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A Method of Interpreting Chinese Traditional Everyday Artefacts in the Context of Sustainable Product Design

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Many scholars and design professionals have advocated the significance and value of reapplying traditional design wisdom to solve contemporary design problems. This research attempts to realise this approach toward design innovation by investigating and describing the general process of how to derive design insights from traditional design wisdom and apply them for contemporary design purposes. The study takes a methodological approach toward investigating and describing the process of interpreting design insights from Chinese Traditional Everyday Artefacts (CTEAs) for the particular design context of sustainable product design (SPD), whereby a descriptive theoretical model is constructed using specific cognitive techniques to guide this interpretative process. The result identifies a new methodological approach to design as interpreting insights and provides substantial knowledge of interpretive thinking involved in the general design process. The provided method and cognitive techniques have been applied in workshops for research and educational functions for an empirical application.

A METHOD OF INTERPRETING CHINESE TRADITIONAL EVERYDAY ARTEFACTS IN THE CONTEXT OF SUSTAINABLE PRODUCT DESIGN

ZHENG YAWEI

Ph.D

The Hong Kong Polytechnic University

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THE HONG KONG POLYTECHNIC UNIVERSITY
SCHOOL OF DESIGN

A METHOD OF INTERPRETING CHINESE TRADITIONAL EVERYDAY ARTEFACTS IN THE CONTEXT OF SUSTAINABLE PRODUCT DESIGN

ZHENG Yawei

A Thesis submitted in partial fulfillment of the requirements
For the degree of Doctor of Philosophy

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Certificate of Originality

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__________________________________(Signed)

ZHENG Yawei (Name of Student)

Abstract

Many scholars and design professionals have advocated for the significance and value of reapplying traditional design wisdom to solve contemporary design problems. This research attempts to realize this approach toward design innovation by investigating and describing the general process of how to derive design insights from traditional design wisdom and apply them for contemporary design purposes.

This research takes a methodological approach toward investigating and describing the process of interpreting design insights from Chinese Traditional Everyday Artefacts (CTEAs) for the particular design context of sustainable product design (SPD). The research tries to build a descriptive theoretical model with specific cognitive techniques to guide this interpretative process.

By its nature as descriptive research, the research applies a qualitative inquiry paradigm to conduct both theoretical and empirical investigations. Modified analytic induction is used as the primary inquiry method to develop a loop of empirical experiments and theoretical modification is used as the basic unit of the research tasks. Empirical experiments are field studies of CTEAs in different Chinese regions and six design workshops conducted in different Chinese design schools and participated in by 119 design students and professionals. These workshops were designed to test different phases and situations of the interpretative process.

Theoretical investigation was carried out by seeking theoretical explanations and solutions for understanding and describing emerged patterns and concepts of the interpretive process from the empirical experiments. Related theoretical concepts and explanations from design methodology and cognitive psychology have been studied and organized to form the theoretical framework. The framework represents a general structure of insight interpretation in the design process.

To support in-workshop interpretation of CTEAs tasks toward the goal of generating SPD concepts and solutions, a temporary framework of SPD criteria has been built by

structuring selected existing strategic principles and solutions from four evaluation perspectives: human, social, natural environment, and product.

The research finally achieved its objective of building a theoretical model of a design method of interpreting CTEAs for SPD. The model can be represented in two forms: 1) a full process map of interpreting CTEAs for SPD; 2) the abstracted paradigm of ICTEA-SPD (I-SPD) method. The full process map is developed to explore the greatest potential of single SPD insights abstracted from the design of a CTEA. It is a combination of three sequential phases of selecting and investigating CTEAs, abstracting SPD insights, and interpreting insights and evaluating design concepts. To assist the application of this interpretative process, 13 cognitive techniques have also been developed to reduce the difficulty and ambiguity of specific tasks coinciding with the process. The abstracted method paradigm represents how the method can be applied to different research and design needs.

Besides the realization of a particular approach for SPD innovation, the research findings have both theoretical and empirical applications. The research identifies a new methodological approach to design as interpreting insights and also provides substantial knowledge of interpretive thinking that can be involved in the general design process. For empirical application, the provided process and cognitive techniques have been applied in workshops for research and educational functions. They can also be used by professional designers to meet their particular requirements.

Publications

Conferences:

Zheng, Y. W., & Xin, X. Y. (2010, October). *Building a cooperative energy solution for sustainable products: Inspired by studies on Chinese everyday objects.* Paper presented at the 7th Conference on Design and Emotion, Chicago, IL.

Zheng, Y. W., & Xin, X. Y. (2010, September). *A methodology for sustainable product design: Interpreting everyday Chinese objects.* In Lou, Q. Y., & Zhu, C, X (Eds.), Young Creators for Better City & Better Life. Paper presented at the 2010 Cumulus Shanghai International Conference, Tongji University, Shanghai, 6-10 September (pp.380-385). Paper can be retrieved from http://www.cumulusassociation.org/component/content/977-cumulus-working-papers-shanghai-in-progress-2010/162

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Chapter 1:

Introduction and Research Outline

Introduction of Chapter 1

This chapter is written to present the background of the overall research project, to identify the core research question and research goals, and to provide an outline of the thesis. The chapter is divided into five sections:

Research Motivations. This section explains why I chose the research direction of the project. The decision was based on my academic background in product design and cultural artefacts studies prior to pursuing the PhD degree, as well my personal interest.

Theoretical Framework. This section provides an outline of the concepts and their relations as the theoretical foundation of this research and how they direct the research question. Gaps in current theoretical studies are pointed out to provide a structure of the theoretical inquiry of this research.

Research Questions, Objectives and Significance. This section articulates the core research question by framing the logical structure of how this question can be answered. It does so by going through four different stages of theoretical and empirical inquiries. These are sub-questions of the research that also led to the construction of the research methodology. In this section definitions of the keywords of the research question have been given based on reference to existing theoretical definitions and, when necessary, by assigning particular technical meanings specific to this research.

Research Focus and Justifications. This research investigates and describes the general cognitive process of interpreting sustainable design concepts from selected CTEAs. The research is based on understanding the criteria of sustainable design, design discourse of CTEAs, and analytic design thinking techniques. Each of these elements has its own deep-rooted knowledge foundations and variable applicable meanings. I have chosen to focus the scope of the study on analytic design thinking techniques, but have also included selected portions of my work constructing a framework for the interpretation of CTEAs for sustainable product design in order to make the research complete.

Thesis Structure. The last section of Chapter 1 introduces the structure and outline of the whole thesis and how each chapter is related to the goal of solving the research question.

The ten appendices included each have particular uses for understanding the relevant thesis contents. The functions and meanings of those appendices are explained. As the thesis is relevantly long, reading rubrics are suggested at the end to help readers with different purposes and backgrounds to quickly seek out content that may be particularly useful for their own needs.

1.1 Research Motivations

1.1.1 Prior Research Experience and Established Knowledge

Prior to enrolling in my doctoral studies I was led by a consistent interest in exploring the values of Chinese traditional designs to spend three years studying for a master's degree focusing on investigating the aesthetical principles of Chinese traditional artefacts and their contemporary design applications. For my master's level research I visited museums, cultural sites, and family collections to observe traditional Chinese artefacts to understand their embedded aesthetical principles. I studied a number of the Chinese literature and existed research projects related to Chinese traditional designs and their philosophical roots in order to develop my research findings with my empirical findings. This research experience provided me with a fundamental knowledge and research skills enabling me to carry out design study of Chinese traditional artefacts from a particular perspective.

I subsequently assisted on a two-year investigative project studying contemporary lifestyles in various regions of China, providing me with an opportunity to understand the cultural roots of contemporary Chinese everyday lifestyles and to compare ideological differences from different cultural regions. From this research I found that traditional beliefs and institutions influence daily life in contemporary China while constant changes continue to proceed from modern phenomena. The research project had a broad scale of ten different Chinese cultural regions and included collaborations with leading local design institutes and schools. This research experience helped my PhD research by providing opportunities for further collaborations with some of these partner design schools.

1.1.2 Sustainable Design Concepts from CTEAs and Potential Applications

From my previous research studying the design of CTEAs I found many of their design concepts reflected some aspects of contemporary knowledge concerning sustainability. For instance, there are several good examples of efficient use of energy and materials. Many everyday Chinese objects, such as bamboo steamers, bamboo furniture, and sand-fired tea pots have been in use for hundreds of years and also satisfy contemporary sustainable design criteria. Many of these CTEAs also support multiple functions in different contexts. These sustainable design solutions can be reapplied in contemporary product design.

The concepts of sustainability and the principles of sustainable design for the most part originated and were developed in the Western world. Some Chinese everyday objects were designed or invented long before these sustainable design theories were created, but they have certain sustainable design features. Many Chinese researchers studying Chinese traditional objects have pointed out that some of these objects exhibit sustainable design in function, that some would provide energy solutions for modern day problems, and that some support sustainable social behaviours. As Xu Bowen a Chinese design researcher on CTEAs discussed in one of his research articles, "The Application of the Leverage in Traditional Chinese Appliances Design," some ancient sciences and technologies can be referred to in contemporary product design to make simpler but more functional product structures. (Xu, 2004) This convinced me that we can learn from traditional Chinese design wisdom when addressing contemporary sustainability issues in design research and product development.

1.1.3 Retrospective on Traditional Wisdom: a postmodern thought for relieving the world's environmental and human value crisis through design.

According to Stegall (2006), because poorly designed industrial systems, products, and buildings can greatly contribute to environmental and social degradation, the field of design has become a major focal point for sustainability. Researchers in the west world have also recognized the value of traditional wisdom for addressing contemporary problems of sustainability. As Orr (1992) pointed out in his book *Ecological Literacy*, the crisis is the result of an evolutionary wrong turn.... This is not to argue for a simple-minded return to some mythical Eden, but an acknowledgment that earlier cultures were not entirely unsuccessful in wrestling with the problems of life, nor we entirely successful. David Ray Griffin, the editor of *SUNY Series in Constructive Postmodern Thought*, also suggested that there is a "new respect for the wisdom of traditional societies growing as we realize that they have endured for thousands of years and that, by contrast, the existence of modern society for even another century seems doubtful" (Griffin, 1992, p.1). William McDonough and Michael Braungart**,** in their well-known sustainable design book: *Cradle to Cradle*, they stated, "All sustainability is local—we begin to make human systems and industries fitting when we recognize that all sustainability is local…. It would involve local people in building the community and keep them connected to the region's cultural heritage, which the structure's aesthetic distinctiveness itself helped to perpetuate " (McDonough & Braungart, 2002, p.22). These statements also give credence to a return to traditional culture to seek out useful elements to solve contemporary problems.

1.1.4 Lack of Scientific Methods for Interpreting Insights from CTEAs for SPD

Chinese traditional everyday artefacts (CTEAs) inform a number of advanced technologies, many of them artefacts having been used and improved through centuries, if not millennia, of Chinese history. Their forms, structures, and functions are the result of scientific, ritual, and ideological reasoning. Many of the reasons behind why those traditional everyday artefacts were designed, how they were designed, and how they were used inspire contemporary designers in conceptual and technical solutions.

Since design research became a full-fledged independent research discipline in Chinese design schools in the late 1990s, many design researchers and professional designers have conducted research projects that have revealed the design values embedded in Chinese traditional everyday artefacts (CTEAs) for contemporary design purposes. CTEAs are a material and tangible part of the broader universe of traditional Chinese culture, which encompasses a broad geographic area, a long history, and numerous sub-cultural diversities. This makes it difficult to build a research project from a systematic approach to frame them.

In fact, much existing research in the design discipline has been conducted by studying the results of reapplying values from traditional design solutions. According to my literature review of these studies very few of them have been carried out from a methodological approach that tries to build applicable and efficient design methods to help designers find and apply these thoughts from traditional designs. How to learn and think is as important as determining the facts of values at this point; and this became the issue I was most interested in while studying the values of traditional Chinese designs.

1.2 Theoretical Framework of the Research

The research is aimed at building a systematic method for interpreting insights from CTEAs for SPD solutions and product concepts. The core research question is to understand and illustrate the cognitive process of insight interpretation. As the research is conducted for product design practices and education purposes, the illustration of the interpretation process should carry the quality and characteristics of a design method. Thus, there are two basic categories of related concepts involved in the initial research question: 1) the process of insight interpretation; 2) the quality and characteristic of design methods.

1.2.1 The process of Insight Interpretation

Interpreting insights means transferring the idea or meaning of one thing to another situation or context. In cognitive psychology "interpretive thinking" is one of the most important human reasoning patterns, belonging in turn to the category of analogical reasoning. Analogy means two things share some aspect of deep similarity (Medin et al., 2005). In particular, analogy is thought to involve relational or structural similarity, which is the similarity in the relationships that hold among the features in an object (Hesse, 1996).

Cognitive Techniques of Interpretative Thinking

The phrase “cognitive techniques of interpretative thinking” refers to the study of intrinsic techniques and patterns of human cognitive behaviours. Research on human interpretive thinking belongs to the domain of cognitive psychology, which is itself closely related to research concerning design thinking. According to Scheckel (2005), interpretive thinking is the thinking that is reflective, embodied, multi-perspective, contextual, circular, and communal, and that seeks to reveal explanations as well as meanings and significances. In this research interpretive thinking is a deductive process that aims to fit specific applications of an abstracted insight to the insight’s problem-solving nature. Interpretive thinking is discerning, and can be described as a kind of deductive, language-based interpretation of the insight.

The Analogical Problem-solving Nature of Insight

Schilling (2005) argued that insight arises from an unexpected connection between disparate mental representations. Mayer (1992) pointed out the analogical problem-solving nature of “insight”, meaning that insightful problem solving processes use analogical thinking as key reasoning patterns. In this research those “insights” which form the core learning of traditional design solutions have potential to be “interpreted” into contemporary SPD solutions. In examining this interpretive action we can see the fundamental intelligent quality required is the analogical problem-solving technique.

1.2.2 The Quality and Characteristics of Design Methods

Design methodology studies the science of design methods. Dorst (1997) stated that “Design is a string of activities which can be both rational and intuitive, abstract and concrete, analytical and creative” (Dorst, 1997, p.7). Design Methodology studies the science of design process which has been developed from its roots from artificial intelligence for computing techniques in early 1960s. Cross (1984) defined design methodology as the study of principles, practices and procedures of design. Its general goals are to enhance the efficiency and effectiveness of design activities and to develop design as a discipline by gathering, creating, and critically discussing insights about design. According to Dorst (1997), design methodology includes the development of formal models of design activities, from which methods, techniques, and computer tools can then be derived. Kore (2002) stated design methodology is thus essentially teleological in nature: the knowledge and understanding acquired in studying design are not goals in themselves, but they should be translated into methods and techniques to be used both in designing and design education. Design methodology aims at the improvement of design process. In contrast to the methodology of science it is strongly process oriented and takes a normative point of view. These theoretical ideas depict fundamental understandings of nature and functions of design methodology and also help to understand how cognitive techniques are different from design methods.

The Two Fundamental Paradigms of Design Methodology: Design as Rational Problem Solving & Design as Reflective Practice

Dorst (1997) defined Paradigm is “the basis of design methodology which defines the domain and the subject to be studied” (Dorst, 1997, p.11). According to Simon (1969), paradigm design is seen as ***a rational problem solving process***. A radically different paradigm was proposed by Donald Schön (Schön, 1983) describing design as ***a reflective practice***. It is developed by revealing the nature of design problem which is “ill-defined” and that makes solving design problem is not only guided by rational thinking process and also involves designer’s reflective decision makings during the design process. These two paradigms of design methodology have significant influences to the contemporary studies of understanding and describing nature and process of design in different situations.

Creativity, Problem-solving and Design Process

Creativity is one of the most important elements of the design process. Cross (1997) constructed a procedure based on a “creative-leap” example followed by a generic descriptive models using creative design to provide further insight into the example. Dorst and Cross (2001) proposed refinements to the co-evolution model, and also suggested that creativity in the design process can validly be compared to a "burst of development". According to Durling and Cross (1996), creativity is central to designer's thinking, although their methods of working and their attitudes toward the solving of problems may be very different than those of other professionals. Guilford (1950) pointed out, creative thinking occurs when a problem solver invents a novel solution to a problem. Mayer (1992) argued that the term insight has been used to name the process by which a problem solver suddenly moves from a state of not knowing how to solve a problem to a state of knowing how to solve it. A creative event occurs at the moment of insight at which a problem-solution pair is framed, what Schön (1983) called "problem framing". Studies of expert designers suggest that this framing ability is crucial to high-level performance in creative design.

1.2.3 Theoretical Gap: Insight Interpretation and Design Process

These illustrations of theoretical ideas in the two academic areas of cognitive psychology and design methodology are the initial construction of the research question and its theoretical foundation. As it is a type of applied research based on both empirical experiments and formal knowledge, this research tries to make connections between the two abstractive issues of, a.) How the relevant knowledge of insight interpretation can be represented with "design languages", and b.) How it can be adopted in general design processes.

The Interpretive thinking concerning abstracted design insights represents a cognitive style of inspired deductions. Any of the interpreted, specific design solutions gleaned from the insights can be selectively and reflectively relevant to the meaning of the insight. The unique quality of this research is that it has been carried out from a very particular perspective in the conduct of its empirical experiments and applied functions. Applying this to sustainable design, although the nature of a sustainable product design (SPD) insight may come from logical inductive reasoning based on the design pattern from a selected CTEA, the insight still theoretically fits the same basis formed when designers are inspired by these insights in their designing processes. In this case the abstractive knowledge from both academic areas can be more specifically and concretely transformed and represented as effective methods to guide design practice on this particular issue. The transferred knowledge can be referred to in the development of related cognitive tools to improve the performance of design practice. This is the reason why as a doctoral level research project I carried out a methodological research task related to a very specific design issue: interpretation of CTEAs for SPD. More specified relevant and supported theoretical ideas will be introduced in *Chapter 2: Literature Review*.

1.3 Research Questions, Objectives and Significance

1.3.1 Research Title and Keyword Definitions

Research Title: A Method of Interpreting design insights from Chinese Traditional Everyday Artefacts (CTEAs) for Sustainable Product Design (SPD)

Keywords: Interpret, Design Insight, Sustainable Product Design (SPD), Chinese Traditional Everyday Artefact (CTEA)

Keywords Definitions:

"Interpret"

According to Oxford dictionary definition, "to *interpret*" means "to explain meanings and convey one's understanding of a creator's idea…." In this research "interpret" means conveying the design insights (concepts) from CTEAs to particular design contexts for contemporary use.

"Design Insight"

Insight is the realization of a solution to a problem under consideration. Design insight in this research particularly refers to abstracted design solutions from studying and understanding the selected CTEAs. For design as a rational problem solving approach, design insight can be seen as an adaptive solution for a design problem. For design as a reflective practice approach, design insight is inspiration or direction leading designers in making future decisions.

"Sustainable Product Design (SPD)"

According to McLennan (2004), sustainable design is the design of products with the primary concern of balancing economic, environmental, and social costs in their creation. Tischner and Charter stated, "Sustainable product design (SPD) is more than eco-design, as it integrates social and ethical aspects of the product's lifecycle alongside environmental and economic considerations" (p.21). A more concrete definition and the inner theoretical workings of sustainable product design are explained in *Chapter Three: Research Methodology and Process*.

"Chinese Traditional Everyday Artefact (CTEA)"

Artefacts are applied objects, or objects that have an intentional applied function; they are objects intended to fulfil a purpose that initiated their making. According to Risatti (2007), applied objects are objects bound by the idea of a purpose and by the intentional act of form-giving.[1] In the context of this research, Chinese traditional everyday artefacts are any applied objects—functional, decorative, or ritual—that were designed and used in China before the industrial revolution and are still used in contemporary Chinese homes. This definition does not exclude those objects that, although developed in China, may also have been used by people from other cultures. As their production technologies and economical requirements are quite different from those of the present day, most of the investigated CTEAs in this research are handmade or else are semi-handmade with machine-production assistance.

1.3.2 Research Questions

[1] Since applied objects function as made objects as an essential part of their physical form, their function remains long after radical changes have occurred to the social and cultural institutions that originally brought them into being. In this sense, function exists as something independent of social and cultural contexts. Risatti, H. (2007). *A theory of craft: Function and aesthetic expression.*

Research Question:

Is there any method of interpreting design insights from Chinese traditional everyday artefacts (CTEAs) for contemporary sustainable product design (SPD)? What is the process of the method? Are there any thinking techniques that can assist the process?

Sub-Questions:

- What are the fundamental cognitive patterns and processes of insight interpretation?
- How can these fundamental patterns and processes be integrated into design method?
- How can the design method of insight interpretation be specifically applied to the interpretation of insights from CTEAs for SPD?

1.3.3 Research Goal and Significance

This research project was conducted with the primary goal of exploring and describing a scientific method for interpreting design insights from CTEAs for SPD. This method can be represented through the forms of: 1) Structured mental and behavioural tasks guiding the interpretative process to completion; 2) Different cognitive patterns and models for possible methodological conditions; and 3) Suggested solutions for the resolution of difficulties and ambiguities resulting from the interpretative process.

The specific objectives are:

1. To identify the requirements, opportunities, and methods necessary to obtain meaningful (sustainable) design insights from CTEAs for SPD;
2. To describe the methods, dimensions, and forms representing those design insights in applicable design languages;
3. To suggest cognitive models and techniques to connect articulated design insights with specific design requirements and contexts;

The research tries to investigate and apply the essential knowledge of the cognitive process of insight interpretation for building design methods to guide design applications.

The theoretical contribution of the research is the development of the knowledge of design methodology in analogical creative design thinking methods and technique development. The research outcome also helps design practitioners understand and improve their mental processes of insight interpretation. Besides its theoretical contribution to design methodology studies, the research provides easy-to-follow procedures and techniques to guide empirical applications of interpreting insights derived from CTEAs for SPD. Difficulties and ambiguities of learning and interpreting traditional design wisdom for contemporary design purposes can be deduced. For specific theoretical and empirical applications of the research findings, see *Chapter 7: Conclusion and Discussions*.

1.3.4 Brief of Research Methodology

Keeping the goals of this inquiry in view, I have taken a qualitative methodology (modified analytic induction) approach in this research. The research was designed and conducted in three phases:

Phase One: Construction of the initial theoretical model by researching existing theories of insight interpretation and engaging in a small-scale pilot empirical study;

Phase Two: Development of this initial theoretical model through both empirical experimentation and further theoretical studies; the empirical experiments were conducted through six workshops with 119 participants comprised of design students from representative design programs in China. The workshops were designed and conducted with specific different functions in mind for developing and refining the theoretical model.

Phase Three: Description of the ICTEA-SPD [2] method and identification of its application scope.

[2] The name of the method is abbreviated as ICTEA-SPD in the thesis, short for "interpret Chinese traditional everyday artefact for sustainable product design". When the term is frequently mentioned, as in the last three chapters of the thesis, it can also be further abbreviated as I-SPD.

