand and solve problems through their manipulation of information. Design as a discipline responsible for the interface between people and technologies needs to deal with various aspects of human behavior as the main entity, such aspects as cognitive, emotional, cultural, social and organizational factors. Since most knowledge in these domains remains underdeveloped in comparison to science and engineering, research in design suffers from a fundamental difficulty with regard to its origin. Yet, the mission of this symposium is specifically to nurture an optimistic and constructive community of design research through self-critical discussion and collaboration.

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Before we start our argument on the nature of research in design, it is necessary to distinguish two types of so-called “design research.” Without this distinction, as historically experienced, our discussion will be confused and obscure in our attempt to view a wide range of research cases. One use of the term “design research” is the practice of developing information for a particular design project. Here, we use the term “research” in the same way as market research or user research as an activity intended to develop understanding about the domain of concern that includes user needs, social issues, markets, competitive products and related technologies. The other indicates the practice of developing a generalized body or system of knowledge commonly applicable across different cases and commonly validated or agreed to by general academic standard. Types of knowledge that are expected to be developed in this class of activities include theories, methods, principles and tools that become resources for future cycles of developing knowledge or for applications in practical use. In this article, we focus on the latter case, academic design research even though some of the activities are common across both types of “design research.”

This article first reviews the presentations in the session that brought a wide range of research cases for discussion, then searches for dimensions of design research that define different research models. It also describes procedural models used for Ph.D. dissertation research at the Institute of Design, IIT, and finally raises some issues that need further examination and discussion among both design research and practice communities.

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## Design research cases: reflective views of research practice

The research cases presented in the session showed diverse approaches and domains of concern addressing different issues and dimensions of design research. It built a rich resource for the discussion. The brief descriptions below are not an accurate summary of the presentations. They are snapshots captured from the lists of focus points reflectively created by the presenters and participants for individual presentations.

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### Typographic rules:

Karel van der Waarde stated that graphic design knowledge was poorly recorded in a readily usable form of design rules and that experimental research data is not sufficiently archived for practical use. The discussion pointed out the difficulty of accessing research data and its possible irrelevance to the practice. The controversy exists between the specificity of research data and comprehensiveness of the quality expected in design that cannot be addressed by individual typographic parameters.

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### Understanding how design becomes a strategic medium back-stage and front-stage:

Birgit Jevnaker argued the necessity of multiple perspectives on design research not only looking into design practice but also business practice. She introduced the concept of thick and thin boundaries to position and understand design practice. In order to enhance knowledge transfer across disciplinary boundaries, the discussion pointed out the need for design to develop a means of communicating and accumulating knowledge beyond tangible design output.

## Design research cases

Metadata:

Jimmy Peng introduced four categories of activities that frame design knowledge management: 1) create, 2) record and capture, 3) modify and classify, and 4) share. His research uses education as a model case for knowledge management applications to research and practice and attempts to identify design specific metadata for constructing a design knowledge-base. Questions were raised about the relation between advanced system development and research and about evaluation of research output.

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Opportunities and barriers for building experimental research in communication design, behavioral intervention research in health:

Zoe Strickler explained that multi-disciplinary research environments such as Health Behavioral Intervention Research raise the standard of design research by introducing the rigor of measuring its effects to the outcome of the project. She also emphasized the value of Ph.D. programs in design to enhance credibility of design research and to extend funding opportunities. The question was how we evaluate the benefit of design research output. Her case project exemplified an experimental research model in design.

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Innovation landscapes:

Tore Kristensen presented an example of the critical roles design plays in the business environment. Bringing metaphor to media for communication and thinking within innovation processes are effective forms of design contribution to business. The discussion questioned what this implied for individual, team and organizational work regarding context.

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Designing with evolving systems:

John Broadbent emphasized the importance of collaborative reflection in design based on his insight into the epistemology of the science of chaos – holistic science. He pointed out that recent exponential changes of technology requires design to shift its approach from evolutionary consciousness to conscious evolution. Reductionism vs. holism then, became a focus of discussion questioning, whether they are exclusive alternatives or complementary partners.