Explanations of the research methodology and the elaboration of the three phases of research process are found in *Chapter Two: Research Methodology and Process.*

1.4 Research Focus and Justifications

1.4.1 Research Focus

The research topic is comprised of three fundamental elements: sustainable product design (SPD), Chinese traditional everyday artefacts (CTEA), and Interpret Design Insight (as a creative design thinking method). These three elements themselves each have broad contextual meanings and deep philosophic roots. This makes structuring and carrying out an efficient research project with limited time and resources more difficult. The core idea of this research is exploring and describing how insight interpretation can be understood and applied in design practice. The majority of the project has been directed toward the goal of exploring and describing the method, process, and cognitive tools necessary for insight interpretation in the particular context of interpreting CTEA for SPD to provide the study with more substantial data and to simplify carrying out empirical experiments.

I have also developed limited, and necessarily contingent, frameworks of SPD and CTEAs as a corollary part of this research in order to support the main focus of the research by providing interpretive assistance in analysing the empirical data. The frameworks of SPD and CTEAs are described and explained in *Chapter Three: Building SPD Criteria* and *Chapter Five: Empirical Studies and Experiments*. They are not deemed to be core findings in this research but have been tested and developed in empirical experiments as a way to help workshop participants complete the required experimental tasks.

1.4.2 Some Justifications

1. Interpreting insights for sustainable design from Chinese traditional everyday artefacts represents a particular approach for SPD. This research helps inform the realization that CTEAs can be a resource for design students and professionals seeking inspiration and design solutions in their own work related to SPD. Based as it is in CTEAs that were originally developed under social, cultural, and technological contexts quite different from the our own contemporary life, this recommended approach is unconventional and is informative to more fundamental approaches used in education and industry to address sustainability problems. This approach is unique insofar as it seeks design solutions from ancient knowledge sources and also reminds practitioners to think critically about contemporary production systems and values of modern society during their design processes.

2. The structured SPD criteria, which provides a working response to the question of what, precisely, within design can be considered SPD, in this research is based on my study of selected existing academic literature and other primary and secondary resources. It is also developed for the particular context of this research to evaluate what insights can be seen as sustainable design insights and also to test if the products of the I-SPD method are SPDs. The basic method to build this SPD criteria framework is to collect, compare, categorize, and abstract existing SPD principles and strategic solutions from my studies. The SPD framework represented in this thesis is not a fundamental framework for SPD. Some of areas of SPD such as “industrial ecology” and “green economics” are not included as they are not directly related to the design of CTEAs.

3. This research also suggests a framework for focuses of embedded design values within CTEAs which came from my existing knowledge and empirical experiences with CTEA studies (to see chapter 5). I used this structure to guide my workshop participants and to provide them with a more holistic understanding of the significance of and potential design opportunities available from interpreting design insights from CTEAs. This framework was influenced by Xin’s (2007) research: Product Innovation in A Cultural Context. He suggested a framework of *Interpreting Cultural Artefacts* (ICA) which constructs different design elements with three dimensions of design reasoning of the cultural artefacts (Evident Attributes, Deeper Reasoning and Influential Factors). I

modified this framework to build my own framework structuring embedded design values of CTEAs which may lack sufficient theoretical evidence, but which suggests a way of holistic understanding of CTEAs and which helped workshop participants make clearer connections between CTEAs and their own design tasks and purposes.

1.5 Thesis Structure

1.5.1 Brief overview of Each Chapter

Chapter 1: Introduction and Research Outline

This chapter is written to introduce the research background, motivations, and theoretical framework of the research, and to provide a brief overview of the research objective. This helps readers of the thesis to obtain a quick overview of the research and outline of the thesis.

Chapter 2: Literature Review

The literature review covers important theoretical ideas supporting the research. It provides readers a theoretical base through a survey and analysis of published works that pertain to the research area under investigation. It is structured according to the theoretical framework of the research and explains how the important theoretical ideas are generated and processed with the empirical experiments. The major theoretical work is carried out in the related areas of cognitive psychology and design methodology studies. I listed the most relevant theoretical ideas and explained how they are relevant with this project. I also did comprehensive literature reviews on the topics of cultural artefacts studies and sustainable product design to support my empirical experiments.

Chapter 3: Research Methodology and Process

This chapter describes the nature of the research, research methodology, and research design and performance. It also explains how the research outcome was developed and processed from the six workshops conducted in Chinese design schools.

Chapter 4: Building SPD Criteria

This chapter is written to represent and explain how the framework of SPD criteria was built for the research. It answers the question: What are the background resources for this criteria framework? The SPD criteria framework serves as an evaluation method for decision making while seeking sustainable design insights from CTEAs, as well as guiding interpretive insights and aiding the development of SPD concepts from the interpreted design ideas. This framework was built particularly for the purposes of this research but can also aid understanding of the general strategic standards of SPD.

Chapter 5: Empirical Studies and Experiments

The inquiry methods of this research include both theoretical studies and empirical studies. Chapter 5 is written to introduce the empirical studies and their functions in the different phases of empirical data collection. There are two varieties of the empirical studies in this research: 1.) field studies on CTEAs, and 2.) experimental design workshops used to test and develop the theoretical model and critical thinking technique tools which allow the model to assist the users. The section responds to several relevant questions -- How and why were these empirical studies designed and conducted? What are the valid results from the experiments? How are these results meaningful for the development and illustration of the final research outcomes?

Chapter 6: Research Findings

This chapter explains the form, validity, and organization of the data obtained through the secondary and empirical studies of the inquiry process. It also introduces how the various empirical data were processed to generate the research findings. The primary research finding is a process method for interpreting (sustainable) design insights from CTEAs for SPD. Secondary research findings are explanations of proposed critical thinking techniques and suggested tools for assisting users of the interpretive method. Finally, the method has also been developed into an abstract form to cooperate with the two fundamental design paradigms. This abstracted paradigm was examined in the final workshop.

Chapter 7: Conclusion and Discussions

The final chapter is written to synthesize the research by answering the primary research question and sub-questions. The knowledge contributions, significance and applications of the main research findings are also discussed here. Additionally, research limitations, suggestions, and possible further research directions are also included as the final section of the thesis.

Ten Appendices are attached. ***Appendix A*** contains the original data from the collection and coding of SPD principles from the literature review. These were used to develop the SPD criteria. ***Appendix B*** is a sample of the workshop curriculum, including the structure, process, objectives, and logistics of the workshops. ***Appendix C*** is the "road-map" used to develop the I-SPD method through the six workshops, representing the process of applying the research methodology. ***Appendix D*** is a list of 109 design students from the five formal workshops and their final design project titles, including a short description of each group project.

Appendices E-J these six parts are related to application examples of the related cognitive techniques which are developed as affiliate research findings to the process and structure of I-SPD Method.

1.5.2 Reading Rubrics

As the thesis is relatively long and contains elaborations and cases related to different related theoretical terms and ideas, I propose the following reading rubrics for readers with different purposes:

For researchers and specialists: Chapter 1 provides a quick overview of the whole research project. Chapters 3, 5, 6 are important for understanding how the research was designed, how data was processed, and how findings were derived. The research methods used empirical studies performed as part of this research can also be helpful for similar research endeavours. Chapter 6 is relatively important for providing explication and reference to the findings and their possible applications for other related research. Appendix C can be helpful to learn the methodology and process of the research.

For design practitioners: The theoretical studies in this research cover literature related to SPD and the fundamental knowledge of design creativity. Chapters 2 and 4 can be useful for practitioners to develop a comprehensive understanding of existing knowledge and strategic solutions related to design methodology, techniques of creativity in design thinking, as well as SPD. In Chapters 6 and 7 there are some design examples from applying the I-SPD method which may be of interest. Appendix D provides illuminating example design cases from the workshops.

For design educators: Chapters 3 and 5 are valuable for design educators to learn and reference the workshop model in their own teaching curriculum. Appendix B can be used for designing relevant workshops or subject syllabi for students learning and applying the suggested methods and tools from the research. This workshop model has been tested and improved through my experience coordinating the five workshops and is applicable for different levels of design students.

For the general readers who have interest in the topic: Chapter 1 can be helpful as a brief overview of the whole project. Chapter 2 can be helpful to learn some fundamental knowledge about the overarching topic. Chapters 6 and 7 are valuable to learn the outcomes, applications, and significance of the research.

This research and thesis has been the product of my passion and efforts and is possible due to the great support I have received from my supervisors, the partner Chinese design schools, and the thesis examination committee. I am hopeful that this thesis will be meaningful and helpful for people who have an interest in or are working on the interpretation of Chinese traditional artefacts in different applications.

Summary of Chapter 1

This chapter provides an outline of the whole work, including the research background, theoretical framework, identification of research question and goals, and research focus. Basic information about the thesis and how to read the thesis for different purposes have also been illustrated. Further detailed elaboration and explanations of the listed important research information will be introduced in following chapters. Some points of these later chapters will also refer back to the ideas from this chapter.

Chapter 2:

Literature Review

Introduction of Chapter 2

Theoretical investigation is a very important research task of this project because of the complex concepts and their logical relations involved in the research question. Cross-disciplinary knowledge from cognitive psychology, design methodology, cultural artefacts studies, and sustainable product design have been investigated and structured for developing the research findings. This chapter is written to introduce how the theoretical framework of the research question has been structured and illustrated, and also to explain the theoretical foundation of the empirical experiments and the research findings.

The first section introduces theoretical studies of insight interpretation from the approach of cognitive psychology. Cognitive psychology has been closely connected to design methodology studies throughout the latter's contemporary development. This research project tries to explore and build more connections between these two research areas by investigating and discussing how existing studies in design methodology are influenced by the studies of cognitive psychology from the particular approach of insight interpretation in product design process.

The second section of the literature review presents the foundational knowledge of the field of design methodology, introducing the dominant paradigms developed by existed researches in this area. There is also a review of researches on framing of design problems by academics and practitioners.

The third section takes the review of interpretive thinking in design one step further and examines research on the relationship between modes of thinking and the design process itself. It introduces the research looking at the use of interpretive thinking for gaining design insights and proposes a model for doing so.

The fourth section provides an overview of practices and researches on interpretation of Chinese traditional artefacts for contemporary design uses. It reviews culturally-oriented product innovation with different approaches and methods.

The fifth and final section examines the notion of "Sustainable Product Design" (SPD) and its relationship with the broader history of sustainability thinking and practice in design field. In *Chapter 4: Building SPD* Criteria is written to illustrate what are the collected SPD principles and how these principles have been structured into SPD criteria to support the empirical experiments of interpreting CTEAs for SPD for the research purposes.

2.1 Cognitive Psychology of Insight Interpretation

2.1.1 The Interpretive Thinking Process

According to Travis (1986), interpretation is the assignment of meanings to various concepts, symbols, or objects under consideration. Two broad types of interpretation can be distinguished: interpretation of physical objects and interpretation of concepts (or conceptual models). In logic, an interpretation is an assignment of meaning to the symbols of a language. A conception of meaning might be scrutinized in one of either two ways. One way is to look at the phenomena. One might examine what distinctions can be drawn-not only between one thing and another that words in fact mean, but also between another that words might say. This is the definition of "interpretation" in Linguistics.

Reif and Allen (1992) argued that, in psychological studies, interpreting a scientific or design concept is a complex cognitive task the ability to interpret and use scientific concepts is an essential prerequisite for problem solvers. Interpreting concepts is to achieve the unambiguity, precision, and generality necessary to solve problems. Reif (1987) studied different types of scientific conceptual interpretations (formal: basic scientific concepts, informal: fragments of knowledge, idea: intuitive scientific knowledge). The interpretive process generally involves specification, comparison, and adaptation. Specification is to use specific knowledge to identify or construct the interpreted concept. Comparison is to use coherent knowledge to compare the new situation to the interpreted concept Adaptation is to match the new situation by describing applicable explanations and predictions.

Reif (1987) also suggested methods of reducing difficulties and ambiguities in the interpretive process: 1) The need for unambiguity and precision requires fine discriminations; 2) Careful use of language and other symbol systems is required to ensure that all symbols are unambiguously related to their referents and to each other; 3) Concepts must be specified abstractly to achieve generality, but which also require procedural knowledge ensuring their unambiguous interpretation in any scientific instance; 4) Knowledge must be coherent and consistent; 5) It is important to develop intuitive scientific knowledge which can be used quickly and effortlessly.

2.1.2 The Problem Solving Nature of Insight

Definition of Insight

Davidson (1996) defined insight as an "unconscious leap in thinking" or a "short-circuiting of normal reasoning" that leaves us with a black box of unknown contents. "Insight" refers to that glorious moment when one suddenly "sees" the solution to a problem. Mayer (1992) pointed out that the term insight has been used to name the process by which a problem solver suddenly moves from a state of not knowing how to solve a problem to a state of knowing how to solve it. Hebb (1949) thought that insight involved a restricting of thought, the elements of which he took to be conceptual rather than perceptual. He thought that insight was essential for extracting meaning and for comprehension.

Insight is typically defined as a process whereby an individual moves suddenly from a state of not knowing how to solve a problem to a state of knowing how to solve it (Mayer, 1992). The concept of insight is closely related to those of understanding and comprehension. Dominowski and Dallob (1995) pointed out to gain insight is to understand something more fully, to move from a state of relative confusion to one of comprehension. To summarize its major characteristics, insight is: 1) a form of understanding of a problem and its solution; 2) the product of a process of restructuring; 3) dependent on the features of the problem situation; and 4) only one determinant of success in problem solving.

The concept of insight is closely related to understanding and comprehension. To gain insight is to understand something more fully, to move from a state of relative confusion to one of comprehension. Guilford (1950) stated creative thinking occurs when a problem solver invents a novel solution to a problem. Wallas (1926) has stressed that insight refers to a family of phenomena occurring in the creative work. The family includes problem finding…problem resolution, synthesis, discovering similarities, analogies, increase in certainty, recognizing error, and so on.

According to these fundamental statements about the nature of insights, I have defined insight to be the sudden realization of a solution to the problem which is under consideration. In the particular research context of this project, in order to select artefacts for inspiring the generation of a new SPD idea there is a spontaneous selection and learning from the CTEAs. For this non-directed open selecting and studying of CTEAs the realization of this inspiration could be defined as a "design insight". Generally, in this research the concept of "design insight" refers to inspired abstracted meanings from studying CTEAs that could be interpreted as specific sustainable design solutions or ideas.

The Problem Solving Nature of Insight

Mayer (1995) identified several views of the nature of insight from a problem solving perspective.

1) Insight as nothing new. A prevailing view of insight is that it is nothing more than the exercise of stimulus-response associations—that is, the occurrence of finding a response that has been associated with the problem situation or similar situations in the past.

2) Insight as a completing schema. The two phases of problem solving are problem representation and problem solution. Representation occurs when a problem solver builds an internal mental representation of a problem that suggests a plan or solution. The solution occurs when a problem solver carries out a solution plan.

3) Insight as a sudden reorganization of visual information. This view emphasizes the visual nature of insight. Just as perception involves building an organized structure from

visual input, creative thinking often involves the reorganizing or restructuring of visual information.

4) Insight as the reformulation of a problem. One key to insight is in looking at the givens or the goal in a new way.

5) Insight as the removing of mental blocks. Insight involves overcoming the way one has learned to look at a certain situation, so that one can find new solution opportunities.

6) Insight as finding a problem analogy. Insight involves grasping the structural relations of one problem and applying them to the solution of a new problem. Modern cognitive psychologists have investigated the conditions under which problem solvers abstract the structural organization from previous problems so it can be applied to new problems, and the role of mental models in problem solving.

These theoretical ideas of the nature and functions of insight helped me to establish the basic structure of the logical process of solving the research question, particularly in the case of insight as finding a problem analogy. It made me understand the nature of how to be inspired by the designs of traditional artefacts for generating new design ideas. I defined this process as an analogical problem solving process. This process is based on analogical reasoning as one of the fundamental human reasoning patterns.

Insight Problem Solving and Non-insight Problem Solving

In terms of the visual-spatial metaphor, the constraint for insight problem solving is to see where to go, whereas the constraint for non-insight problem solving is to move oneself successfully to the readily perceived destination. This characterization of the differences between insight and non-insight problem solving suggests that the two types of problem solving should rely on different skillsets. Insight problem solving should rely more on a pattern-recognition process, whereas non-insight problem solving should rely more on reasoning skills and the ability to maintain a representation of where one is and where one is going.

For instance, Kohler (1925) described insightful problem solving as the arrival of “complete methods of solution” that occur suddenly and have never been formerly practiced, to the problem-solver's knowledge. Insight may involve the immediate knowing of something without the conscious use of reasoning. Insight invites metaphors and elicits comparisons with evolutionary theory. A single metaphor is always imperfect, but a set of metaphors illuminate when they all converge on the same target.

These theoretical ideas explain how insight works as part of the human thinking process. Due to their problem solving nature, insights are suddenly perceived in a context where the problem solver is trying to find a solution. In this research, the design insights emerge through observations of or scanning information about artefacts. The insights will begin as an ambiguous understanding and later be defined and transformed into an idea or pattern that is readable and actionable in a design context. In this research, insight works in a reverse way than the definition provided above; rather, insight is the process of beginning with a given solution and searching for adaptable contexts where the insight can be used to solve issues of sustainability. This is the characteristic of the meaning of insight from its traditional definition. To solve a given problem by the method outlined in this study, a sudden and meaningful inspiration from CTEAs is required. From this approach, the insights are found, abstracted design ideas and solutions are inspired by selecting and investigating CTEAs.

2.1.3 Cognitive Process of Insightful Interpretive Thinking

According to Schilling (2005), several domains of research have suggested that insight arises from an unexpected connection between disparate mental representations. At least five prominent hypotheses about the process of insight incorporate unexpected connections within or across representations as one of the underlying mechanisms of insight. These five hypotheses consider insight to be: 1) completing a schema; 2) reorganizing visual information; 3) overcoming a mental block; 4) finding a problem analogy; and 5) random recombination. All these explanations turn out to be highly congruent when viewed from a network perspective.

According to the three-process theory of Davidson (1986), insight comprises selective encoding, selective combination, and selective comparison. Insightful thinking occurs when these processes are successfully applied in situations where the individual does not have a routine set of procedures for solving a problem.

Selective encoding occurs when a person suddenly sees in a stimulus, or set of stimuli, one or more features that previously have not been obvious. Selective encoding can contribute to insight by restructuring one's mental representation, so that information that was originally viewed as being irrelevant is now deemed relevant. Selective combination occurs when one suddenly puts together elements of a problem situation in a way that previously has not been obvious to the individual. Selective comparison occurs when one suddenly discovers a non-obvious relationship between new information and information acquired in the past. When selective comparison occurs, analogies, metaphors, and models are used to solve problems. The person having an insight suddenly realizes that new information is similar to old information in certain ways, and then uses this realization to better understand the new information.

The three processes appear to all hold selection and relevance as high in importance. When encoding, one selects only some of the often numerous possible elements that constitute the problem situation; the key is to select the relevant elements. In selective combination, an individual selects one of many possible ways in which elements of information can be combined or integrated; the key is to select a relevant way of combining the elements in a given situation. In selective comparison, an individual selects one or more of numerous possible elements of old information with which to relate new information. The key is to select the comparison or comparisons that are relevant to one's purposes.

The interpretive thinking derived through abstracted design insights represents a cognitive style of inspired deductions. Any of the interpreted, specific design solutions gleaned from the insight can be selectively relevant to the meaning of the insight. Although the nature of the SPD insight comes from logical inductive reasoning of the design pattern from the selected CTEA, the insight still theoretically fits the insightful thinking theory when designers are inspired by these insights in their design processes. The theory can then be referred to in the development of affiliate cognitive tools to improve the performance of design interpretations from the abstracted insights.

2.1.4 Insight Interpretation as Analogical Ideal Generation and Creativity Technique

Idea Generation and Creativity Techniques

Idea generation is the central process of innovation in which new ideas are created deliberately and systematically. Sherwood (2002) suggested all the tools and techniques to support creativity and idea generation largely fall into two categories: springboards and retro-fits. These creativity techniques can also be classified in terms of intuitiveness and structuredness (Moon, Ha, & Yang, 2012; Shah, Kulkarni, & Vargas-Hernandez, 2000; Shah, Smith, & Vargas-Hernandez, 2003). Unstructured/intuitive creativity techniques aim to increase the flow of intuitive thoughts and facilitate divergent thinking and are mainly focused on the quantity of solution proposals. Structured/logical creativity techniques analyse functional requirements and generate solutions based on engineering principles or catalogued solutions from designers' past experiences.

A number of techniques have been found to improve creativity and to be particularly appropriate for architects and engineers because of the relative ease with which they can be applied in design problems. These techniques are:

- Brainstorming (separating the judgemental and creative minds)
- Brain Writing (There are many varieties, but the general process is that all ideas are recorded by the individual who thought of them. They are then passed on to the next person who uses them as a trigger for their own ideas.)
- Gallery Method (is a mixture of physical and mental activity whilst generating ideas. The participants move past ideas as in an art gallery rather than ideas moving past in the participants)
- Mind Mapping (also called "spider diagram" represents ideas, notes, information etc. in far-reaching tree-diagrams)
- Metaphor (a retro-fit technique for idea generation in which the key question is "How the focus of attention be something else?". It is similar to analogy and simile.)

- Five "Ws" and "H" (the six universal questions are an influential, inspirational and imaginative checklist.)
- Six Thinking Hats (a technique by Edward de Bono. The term is used to describe the tool for group discussion and individual thinking.)
- Delphi (predicting the future and reaching consensus)
- Manipulation (looking at generalities rather than specifics)
- Pattern (looking at specifics rather than generalities)
- SCAMPER (is a checklist that will assist in thinking of changes that can be made to an existing product to create a new one. S-Substitute, C-Combine, A-Adapt, M-Modify, P-Put to another use, E-Eliminate, R-Reverse)
- Analogies is used to estrange designers from the original problem statement and to come up with inspiration for new solutions and approaches.

Insight Interpretation as Analogical Idea Generation and Creativity Technique

From the above overview of established idea generation and creativity techniques and cognitive studies of insight interpretation, insight interpretation can be defined as an analogical problem solving technique. Analogical reasoning is the basic cognitive pattern used during the process of insight interpretation.

Goel (1997) argued analogical transfer requires the use of generic abstractions, where the abstractions typically express the structure of relationships between generic types of objects and processes. The studies of analogical reasoning in cognitive psychology as Gick and Holyoak (1983) suggested that generic abstractions are not merely abstraction over features of objects, but that they capture the relational structure among objects and processes. In the context of design generic abstraction may specify, for example, the structure of geometric, topological, temporal, casual and functional relations among design elements. In brief, analogical design involves the learning and transfer of the generic design abstractions from one design situation to another design situation. The more specific techniques of analogical design thinking will be discussed in the following section: "Interpretive thinking patterns in design process".

2.2 Fundamental Qualities and Characteristics of Design Method

2.2.1 Studies on Design Methodology

Design Methodology

Buchanan (2001) provided the definition, “Design is the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual collective purposes.” Design methodology is about the management of design processes. Dorst (2007) pointed out “Early design methodologies were compiled by engineers who applied the same systematic thinking they had used in designing their products to analyse the design process itself” (p.11). Research on design methodology is concerned with construction as a human activity – how designers work, how they think, and how they carry out design activity.

Roozenburg (1995) addressed in design methodology there are two principle questions: 1) What is the essential structure of the act of “designing”, and 2) How should the design process be approached to make it as effective and efficient as possible? The abstract structure and a field of knowledge are two forms of constructing design activities.

Roozenburg (1995) also defined design methodology as the branch of science that critically studies the working procedures that product designers follow, in other words as the study of methods that are or can be applied in the act of designing. It aims at providing conceptual tools for designers to organize the design process effectively and efficiently. Design methodology provides designers with knowledge on the design process. Component parts of this knowledge are:

a) Models of design and development processes representing the structure of thinking and action in design,
b) Methods and techniques to be used within these processes, and
c) A system of concepts and corresponding terminology

In design methodology there are two principle questions:

a) What is the essential structure of designing?
b) How should the design process be approached to make it effective and efficient?

Two Fundamental Paradigms of Design Methodology

A particular study on design methodology by Dorst (2007) found as in any scientific undertaking, the basis of design methodology is formed by paradigms that define the domain and the subject to be studied. In doing this, these paradigms also define the methodologists' perception of the scope, characteristics and ways of working of design methodology itself. This study made a significant progress of exploring the science of design methodology. The study compared two fundamental design paradigm: Design as Problem-solving and Design as Reflective Practice.

1. Design as Problem-solving

According to Newell and Simon (1972) the "rational problem-solving paradigm" developed in the 1960s and 70s was largely inspired by developments in artificial intelligence and the cognitive sciences. The theory can be captured by four propositions.

1) A few gross characteristics of the human information processing system are invariant, regardless of the nature of tasks and problem solvers.

2) These characteristics are sufficient to determine that a task environment is represented as a problem space, and that problem solving takes place in a problem space.

3) The structure of the task environment determines the possible structures of the problem space.

4) The structure of the problem space determines the possible programs that can be used for problem solving.

The problem-solving approach of design methodology serves as the "first generation" method. The positivist background of these theories led to a view of design as a rational (or rationalizable) process. Criticism of these theoretical models raised interest in the underlying fundamentals of design theory, namely the logical form and status of design. It also fostered a need for more detailed descriptions of the design activity, leading to more attention for designers and design problems, rather than just for the design process (Dorst, 1995).

Problem solving theories introduced by Herbert Simon (1992) provided a framework for this extension in the scope of design studies by allowing the study of designers and design problems within the paradigm of technical rationality. This paradigm, in which design is seen as a rational problem solving process, has been the dominant influence shaping prescriptive and descriptive design methodology ever since.

Hatchuel (2002) analyzed the work of Simon on design in its original context, as part of Simon's bigger project in the development if a theory about "bounded rationality". He argues that there are three important differences between situations of design and problem solving:

1. The design situation includes the unexpected expansion of the initial concepts in which the situation is initially framed.
2. The design situation requires the design and use of "learning devices" in order to get a solution.
3. In designing, the understanding and designing of the social interactions is part of the design process itself.

For Hatchuel, design includes problem solving, but it cannot be reduced to problem solving.

2. Design as Reflective Practice (Design as Learning)

A radically different view which tries to arrive at a much closer description of design as it is often experienced by designers concentrates on the learning that takes place during design projects. According to Lowson and Dorst (2009), "In this thinking design can be seen as learning, specifically learning from the uncertainties of the elements of the design problem (p.34). Design can be described as a process of going through "learning cycles" (propose-experiment-learn) until a designer has created a solution to the design problem.

This description of design was most clearly articulated by Schön (1983). He described design and work in the other professions he studied as a process of "framing" a problem (a form of "seeing as"), performing "moves" towards a solution and the "evaluation" of these moves that might lead to new moves or to the seeking of a new frame (Schön, 1983).

Dorst (2006) pointed out for many design projects the problem solving steps can be quite logical, routine, and implicit, without any real need for choice by the designer. Dreyfus (2002) held that problematic situations are the result of a "break-down" in this normal, fluent problem-solving behaviour. These "breakdowns" are then the moments of real choice. These breakdowns are the points that Schön (1983), in his work on reflective practice, describe as "surprise". Schön described them as the turning points in the designer's reflective conversation with the situation.

The two paradigms for design methodology represent two fundamentally different ways of looking at the world, positivism and constructivism. Dorst (1995, 1997) compared these two paradigms of design methodology. He asserts that:

"Describing design as a rational problem solving process is particularly apt in situations where the problem is fairly clear-cut, and the designer has strategies that he/she can follow while solving them. Describing design as a process of the reflection-in-action works particularly well in the conceptual stage of the design process, where the designer has no standard strategies to follow and is proposing and trying out problem/solution structures" (Dorst, 1995, p.274).

2.2.2 The Problem Solving Nature of Design Thinking

Herbert Simon (1988) stated that the artificial world is centred precisely on an interface between inner and outer environments, that it is concerned with attaining goals by adapting the former to the latter. Design is concerned with how things ought to be, and enacts this focus by devising artefacts to attain goals. The "outer environment" is represented by a set of parameters, which may be either known with certainty or else only in terms of a probability distribution. The goals for adapting the inner to the outer environment are defined by a utility function, which is a function, usually scalar, of the command variables and environmental parameters.

In this research, the nature of design thinking is understood to be heuristic problem solving. [1] It is an every activity of design, including the cognitive activities of thinking and scheming and other activities using visible and physical materials to realize the ideas and designs that aim to fulfil the functional or aesthetic needs of the target group. From general theories of human cognitive processes, the human problem solving process exists in a cycle that psychologists (as Bransford & Stein, 1993) have described as The Problem-Solving Cycle. Davidson (2003) pointed out the cycle consists of the following stages, in which the problem solver must:

1. Recognize or identify the problem.
2. Define and represent the problem mentally.
3. Develop a solution strategy.
4. Organize his or her knowledge about the problem.
5. Allocate mental and physical resources for solving the problem.
6. Monitor his or her progress toward the goal.
7. Evaluate the solution for accuracy.

The cycle is descriptive and does not imply that all problem solving proceeds sequentially through all stages in this order. Rather, successful problem solvers are flexible. The steps are described as a cycle because once they are completed, they usually give rise to a new problem, at which point the steps need to be repeated. In this way the cycle also represents the dynamic of the evolutional process of the human artificial world.

Well-Defined Problems and Ill-Defined Problems

[1] Heuristic refers to experience-based techniques for problem solving, learning, and discovery. In psychology, heuristics have been used to explain how people make decisions, come to judgment, and solve problems.

A problem is an obstacle, implement, difficulty, challenge, or any situation that invites a response, the resolution of which is recognized as a solution or contribution toward a known purpose or goal. The word problem is also used in a general sense to refer to any mental activity having some recognizable goal, although the goal itself may not be apparent from the start. According to Kim (1990), problems may be characterized by three dimensions: domain, difficulty, and size. Domain refers to the realm of application for the problem. Difficulty pertains to the conceptual challenges involved in identifying an acceptable solution to the problem. A difficult problem is one that has no obvious solution, nor even a well-defined approach to seeking a solution. Size denotes the magnitude of work or resources required to develop a solution.

Furthermore, there are two classes of problems: well-defined and ill-defined. The real difficulty of solving an ill-defined problem is in clarifying the nature of the problem: how broad it is, what the goal is, and so on. Although well-defined problems have a clear path to a solution, the solution strategy for an ill-defined problem must be determined by the problem solver.

The solution for a difficult task cannot be obtained in a straightforward fashion. The ideation phase consists of a sequence of generate-and-test cycles; potential solutions or intermediate results are concocted, evaluated for their utility, and examined to guide the next cycle of idea generation. For most difficult problems, the implementation will evolve gradually over time, rather than all at once.

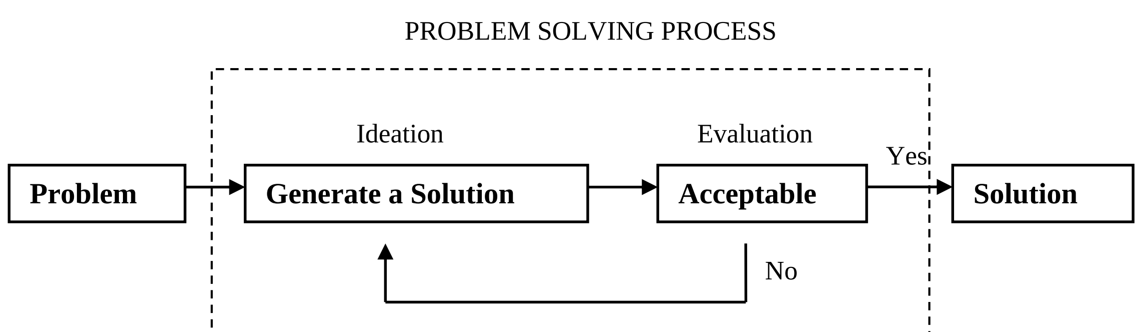


Figure 2.1: Components of the Problem Solving Process (Kim, 1990)

“Ill-structured” Design Problems

According to Christopher (1997), design problems commonly arise from “conflicting forces”, such as the conflict between wanting a room to be sunny and wanting it not to overheat on a summer afternoon. Designers usually are not told how many windows to put in a given room; rather, they work from a set of values that guide them toward a decision that is best for the particular application.

Buchanan (1992) stated that ill-formulated design problems are “wicked problems”. Design problems are “indeterminate” and “wicked” when the design has no special subjective matter of its own, apart from what a designer conceives it to be.

Bryan Lawson (1992) summarized the salient features of design problems and solutions, as well as the lessons that can be learned about the nature of the design process itself, as follows:

Design Problems	Design problems cannot be comprehensively stated. Design problems require subjective interpretations. Design problems tend to be organized hierarchically.
Design Solutions	There are an inexhaustible number of different solutions. There are no optimal solutions to the design process. Design solutions are often holistically responsible. Design solutions are a contribution to knowledge. Design solutions are parts of other design problems.
Design Process	The process is endless. There is no infallibly correct process. The process involves finding as well as solving problems. Design inevitably involves subjective value judgment. Design is a prescriptive activity. Designers work in the context of a need for action.

Table 2.1: Features of Design Problems and Solutions (Lawson 1997)

Prior knowledge plays a role in both analogical reasoning and expert problem solving. The key to creative problem solving continues to be the process by which a person understands the underlying structure of a problem, a process called insight.

Simon (1973) noted that the boundary between well-structured and ill-structured problem solving is indeed vague and fluid. There appears to be no reason to suppose that concepts as yet un-invented and unknown stand between us and the fuller exploration of those domains that are most obviously and visibly ill-structured. This assumption suggests that there may be nothing other than the size of the designer's knowledge-base to distinguish ill-structured problems from well-structured problems. Thus, general problem-solving mechanisms that have shown themselves to be efficacious for handling large, albeit apparently well-structured, domains, should be extendable to ill-structured domains without any need for introducing new qualitative components.

Dorst (2006) pointed out that there may be elements within the process of solving ill-structured problems that can actually be more or less straightforward steps, but that doesn't mean that the solving of ill-structured problems can be reduced to these straightforward steps. He concludes that: 1) the "design problem" is not knowable at any specific point in the design process; 2) the "design problem" is hard to identify because it evolves in the design process; 3) the connotations of the very concepts used to describe a "design problem" shift as a part of the design effort. From Schön (1982), good design is a prime example of reflective practice, which is the flexible process of trial and error that a practitioner engages in to deal with the "messy" problems of life. The designer shapes the situation in accordance with his initial appreciation of it, the situation "talks back", and he responds to the situation's feedback.

2.2.3 Design Process and Design Method

Design Method

Roozenburg (1995) defined a method is the consciously applied formal structure of an action process. According to Newell (1983) method has the following characteristics: 1) It is a specific way to proceed; and 2) It is a rational procedure.

A method is general, meaning it is applicable to more than one problem. Only methods that sufficiently "organize" someone's behavior will lead to a significant greater chance of success. Additionally, the use of method is observable. From an experimental point of view one must be able to ascertain whether someone acts according to the method in question.

The influence of systems analysis and system theory on design established the grounds for the development of "systematic design methods". This is the first "generation" of design method. Researchers began looking at rational methods of incorporating scientific techniques and knowledge into the design process to make rational decisions to adapt to prevailing values. They were attempting to work out the rational criteria of decision making while trying to optimize design decisions. Herbert Simon, in his book The Science of the Artificial (Simon, 1968), defined design problems as "wicked" problems, for which finding appropriate solutions was very difficult and each solution to a problem created new problems requiring resolution. Researchers such as Cross (1993) and Rittel (1972) criticized the "first generation" design methods as simplistic and not incapable of meeting the requirements of complex real-world problems.

Structured design methods are procedures, techniques, and tools that help guide and facilitate the solving of design problems. According to Stoll (1999), design methods benefit the design problem solving process in two ways. First, design methods provide discipline and objectivity by formulizing various procedures of design. Second, in group scenarios design methods can facilitate the team approach by making the problem solving process explicit. All members of the team can see and understand what is going on and contribute to the process.

Roozenburg (2005) addressed design methods as heuristic methods based on "weak" forms of knowledge. They do not guarantee a result but do increase the chance of achieving a result.

The limitation of design methods is that, in general, they aim at one aspect or part of the design problem only, without indicating how the result can be "integrated" in an overall solution to the problem. The challenge is to transform individual experiences, frameworks, and perspectives into a shared, understandable, and, most importantly, a transmittable area of knowledge. Though open to interpretation, it is a shared belief in an exploratory and rigorous method to solve problems through design, an act which is the ultimate aim of designers.

Design Process

According to Christopher (1970, 1992), “process” is a naturally occurring or designed sequence of operations or events over time which produce desired outcomes. Process contains a series of actions, events, mechanisms, or steps which contain methods. Method is a way of doing something, especially a systematic way through an orderly arrangement of specific techniques.

There are many similarities between the design processes in such diverse fields as architecture, mechanical engineering, and the development of the “objects” of management, such as policies, strategies, and organizations. The form of the design process appears to be neither dependent on the content of the problem, nor on the type of objective being designed. The same procedure is followed in all design processes and consequently comparable methodological problems occur. Many design methods have their origin in the same more general methodologies such as the systems approach, operations research, and decision theory.

Process is a naturally occurring or designed sequence of operations or events over time that produces desired outcomes. Process contains a series of actions, events, mechanisms, or steps. A method, on the other hand, is a way of doing something, usually a systematic way that follows an orderly arrangement of specific techniques. Method should have a process but the process can occur in various sequences. It can also be in the form of a conceptual model or framework.

Joseph (1996) noted that objections to systematic design methods have often consisted of a refutation of the validity of the system by describing examples of design activities of design problems outside the system. Such activities might be characterized as the less mechanical parts of the design process or those that call for human undertaking and interaction.

Akin (1984) stated the compartmentalization of the design process into three rigid phases: analysis-synthesis-evaluation. Swann (2002) identified the design process as iterative. It can only be effective if it is a constant process of revisiting the problem, re-analysing it, and synthesizing revised solutions. Research by Lowson (1984) compared the ways in which designers (in this case architects) and scientists solved the same problem in order to look for underlying rules which would enable them to generate the correct, or optimum, solution. The finding was that designers tended to suggest a variety of possible solutions until they found one that was good or satisfactory. The evidence from the experiments suggested that scientists problem-solve by analysis whereas designer problem-solve by synthesis; scientists use "problem-focused" strategies and designers use "solution-focuses" strategies. He also asserts that the design process is a research process. The action of designing is the same as the moment of synthesis that occurs in all forms of research, when the various parts of the data and analysis begin to make sense.

The literature on design and product development contains a variety of models of designing. Roozenburg (2005) argued that "The first model sees designing conceived as a specific form of problem-solving. In problem-solving steps can be distinguished which form a cycle that plays a part in each phase of the product design and product development process. The second type of models describes product design as a process in which the design of a product is worked out on different levels of abstraction. These levels correspond to various forms in which a design in the making can be represented. The third type considers the phase models of the product development process. These comprise activities of the product design process, as well as of production development and the development of the market plan. The three types of models portray different dimensions of designing products" (p.83-84).

2.2.4 Creativity in Design Process

Creativity is the phenomenon of creating something new. It is generally understood to be associated with intelligence and cognition. Creativity is a fundamental cognitive ability of human beings which intrinsically exists and develops during the life process. Barron and Harrington (1981) demonstrated the relationship between human's personality and creative capability. They argue that biological differences affect creative abilities. Daley (1984) argued that "Pure reason inhabiting mind, and sense experience being a function of body, offered a conceptual framework in which the criteria for knowledge, and for creativity, were describable" (p.292). Without sense experience there would be no ideas. The very concept of perception is meaningless without a logical prior system of categorical organization. Knowledge and environment also influence creative abilities. Sternberg (2006) developed an investment theory of creativity, a confluence theory (Sternberg & Lubart, 1991, 1995) according to which creative people are those who are willing and able to "buy low and sell high" in the realm of ideas (see also Rubenson & Runco, 1992, for the use of concepts from economic theory). Buying low means pursuing ideas that are unknown or out of favour but that have growth potential. According to the investment theory, creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment.

Marc Newson, one of the most influential industrial designers, argued that different design disciplines (architectural, interior, product, etc.) are different forms of expressing creativity. He sated creative thinking requires a process that is quite different from that of rational thinking (Designer of Scale: Marc Newson at TEDxSydney, 2013). Whereas rational thinking depends on categories and labels that have been set up in advance, creative thinking demands that we form new categories and labels. Rational thought leads us to find the similarities between a new experience and previous experiences. Rubinstein and Firstenberg (1999) addressed creative thought looks for the differences among experiences, seeking unique ways of both interpreting situations and acting upon them.

Kinds of Creative Contributions

Sternberg (1999) demonstrated creative contributors make different decisions regarding how to express their creativity. The basic idea is that creativity can be of different kinds depending on how it propels existing ideas forward. When developing creativity we can develop different kinds of creativity ranging from minor replications to major redirections of thinking. A creative contribution represents an attempt to propel a field from wherever it is to wherever the creator believes the field should go. Thus creativity is, by its nature, propulsion. The eight types of creative contribution are divided into three major categories: contributions that accept current paradigms (replication, redefinition, forward incrementation, advance forward incrementation) contributions that reject current paradigms (redirection, reconstruction, reinitiation), and paradigms that attempt to integrate multiple current paradigms (integration).

Creativity is the basic intelligent ability of a designer. According to Cross (1990) design ability is a multi-faceted cognitive skill possessed in some degree by everyone. Gardner (1983) distinguished six forms of intelligence: linguistic, logical-mathematical, spatial, musical, bodily-kinaesthetic, and personal.

Jones (1970) described a cognitive process of design that can be broken down into three stages:

1. Divergence: this stage is the act of extending the boundary of a design situation so as to have a large enough, and fruitful enough, search space in which to seek a solution;
2. Transformation: this is the stage when objectives, brief, and problem boundaries are fixed, when critical variables are identified, when constrains are recognized, when opportunities are taken, and when judgements are made;
3. Convergence: at this stage the problem has been defined, the variables have been identified and the objectives have been agreed to;

March (1984) identified the iterative procedure of design process of PDI model (production/ deduction/induction). He writes of rational designing as having three tasks: 1) the creation of a novel composition, which is accomplished by productive reasoning; 2) the prediction of performance characteristics, which is accomplished by deduction; and 3) the accumulation of habitual notions and established values, an evolving typology, which is accomplished by induction.

Creativity emphasises the intuitive internal creative processes of the designer. Amabile (1983) noted that research into creativity has been mainly undertaken within psychology, and even there it is relatively unrepresented. The creative perspective on the design process is exemplified by Glegg (1971), who provided this outline:

1. Design perception of realities: observation through the senses - mainly sight in most disciplines.
2. Description of objects: objects are typically described adjectivally rather than by using simple noun descriptions.
3. Behaviour of elements: the main focus is on the interrelationships between elements. Although elements have intrinsic characteristics their properties are more commonly defined by other elements and external influences.
4. Mechanism of choice: where design is seen as a creative process the dominant mechanism of decision-making and evaluation is the use of “feeling”.
5. Design methods: a range of methods have been developed to facilitate the designer’s use of the right hemisphere of the brain. Such methods include associative and analogical techniques such as “synectics”, mind maps, and brainstorming. Many of these methods are also intended to discourage analytical thinking or use of the left hemisphere of the brain. Other methods provide guidance in specific domains for visual creativity and manipulation of concepts. These techniques include concepts of visual balance, the flow of form, repetitive elements, and geometrical transformation. All creative design methods necessarily depend on a sufficient base of experience residing within the designer(s).
6. Design process structure: design process models are often similar to more technically based process models. The creative aspect of design process is seen as “intuitive” or mysterious and is the most dominant aspect of the process with all other process elements having a supporting role.
7. Theories about the internal process of designers and collaboration: some theories are romantic in style emphasising the creative genius of the individual. Other theories try to explain creativity as a function of particular biological and psychological processes. The description of individual designer’s creative

processes refers to the designer's intuition, experience, feelings, and style together with the domain's tradition.

8. General design theories: design is seen as a creative activity.
9. Epistemology of design theory: assessment of the validity or coherency of design information, methods, and theories is seen to be part of the intrinsic creative activity of the designer or design theorist.
10. Ontology of design: there are many ontological bases espoused by those who view design as creative process. This metaphor of design includes human values, attitudes and assumptions.

Dorst and Cross (2011) proposd a model of creative design as co-evolution. They argue that "creative design seems more to be a matter of developing and refining together both the formulation of a problem and ideas for a solution, with constant iteration of analysis, synthesis, and evaluation process between the two notional design 'spaces'-problem space and solution space." They address the problem space and the solution space co-evolving together, with exchange of information between the two spaces. Their observations confirm that creative design involves a period of exploration in which problem and solution spaces are evolving and are unstable until (temporarily) fixed by an emergent bridge which identifies a problem-solution pairing.

2.3 Insight Interpretation in Design Process

2.3.1 Interpretative Thinking as a Driver for Creativity in Design Process

According to Scheckel's (2005) explanation, interpretive thinking is "thinking that is reflective, embodied, multi-perspective, contextual, circular, and communal, and that seeks to reveal explanations as well as meanings and significances." Rodrigo (2010) demonstrated interpretation is seen as the act of positioning, of situating ideas within a set of relationships, of holding a point of view. These ideas supports the direct relation of interpretative thinking process and the creative design process.

Concepts are generalizations about the world that can be used for inference. Smith (1981) advocated no experience is exactly identical to a previous experience, but because our minds are able to retain concepts we can acquire and then re-use knowledge from experience in the world. Howard (1987) also addressed concepts allow us to make inferences about the world. Concepts are created from invariance over experience. Concepts are identified as units of knowledge within the agent, but their use within a situation allows for concepts to change the use of other concepts.