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Textual-visual analysis:

Leong K. Chan discussed the importance of designer-client-user relationship and contextual factors in analyzing the effectiveness of a proposed design. The discussion also pointed out the importance of incorporating historical changes or time factors into the analytical view of design research. Another discussion focus was on the need for methods that can bridge between macroscopic factors in large-scale social problems and microscopic factors of individual user experience such as cognition and emotion.

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Developing information framework:

Youn-Kyung Lim presented the model of her dissertation research for developing design information framework (DIF) to bridge different activities, viewpoints and information representation formats (Lim & Sato, 2001). She explained that different output expectations require different research models. Theory and methodology oriented research tend to be abstract thus eliminating compelling stories that focus on user needs. For this reason, she proposed DIF with the capability to construct tools for generating scenarios and specifying prototype models for intuitive access to design problems and proposals (Lim & Sato, 2003).

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Defining the use of color in graphic design:

Sylvie Pouliot discussed needs for developing and breaking empirical cycles of color education in graphic design. The difficulty is to create a connection between practice and general color theories, because color semantics and color

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effects in relation to people are highly context dependent. The question is whether it is possible to develop principles and guidelines flexible enough to adapt to practical cases.

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Developing research into human-centered product architecture:

Adriano Galvao introduced his Ph.D. dissertation research that intends to develop the concept and methodology of human-centered product architecture. This research extends the existing methods of product architecture to incorporate the structure of user interactions and to respond to the change of use context (Swanson, Galvao & Sato, 2003). The discussion suggested that mutual influences between product architecture and user experience would be an important subject for investigation.

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Formal style determinants:

Kuohsiang Chen pointed out that not much research has been done in the area of user's psychological preferences. He explained that computer-supported methods effectively assist design to incorporate user's preference patterns such as psychological response to formal features. The discussion raised issues such as the positioning of computer-supported methods in different design activities and balancing between automated processes and designer's decisions.

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## Dimensions of design research methods

There are some very basic dimensions that characterize different research models; these can be used as landmarks for positioning, interpreting and constructing specific research projects. The dimensions include: general to domain-specific, inductive to deductive, qualitative to quantitative and variable to specific or case-specific. Another way of characterizing design research is to categorize it into theoretical, methodological and empirical/experimental. Different research questions set different goals, different courses of actions and different outputs. Understanding these differences is important for forming appropriate research programs that develop scientifically valid, consistent and complete research actions and outputs.

### General design research versus domain-specific design research

Research in general theory of design

The process of design starts with a given information describing situations, problems, goals, requirements, etc. and ends with sufficient specification to implement an artifact. Through this process, designers carry out knowledge operations such as translation, generation and validation. The nature of this generalized process model and basic categories of knowledge used in the process such as attributes and functions are common throughout all disciplines involved in the creation of artifacts. Research in general theory of design, as defined here, is scientific acts to reveal the general structure of design as cognitive and social processes of people, groups and organizations. Clear distinction must be made between what theoretical research means here and the same term sometimes used to indicate historical, critical or literal studies that attempt to discuss the meanings of design from external views (Sato, 2000).

In order to build a sound theoretical system, two threads of research are necessary. One is to describe the nature of design based on observation and case studies of design activities in real practice and in experimental situations, which are equivalent to experiment and field observation in both natural and social sciences. The other is an axiomatic approach that first develops an epistemological description of basic concepts and their relations in design, and then constructs a formal theoretical system by deductive processes starting from axioms (Yoshikawa, 1987, Suh, 1990). Within general design research, therefore, inductive and deductive approaches, and theoretical, methodological and empirical researches are embedded along with other dimensions. General theories of design provide a common foundation for different design methodologies as empirically developed, to explain their mechanisms with common terms and further enable complementary relations among them to build rich and coherent resources of design methods and tools for practice.