Cross (1997) described a model of creative design by addressing cognitive techniques and procedure of associative design thinking. Creative design can occur by combining features from existing designs into a new combination or configuration. Creative design by mutation involves modifying the form of some particular feature, or features, of an existing design. The term 'analogical thinking' has long been and suggested as a basis for creative design. The two are both related to the process of interpretive thinking in design.

In "Interpretation in Architecture: Design as a way of Thinking", Snodgrass and Covne (2006) argue that "to design is to interpret". The act of interpretation is seen as the act of "positioning" within a set of relationships. At its core, they argued that design is interpretational when designers are involved in the process of decision making, of assessing possibilities, and of making creative decisions.

During the design activity designers interpret by constructing from expectations. Whenever a designer brings something from the external world into their internal world, interpretation occurs. Kelly and Gero (2011) provided this summary:

1. Concepts are changed by the situation within which they are used: a concept might be represented as a discrete unit of knowledge, but these units of knowledge are never used in isolation. Their use is tied to the situation and to other concepts used at the same time.
2. Interpretation begins with construction from expectation and can lead to a change of situation when construction is not possible. When interpreting, designers attempt to construct from their expectations. When expectation cannot be met then

interpretation leads to either a change in the concepts in the situation, or else a change in the way that each concept in the situation is used.

3. A change of situation through interpretation can be a driver for creativity. When conceptual expectations cannot account for perceptual data new concepts can be brought into a situation, changing it.

Goel (1997) pointed out analogical design involves the recall and transfer of elements of a solution for one design problem to the solution for another design problem. Design, especially creative design, involves a variety of other design tasks such as interpretation of potential difficulties with a candidate solution, refinement of a candidate design, evaluation of a candidate design, interpretation of evaluation information, and reformulation of the problem. Analogies, in general, may help address any of these design tasks.

2.3.2 Interpretive Thinking Patterns in Design Process

Objective Interpretation and Subjective Interpretation

Gadamer (1986) claimed that interpretation is a dualistic activity: it is both a revealing of what the thing itself points to and also an attribution of value to something. The revealing of what the thing itself points to could be called an "objective interpretation". This is the case when some external element impresses its meanings upon the observer. The attribution of value, called "subjective interpretation", is when the subject, in an act of will, impresses meaning and value upon something.

According to Dorst (2007), whether a part of design activity will involve "objective" or "subjective" interpretation ultimately rests with the designer working on the design problem. Empirical evidence has shown that there are a number of influences on this interpretive behaviour exhibited by designers (Dorst, 1997):

1. Inasmuch as a design project is a problem solving process for the outside world, it needs to be controlled and the design decisions must be justified to the stakeholders. In that case there is an emphasis on objectifying the goals and decisions in the design project, to

effectively eliminate the implicitness and elements of subjective interpretation for design activities. The "objectivity" of the steps in a design process and of the terms used to describe the design process can thus be considered an artificial construction by the designer for special purposes. This interpretive thinking pattern can be used to interpret insights for a given design problem from the problem solving design paradigm.

2. "Subjective Interpretation" can be very important in a design project when the design problem is ill-structured. In such a situation, subjective structuring is the only way to make sense of the problem. The problem can be structured by imposing the personal goals of the designer to the design problem, which can be achieved when the designer subjectively chooses priorities. This interpretive thinking pattern can be referred to in this research, when interpreting insights through the method of identifying the design problems. Identifying the design problems requires the designers to make subjective decisions and have a certain degree of intelligence.

The design activities in which "objective interpretation" plays a major role are described by the rational problem solving paradigm. Activities that involve "subjective interpretation" are most easily described by the paradigm of reflective practices.

Research of human interpretive thinking belongs to the domain of cognitive psychology, which is itself closely related to research concerning design thinking. In this research interpretive thinking describes a dualistic process which moves from inductive thinking to deductive thinking to abstract the generic meaning of the insight and fit specific applications of the abstracted insight to the insight's problem solving nature. Insight interpretation is discerning, and can be described as a kind of deductive, language-based interpretation of the insight. I propose different specific contexts that can rationally imply the meaning of the SPD insights. As Fullerton (1915) pointed out, it is the task of reflective thought, not in the first instance, to extend the limits of our knowledge of the world of matter and of minds, but rather to make us more clearly conscious of what that knowledge really is.

Design Language and Interpretation

This research uses the linguistic form to represent abstracted meanings as insight. When one thinks of the designing process, language is not usually the first type of representation that comes to mind. Visual forms, equations, and diagrams are those forms most often thought of when it comes to describing design thinking. Moreover, designers produce representations in various formats, including drawings, equations, diagrams, and multimedia. More often than not, these representations are accompanied by language-based descriptions. Language is a medium by which designers give an account of design, although it is almost always accompanied by visual forms (Dong, 2009).

According to Krippendorff (2006), language is a system of signs and symbols. He considers language to be a medium of representation, and so considers truth to be the validity criterion and looks for references in the non-linguistic, and often the physical, world. In language, artefacts are conceptualized, constructed, and communicated; their meanings are negotiated and their fate is determined. Such processes cannot be described or measured in cognitive, ergonomic, or technological terms. They must be explained in linguistic terms.

The conceptions provided by language are an indispensable part of how artefacts are perceived, conceptualized, and communicated about. Narratives place artefacts into grammatical constructions that provide not only the linguistic context of the noun object, but also define the dimensions in which the reader is likely to view the artefacts. Language is a cultural artefact that enables humans to coordinate their conceptions, engage in joint action, and construct and reconstruct the realities they see. When it comes to the use of language, acting, perceiving, and communicating are inseparably tied to a constructive understanding (Krippendorff, 2006).

Arthur (2009) discussed design as expression within language. According to his notion of design, there are articulate and inarticulate utterances in a language, there is conciseness in language, and there are degrees of complication in what is expressed in language. An idea expressed in language can be simple and expressed in a single sentence, or it may take up an entire book.

Semantically labelling a design concept with a word assists the designer to recall the concept from memory at a later time. Creating the semantic label for the design concept also allows designers to "think by writing" in ways similar to the "think by sketching" method. It is to the texts that designers produce while designing that people turn to for insight into the design process and the designed work—these texts show what the designer was truly thinking. Richard Buchanan (1989) theorized that "design actually involves a skilful practice of rhetoric…through all of the activities of verbal invention and persuasion that go on between designers, mangers and so forth, but also in persuasively presenting and declaring that thought in products. The language of design texts serves a constitutive and instrumental role in design" (p.91-109).

Different Models for Design Reasoning

Dorst (2011) synthesized the most basic reasoning patterns by comparing different "settings" of the knowns and unknowns in a stylized equation:

What (thing) + How (working principle) leads to Result (observed);

1. *What* +*How* leads to ???

This is the deductive logic of analytic thinking. In deduction we know 'what' and we know 'how', as well as how the two operate together. This allows us to predict results with some reliability.

2. *What* + ??? leads to *Result*

This is inductive logic. We know the 'what' in the situation and we can observe results, but we lack knowledge of the "how".

These two forms of analytical reasoning predict and explain phenomena that are already in the world. What if we want to create valuable new things for others, like in design and other productive professions? The basic reasoning pattern then is known as "Abduction":

What (thing) + How (scenario) leads to Value (aspired)

1. ??? + How leads to Value

Abduction comes in two forms that have in common that we assume knowledge of the target ‘value’ we set out to achieve. In the first. ***Abduction-1***, which is often associated with “problem solving”, we also know the “how”, a “working principle”, and how that will help achieve the value we aim for. What is still missing is a “what” (an object, a service, a system), so we set out to search for this missing component. This is often what designers and engineers do – create an object that works within a known working principle, and within a set scenario of value creation.

2. ??? (thing) + ??? (scenario) leads to Value

In the second form of ***Abduction-2***, we only know the end value we want to achieve. We have to create a “working principle” and a “thing”. These models of design reasoning have been applied in this research to provide effective thinking techniques during the insight interpretation process.

2.3.3 A Model for Interpreting Insights: Completing the Insight Schema with Adaptive Alternatives

According to Durling and Cross (1996), creativity is central to designer’s thinking, although their methods of working and their attitudes toward the solving of problems may be very different than those of other professionals. Creative thinking occurs when a problem solver invents a novel solution to a problem (Guilford, 1950). Mayer (1992) found the term insight has been used to name the process by which a problem solver suddenly moves from a state of not knowing how to solve a problem to a state of knowing how to solve it.

A second quality that characterizes the suddenness of insight solutions is the seeming non-ambiguity of the recognized product. The source of the non-ambiguity may result from certain distinctive properties of the situations that elicit sudden recognition. The recognition of insight solutions has two qualities: first, prior to the solution, there are a number of problem elements that are presented together but lack coherence; second, when the solution is found, the designer perceives distinct coherence in the relationship between the problem elements. Insight may be associated with situations in which one coherent pattern can be substituted for another. According to the insight-as-completing-a-schema view (Mayer, 1995), creative problem solving involves figuring out how the givens and goals of a problem fit together within a coherent structure. That is, insight occurs when a problem solver fills in a gap in a structure complex.

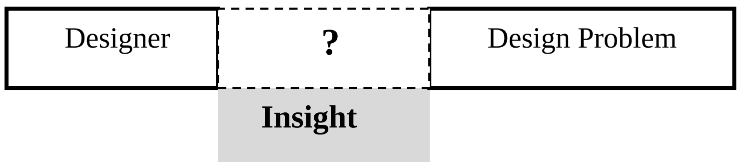


Figure 2.2: Insight as Completing a Schema

A problem may be a coherent set of information with a gap. To solve the problem, the individual must find a way to fill the gap in a manner that completes the structure. This view is contrasted with traditional associationism views, because it posits that the strength of association between ideas is not what leads learners to a particular solution, but rather the degree to which an idea fits the learner's schema of the requirements of the problem.

Due to the creative nature of design problem solving, there could be numerous specific design solutions for one design problem. The amount of creative thinking in design manifests the quantity and quality of solutions that a designer sees in response to a design problem. The connection and selection process that occurs in a designer's mind is very fast. In the workshops, participants were able to give scores of initial ideas to design problems.

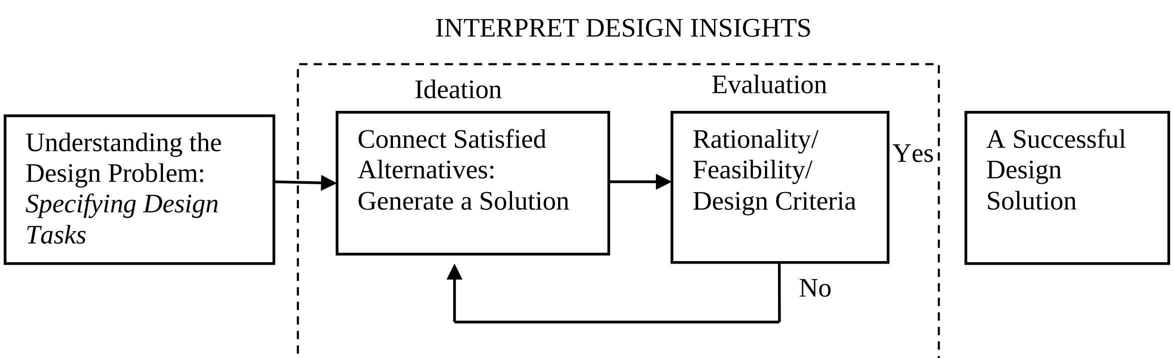


Figure 2.3: A Problem Solving Model of Interpreting Design Insights

According to the insight abstracting format explained in the previous chapter, every insight can be described in a syntax form, which represents a way of panning the elements of a design scheme. Those elements can be types of material objects that cooperate to serve certain functional or aesthetical purposes. They can also be descriptive attributes or themes that relate to human values and reflected behaviours, generated from the design reasoning of the studied artefacts. Those kinds of insights are highly abstracted to inspire designers with new approaches or methods in adaptive new design contexts to solve similar or related design problems.

Abstracting design insights from artefacts studies is an inductive thinking process. The "syntax" of the design insights equals the "structure" of filling the gap between the design problem and the designer's understanding of the problem. Every insight can be a possible method to solve the design problem.

Schooler (1995) emphasized that the ability to find alternative approaches to problems requires the designer to recognize analogies. Analogies represent one of the central sources of insight, as they enable the individual to conceptualize better the ill-defined problem space in which he is working by relating it to some other problem space that is better defined.

It is a characteristic of the search for alternatives that the solution is built from a sequence of component actions; the enormous amount of alternatives arises out of the innumerable ways in which the component actions, which need not be very numerous, can be combined into sequences. At the first stage, designers should study the design problem to define scope and approach. The philosophic roots of the design problem should be considered if a designer wants to create new values. Redefining the philosophic problem of the design tasks can lead to more creative concepts. Thus, the scope of choosing adaptive alternatives increases while there is a broad boundary for insight when it comes to completing the schema of the problem solving process.

2.3.4 Particular Context of Insight Interpretation in This Research: reapply abstracted SPD solutions from CTEAs

In this research, design insight can be briefly defined as abstracted design solutions inspired by the selected CTEAs; these solutions might solve a given design problem or be discovered without a problem in mind, and applied to a problem later. They are perceived and described during the process of investigating and understanding how the selected CTEAs were designed to achieve the SPD attributes. The insights are abstracted from original design solutions and can potentially be applied in other design contexts to make specific design concepts. The generated design concepts have similar fundamentals of design, either in approach, methodology, or both.

The reason why design insight, in the context of this study, is defined as an abstracted design solution, is because the purpose of building this method is to solve one or more related design problems for the requirements of contemporary society. The shifting of different design contexts requires the embedded meanings to be extracted from their original contexts to fit a category of contexts.

Abstraction is a basic human cognitive pattern for knowing and building knowledge. Mind, language, and symbolism are the primary characteristics of humans. It is a quality of humans to know the world through reading information about, connecting to existing knowledge, comparing and finding similarities with, and categorizing information. The abstractive thinking used in this research is related to personal knowledge structures and patterns of logical thinking. The quality of insights and speed of conjuring insights can be improved through training, modes of which will be suggested at the end of the chapter 6: Research Findings.

The aim of abstractive thinking is to extract general meanings for design thinking, which aims to solve specific design problems through studies of the selected artefacts. The objective of abstracting design insights from artefact study is to devise adaptable solutions to designated or immediate design problems according to the designer's knowledge, skills, and logical thinking ability. In this research, the design problems are specifically defined in everyday, sustainability problems caused by user behaviours, lifestyles, existing products, product systems, and aesthetical or moral human values.

Xin (2007) demonstrated that the insights of cultural artefacts may be captured by impact analyses of cultural artefacts, visual language analysis, and even shape grammar. They directly feed into new product designs. The grammar of cultural artefacts provides a grammatical structure of design decision factors that can be used as a procedural design guideline. Visual language analysis and shape grammar are conventional tools used to transform exterior visual and formal appearances into new product concepts.

Propelled by the previous phase of artefacts studies, the design insights are abstracted by organizing information from design investigations to the chosen artefacts. Key tasks for the I (CTEA)-SPD method include finding and describing connections in the design of the selected artefacts and how these elements satisfy the SPD criteria. In this research, this process is called design reasoning. The insight can be articulated to a more abstracted level by extracting the structure of the information of the specific design reasoning. By referring to the structure of the design reasoning, designers can fit the design reasoning to reformulate other design problems. A pattern of cognitive processes on how to abstract insight will be introduced and explained in the research finding chapter. The pattern is built on observations of the practical behaviours exhibited in workshops and on explorations of theoretical evidence. The pattern is a model of abstracting design insight. It can help to guide abstracting activities for generating quality design insights, and to reduce the intellectual difficulties of the process.

2.4 Interpretation of Chinese Traditional Artefacts for Product Innovation

2.4.1 Design Practices in a Cultural Context

Practices in Contemporary China

Xin and Cagan and Vogel (2007) argued that "Developing products with reference to traditional Chinese elements has become a common strategy for many local and international companies competing in the Chinese market" (p.4). Many companies (such as Shanghai Tang of Richemont, itself a French fashion company) and designers have developed design strategies applying patterns and symbols from Chinese traditional designs in contemporary products. Some Chinese product designers and companies have also begun seeking inspirations and design solutions from indigenous ancient culture. In practice, most successful designs which apply traditional attributes use those features as Chinese cultural markers that are easily identifiable as such by lay consumers. Chinese interior and home product designer Cui Huafeng (崔华峰), his designs have been warmly received by both domestic and foreigner clients in recent years, is a particularly good example. Most of his designs have obvious influences from Chinese traditional aesthetics.

Figure 2.4: Chair Design from Chinese Designer Cui Huafeng

From Eastern to International: Isamu Noguchi's Design Philosophy of Interpreting Traditional Japanese Designs

In design practices and theoretic researches in China and also many other Eastern cultures, interpreting traditional designs is a significant approach in the history of design. One of the most successful design practitioners who had great influence in contemporary design from this approach is the American-Japanese designer and artist Isamu Noguchi (1904-1988). Noguchi was born in American and established his fundamental design and art skills while there. He studied Asian traditional arts and designs to get inspirations for his most successful works, particularly from his ancestral home of Japan. In his products and landscape designs there are no direct visual interpretations from Japanese cultural objects; however he successfully implied the abstracted meanings from traditional designs and crafts to fit modern applications. From his designs we can see the new functions and values of those traditional insights. Among his product designs are the "Radio Nurse" baby monitor, which was made of plastic but carried an implied form of traditional Japanese woodwork, and the Akari Light Sculptures, which combines product functionality, artistic forms, and cultural identity.

Figure 2.5: "Radio Nurse" Baby Monitor, Isamu Noguchi for Zenith Plastics Co., USA, 1937.

Figure 2.6: Akari Light Sculptures Designed by Isamu Noguchi which Apply Traditional Japanese Lantern Designs and Crafts.

2.4.2 Theoretical Approaches and Methods

Some Chinese scholars have attempted to explore qualitative methods and tools for analysing traditional Chinese artefacts and the complex cultural background behind them. Beginning in the 1980s, Chinese researchers, artists, and designers began using globally accepted methods to illustrate and discuss the values of traditional Chinese artefacts and folk arts. The first work to detail relationship between the art of traditional craftmaking and design field was Zhang's (1989) *The Art of Making Things* (《造物的艺术论》). It provided an objective view of the making of traditional artefacts by discussing the intrinsic design philosophies and techniques of the act.

In the discipline of design, specifically, the study of Chinese everyday artefacts has mostly emerged from a desire to get cultural inspiration that can be used for design in general. The objectives of recent design-focused studies can largely be divided into four categories:

1. Appreciation and Understanding

In contemporary design research related to China, identifying the implicit values of traditional Chinese culture is popular in both domestic and foreign research. In China itself, studies on Chinese traditional artefacts tend to be more comprehensive by virtue of their continuity with cultural studies. Many of these researchers also bring backgrounds in cultural studies, the arts and philosophy. Some are themselves artists with at least some working knowledge of Chinese painting, sculpture, and calligraphy. As indigenous scholars they have grown in the culture, tacitly critiquing and practicing Chinese cultural heritage from a young age. Appreciation and understanding are more accessible to Chinese researchers in their personal experience and view of the world. Their research aim is to reveal the truth of Chinese civilization of making things and to express their sympathy for the nation (as Zhang, 1989). Many of these researchers can be referred in understanding the traditional culture behind artefacts in the further research.

2. Reveal Symbolic Meaning and Design Context

Contextual research is very important in artefact study. It reveals the rationality and logic behind the inventing and crafting of Chinese everyday artefacts. Comprehending an object's historic context is crucial for understanding other attributes of a cultural artefact. Symbolic meanings are discovered by cross-research with archaeology and close study of literary references. This type of cross-disciplinary research not only illuminates the stories behind the artefacts, but also is invaluable in understanding how to relate the objects back to their original user context (as Li, 2004). These studies provide important evidence for the cultural and historic contexts of the CTEAs forming the basis of this study.

3. Discover Advanced Techniques and Design Thinking

Obviously our contemporary age has seen great advancement in science and technology, and the design field is no different. There has also, however, been growing appreciation for pre-modern cultures and the potential to learn from these cultures as a way to inform current practices. Taking pre-modern China as an example, techniques used in everyday craftwork show a tacit understanding of problems faced by contemporary designers such as conservation of materials and energy, attention to aesthetic beauty through decoration and shape, etc. (as Xu, 1998). Chinese research into this area is applicable to some of the CTEA cases presented here.

4. Systematic Approaches

In recent years, some researchers have begun to develop methods and tools for how to refer to the making of traditional artefacts and cultural symbols in contemporary design and product innovation processes. This research approach helps to open a door to international design researches to investigate Chinese traditional culture by providing scientific tools to see the cultural element from outside. Leong (2003) developed a matrix model of studying cultural artefacts which contains four axes: Material/Design, Behavior, Institution, and Philosophy. Crilly (2010) developed a function matrix representing how the different functions of an artefact plays. These functions are classified according to purpose, effect, or meanings.

In theoretic studies, there is a lack of in-depth research and appropriate methodology to assist designers understand how culture can be consciously integrated into the product design process (as Moalosi, 2007). There is also lack of solid theoretical framework linking design and culture (as Saha, 1998). Such a framework is required and needs to go beyond the considerations of surface manifestation of culture that have been widely accepted in design methodologies. Moalosi (2007) advocated it must go on to address how the core components of culture can be embedded in designing products. Taylor (1999) argued that the lack of theoretical studies of culture-oriented design challenges designers to gain a deeper understanding of user's culture while embodying cultural factors in when developing new products.

Xin and Cagan and Vogel (2007) pointed out that as many Chinese artefacts are highly symbolic, to obtain a holistic understanding of these artefacts requires the extraction of the hidden meanings behind the evident attributes and a sophisticated understanding of the deeper cultural influences. At the same time, a holistic understanding of the cultural artefacts provides a unique way of understanding the underlying tradition. Xin (2007) developed a tool: ICA (Interpreting Cultural Artefacts) useful for qualitative analysis of both specific cultural artefacts and related traditions. It reveals both evident design features and the deeper cultural meanings of a cultural artefact in three levels: evident attributes, deeper reasoning, and influential factors. Being the only formal method for Chinese artefacts study developed specifically for the design discipline, the tool of is adopted for this research to analyse the cultural background of the selected CTEAs. He also refers to the SETIG model (Social, Economic, Technological, Ideological and Geographical) developed by Vogel and Cagan (2001) to analyse the broader cultural contexts of the artefact. This method helps designers and design researchers structuralize and communicate the complex design reasoning of the cultural artefacts. It is also a useful tool to interpret cultural artefacts for design insights.

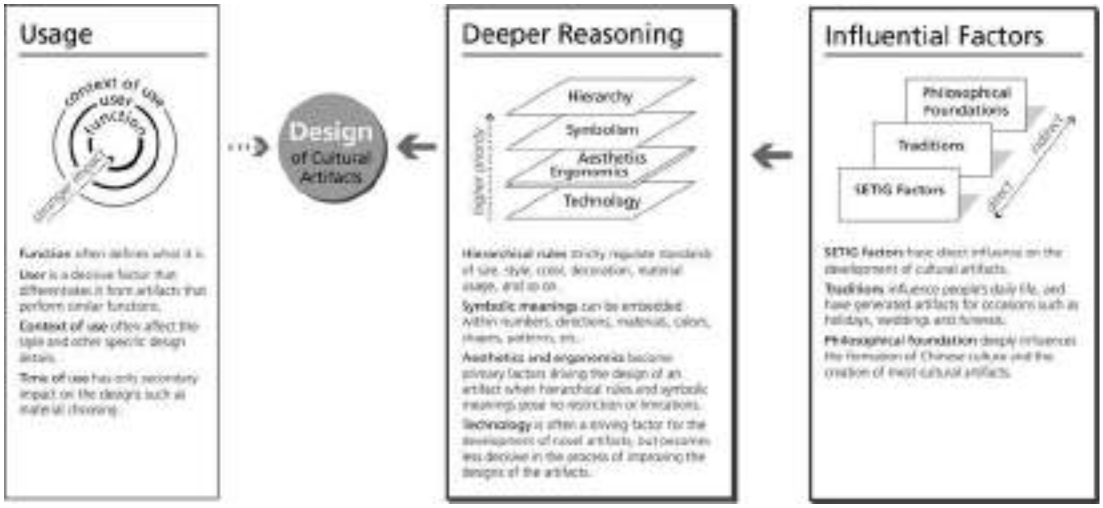


Figure 2.7: Different Factors that Have Impact on the Design of Cultural Artefacts (Xin, 2007)

In his PhD thesis, Xin (2007) points out that creating cultural products requires the understanding of both cultural artefacts and related cultural behaviours and integrating this understanding into unique product/service solutions that are appropriate to the cultural context. Cultural product initiatives tie together methods and tools into a formal process. The focus is on the front end of a new product development process aiming to develop actionable cultural insights to inspire concept generation of new products and services based on the study of cultural artefacts and behaviours.

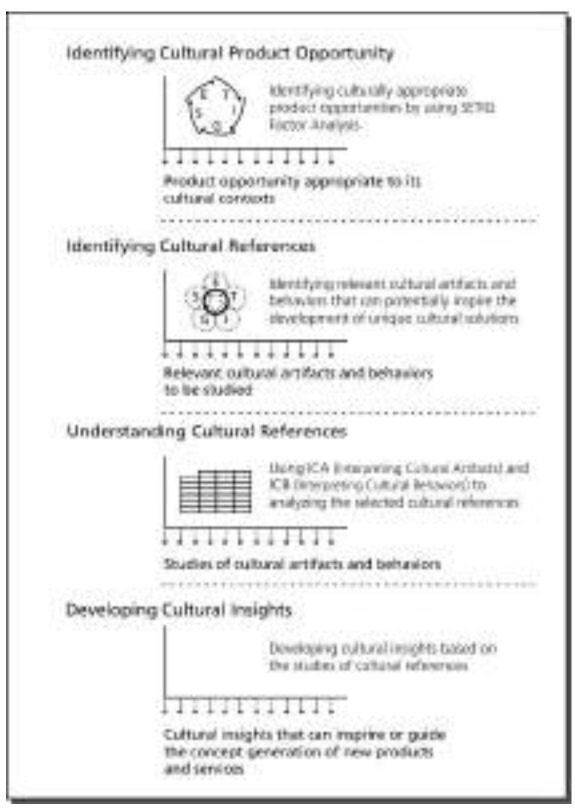


Figure 2.8: Cultural Products Development Process (Xin, 2007)

As one of my PhD supervisors, Xin's research on Chinese cultural artefacts and his contributions to this area have many influences to this research project, especially his idea of structuring different dimensions and levels of interpretation, which inspired me to develop my own tools for studying and understanding CTEAs.

2.5 Fundamental Knowledge of Sustainable Product Design

Sustainable Product Design (SPD) is a synthetic and highly abstract concept. The theoretic research on SPD stems from multi-disciplinary domains which including philosophy, ecology, sociology, economy, engineering, environmental studies, and anthropology. As sustainable product design is the particular goal of developing the I-SPD method in its application value, it is difficult to gain an in-depth understanding without systematically learning its related knowledge and practices. Studies of SPD can have content from different aspects and utilize methodologically different approaches. They also consider different dimensions of design study, such as philosophical explanations, methods explorations, and guidelines collections. In this research, to support the empirical experiments of research and design practices to develop the I-SPD method, I tried to learn and construct the existing knowledge of SPD in two ways. First was by systematically studying the fundamental knowledge of SPD. Second was by building a framework of design criteria to guide the design and evaluation process of the method. In this part of literature review, I briefly combine the important background knowledge of SPD. It can help readers and users of the method to gain a quick understanding of this fundamental knowledge. The SPD criteria building will be introduced in chapter 4: Building SPD Criteria.

2.5.1 Sustainability and Sustainable Development

Purpose of SPD: "Sustainability" and "Sustainable Development"

The purpose of sustainable product design is for the "Sustainability" and "Sustainable Development" of the human species as well as other living species of the natural world. The concept of "sustainability" was rooted in environmentalism and green politics. Wall (2010) stated unease about the adverse consequences of human actions on the environment predates the modern concept of "environmentalism".

In 1987, the World Commission on Environment and Development (WCED) published *Our Common Future*, also known as the *Brundtland Report,* which linked social, economic, cultural, and environmental issues with global solutions. It popularized the term "Sustainable Development." The British Council for Sustainable Development, which later became The World Business Council for Sustainable Development, subsequently published *Changing Course*. This book established business interests in promoting sustainable development practices. In the same year, the UN Conference on Environment and Development (UNCED) was held in Rio de Janeiro. Agreements were reached on *Agenda 21*, the Convention on Biological Diversity, and the Framework Convention on Climate Change, the Rio Declaration, and non-binding Forest Principles. In May 1999, the UK's Sustainable Development Strategy was published and defined sustainable development in terms of four objectives:

1. Social progress that recognizes the needs of everyone.
2. Effective protection of the environment.
3. Prudent use of natural resources.

The Prism of Sustainability

The concept of quality of life is based on, but not restricted to, a certain standard of living. It includes non-monetary values such as a healthy environment, equal opportunities, and the level of social cohesion in society. Furthermore, standard of living is determined not only by monetary income but also by the kinds of goods and services available, whether they are purchased, donated, or self-made, to humans in their everyday lives.

Sustainability in this sense can be understood as consisting of four dimensions, as depicted by the prism of sustainability (UNCSD, 1996).[2]

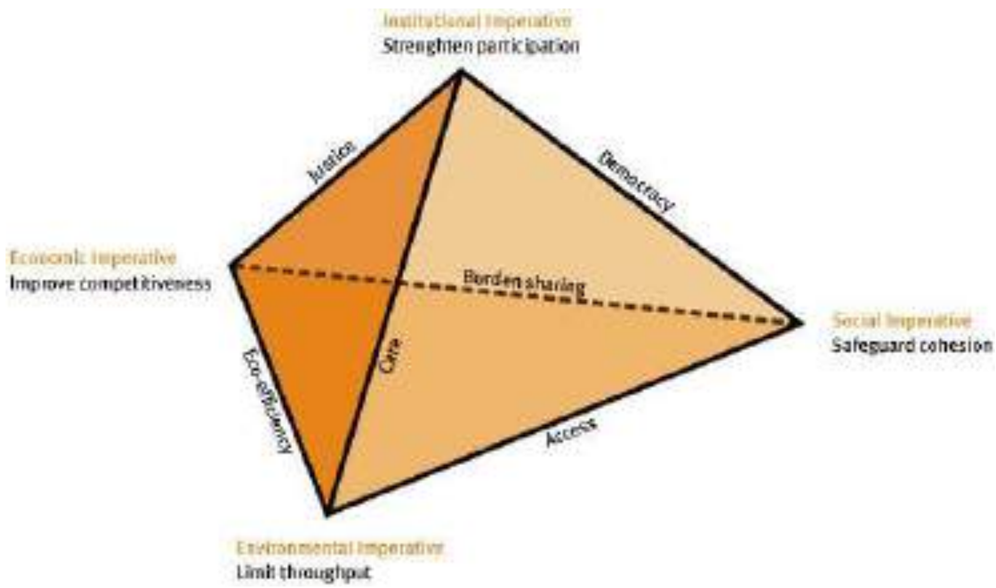


Figure 2.9: The Prism of Sustainability (Spangenberg, 2000)

In the prism, the environmental dimension is quite clearly defined to be the sum of all bio-geological processes and the elements involved in them. Sustainability demands that the viability of ecological systems be preserved as the natural base sustaining human civilization.

The social dimension consists of the personal assets of individuals, their experiences, dedication, and resulting behaviours. It also calls for human development, for improved health standards and skills, and for the absence of poverty and misery.

Institutions contain explicit and implicit rules of societal decision-making and the means of implementing these rules. From a sustainability perspective, the following elements are

[2] The first United Nations Conference on Sustainable Development was in 1992. The United Nations Conference on Environment and Development (UNCED) was organized by the United Nations Department of Economic and Social Affairs in 1996.

desirable: a maximum of participation; equal opportunities regardless of social status, ethnic background, or gender; equity in the justice system; and an ethical administration.

The economic dimension is singled out as a specific subsystem of society because of its inherent characteristics, such as its logic of economic efficiency, short time-frames, and its perception of human beings as profit-maximizing individuals. To meet the demands of economic development for societies and individuals, the competitiveness of the economic system must be part of the sustainability concept.

This prism explains how humans can work on the sustainable development of the whole eco-system by their activities and decisions. It gives directions for designers to figure out how designs can be made or improved to contribute to the design aspect of sustainability.

The *Brundtland Report* (WCED, 1987) also made recommendations for a new approach to design and produce items, setting out terms for "a production system that respects...the ecological base and a technological system that searches continuously for new solutions." The particular focus on design is justified, as 80% of a product's environmental and economic costs have occurred by the final design stage, before production begins. Therefore, integrating considerations relating to sustainability into design has the potential to bring far-reaching benefits.

2.5.2 Development of Sustainable Product Design (SPD)

1. Early Phase: Design for Safety and Eco-Efficiency

"Eco-design" and "Design for Environment" became known and greatly emphasized in design industry science as of the 1990s. Quite a lot of textbooks and numerous journal articles explained the concepts and provide design tools and strategies.

Joseph Fiksel (1996) defined "Design for Environment" as "systematical consideration of design performance with respect to environmental, health, and safety objectives over the full product and process lifestyles". For Fiksel, design for environment is a way to "achieve sustainability while seeking competitive advantage". In this book, Fiksel encompasses the issues of occupational and consumer health and safety, ecological integrity, pollution and toxic use reduction, safety and energy use in transport, minimization and reduction of waste, product disassembly and disposability, and recyclability and remanufacture. Design for environment is the “design for safe and eco-efficient.” Different approaches to product design have been provided, including material substitution, waste source reduction, substance use reduction, energy use reduction, product life extension, and design for disassembly, recyclability, reusability, remanufacture, and energy recovery. Fiksel’s definition of design for environment is quite broad and can be seen as encompassing sustainable design. However, in practice, it tends to focus on maximizing the environmental attributes of products, and rarely considers the social factors of the product lifecycle.

At the same time, “Design for X” has become the label of a widely summarized collection of design guidelines. The early evidence of “Design for X” can be traced back to the 1960s. At that time, the subject of designing for economic manufacture received noticeable attention from professional bodies. In 1965, some industrialists reported their experiences with “design for mechanized assembly.” Following came a string of new terms, like Design for Manufacturability, Design for Inspectability, Design for Environmentality, Design for Recyclability, Design for Quality, Design for Reliability, and so on. “Design for X” has become one of the best approaches to implement environmental considerations in design practices.

Tomas Graedel and Braden Allenby (1996) described “Design for X” as a modern approach to industrial product design. They noted that “X” could be one of various aspects, including assembly, compliance, environment, manufacturability, reliability, or serviceability. In their book, *Design for Environment*, they give practical recommendations on designing for energy efficiency and recycling, minimizing industrial process residues, and choosing materials. Although Graedel and Allenby presented a very practical approach to “Design for Environment,” their framework doesn’t consider social factors in production and consuming, and these factors should be encompassed in sustainable product design.

2. The Motivation of Sustainable Design and Social Considerations

The motivation of sustainable design was famously articulated in E. F. Schumacher's 1973 book, *Small Is Beautiful*. In it, Schumacher argues that the modern economy is unsustainable and that natural resources should be treated like capital as they are not renewable. He also argues that nature's resistance to pollution is limited as well. Schumacher's prescription is seeking an "enoughness" that satisfies human needs and understands the limitations and appropriate use of technologies. Schumacher was one of the first economists to question the appropriateness of using GNP (Gross National Production) to measure human well-being, emphasizing that "the aim ought to be to obtain the maximum amount of well-being with the minimum amount of consumption."

Design for social sustainability can be reflected from Ecological Literacy (also referred to as ecoliteracy) by Orr (1992) who thereby input a new value into education: the "well-being of the earth". Eco-literacy focuses on understanding the principles of organization of ecosystems and their potential applications to understanding how to build a sustainable human society. Ecological literacy is a powerful concept, as it creates a foundation for an integrated approach to environmental problems.

Victor Papanek is known as a critic of industrial design culture and a strong advocator of socially and ecologically responsible design for products, tools, and community infrastructures. His last book, *The Green Imperative* (1995), resonates with many contemporary themes of concern to designers. Apart from the explicitly ecological material, these themes include a renewed interest in vernacular architecture, in the concept of dwelling, in de-centralized production, and in ethical consuming. Such ideas also formed a part of the Zeitgeist at the end of the 1960s when *Design for the Real World* (1971) appeared. Besides delineating such general ecological degradation, Papanek (1971) criticized the role that commercial design has played in this despoliation. He is particularly critical of large-scale, highly centralized production, and argued for the expansion of a small-scale, de-centralized alternative. The book also pleads for the ecological necessity of reducing our reliance on over-designed consumer goods.

Papanek also argued that design should be more ethical. He means that design professions should construct codes of ethics that are genuinely regulative, protective, specific, and transparent to outside inspection. Such an approach would mean an end to the "self-serving" codes of conduct that characterize the majority of modern professional design ethics. He also meant that both designers and end-users should ask whether a design helps or further marginalizes the disenfranchised and poor sections of society, whether it eases pain, whether it aids environmental sustainability, and so on. This is a theme that has consistently run through Papanek's writing in the past thirty years.

3. Re-thinking Design and Re-innovation: Aim on 100% Sustainability

Edwin Datschefski is an active sustainable design consultant who provides the concept of "Bio Thinking" at the beginning of the 2000s (Datschefski, 1998, 2001). He described "Bio Thinking" as "Looking at the world as a single system, and developing new ecology-derived techniques for industrial, organizational and sustainable design."

Datschefski (1989) developed the cyclic/solar/safe methodology for assessing the environmental performance of products and processes, as featured in *The Total Beauty of Sustainable Products*. His approach has both simplified the way people look at sustainability and offered a radical, product-based focus. He believed that our approach to product design is so fundamentally wrong as to be barely comprehensible. In *The Total Beauty of Sustainable Products*, he challenges those involved in designing, making, or selling consumer products with the huge and urgent job of re-thinking every product on the planet to make them 100% sustainable: good for people, good for profits, and good for the environment.

The American architect William McDough and the German toxicologist Michael Braungart developed a protocol called "Cradle to Cradle Design," which echoes the framework outlined by Dachefski. Their book is a manifesto calling for the transformation of human industry through ecologically intelligent design. Through historical sketches on the roots of the industrial revolution; commentary on science, nature, and society;

descriptions of key design principles; and compelling examples of innovative products and business strategies already reshaping the marketplace, McDonough and Braungart (2002) made the case that an industrial system that "takes, makes and wastes" can become a creator of goods and services that generate ecological, social, and economic value.

In *Cradle to Cradle*, McDonough and Braungart (2002) argued that the conflict between industry and the environment is not an indictment of commerce but an outgrowth of purely opportunistic design. The design of products and manufacturing systems growing out of the Industrial Revolution reflected the spirit of the day, and yielded a host of unintended yet tragic consequences. When designers employ the intelligence of natural systems, such as the effectiveness of nutrient cycling and the abundance of the sun's energy, they can create products, industrial systems, buildings, and regional plans that allow nature and commerce to fruitfully co-exist. The book makes plain that the re-invention of human industry is not only within our grasp, but it is our best hope for a future of sustained prosperity.

4. Promote Design Efficiency and Compatible Profits

Lewis and Gertsakis presented a step-by-step design strategy to approach design for environment in their book, *Design + Environment* (2001). In this book, the first step in the process is to undertake an assessment of environmental impacts using life-cycle assessment and other tools provided in the book. After that initial step, design for environment becomes an integral part of the normal design process. This book provides more actionable and detailed strategies and case studies for design practices. It's an actionable eco-design handbook that promotes eco-efficient product design.

In the book *Sustainable Solutions*, Tischner and Charter (2001) described that "Sustainable Solutions" are: products, services, hybrids or system changes that minimize negative and maximize positive sustainability impacts—economic, environmental, social and ethical—throughout and beyond the lifecycle of existing products or solutions, while fulfilling acceptable societal demands/needs. Sustainable solutions require multistakeholder engagement and involve changes or shifts in consumption and production patterns. The aim of sustainable solutions is to create a positive net sustainable value (positive impacts should outweigh negative impacts) for all stakeholders in the delivery process. Changes may be incremental at the product level or radical if system shifts are needed.

The aim of sustainable solutions is to demonstrate the enormous business opportunities relating to eco-design and sustainable product design. These solutions approach the elements of consumption and production in an integrated manner. This means that policy makers, businesses, and other stakeholders will need to move into the contentious and fuzzy area of the links between consumption and quality of life to create room for new ideals and innovations that can create incalculable benefits to all.

5. Designers' Ecological Literacy

In order for design to be most effective, ecological and social considerations have to be built into the earliest stage of product conceptualization and design development. Building the considerations into early stages has the effect of preventing impacts, thus minimizing the need for remedial action further down the chain. Detrimental impacts are reduced through a systems approach to design. Victor (1998) insisted in article: *Design for A Sustainable World*: “designers have to do the same in order to create new forms of practice. The power of design is in conception and planning, first generating an idea and then embodying that idea in a product, whether an object, system or environment”.

The successful implementation of design for sustainability requires an informed designer. Sustainability-related information is diverse and is, by and large, inaccessible to most designers in terms of both availability and language. This lack of accessibility has led to the realization that the designer's role and his training will have to be redefined in order for the design process to successfully include environmental considerations. To effect change, a new emphasis on contextual “external” elements of design is needed. This emphasis should examine every aspect of a product—its manufacture, its use, its disposal, its meaning, its environmental consequences, and its cultural significance.

Summary of Chapter 2

According to the theoretical framework which is elaborated in this chapter, the knowledge background of this research combines several inter-related theoretic concepts. Many of the theoretical concepts and ideas which are not obviously but intrinsically related to the research question and they have cross-disciplinary roots and highly abstract meanings. This makes the difficulty of building a theoretical framework in two ways. One is in clearly defining the related theoretical concepts and their meanings to the research question. Another is how to integrate those theoretical concepts as key variables to describe the research question. The cognitive process of insight interpretation, fundamental qualities and characteristics of design methods, and insight interpretation in design process are the core investigated theoretical concepts in the literature review. They frame the theoretical framework of the research topic, guiding the research process and also implying the possible solution to the research question. How the research findings are related to these theoretical ideas will also be discussed in *Chapter 7: Conclusion and Discussions*.

Chapter 3:

Research Methodology and Process

Introduction of Chapter 3

This research is aimed at developing a method for finding and interpreting valuable "design insights" from CTEAs for SPD purposes. The I-SPD method is developed by describing the fundamental cognitive process and required creative techniques. The research is expected to explore the structure, patterns, and models of the interpretive process. The I-SPD method is designed to guide design practices that can be applied by design practitioners and students to generate SPD solutions and develop design concepts by interpreting CTEAs.

This chapter explains the nature of the research and the adaptive inquiry paradigm and methods for collecting both theoretical and empirical data. The chapter describes how the investigation and data analysis are designed and processed. The process of empirical study and list of outcomes from each experiment (workshop) are also presented and discussed to examine the quality of the research activities.

There are four parts of this chapter. The first part explains why the adapted research methodology satisfied the nature of the qualitative research. The second part describes the building and content of the research methodology. The third part introduces the concrete research processes and illustrates the research activities plan systematically. The plan lists specific research methods to achieve goals in each stage of the research process. The last part discusses the workshops as experiments of the research to get empirical data to test and develop the theoretical findings in different research phases, and how these workshops were conducted, and what are their outcomes.

3.1 Research Nature

Research is by definition original work that seeks to answer a question. Understanding the nature of a given research project facilitates a clear research logic and ensures that the designed research process can scientifically lead to the expected research outcomes. The nature of research is defined by the researcher's understanding of, approach to, and solutions for the research problem. From this definition, the adaptive philosophic paradigm can be found. In this context, research nature can be defined as an adaptive inquiry paradigm that provides solutions for the research topic.

Lincoln and Guba (1985) concluded that the tasks of planning or designing a naturalistic inquiry are: 1) determining the focus for the inquiry; 2) determining the fit of the paradigm; 3) determining the fit of the inquiry paradigm to the substantive theory selected to guide the inquiry; 4) determining where and from whom data will be collected; 5) determining successive phases of the inquiry; 6) determining instrumentation; 7) planning data connection and recording modes; 8) planning data analysis procedures; 9) planning logistics; and 10) planning for trustworthiness. This model was applied in the research to structure the basic research process and tasks.

3.1.1 Qualitative Research Paradigm

According to the definition given by Gliner and Morgan (2000), paradigm is a way of thinking about and conducting a research. It is not strictly a methodology, but more of a philosophy that guides how the research is to be conducted. Paradigm is a framework within which theories are built; it fundamentally influences how you see the world, determines your perspective, and shapes your understanding of how things are connected. It fosters a particular world view that influences your personal behaviour, your professional practice, and the position you take as regards the subject of your research. Guba and Lincoln (1994) stated that the basic beliefs that define a particular research paradigm may be summarized by the responses given to three fundamental questions: 1) the ontological question (e.g. what is the form and nature of reality?); 2) the epistemological question (e.g. what is the basic belief about knowledge; what can be known?); and 3) the methodological question (e.g. how can the researcher approach whatever he believes can be known?).

The research objective determines what methodological domain the research belongs to. The key research question is also a methodological question. In this study, the key research question asks how designers can understand and apply the embedded sustainable design insights of CTEAs. According to the key research question, the core research objective thus is constructivist in nature, which means that it is one possible solution to the research problem. This research is a structured and concrete way of solving the research problem.