Design methodology, developed based on general theory, is considered “general design methodology” that is still not directly applicable to real practice. It needs to further develop into domain-specific methodology by adding domain-specific knowledge to effectively support design practice in specific areas.

#### Domain-specific design research

Design of a particular artifact requires a body of knowledge specific to its nature such as intended use, user characteristics, operation methods, material, mechanical structure, electric circuits, software and manufacturing methods. As mechanical engineering directs its concern to the mechanical aspect of artifacts, and electrical engineering concerns the electrical aspect, design, as we particularly use the term human-centered design, concerns the human aspect. Engineering, a well-established disciplinary system responsible for creating artifacts, builds its practice of designing artifacts on the basis of the system of knowledge and methods originated in natural science. The role of design is to offer the structure and quality of interactions

between people and technological systems. This indicates that the intellectual foundation of the design discipline is in the interdisciplinary areas of human science, social science and technology. Therefore domain specific design research develops its framework particularly with human-centered viewpoints in this interdisciplinary area. Research within any specific domain interest such as interaction design, universal design, design management and sustainable design belongs to this category (Sato, 2000). Most of the design research cases presented belong to this category since they all address “design,” except for some general aspects of work by Peng, Broadbent and Lim.

#### Experimental/empirical research

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As a basis for understanding design practice or the subject domain of design research, an experimental approach takes the critical role of scientific inquiry in design research. Diverse research methods have been developed in different subdivisions within this approach. Design research inherits some of these well-established methods from other disciplines.

The empirical/experimental model of design research seeks to create knowledge that not only serves the design profession but serves others as well. This model creates free, i.e., unbound knowledge, that, for example, adds to our understanding of human processing of information from a design perspective. This can be considered basic research. The model trades heavily on various forms of scientific research. The goal is to answer a very specific question through developing substantial evidence (Poggenpohl & Sato, 2003).

One dimension in this class of research relates to conditions of data inquiry whether controlled or not. Controlled experiments are basic to scientific inquiry as traditionally used in areas such as natural science, engineering and psychology. There are different roles for experiments; one is to identify relationships between variables of concern, another is to validate theoretical hypotheses, proposed methods and designed objects. Some of the research cases include this class of research as a part of their methods or

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as a source of relevant data. Design research that concerns user physical, perceptual and cognitive performance in relation to design parameters, such as typographic features, colors and form, often employ this method. There is some criticism to this approach as analytical and reductionistic that obscures the overall quality of design because it must isolate a very few variables, filtering out the rest as argued by Broadbent. Yet, there is strong need for this kind of research to produce very specific data and guidelines for various aspects of design such as human factors, safety engineering and usability. Many design areas also can benefit from having such research to generate principles and guidelines for design and evaluation, for example in typography or color application as indicated in presentations by van der Waarde, Chan and Pouliot.

The other end of data inquiry is uncontrolled conditions. Observation and instrumentation are origins of scientific inquiry and critical to some areas such as earth science and biology. Some research in social science also attempts to achieve uncontrolled conditions without having interference to the subject of investigation. Statistical analysis is a common method to interpret the acquired data and validate the initial hypothesis as used in controlled experiments. Ethnographic methods have become common in user studies in the early phase of design and also in design research. Jevnaker mentioned the effectiveness of the grounded theory approach in some areas of design research where we do not have established theoretical frames.

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Design research often uses combinations of different types of data acquisition, analyses and inquiry methods to supplement the limitations of each method.

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The research case by Strickler presented an example for applying empirical methods to assess the effect of real design output. This type of research has not been widely conducted because it often requires a relatively long-term commitment and involvement of multiple stakeholders through the project cycle from pre-design studies to post-design studies. It also provides opportunities to examine not only the direct effects of design but also relations between different stakeholders in design development such as designers, clients and users. For example, methodology development for participatory design needs extensive investigation in the social and behavioral mechanisms of design as a social interaction process.

There are many methods between the poles of controlled and uncontrolled experimental research. Design research often uses combinations of different types of data acquisition, analyses and inquiry methods to supplement the limitations of each method.