Maxwell (1996) defined qualitative studies as understanding the meaning of the events, situations and actions that study participants are involved with, understanding the context within which participants act and the influence that context has on participants' actions, identifying unanticipated phenomena and their influences, generating new grounded theories, understanding the process by which events and actions take place, and developing causal explanations. Bogdan and Biklen (1982) offered five general distinguishing characteristics of qualitative inquiry. They point out that: Qualitative research has the natural setting as the direct source of data and the researcher as the key instrument. Researchers, being concerned with context, feel that the greatest understanding of a phenomenon can be gained by personal, first hand observation of it in the setting where it occurs and as it occurs naturally. The assumption is that context or setting is an important determinant of the behavior under study.

They also emphasize the descriptive nature of qualitative research; qualitative researchers are concerned with a process, as well as with final outcomes. Qualitative researchers tend to analyse their data inductively and their essential concern is to find meaning.

These definitions explain the nature of the adaptable research paradigm toward the research objectives. The research aims to build a design method using processes and tools to help designers understand the embedded sustainable design attributes of CTEAs and create abstracted design insights from this understanding with the goal of transforming these design insights into meaningful design solutions. This method doesn't suggest in a rigorous, step-by-step process but emphasizes the users' understanding of the whole process so that it can be used in a flexible way to meet their specific needs. How the process is integrated to meet its multiple implicational functions will be introduced in *Chapter 6: Research Findings* to present the research finding.

The research's ontological investigation of the related basic concepts are also included in the major research tasks. These investigations are sub-objectives of the research—they search the scientific evidence and theoretical descriptions to explain why the I-SPD method has general meanings. They also support the design of some tools as required cognitive techniques to help to reduce the difficulties and ambiguities of applying the method. Beyond the key research task of building the I-SPD method, the research also explains how the method is built by giving scientific evidence to describe why the method is useful to design practices in a general context.

3.1.2 Qualitative Inquiries

The research is built on a hypothesis that a design method can be developed for interpreting Chinese traditional everyday artefacts to sustainable product designs. This design method is an indigenous approach that incorporates traditional Chinese wisdom to solve contemporary design problems. This hypothesis investigates three theoretical elements: how to determine the values of CTEAs to SPD; how to interpret the values into SPD; and how to construct the interpreting process as a design method.

The initial task of the present research project is to build criteria for SPD to determine what design attributes of CTEAs imply SPD-related information. The SPD criteria also serve the function of evaluating the SPD concepts or solutions generated by the process. The process and result of building the SPD criteria for the research will be introduced in the following chapter.

This research focuses on two key inquiry tasks: 1) to investigate and describe how CTEAs can inspire SPD; and 2) to determine how to construct the theoretical and empirical findings into an integrated design method. These two tasks were investigated through the use of empirical studies and theoretical investigation. The naturalistic inquiry methodology has been applied in the investigations. The inquiry structure is illustrated by the below diagram:

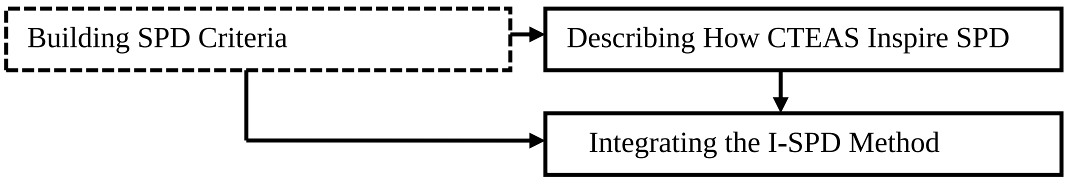


Figure 3.1: Inquiry Structure of the Research

This inquiry structure represents how the three essential investigations can be constructed to solve the research problem. It means the research can be structured in three mutually related parts to answer the key question and sub-questions. This inquiry structure is the outline of the research framework.

3.2 Research Methodology

Leedy and Ormrod (2001, p.14) defined research methodology as “the general approach the researcher takes in carrying out the research project”. Williams (2007) stated that qualitative research involves a purposeful way of describing, explaining, and interpreting the collected data. Qualitative research builds its premises on inductive, rather than deductive reasoning. Through it, the researcher tries to explain the observational elements that pose questions.

3.2.1 Specified Objectives and Research Framework

The research objective and its sub-objectives are based on my comprehensive understanding and initiate solution of the research problem. The research objective defines why and how the expected research outcomes can solve the research question. I designed the research based on in what way the research question can be answered objectively and also in what extent I can answer the research question within the time and resource limitations. They imply the fundamental logic and rationality of the research design.

The key objective of the research is to investigate and describe the general process, thinking patterns, and techniques of finding and interpreting design insights from studying Chinese traditional everyday artefacts for sustainable product design purposes. According to the key research objective, the research contains a series of specified objectives.

The specified objectives are:

- To structure the method of selecting and studying CTEAs for SPD insights.
- To develop possibilities, methods, and techniques for articulating meaningful SPD insights from the selected CTEAs.
- To explore and describe the process and thinking patterns of how those insights can be interpreted into specific SPD concepts and solutions.
- To integrate the whole interpreting process into an actionable design method for guiding SPD practices.
- To identify opportunities and contexts for applying the method and evaluate the performances of the method.
- To develop a framework of SPD criteria by structuring existing sustainable design principles to guide the interpretive process in empirical experiments.

The structure of these specified objectives also represents the logical steps of solving the research problem. Those research tasks can be organized as a research framework as in the diagram below:

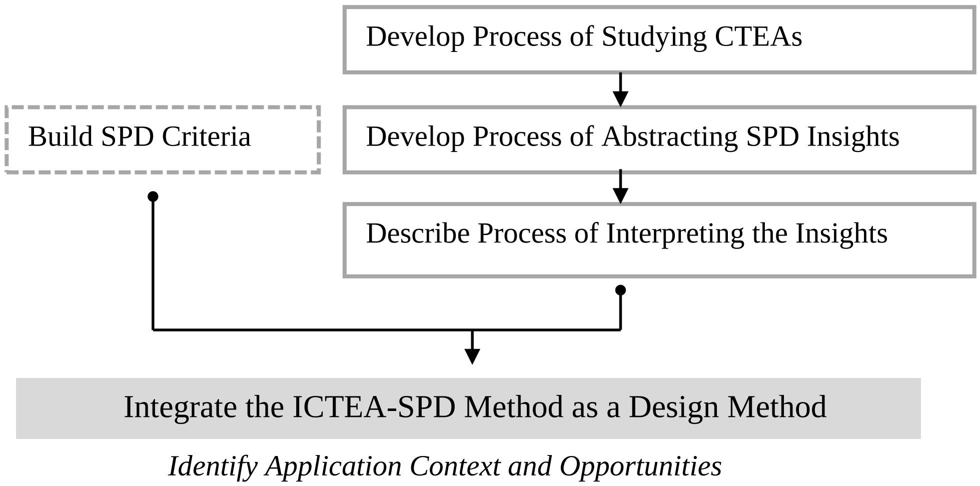


Figure 3.2: The Research Framework

According to the focus of the research question, which is to clarify and illustrate the insight interpretation process and represent the process in the form of a design method, the three steps of studying CTEAs, abstracting SPD insights, and building a method of interpreting the insights are essential questions used to build the ultimate solution of the research question. To consider the research framework in a comprehensive way, there is a clue as to how one may derive meanings from data and how to develop these meanings into knowledge so as to guide the SPD practice. Studying CTEAs is for getting data, abstracting insights is for generating meaning from the data, and the method of interpreting the insights is for developing the meaning into design knowledge. This clue guides the logic of the eventual construction of the research process. The research framework clarifies the logic of complexity of the research by defining the essential variables which are represented by the three core investigation questions.

3.2.2 A Naturalistic Inquiry Method: Modified Analytic Induction

The research is designed to conduct empirical investigations involved in different theoretical investigation stages. The adaptive naturalistic inquiry for data gathering should satisfy the emerging, testing, and modifying nature of the final theory generating scheme.

In designing the research methodology, specific research methods will be selected and interpreted to fit the research's philosophic nature.

The inquiry paradigm used for this research is the naturalistic mode. Naturalistic inquiry refers to conducting inquiry into phenomena in the settings in which they naturally occur. In their book *Naturalistic Inquiry*, Lincoln and Guba (1985) presented a list of the interrelated characteristics of naturalistic research. Among these they identified the human instrument for data gathering, the utilization of tacit knowledge, inductive data analysis, and other characteristics that fit some of the attributes of this research. The naturalistic mode gives a better understanding of the research nature and provides a comprehensive idea of how the research will be constructed.

The research is a qualitative research in the Constructivism paradigm; it focuses on its research purpose from the foundation of its research problem and research objectives. The specific methods for data inquiry in this research come from the qualitative research methods of case study and multi-site studies.

A case study is defined by Bogdan and Biklen (1982) as "a detailed examination of one setting, or one single subject, or one single depository of documents, or one particular event." The authors note that case studies vary in complexity. Multi-site studies are obviously more complicated than case studies in many ways. For example, multi-site studies are usually oriented toward developing theory. Bogdan and Biklen delineated two types of methods: modified analysis and constant comparative method.

Modified analytic induction is a method of collecting data, analysing data, developing theory, and testing theory in a looping or iterative fashion. The method can utilize open-ended interviewing, participant observation, or document analysis. It is appropriate for addressing a specific problem, issue, or concept. The researcher begins with an in-depth, open-ended interview of a respondent considered to be a good or typical example of the focus of the inquiry. A general theory was then proposed by Wiersma (1995).

A second respondent is then interviewed and subsequently asked to recommend other respondents. This method is known as "snowball sampling." As the interviews (or observations) continue, the theory is modified accordingly. As this procedure progresses, the researcher also interviews negative cases, or respondents that are expected not fit into the theory. The theory is then tested and modified accordingly. This process continues until there are no more cases encountered that do not fit the theory. The research question, like the theory, can be changed during this process.

The constant comparative method is also a looping process or "doubling back" between theory and data. Bogdan and Biklen traced the description of the process to Glaser. The theory formulation-data collection method proceeds in a similar fashion, except it is carried out over many more sites. The theory formulation-data collection method also continues to the point of theory saturation or redundancy.

Modified analytic induction as the major inquiry method to collect and process data which fits the requirement of research methods. Searching for variables and their relations is the nature of developing the theoretical solutions for the research question. This research implies the basic model of this qualitative inquiry method to search and exam patterns, process and tools from both empirical data analyses and theoretical deductions.

3.2.3 Applying Modified Analytic Induction for the Research Purpose

According to the research framework, there are two parts to the data collection process. The first part is to develop the SPD criteria for guiding the other research processes. In this research, this part is designed to focus on collecting theoretic data by reviewing literatures and uses a basic inductive analysis method to process the theoretical investigations. The specific method for generating SPD criteria for this research will be introduced in the next chapter, as it is an independent part of the main theoretical investigation tasks.

The general process and core cognitive patterns of how to select, receive inspiration from, and be inspired to create new SPD concepts are constructed in a designed empirical investigating process that uses applied modified analytic induction as the basic inquiry method.

To acquire the research objectives, inquiry activities must be coordinated to the mechanism of multi-site studies by applying modified analytic introduction. The process of getting data, analysing data, developing theory, and testing theory is a loop. The theory will be modified in several turns by the cases until the final theory fits the general context.

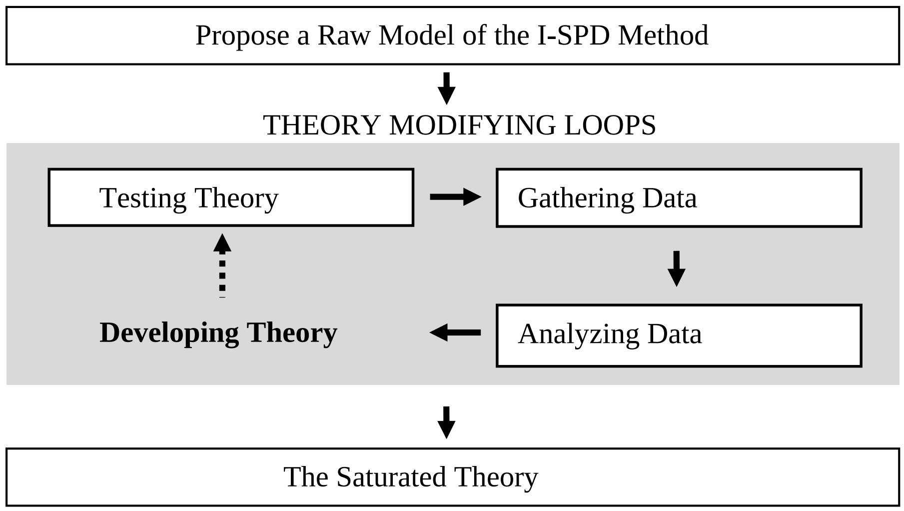


Figure 3.3: Inquiry Process of the Research

Form of Empirical Study: The Workshops

For this research, the cases studied for the purpose of proposing and modifying the formal theory takes the form of workshops. The workshops were designed, organized, and conducted for the purpose of data gathering and theory testing. Major participants of the workshops were design students with sufficient Chinese cultural backgrounds. The initial model of the I-SPD method was proposed through a semi-organized design workshop of me and a small group of professional product designers who are interested in traditional designs of Chinese artefacts. This workshop was designed to discuss a hypothesis of how the whole interpretive process should combined with the three basic phases of studying CTEAs, articulating SPD insights, and interpreting insights. As properly trained as a product designer, my individual personal design works also helped to develop the initial model. The professional group chose artefacts that interested them and were required to demonstrate new product concepts which are inspired by the interpreted artefacts. We discussed other possibilities of the fundamental process and agreed on this initial model which was put forward to further workshop tests.

3.3 Research Design

The concrete research process is designed as three phases from a normal plan: research design, collecting data and conclude findings. Research design is about both research methodology and theoretical foundation building. Data collection is to conduct empirical theoretical investigations by using modified analytic induction inquiry method. Conclude finding is to describe the findings and demonstrate applicable value of the research.

3.3.1 Identify Research Tasks

According to the outline of the research and inquiry objectives, the research activities were designed in three sequential phases. The following tables address the objectives and research methods for each phase.

Phase 1: Methodology and Theoretic Foundation	
Research Activities:	**Objectives:**
1.1 Background studies and theoretic positioning.	1.1 To specify the research scope and define objectives.
1.2 Understand research nature and construct the research to fit its qualitative research nature and naturalistic inquiry paradigm; the research is conducted using the modified analytic induction method.	1.2 To select an adaptive research methodology and build the research process and inquiry methods and techniques.
1.3 Structure fundamental aspects of relations between insight interpretation and design method to build the research framework. Review literatures, online resources, and design projects to categorize the information into different design principles to fit the framework.	1.3 To explore the key theoretical concepts which related the research question. To build the SPD criteria for the workshops.
1.4 Conduct empirical studies on CTEA studies in different areas of China to get a general understanding of CTEAs and test research methods.	1.4 To define the general strategies and criteria for guiding the study of CTEAs.
1.5 Organize pilot design workshop to learn about the general patterns characterizing interpreting approaches and processes.	1.5 To propose initial theory mode for interpreting CTEAs' embedded design insights and evaluating the generated designs as application results.

Table 3.1: Phase 1 Research Activities and Objectives

Phase 2: Data Collection	
Research Activities:	**Objectives:**
2.1 Design and conduct workshops on the given tasks and processes. The process is moved in turns of cycles from workshop to theoretical study. ▪ Observe and collect behaviour patterns in workshops. ▪ Find problems and difficulties in the interpreting process. ▪ Search supported theories to propose solutions for the problems and difficulties. ▪ Test the proposed solutions and improve the process.	2.1 To research and build the specific actions and steps for the method.
2.2 Observe workshops and collect participants' reflections on the compulsory processes and tasks. ▪ Design the affiliated tools by investigating the theoretical techniques for difficult tasks during the process. ▪ Test and adapt the tools through additional workshop-theoretical study cycles.	2.2 To find required techniques for the interpretation process and design usable forms of these techniques.
2.3 Design and test the evaluating method and criteria through turns of workshops.	2.3 To build evaluation method and criteria for the design outcomes from the workshops.
2.4 Conduct and observe freestyle workshops, in which the taking process and applying the given tools are not compulsory tasks. ▪ Observe and analyse the participants' illustrated thinking process. ▪ Evaluate their final design outputs.	2.4 To develop the form of representing the ICTEA-SPD method.

Table 3.2: Phase 2 Research Activities and Objectives

Phase 3: Describe Research Findings	
Research Activities:	**Objectives:**
3.1 Review the whole research process and workshop data.	3.1 To explain and manifest the rational logic of the development of the method with substantial design cases from workshops.
3.2 Refer to Qualitative Research Evaluating Methods and invest workshop participants by conducting focus groups. Organize seminars and talks to collect professional opinions.	3.2 To investigate the effectiveness and limitation of the method from the perspective of others.
3.3 Synthesize the research findings and conclude other research outcomes.	3.3 To combine the research findings in the thesis to other organized forms and point to possibilities and directions for further research.

Table 3.3: Phase 3 Research Activities and Objectives

Affiliate Research Activities

Beyond the workshops held in the five external collaborative Chinese design schools and field investigations of CTEAs in different regions of China, I also conducted several affiliate research activities to examine the research findings while collecting professional ideas. These activities include lectures (Hong Kong and Mainland China), seminars (Hong Kong and Mainland China), and presenting research outcomes in design conference (China and America). The six workshops provided a great deal of quality design works from interpreting CTEAs. Those affiliate research activities also collected lots of meaningful ideas and supports to as well as developed my understandings and thinking of the research.

Profile of Conducted Research Activities

1) SPD framework building. Building SPD principles and criteria was conducted as the first research task when the project was shaped. Beyond understanding its historic background and various perspectives and research focuses, the cross-disciplinary philosophic background was also explored to form an in-depth understanding of SPD. The nature of SPD knowledge is quite open; it developed constantly with the growing of related sciences, economies, and policies. A large group of design researchers, practitioners, scientists, and philosophers address the different issues, aspects, and dimensions of how design and human-environmental sustainability interact. There is complete and accurate work for developing the SPD framework in an open structure. To solve this problem, a structure of the fundamental aspects of SPD was developed to frame the study's literature-based research. This development consisted of collecting, comparing, and categorizing generally agreed-upon SPD principles and coding the main themes to create the abstracted form of criteria. This process will be detailed in chapter three.

2) Field study is to test and refine possible research methods and propose the initial theory model. Research methods were initially schemed from field studies during the first phase of the empirical study. During these field studies, I observed and collected several traditional everyday artefacts in the countryside Anhui and Jiangsu provinces, as well as in urban Shenzhen. The pilot study had two purposes: to seek adaptable artefacts research methods and techniques and to study groups of selected artefacts through different methods to explore their embedded design values and meanings. The collected design values and meanings were described in field notes, articulated insights, and sketches. Beyond the researcher's personal views, some design students and professional designers in Hong Kong were invited to develop the rough model of the I-SPD method, which will be further tested and refined in the next research phase.

3) Developing the process and tools through workshops. I organized the first three rounds of workshops to include both graduate and undergraduate design students. Each workshop contained five to six small groups of three to five students, and was initially scheduled to last five to six days. During the workshops, I gave lectures, organized discussions, and conducted group work on individual design projects. In some of the workshops, I also

organized field studies to collect artefacts from different cultural origins. Field notes and student interviews were conducted during the workshop. Audio records of interviews, student design work, and questionnaires were taken from the workshops. The concrete process was developed in these initial workshops; some of the tools were shaped and tested during workshops while incoming data was analysed.

4) Integrate the process and tools in a design method. The second batch of workshops was filled by two different group of participants. The fourth workshop was for higher-grade graduate students of product design. Many of them already have some industrial experience. The fifth workshop tested and observed junior undergraduate students and most of them are not from product design fields but related disciplines such as textiles and handicrafts. The reason I chose these two different kinds of participants is the goals of the workshops are different. The fourth workshop for senior graduate student is to explore and identify possibilities and conditions of how the interpretive process can fit the two fundamental design paradigms of design as "rational problem solving" and as "reflective actions". Students required established design and research knowledge to finish this goal. The fifth workshop was designed to observe different possibilities of how the given methods and tools which developed from previous workshops can be applied in self-initiated circumstances to solve particular problems during the whole interpretive process. These two workshops conducted in a period of six months as the last phase of the empirical study in this research. During these two workshops, the full process, and all the tools were introduced before students engaged in design practices. Flexible uses of the process and its evaluation method were determined during this research phase.

The empirical study was performed over the duration of three years, including the field studies of CTEAs and 6 workshops. 109 Chinese design students, 5 design professionals, and 5 teaching staffs were involved in the workshops. How the workshops was designed and conducted will be introduced in the last section of the chapter. The model of workshop design is also attached with the thesis as appendix B as a reference for readers of the thesis. The empirical experiments will be explicitly explained in *Chapter 5: Empirical Studies and Experiments*.

3.3.2 Time Span, External Cooperation

Time Span and Arrangement

The research was conducted over four years, including drafting this thesis, analysing the data, and conducting the literature review. The time table below shows the durations of the key research tasks:

<table>
<tr><td colspan="12">YEAR 2008. August – 2012. May</td></tr>
<tr><td colspan="2">2008</td><td colspan="3">2009</td><td colspan="3">2010</td><td colspan="3">2011</td><td>2012</td></tr>
<tr><td colspan="5">Research Design</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">CTEA Field Studies</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">SPD Framework/Criteria Building</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">The Six Workshops</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Theoretical Studies</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Describing Research Findings</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Composing Thesis</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Affiliate Research Activities</td><td></td><td></td></tr>
</table>

Table 3.4: Research Activities Time Arrangement

External Collaborations

The research was hosted by The Hong Kong Polytechnic University and also received kind and effective support from China’s five leading mainland design schools, which are located in five different provinces with distinct traditional cultural identities. These schools are:

1) *Apartment of Industrial Design*, Sichuan Fine Art Institute (Chongqing, Sichuan). Website: http://www.scfai.edu.cn/english/

2) *School of Media and Design*, Shanghai Jiaotong University (Shanghai, Shanghai). Website: http://en.sjtu.edu.cn/

3) *Department of Industrial Design*, Shandong University of Art and Design (Jinan, Shandong). Website: http://www.sdada.edu.cn/wsb/

4) *School of Art and Design*, Department of Wuhan University of Technology (Wuhan, Hubei). Website: http://english.whut.edu.cn/

5) *School of Design*, Guangzhou Academy of Fine Arts (Guangzhou, Guangdong). Website: http://www.gzarts.edu.cn/

3.4 Process of Empirical Studies

3.4.1 Workshop Design

Workshop is designed for collecting empirical data by using the participant observation research method. In this research, a series of workshops were designed to test the initial theory model and refine and develop the model into a concrete process with structured research and design tasks. These tasks represented the essence of several concrete cognitive activities, which combine into the cognitive process of interpreting CTEAs in general circumstances. The tasks were synthesized from observation of the students' design behaviours and gaining an understanding of their inner thinking processes through individual and inner group tutorials.

The workshops were designed in advanced progress, which means that the basic structure of each workshop was determined by the findings from the previous workshop. The method used to design and conduct each workshop applies the modified analytic induction methodology. The steps were: 1) find what techniques and guidance the participants need for an easy and effective interpreting process in the previous workshop; 2) propose several possible solutions as tools (or guidelines) to affiliate the design process or the given structures of the vague or ambiguous activity patterns; 3) test the proposed tools by adding supplementary instructions and teachings to the following workshop; 4) enter the next round of workshop and theory investigation until the theory can be satisfied by general workshop conditions.