### Theoretical Model

Theory in general is a coherent system of propositions to explain about a subject of concern in formal and abstract terms. It has to be logically developed from proven facts or other theories by deductive mechanisms. In some areas of research, theories are more loosely defined. Where a formal representation system exists, deductive processes are used to construct theories. In design, as in other physical or social sciences, theories are to explain phenomena in real world. In order to set hypothetical propositions, we make observations or experiments to support the inductive process of forming hypothetical propositions. Inductive processes are often used for identifying a pattern that leads to a hypothetical theory, or for validating how well theoretical propositions represent the subject. General Design Theory is a good example of output from theoretical models of design research. It is the first axiomatic approach to design research. As previously discussed, there is a category of theoretical research that addresses the domain-specific interest.

### Methodological model

The goal of this class of research is to produce useful methods for practice or generalized methods. The scale of methods ranges from a method that supports a very specific activity in the design process to a method that supports the entire design process. Results of research are usually implemented as a tool to demonstrate its applicability and effectiveness for the intended roles in design. Some methods are focused on “design” practice and others are aimed at design-related activities common across different disciplines such as engineering and management. Concerning the pattern of knowledge flow, this type of research is similar to the development of new fabrication technology based on scientific principles that enable new ways to design products. It requires some theoretical or scientific foundation to construct effective and replicable methods coherent to the assumed design process model.

The problem most frequently pointed out for this research model is the validation of proposed methods. The effectiveness cannot be easily measured since it requires real use of the method in practice and the evaluation involves many variables. This problem is common to all methodological research across disciplines including engineering design. There are several mechanisms that can be used as pragmatic alternatives to standard scientific validation procedures such as the cycle of hypothesis formation and logical or experimental proof. One is to set clear achievement goals and criteria prior to the development and evaluate the result against them. If the proposed method or concept is verified for enabling the specified function previously unavailable in the design process, the research result is validated. In order to enhance this validation, it is critical to develop a structured argument with a rationale or commonly accepted chain of logic to explain how the original questions and final proposal are connected.

## Case-based model

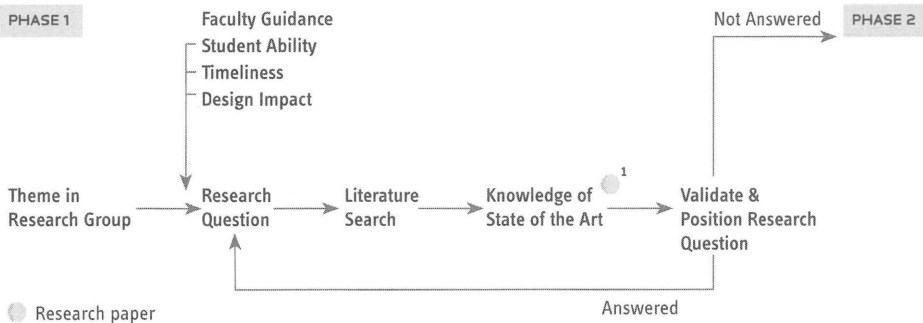
This model uses past real cases as a source of research data or creates a case for simultaneous data inquiry with or without research intention embedded in it. This provides a basis for inductive generation of hypotheses or validation of proposed hypotheses while the case project achieves its own objectives. Case studies in business and design fall into this category. In a specific area, sometimes procedure and data format are standardized for comparison of similar cases and for archiving data for the future.

## Procedural structure of Ph.D. dissertation research

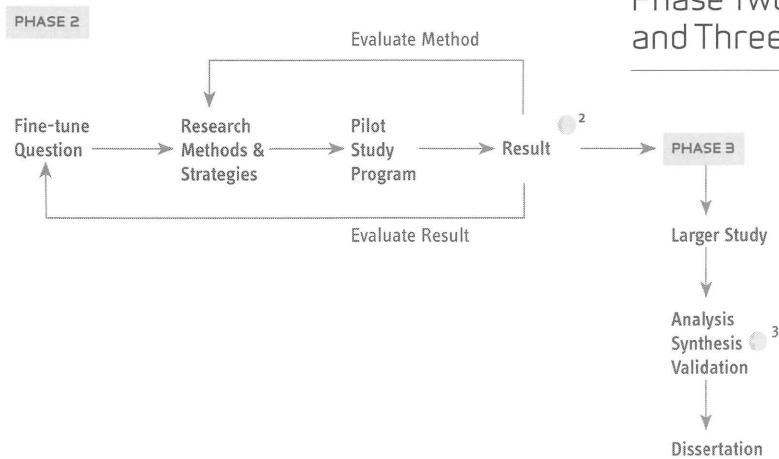
Procedural models for different types of design research have been described for Ph.D. students to efficiently organize their research activities. These models exemplify primary activities and their relationship to design research.

FIGURE 1:

## Shared Model of Phase One



The Ph.D. candidate joins a research group that is exploring a particular area of interest. Within the understanding of work and research in this interest area, the candidate seeks to pose a research question. The faculty considers the following: the student's abilities and general preparedness to answer the question, whether the question is timely (able to be answered in a reasonable time) and whether it will have impact on the field of design and beyond. If the question is legitimate and answerable, the student engages in secondary research to determine if the question has been answered. If it has been answered, another question is created; if it is not answered, the question is fine-tuned based on methods and need for evidence (*see figure 1*). Virtually all dissertation research begins with this process, subsequent research development is based on a specific research model. Two models are presented the experimental variation of the empirical model and the methodological model.



Following a successful conclusion to phase 1, the research question is fine-tuned based on methodological possibilities and their ability to develop evidence through data collection and analysis. When the question and method are in place, a pilot study is launched to test drive the investigation. Problems regarding the design of the investigation, experimental materials, confusion on the part of subject/participants, analytical pitfalls and the reasonableness of the results can result in modification or redesign of the investigation. An appropriate outside adviser often consults on issues of method at this time. If the investigation can be resolved and results seem promising, a larger study (phase 3) is undertaken to more fully develop findings. The findings are analyzed usually from several perspectives, the results are synthesized and the dissertation is written (*see figure 2*).

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Three possible papers result from this work at various points in its development. The first paper discusses existing research, its significance, controversies and problems with regard to the research question under consideration. (It is often difficult to find a publisher for research summaries, however such papers provide a general platform for future development.) The second paper can result from the pilot study by focusing on the method issues and the promise of results. In this paper, the candidate is publicly establishing their research territory. The third paper is a product of the larger study and its analysis and synthesis of results. This is the paper we most often associate with writing research.

The methodological model shares the same first phase as the one for the experimental model (*see figure 1*). After research questions are formulated, knowledge of the state of the art is developed through various forms of survey on practice and literature search revealing interconnections between different methods, theories and applications from the perspective of these questions. Through this information development, the Ph.D. candidate needs to identify issues and problems in design practice, develop a map of historical development and different approaches of existing research efforts, relevant theories and methods in

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any related areas regardless of disciplinary boundaries. The second phase generates a conceptual/ methodological proposal as an alternative solution to the questions established earlier as shown in Figure 3. The key research activity in this phase is to introduce a well-structured program of the research and construct concepts of methods as a proposal. This involves identification of specific design functions and effective methods of improving or enabling their performance. The third phase most clearly characterizes this research model. The proposed methods or concepts are implemented as a working tool to support design practice. More publications are produced during this phase because the system implementation can be well and easily described in the form of technical reports.