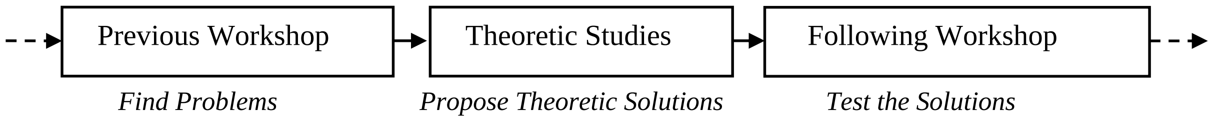


Figure 3.4: Method of Workshop Design

The fixed rough structure of all the workshops comprised: 1) project briefing: scope and purpose of "interpreting CTEAs for SPD purposes"; 2) knowledge introducing: understanding SPD and the SPD framework for the project; 3) conducting workshop activities of CTEAs studies and interpreting to SPD concepts; 4) investigating the effectiveness and participants' understandings of the workshop constructions which include: the given methods, tools, workshop organization, and required knowledge. According to the different investigating contents and purposes for the theory (I-SPD Method) development, concrete activities are designed before or during the workshops. A sample workshop plan (for Shandong workshop in January 2011) is attached with this chapter to illustrate the structure of workshop contents. Required materials for the workshops are listed below:

Form of Required Materials	**Material List**
Files *(With specified contents for each workshop)*	▪ Workshop Guide/Poster ▪ SPD Framework with Criteria ▪ CTEAs Selection Guide ▪ Teaching Materials ▪ Tools and Guidelines for Tested SPD Method ▪ Questionnaire
Resources	▪ 1–2 Teaching Assistants (lecturers in design background) ▪ 15–25 Participants (Bachelor or Master's students with an academic design background) ▪ 1 Multimedia Classroom
Facilities	▪ Projector ▪ Camera ▪ Digital Recorder ▪ Paper Boards ▪ Other Stationeries

Table 3.5: Required Material for Workshops

3.4.2 Selection of the Collaborating Chinese Design Schools

The five design schools were picked as the result of investigation and the conditions of research resources. They are among the best design schools in China. Other general criteria included: location in varied Chinese traditional cultural regions, good resources for teaching and research, and continuing positive response to the prospect of collaborating with the project.

For specific investigation purposes, the five chosen Chinese design schools provided different types of design education according to the university's styles: engineering background, art background, and synthetic background. Thus, the participants for each workshop had different types of design and research abilities. Engineering background design students were more sensitive to logical thinking and process developing. Art based students exhibited more free thinking and creativity in developing design concepts. Synthetic background design students were good at accomplishing the requirement in both design and research tasks as a whole project.

The art based students were used for the first and last workshops to find more possible design patterns and different application patterns of the I-SPD method. The engineering based and synthetic based design students were mostly Master's students with strong capability in both theoretic understanding and logical thinking, with good design practice abilities. The workshops for those students were designed to develop specific processes and techniques for the ICTEA-SPD method.

3.4.3 Workshop Brief and Functions in Theory Development

1. The Pilot Workshop (Year 2010. May–July)

Workshop Brief: Conducted after initial field studies, participants at this workshop tried to experience the design process of interpreting the studied artefacts.

Functions in Theory Development:

- Developing adaptive artefacts and selecting a method from the SPD framework;
- Constructing the rough structure of the process in selecting CTEAs, abstracting insights, and interpreting insights.

2. Sichuan Workshop (Year 2010. September)

Workshop Brief:

Western China. Sichuan Fine Arts Institute, School of Art and Design. 18 graduate students in Product Design and 5 undergraduate students in product or visual commutation design. One week duration of full day sessions.

Figure 3.5: Sichuan Workshop Scene

Functions in Theory Development:

- Testing the pre-designed workshop model, which was based on 1) understanding the SPD framework; 2) selecting and studying CTEAs; 3) gleaning abstract insights; and 4) interpreting insights with conceptual design.
- Assessing participants' behavioural and cognitive patterns in applying the rough process with concrete steps.
- Addressing key problems and issues when applying the full process for theoretic studies.
- Evaluating the initial method according to the quality of SPD concepts that arose from it.
- Receiving participant feedback on the workshop process and effects, through questionnaires.

3. Shanghai Workshop (Year 2010. December)

Workshop Brief:

Eastern China. Shanghai Jiaotong University. School of Media and Design. 20 graduate students: 17 in product design and 3 in other related design research areas. One week duration of full day sessions.

Figure 3.6: Shanghai Workshop Scene

Functions in Theory Development:

- Testing the structured workshop model with the previous reference.
- Testing the studied behaviour and cognitive patterns found in the previous workshop.
- Observing and searching for new patterns in participants' activities to further detail the whole process.
- Locating new problems and issues and applying them to the whole method.
- Evaluating the refined method according to the design outcomes. Completing the evaluating criteria and method.
- Getting participant reflections on the workshop processes and effects, through questionnaires.

4. Shangdong Workshop (Year 2011. January)

Workshop Brief:

Northern China. Shandong University of Art and Design. Department of Industrial Design. 19 undergraduate students in product design and 2 graduate students joined this workshop. One week duration of full day sessions.

Figure 3.7: Shandong Workshop Scene

Functions in Theory Development:

- Testing the detailed full process with the tools, guidelines, and evaluating criteria provided by first-year undergraduate students.
- Emphasizing the abstraction and interpretation of design insights by requiring each participant to practice on a certain amount of cases to get a better understanding of the whole process.
- Detailing the specific problems and behaviour patterns through observing participants behaviours and collecting their feedbacks.
- Investigating the cognitive relations of each participant's final new design concepts to the CTEAs studied and design insights abstractions.
- Evaluating the refined method by the design outcomes. Completing the evaluating criteria and method.
- Getting participants' reflections of the workshop processes and effects, through questionnaires.

5. Wuhan Workshop (Year 2011. April)

Workshop Brief:

Middle of China. Wuhan University of Technology. School of Art and Design. 23 graduate design students in product design and related areas. One week duration of full day sessions with one half-day focus group reflecting on the method effects.

Figure 3.8: Wuhan Workshop Scene

Functions in Theory Development:

- Introducing the whole method with detailed steps, tools, and guidelines before the participants begin to apply it.
- Requiring the participants to apply the design method to solve their designated design problem.
- Observing participants' behaviours and cognitive patterns when solving the design problems.

- Investigating the cognitive relations of each participant's final new design concepts to the CTEAs studied and design insight abstractions.
- Evaluating the refined method according to the design outcomes. Completing the evaluation criteria and method.
- Recording the problems and issues of each group and the effects and rationalities that occurred, using participant feedback from the focus group.
- Proposing flexible ways of representing and applying the design method.

6. Guangzhou Workshop (Year 2011. June)

Workshop Brief:

South of China. Guangzhou Academy of Fine Arts. School of Design. 23 undergraduate students in design and related areas. The workshop was conducted in 4 weeks as a school course.

Figure 3.9: Guangzhou Workshop Scene

Functions in Theory Development:

- Conducting initial design practice for each participant by requiring them to design a new product inspired from a CTEA.
- Introducing the method in a precise and flexible way for each phase of the method.
- Delivering the full process map and tools to each of the participants to help them prepare to apply the method.
- Assigning tasks for the groups in different phases. Evaluating their assignments.
- Requiring each participant to describe their design process by referring to the method and addressing their applied process steps and tools.
- Investigating the different levels and effects of the flexible applications of the method.
- Completing and testing the evaluation method of the method application and effects by evaluating participants' final design works.

3.4.4 Post Workshop Effects on Further Workshops

Except for this research project, the form and contents of the workshop have been applied only in some mainland design schools for teaching and research purposes for redesigning local traditional artefacts. More design works and participant feedbacks on the introduced SPD method are consistently collected after the workshops. Beside the five schools more Chinese design schools are in contact to facilitate a further series of workshops focused on interpreting traditional Chinese artefacts. If resources permitted, I would aim to build a design and investigative network for CTEAs in China to cover most Chinese cultural regions. The network of the schools involved in the workshops and the design schools that they collaborate with would be valuable for further research on the scope of interpreting traditional Chinese cultural artefacts for both education and industry purposes.

Summary of Chapter 3

The research process is integrated in that defining the research questions and objectives, collecting and managing data, and communicating the findings occur within established frameworks and in accordance with existing guidelines. The frameworks and guidelines provide researchers with an indication of what to include in the research, how to perform the research, and what types of inferences are possible based on the data collected.

The method as a whole is organized according to the logic of choosing and studying everyday Chinese objects, interpreting the found insights into design ideas or design references, and developing and evaluating design concepts. This logic is described in the previous chapter as a general research methodology for interpreting CTEAs for design purposes. It proceeds naturally when designers attempt to achieve some inspiration from studying traditional cultures. To use the scientific research method to ensure the usability and effectiveness of the proposed design process, concrete tasks and shaped tools are supplied. There are 3 phases of tasks, and 13 tools are suggested. The tasks, objectives, and the tools were developed by group studies that were initially formed to conceive the method and through six rounds of workshops. The method with tools has been presented and discussed in several international design conferences. Many abroad specialists and academics have provided their previous ideas to make the method applicable to artefacts from different cultures.

Chapter 4:

Building SPD Criteria

Introduction of Chapter 4

This chapter is written to introduce how the SPD Criteria was developed for the research project and why it is required for this research. The chapter is composed of five sections:

Importance and Objective of SPD Criteria Building. This section is written to illustrate why building a framework of SPD criteria is necessary for this research. The SPD criteria serves three basic functions in the research: determining target CTEAs, identifying SPD insights from CTEA studies, and guiding interpretive insights to SPD ideas and concepts. The criteria should be represented in standard language structure with directly interpretable meanings. It is helpful to participants and users of this research by providing a general and quick understanding of SPD.

Method of Building SPD Criteria. The criteria were developed from existing knowledge of SPD. As this criteria framework is particularly designed for the purposes of the research it is different from other SPD frameworks for general contemporary industrial situations. It addresses some particular aspects of strategic principles and solutions related to SPD. In this research, after trying different methods to develop a useful SPC criteria framework I finally chose to build a framework for explaining how an artefact can influence human-environment sustainability and then used the framework to collect existing SPD principles and code these principles to develop the abstractive criteria.

Collecting SPD Principles from Literature. To expand my knowledge scope of SPD I reviewed the basic focuses of SPD practices and theoretical studies. This provided a fundamental understanding of SPD and gave further directions for additional literature reviews. Through this process I spent quite a lot of time learning about and selecting representative SPD principles and strategic ideas. This work made up a majority of the whole research process. In this research the collected SPD principles were updated until end of year 2011 when the final workshop has been conducted. The full documentation of collected design principles is attached as an appendix to the main content of the thesis.

Structuring the Collected Principles. This is the final work of completing the SPD framework. It is comprised of two steps: categorizing the collected principles and simplifying the criteria structure. I briefly show the coding record of the final stage of the collected principles.

Describing the SPD Criteria. This section is written to explain the essential meanings of the abstracted criteria which have been organized through four approaches: product, human, social and environmental. In the end, significance, knowledge contribution and limitation of the criteria framework are discussed.

4.1 Importance and Objective of SPD Criteria Building

4.1.1 Importance of SPD Criteria Building

By its nature, design is aimed to fit its contemporary requirements, to solve present problems. The initial research task providing the theoretical foundation of identifying SPD values is the act of building criteria according to the this current situation. The criteria are built to evaluate whether a designed product is sustainably designed by judging whether its design attributes and functional or aesthetical effects could contribute to the sustainability of the human species and the Earth's environment. It also serves as evaluating criteria and a method for selecting the best of the abstracted design insights and the "interpreted" design concepts.

Contemporary SPD criteria can help to study CTEAs effectively for SPD purposes. These CTEAs which were designed or developed throughout history are not directly driven by current considerations of sustainability issues. Their original design contexts may be quite different from today's social, environmental, technological, ideological, and economical situations. There is also a lack of formal evidences describing the original design motivations and processes for these artefacts, except for what can be observed in contemporary situations. This makes it difficult for the researchers and designers who intend to investigate CTEAs original design reasoning and solution to reach accurate results.

Building SPD criteria to guide the process from studying CTEAs to interpreting design insights directs the goals of generating SPD ideas and concepts. The study of CTEAs focuses on their practical meanings for contemporary SPD. Selecting the artefacts that are sustainable products also needs to be based on contemporary criteria of SPD. Some of their original functions, manufacturing, and cultural meanings may have changed or vanished in contemporary contexts. Moreover, subjective understanding of and personal emotions toward those historic objects may influence designers' judgments and decisions about whether the design insights from the artefacts and their interpretations can fit contemporary requirements. Building objective criteria to evaluate the design insights and design interpretations is important and practical for the project needs.

The framework of SPD criteria is a structured method of discerning valuable design insights from these non-industrial products. Investigating and organizing existing sustainable design principles and criteria from both academic research and industrial practice make the objective standards for the empirical experiments on structuring and evaluating participant activities and results.

Although the studied subjects are those CTEAs which may imply SPD values according to the SPD criteria, the study does not criticize, evaluate, or articulate the characteristics and values of the artefacts themselves. Instead, it uses these selected objects as resources to find inspirations for contemporary sustainable design. The effectiveness and cultural adaptations of interpreting these objects using the design thinking process are enhanced by the developed and systematically organized SPD theories.

Based on the above ideas, the study directly explores the practical values of interpreting traditional artefacts for SPD. It also reduces difficulties for designers from other cultures or with less knowledge of traditional artefacts to get useful SPD inspiration effectively.

4.1.2 Objective of SPD Criteria Building

The SPD criteria plays three functions in this research. First, it is used as a tool to select everyday artefacts for study. The artefacts should be used and can be investigated directly to get first-hand data about their whole lifecycle. Second, it is used to determine the valuable design insights[1] evident in CTEAs and helps to interpret these artefacts to create sustainable design solutions.[2] This can make the found insights concrete enough for further interpreting into design language and product elements in different design contexts. Third, it can be used as the last step of the interpretation process to evaluate the generated product concepts according to whether they satisfy the sustainable design requirements.

Based on the above, the SPD criteria should be required to determine and evaluate meanings to the specified material artefacts as well as to the abstracted design insights. It can thus identify the sustainable attributes of the evaluated design concepts and existing products. It also should directly relate to the design strategies of CTEAs which were designed and produced in non-industrial ways. These requirements determine the form and content of the SPD criteria. It should be clearly structured by different approaches and under each approach there should be specific abstractive strategies which explain how the approach can be applied to evaluate and interpret the contemporary meanings to the ancient situations where those CTEAs were invented and used. For ease of use, the criteria should also be in clear, simple, and direct language.

4.2 Method of Building SPD Criteria

4.2.1 Problem and Difficulty of SPD Criteria Building

Theories, discussions, and practices of SPD come from continual development of understanding human-environmental sustainability and possibilities of how design can contribute to sustainability. Because of the cross-disciplinary background of sustainable design, the collected design principles are not only specified in design—they also relate

[1] “Design insight” in this research refers to abstract thinking from artefacts studies, which can inspire designers to have new ideas for creating sustainable products. The design insights should be abstracted to a certain context-free level, thus allowing interpretation in other design contexts to solve specific problems.
[2] In this research, “design solution” is defined as a design idea, which can be technical, functional, or aesthetic, that can be used to achieve specific design tasks.

to multi-disciplinary works in sociology, ecology, economy, politics, and other social and natural sciences. This makes the criteria of SPD complex and difficult to navigate. It requires large quantities of literature review and data analysis to achieve a comprehensive understanding.

It also is a significant challenge to organize the studied SPD knowledge to develop a system of criteria fitting both contemporary and ancient situations. For example, many solutions for SPD are important for contemporary industrial production (such as how to design products to make efficient and cleaner industrial manufacturing), but these solutions are not relevant to ancient technological, social, and economic situations.

As this SPD criteria framework was designed for research experiment participants and users of the research outcome who may not have sufficient systematic knowledge of SPD, the criteria should be represented in easily understood language. Many existing theories of SPD are represented with specialized knowledge and philosophical roots. This also makes developing a simple and easily applied theoretical structure for SPD difficult.

4.2.2 Methods and Problems

To resolve the above difficulties, I tried several different methods to build and organize criteria of SPD for the particular research purposes. 1. Cultural comparison which is oriented from Western and Eastern perspectives and structuring the abstracted criteria according to the fundamental approaches of human-environment sustainability were primarily used at the early stage of research. The generated SPD criteria frameworks were tested in the early workshops. The practical function to guide, select, and interpret CTEAs of the early SPD framework was insufficient because the meaning was too broad and not directly related to the factors of CTEA and product design.

2. Directly using existing frameworks. I also used existing frameworks for SPD to collect and develop the criteria. (e.g. Shedroff, 2009 and Biswas, 2009) GRI (Global Reporting Initiative) also suggests the “Categories and Aspects” diagram of Sustainable Design. After testing these frameworks in workshops, I discovered that most aspects are not

directly related to analysis of CTEAs and also they are not easy to understand from text. I needed to explain a lot of specific technical knowledge to participants to provide them with a basic understanding. Application of the frameworks is also not direct or effective.

3. Trying to synthesize a comprehensive SPD framework by including all the information available. I also tried to build a comprehensive framework for SPD by synthesizing sustainable design principles I collected from academic literature, including books, academic articles, and internet resources. Although many of those collected design principles, ideas, and strategies are similar or related, it is still very difficult to put them together. Comprehensiveness and correctness is still deficient, especially for the decisions of combining similar design principles.

These failures led me to develop a more stable framework more directly related to CTEAs for this research. The framework should specifically emphasize fundamental factors of how an artefact can influence human-environmental sustainability. This method was also influenced by Biswas's (2009) SPD framework which organized the existing SPD knowledge from a product lifecycle management perspective. The model is introduced below, illustrating the method and process of building the final SPD criteria framework.

4.2.3 A Framework for SPD from Artefact Perspective

An artefact is designed for satisfying human needs and desires. An artefact can affect human-environment sustainability from its direct impact on individual humans, human groups, artificial environments, and natural environments. This idea is influenced by Norman (1988). In actual context, a product also exists in a role of a product system in which several products are connected in some everyday human behaviour scenario. Human behaviour also influences others' behaviours through a product or a product system. By this explanation, the meanings of the artificial world, the below diagram is designed to describe the relation between designing a product and its effects on social, natural, and artificial environments from a systematic understanding.

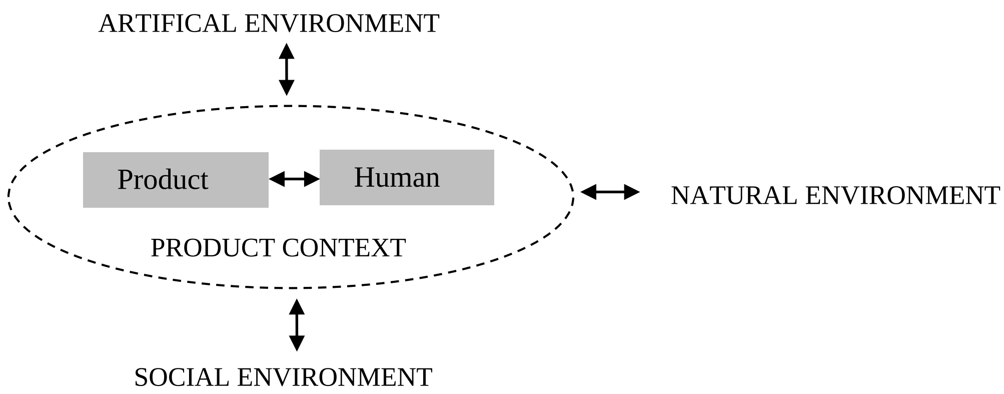


Figure 4.1: Product and Human-Artificial-Natural Environmental Sustainability

In the above diagram, the concept of "environment" is structured to have three aspects: 1) the social environment, which includes individual humans, organizations of humans, and functions of different human groups; 2) the artificial environment, which describes all the physical and unphysical human works created for certain purposes; and 3) the natural environment. The diagram shows how a single product and its user can be combined into a product context. This product context is shaped by artificial, social, and environmental constraints. Meanwhile, the human activities of making, using, and disposing of products change the three factors that makes up the environment. It is a dynamic system, where all the elements are inter-related and restricted.

Given this explanation of how products affect humans and their social and natural environments, the fundamental elements that a product design can affect when it comes to holistic sustainability are: the product (artificial), human individuals and societies (human group), and the natural environment. These fundamental elements connect the universal meanings of the artificial world, wherein exist both the traditional artefacts and contemporary designs. From this abstracted framework of the four elements, a systematic and holistic framework can be structured for collecting generally accepted SPD principles.

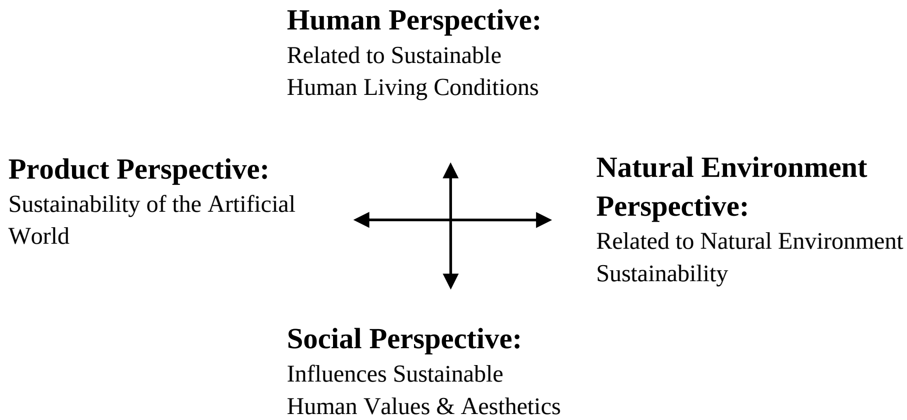


Figure 4.2: An SPD Framework—the Four Perspectives of Sustainable Product Design

This framework was built for the research purposes but not aim to cover a whole picture of SPD design principles for a comprehensive understanding. The four approaches of the framework have direct meanings for studying and interpreting SPD insights from CTEAs. As it is highly abstracted to cover the fundamental aspects of how a product can influence the sustainability. They are context free approaches which are adaptive for both contemporary and historical meanings of designing, making and using an artefact.

4.3 Collecting SPD Principles from Literatures

4.3.1 Different Focuses of SPD Practice

To collect design principles according to the structure of the pre-built SPD framework, I studied different focuses of practice which helped me to select relevant literature to read. Research on sustainable design can still be considered a new area, although it has passed its first decade. The future development of the area will be more comprehensive and sub-divided into different approaches and emphases. Systematically studying of literatures, projects, and online resources show many different research focuses, including implementation of legislation, eco-innovation, corporate social responsibility, product service systems, eco-redesign, impacts of user behaviour, design for disassembly, and reverse manufacturing.