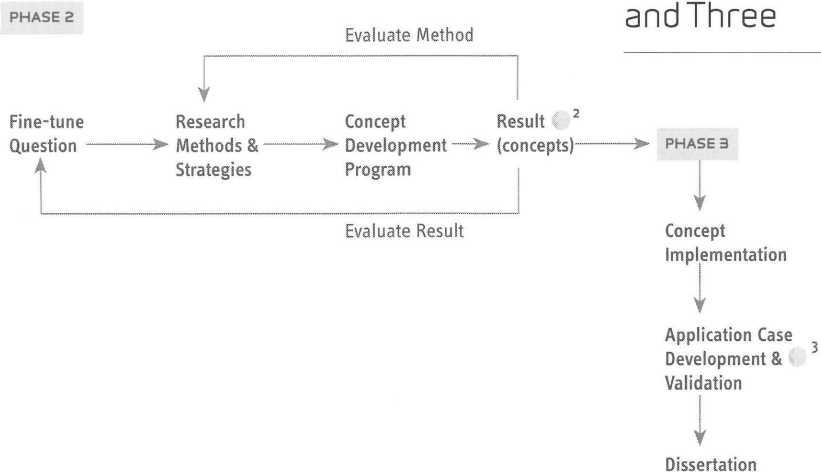


FIGURE 3:

## Methodological Research Model Phase Two and Three

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## Issues of design research

There are some issues that need critical examination for the future development of design research. The issues that were raised in the discussion and presentations directly or indirectly are summarized in this section.

### Applicability and accessibility of research output

In spite of its relatively short history and limited resources, design research has produced some significant output. However most of the research output remains inaccessible and underutilized because of the lack of a commonly understood categorization scheme, established dissemination media and archival compilation. This problem also comes from the culture of design itself, that puts little value on referencing other work or information sources, unlike other disciplines built upon an accumulated body of knowledge. Some difficulties pointed out in the discussion can be attributed to the difficulty of applying basic research findings such as theories, methods and guidelines to practical design projects. Is design research producing unusable output? Yes, and No. In any discipline, many layers of research are necessary to build mutually supporting platforms of research output that make their applications ready for practical use. Since the design discipline is expected to provide for the quality of overall human experience with designed artifacts, analytical viewpoints representing individual aspects of the design tend to become less prioritized. It is critical to develop a lifecycle of design knowledge throughout different sectors of the design community. In order to respond to these issues, it is important to investigate and establish effective research indexing models.

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### Reductionism and Holism

As I discussed earlier, critical views refer to existing approaches of scientific research as reductionism that decomposes a whole into a level that becomes irrelevant to understanding the subject of concern. Alternative methodologies have not been well established even in other disciplines. Design has not established even enough volume of research production in reductionistic realm to

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be legitimately concerned with this criticism. In Biology, there are subdivisions from cell biology to ecological study to animal behavior covering a wide range of scope and perspective. As brought up in the discussion of Chan presentation, the ultimate goal of design research is to provide understanding regarding how micro-level variables are connected to macro-level variables.

### Communicating with other disciplines

Positioning design practice and research within the real life of other disciplines enhances critical examination of roles for design and design research. As Broadbent explained, the complexity of the domain of concern for design has been exponentially increasing. This complexity brings not only the increase of scale range (vertical complexity) but also the intensity of interactions between factors across boundaries of disciplines (horizontal complexity). It means subjects of design are linked and integrated with subjects of other disciplines. In order for design research practice to effectively produce useful outputs and contribute to both design itself and the rest of the world, communication, collaboration and mutual contributions are critical.

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### | ACKNOWLEDGEMENTS |

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I would like to thank all participants for their insights and constructive arguments. Besides our presenters introduced in this report, the following discussants also participated: Thomas Schedtt Rasmussen, Arlene Gould, Hsin-Chien Huang, Ronald Hofer, Kok-Hin Chan, Pierre-Henri Dejean, Jay Rutherford, Regina de Oliveria Heidrich, Barbara Martinson. Special thanks goes to Meredith Davis and John Broadbent for co-moderating the sessions with me and offering inspiring insight to support my rather struggling process to summarize diverse viewpoints and experiences of design research as presented in our sessions. Yet, I am solely responsible for any misinterpretation or shortcoming in this article. Special thanks also goes to Adriano Galvao, my doctoral assistant.

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