A widely accepted definition of sustainable products is that they are those products providing environmental, social, and economic benefits while protecting public health, welfare, and environment over their full commercial cycle, from the extraction of raw materials to final disposition. Sustainable products can be material products or services. Research on SPD can be condensed into three major focuses: minimize environmental impacts from products to product life cycles; minimize environmental impacts from products to product service systems (PSS); and implement social innovation and cultural-centred sustainability.

1. Minimizing Environmental Impacts: From Designing Product to Product Lifecycles

Lewis and Gertsakis (2001) presented a step-by-step design strategy with tools on how to approach design or environment in their book, *Design + Environment*. In this book, the first step in the process is to undertake an assessment of environmental impacts, using life-cycle assessment and other tools provided in the book. Following that first step, design for environment becomes an integral part of the normal design process. This book provides more actionable and detailed strategies and case studies for design practices and process control.

Industrial Ecology and Life Cycle Assessment (LCA)

An "industrial ecology" is an industrial system that is fully integrated into the natural cycles of the materials used. It closes the loops left open in conventional industrial processes and optimizes recycling and the use of each material separately. It also allows for the creation of more complex "food webs of materials".

Industrial ecology is primarily a "systems view"; it shares concepts common to the lifecycle approach, which places the industrial system in the context of wider surrounding systems. In their book, *Industrial Ecology*, Graedel and Allenby (1995) addressed the role of both product and process design in developing industrial ecosystems and discuss the importance of Life Cycle Assessment (LCA) and other design/environment approaches in the overall industrial ecology concept. Design plays a vital role in the success of industrial ecology.

Perhaps the key to creating industrial ecosystems is to re-conceptualize waste as products. This conceptualization fosters the search for ways to reuse waste, as well as the active selection of processes with readily reusable waste.

Industrial ecology provides a powerful prism through which to examine the impact of industry and technology, their associated impacts on society, and the economy's impacts on the biophysical environment. Industrial ecology examines the local, regional, and global uses and flows of materials and energy in products, processes, industries, and economies. It focuses on the potential role of industry in reducing environmental burdens throughout the product lifecycle. By Erkman (1997), the field encompasses a variety of related areas of research and practice, including:

- material and energy flow studies ("industrial metabolism")
- de-materialization and de-carbonization
- technological change and the environment
- life-cycle planning, design, and assessment
- design for the environment ("eco-design")
- extended producer responsibility ("product stewardship")
- eco-industrial parks ("industrial symbiosis")
- product-oriented environmental policy
- eco-efficiency

Evaluating Strategies: Metrics and Indicators

Metrics are not necessarily a thorough measure of the overall environmental performance of a product. If you develop and use a set of metrics, that set will reflect your priorities. Therefore, for a set of metrics to measure overall environmental performance, your priorities should be developed in the context of lifecycle thinking.

Legislative Focus: Product Stewardship

As part of the legislative focus on product stewardship, the EU has developed an integrated product policy that “explicitly aims to modify and improve the environmental performance of product systems.” The most radical recommendations of this policy came from the Swedish Eco-cycle Commission, which called for all producers to develop responsibility over their manufacturing sectors and to include the environmental impacts associated with use and disposal of products and materials.

Material Choosing and Material Flow Analysis (MFA)

Material flow analysis (MFA), or substance flow analysis (SFA), is a method of analysing the flows of a material in a well-defined system. MFA is an important tool of industrial ecology, and is used to produce a better understanding of the flow of materials through an industry and the connected ecosystems, to calculate indicators, and to develop strategies for improving the material flow systems. Material flow analysis is the basis for a material flow management.

Design Methods: Design for 3Ds and 3Rs

Design for 3Ds and 3Rs are tools that have since been collectively named “Design for X”[3] since the 1970s. They focus on different aspects of the product lifecycle. For example, recycling focuses on the environmental impacts associated with products’ end-of-life. “Design for X” (DfX) tools do not embrace a whole life cycle perspective. The typical DfX tools are 3Ds and 3Rs.

<table>
<tr><td>3Ds</td><td colspan="2">Design for Disposal
Design for Disassembly
Design for Durability</td></tr>
<tr><td rowspan="2">3Rs</td><td>Recycle</td><td>Material recycle
Components recycle
….</td></tr>
<tr><td>Reuse</td><td>Reuse packages</td></tr>
</table>

[3] Design for X represents a wide collection of specific design guidelines. It serves as a design methodology to address different issues that may occur in a phase of product life cycle. The term is from Huang, G. Q. (1996). *Design for X: Concurrent engineering imperatives*. London, UK: Chapman & Hall.

		Reuse components Reuse products ….
	Reduce	Minimize weight Minimize size Minimize volume ….

Table 4.1: 3Ds and 3Rs

2. from Products to Product Services Systems (PSS)

A product services system (PSS), otherwise known as a function-oriented business model, aims to provide sustainability for both consumption and production (Mont, 2004). Product service systems occur when a firm offers a mix of both products and services, rather than focusing on either products or services, as was traditionally done. As defined by Goedkoop (1999), product service systems are “a marketable set of products and services capable of jointly fulfilling a user’s needs” (p.18).

The initial move to PSS was largely motivated by the need on the part of traditionally oriented manufacturing firms to cope with changing market forces and their recognition that combining services with products provides higher profits than offering products alone. While not all product service systems result in a reduction of material consumption, they are more widely being recognized as an important part of a firm’s environmental strategy.

In fact, some researchers have redefined PSS as necessarily including environmental improvement. Mont (2004) defined PSS as a system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers’ needs, and have a lower environmental impact than traditional business models. Mont elaborates that a PSS is a pre-designed system of products, services, supporting infrastructures, and necessary networks that is a so-called dematerialized solution to meeting consumer preferences and needs. It has also been defined as a “self-learning” system, one of the goals of which is continual improvement.

3. Social Innovation and Cultural Innovation

Design for Social Responsibility

Social responsibility encompasses the fabric of societal structures, including peace and human rights, dignity and democracy, employment and social integration, security and safety, and the constructive integration of female and male attitudes. As a strategy in current design research and practices, social innovation has been widely practiced in different levels of collaborations among the disciplines of social science, economics, and politics, in the interest of exploring and emphasizing social needs for the sake of sustainable development.

Social innovation emphasises the creativities in solving everyday problems of social communities. Creative communities are "active group of people who, without waiting for big changes (i.e. changes in the entire economic, cultural, technical and political system) organize themselves to solve a problem or to open a new possibility, and in so doing improve the social fabric and reduce the ecological foot-print" (Manzini, 2005a, p.33). "They are group of innovative citizens organising themselves to solve a problem or to open a new possibility, and doing so as a positive step in the social learning process towards social and environmental sustainability" (Manzini, 2005b, p.64).

Vezzoli and Manzini (2008) presented the four fundamental levels of design intervention which toward to rebuild socio-cultural sustainability: environmental redesign of existing systems; designing new products and services; designing new production-consumption systems; and creating new scenarios for sustainable lifestyle.

Toward Cultural Ecology— a Cultural Centred Sustainability

A cultural approach to sustainability involves looking at each functional area from a cultural perspective. Such an approach enriches identity, distinctiveness, and confidence in a place. This enrichment would reinforce and adapt for modern purposes the characteristics of a place or locality and its traditions, values, myths, and history. Fostering a strong local identity is important for culturally-centred sustainability. So far, local identity is the most philosophic and holistic research focus of SPD. According to the

“the Five Pillars of Sustainability” developed by the Product Life Institute (1995), cultural ecology is the most important aspect of sustainability.

4.3.2 Summarizing the Focuses

Existed researches on SPD were conducted from qualitative and quantitative research methodologies. Some of the researches used both. The four research methodologies most frequently used were field investigations, product assessments, theory comparison and building, and information collection.

1. Field investigations are used to observe and assess the practical design and production strategies, methods, and processes that affect the product sustainability. Case studies can be carried out in factories, markets of product deliveries, and design studios and labs in order to seek design principles, methods, tools, or guidelines of productions. In field investigations, qualitative and quantitative research methodologies can be used in multiple research methods.

2. Assessment of existing products aims to give examples of what products are sustainable and what elements make them sustainable. The criteria of assessment is given by the researcher according to his view on product sustainability, which could be influenced by other researchers’ findings (as Datschefski, 2001). The selected products are defined according to their degree of sustainability. Assessment of products also provides a tool for assessing the different aspects of product sustainability.

3. Theory comparison and building. The fundamental theories of sustainable development come from environmentalism, which has developed rapidly in the last century. Comparing the literatures exploring these theories is a way of discussing sustainable issues in industry (as Orr, 1992). In this kind of theoretical research, theories of design thinking and practices are given by principles and guidelines, which also provide issues for further discussion.

4. In most SPD literature, the authors collect and frame information as design strategies, principles, methods, and tools. They find this information in related literatures, in design and production processes, and also from their own design and management experiences (as Lewis & Gertsakis, 2001). Case studies are usually given to illustrate the design principles and guidelines behind the research to make them easily acceptable (as Papanek, 1995).

As SPD is related to many different perspectives of the lifecycle of products, different approaches can be used to elevate the sustainability of a product. Theory based and practice based initiatives are both rational approaches in SPD research. To enhance the effectiveness of initiatives, researchers often choose to join theory and practice together using both positive and constructive thinking in order to conduct their research.

4.3.3 Collecting SPD Principles

These design principles[4] are collected by reviewing SPD related literatures and also selected of the ones from product, social, environment and human approaches. The collected principles and abstracted meanings (abstracted principles) from categorizing and coding those principles are attached with the thesis as ***Appendix A.***

4.4 Structuring the Collected Principles

4.4.1 Categorizing the Collected SPD Principles

I tried to read as deeply as possible in the academic literature to collect SPD principles during the whole research process. I also continued to update the collection by searching for more recent journal articles and books. By the end of my primary research phase in

[4] In his article "Philosophy and Method" (*The Journal of Philosophy, 48*(22), Oct. 25, 1951, p. 665), Richard McKeon defined principle as the starting point of a process in the operation of things, or a sequence in the development of thought, or an order in the actions or statements of men. In this research, some of the principles are abstracted from their original contents to access the essential meanings.

late-2011 I had collected approximately 400 related design principles. (to see *Appendix A*)

To build the four-perspectives structured framework that would be easy to understand and apply abstracted criteria for SPD, I made a process of three phases of abstraction using the original collected principles. The first phase is putting similar ones into distinct categories, in all generating 52 categories. I named each category according to the shared meanings of those similar principles. The second phase is to further categorize those categories to form second-level categories. The final abstracting phase is to extract the shared meanings (core meanings) of those second-level categories and elaborate them using simple language. I ultimately derived 20 final criteria from these three abstracting phases. The below tables represent the final abstracted principles and their related categories names.

1. Product Perspective: Toward Sustainability of the Artificial World	
ABSTRACTED PRINCIPLES	CORE MEANINGS
▪ Design for Multi-Functionalism ▪ Integrated Solutions	1.1 Design Multifunctional Products
▪ Honest Product ▪ Unobtrusive Function Realization ▪ Design for Simplicity ▪ Promote Emotional Durability ▪ Design for Durability ▪ Design for Details	1.2 Provide Durable and Direct Functions
▪ Corporative Design ▪ Establish Product Service System	1.3 Involve User as a Part of the Design to Simplify the Product
▪ Use Recycling Resource ▪ Use Renewable Energy Resources ▪ Build Closed-Loop Biological and Technological Cycle ▪ Sustainable Manufacturing	1.4 Involve Recycle Plans in Design
▪ Select Appropriate Energy ▪ Select Appropriate Technologies ▪ Select Appropriate Materials ▪ Design for Contexts	1.5 Design Contextually Appropriate Products

Table 4.2: Abstracted SPD Criteria for Product Perspective

2. Human Perspective: Promote Sustainable Human Living Conditions	
ABSTRACTED PRINCIPLES	CORE MEANINGS
▪ Safe Solutions ▪ Non-Toxic Design Solutions	2.1 Use Safe and Non-Toxic Design Solutions
▪ Design for Poverty and Equity	2.2 Design for Poverty and Equity
▪ Emphasize Humanity ▪ Follow Nature's Example	2.3 Emphasize Nature and the Rules of Human Life
▪ Design for Sustainable Consumption ▪ Design for Sustainable User Behaviour	2.4 Design for Sustainable Everyday Life Patterns
▪ Design for Visual Well-Being ▪ Design for Pleasure	2.5 Design for Emotional Well-Being

Table 4.3: Abstracted SPD Criteria for Human Perspective

3. Natural Environment Perspective: Emphasize Natural Environment Sustainability	
ABSTRACTED PRINCIPLES	CORE MEANINGS
▪ Product Lifecycle Assessment ▪ Account Ecological Capitals	3.1 Minimize Environmental Impacts along the Product Lifecycle
▪ Use Renewable Energies and Resources	3.2 Design for Energy Efficiency
▪ Respect Ecological Wisdoms ▪ Respect Environmental Principles ▪ Rely on Natural Energy Flow	3.3 Respect Rules and Principles of the Natural World
▪ Design for Resource Efficiency ▪ Waste Equals Food ▪ Design for Waste Minimization	3.4 Design for Waste Minimization
▪ Material Selections	3.5 Select Material for Functional and Economical Efficiency

Table 4.4: Abstracted SPD Criteria for Natural Environment Perspective

4. Social Perspective: Remodel Human Value and Aesthetics	
ABSTRACTED PRINCIPLES	CORE MEANINGS
▪ Long Term and Systematic Considerations ▪ Holistic Thinking ▪ Design for Future Generations ▪ Focus on the Future	4.1 Encourage Long Term and Holistic Considerations

▪ Respect Traditional Wisdom ▪ Design for Culture Sustainability	4.2 Respect and Develop Local Cultural Heritage
▪ Design for Appropriateness ▪ Design for Sustainable Aesthetics ▪ Design for Sufficiency & Appropriateness ▪ Design Toward Spiritual	4.3 Cultivate Modest Desires and Tastes
▪ Local Solutions ▪ Building Sustainable Technological Communities	4.4 Adopt Indigenous Design Solutions
▪ Design for Social Ecology ▪ Use Better Business Methods ▪ Support Sustainable Economy	4.5 Be Aware of Social-Economic Factors

Table 4.5: Abstracted SPD Criteria for Social Perspective

4.4.2 Simplifying the Framework

In the empirical experiments of workshops conducted for this research, I designed the SPD criteria framework as a "method card" for the participants. They brought the cards with them during their time observing selected CTEAs and also used them to guide the whole interpretive process. According to participants' responses, this is an easy to use method that worked well. How they used the method card will be explained in the next chapter: *Empirical Studies and Experiments.* The simplified SPD Criteria for this research are listed in the following table:

1. Product Perspective: Toward Sustainability of the Artificial World	
1.1	Design Multifunctional Products
1.2	Provide Durable and Direct Functions
1.3	Involve User as a Part of the Design to Simplify the Product
1.4	Involve Recycle Plans in Design Solutions
1.5	Design Contextually Appropriate Products
2. Human Perspective: Promote Sustainable Human Living Conditions	
2.1	Use Safe and Non-Toxic Design Solutions

2.2	Design for Poverty and Equity
2.3	Emphasize Nature and the Rules of Human Life
2.4	Design Sustainable Everyday Life Patterns
2.5	Design for Emotional Well-Being
3. Natural Environment Perspective: Emphasize Natural Environment Sustainability	
3.1	Minimize Environmental Impacts along the Product Lifecycle
3.2	Design for Energy Efficiency
3.3	Respect Rules and Principles of the Natural World
3.4	Design for Waste Minimization
3.5	Select Material for Functional and Economical Efficiency
4. Social Perspective: Remodel Human Value and Aesthetics	
4.1	Encourage Long Term and Holistic Considerations
4.2	Respect and Develop Local Cultural Heritages
4.3	Cultivate Modest Desires and Tastes
4.4	Adopt Indigenous Design Solutions
4.5	Be Aware of Social-Economic Factors

Table 4.6: The SPD Criteria for this Research

4.5 Describing the SPD Criteria

4.5.1 Explanation of the SPD Criteria

As the SPD criteria has been abstracted three times from its original SPD principles, the application scope of each final presented criteria is much wider and comprehensive than each original principle. When I identified those core meanings from each clusters of principle categories, I tried to elaborate essential meaning which were not restrained by contemporary social, economic, and technological conditions to make "timeless" abstracted idea. Thus, these abstracted principles can be used to evaluate both contemporary industrial products and ancient traditional artefacts.

To introduce these SPD criteria in the workshops, it was not enough just to present the final form. My method is to elaborate each criteria by presenting and explaining all the sub-categories of SPD principles. I also provide some design examples collected from on-line resources to explain how the abstracted criteria can be applied. It took time to make the participants digest those elaborations and broaden their understanding and reflective thought concerning each of the abstracted SPD criteria from the final framework. For example, when I explained “2.5 Design for Emotional Well-being” I also elaborated on its sub-categories of “Design for Visual Well-being” and “Design for Pleasure” to inform the participants what is meant by emotional well-being and its context. Then I gave further detailed principles as “Form follows Fun” (Papanek, 1995) and “Expression of Virtue, Fulfilment”, etc. (Gallagher, 2011). Through this elaboration process, participants can get more detailed explanations of each SPD criteria.

Without detailed elaboration, each abstracted criteria can also guide a general direction or strategy of SPD practices. The framework has also been improved by making the language more clear and easy to understand. In the workshop exercises described in this research most students could understand the meaning of each criterion and give substantial interpretations according to their own research and design contexts. According to the evaluations submitted, the SPD criteria framework was confirmed as useful by more than 90% of the workshop participants. More evaluation results can be seen in the final chapter: Conclusion and Discussions.

4.5.2 Significance and Knowledge Contribution of the SPD Criteria

A well designed sustainability product cannot be designed without a comprehensive understanding of SPD. Learning different approaches, principles, guidelines and practices is the research method for building SPD criteria. Because of the complexity of its knowledge background and cross-discipline philosophic roots, there are not many research projects which aim to build a comprehensive structure for SPD. The knowledge system is constructed by cooperated knowledge from environmental ecology, human and social ecology, cultural ecology, industrial ecology and economical ecology. A particular structure has been developed for the purposes of the present research in order to illustrate the intrinsic relationship between a product and human-nature sustainability. It is also developed from my understanding of the requirements of human-nature sustainability and function in the artificial world.

Sustainable design is currently one of the most popular topics in design education and research. That said, according to my study of the topic for this research it is clear that researchers and design practitioners talk about the issue from different perspectives. Philosophical understanding, design guidelines, strategic discussion, cross-disciplinary knowledge building, and talking about specific cases are all possible perspectives for these discussions on sustainable design. It is neither merely a knowledge area nor merely a design standard, but is a fundamental issue of human morality and wisdom. It is an everlasting topic with every human being holding innate knowledge and wisdom necessary to contribute to the understanding of how to make sustainable living into a reality.

During the years of research, I had many chances to teach design students and researchers on this topic. I used different teaching methods in my classes, tutorials, and workshops to help the student build fundamental understanding of what are sustainability and sustainable product design. I tried to explain and apply the SPD framework in such a way so as to ensure students could have some fundamental knowledge. I also tried to introduce how I built this framework and why its limitations show that it is not sufficient for every design context. For research students and researchers, I encourage them to build their own knowledge databases and create different frameworks for their own particular research and work needs. SPD will continuously develop and tools required for it will continue to necessitate progressive adaptation.

4.5.3 Limitation of the SPD Criteria

The proposed SPD criteria framework in this research is built for fitting its functions: representing contemporary standards of SPD which shaped by possibilities of how CTEAs can be interpreted into SPD solutions. It was not aimed to build a comprehensive SPD criteria framework which to cover all knowledge of SPD. Many of theoretical ideas such as sustainable economic and political policies are not included as they based on contemporary economic system and they are not directly related to the approaches of studying the SPD insights from CTEAs.

This theoretical framework with abstractive criteria serves as theoretical foundation of the expected research outcome as a method to guide how designers can interpret CTEAs for SPD. It ensures every research and design decision is toward the purpose of designing sustainable products when users apply the I-SPD method from selecting CTEA, to abstracting SPD insights to interpreting those insights to new design contexts. Comprehensiveness, general meanings, and correctness are important qualities for those generated criteria.

As the concept of both sustainable design and SPD are still quite fresh in both research and practice fields. From early 90^{th} last century the knowledge system of SPD has developed and gradually formed its knowledge structure. It is still quite dynamic in its theoretical foundation and boundary of the field. Updated ideas, methods, philosophic definitions are continued represented through different information channels. This makes the SPD framework with its inner criteria a growing nature. That means the framework needs to be updated time to time to make its validity but it should stand on a fixed research approach to specify its functions and values. In this research it covers many of the SPD researches before year 2011 when the framework was temporally built to satisfy its functions in building the I-SPD method.

The key research objective is to build a scientific method for developing and interpreting insights from CTEAs. SPD serves as the context of building the method. It represents the fundamental statement for interpreting CTEAs in this research which insists interpreting historical and traditional design insights should base on contemporary standards to solve nowadays design problems. Accuracy of the SPD framework is not the core focus of the research tasks and it is still important. This may bring critics and arguments in many ways.

Summary of Chapter 4

The uniqueness of the directly practical value of this research comes from designing and conducting the research based on the systematic and developed theoretical framework of contemporary sustainable product design. Although the study objectives of this method are traditional everyday objects, the study does not criticize, evaluate, or articulate the characteristics and values of the objects themselves. These selected objects are used merely as resources to find abundant inspirations for contemporary sustainable design. The effectiveness and cultural adaptations of interpreting and using the explored valuable design insights are greatly enhanced by the developed and systematically organized SPD criteria.

Knowledge, discussions, and practices of SPD come from the continual development of understanding sustainability for individual human beings in their social and natural environments. SPD theories are not always purely design related, but relate to multiple disciplines including sociology, ecology, economics, philosophy, and other social and natural sciences. This makes the field of SPD complex and difficult to investigate. It requires broad reading and research to get a general understanding before initiating design activities. By generalizing and categorizing the literature reviews in this field (books, academic papers, online resources, discussions, and design practices) this research attempts to provide a framework of existing modern theories of design principles and evaluation criteria for SPD.

Because of the theoretical framework of SPD guided in the study, this research is different from most research studying traditional objects. It provides direct meanings and valuable SPD practices from every research case. It also creates possibilities for people from other cultures or local people with less knowledge of traditional artefacts to get useful inspiration from CTEAs. The specific research aim of studying the objects makes the activities of using the method for SPD more concentrated and efficient.

Chapter 5:

Empirical Studies and Experiments

Introduction of Chapter 5

This research is designed as an investigation based on empirical studies, including field studies of CTEAs in different cultural regions of China and a sequence of planned design workshops. The study also includes theoretical investigations conducted alongside the empirical research process. The theoretical investigations are essential to understand and describe the primary and subordinate findings. This chapter introduces the empirical data and how those data have been processed using theoretical analysis.

Field Studies of CTEAs were the first part of the empirical study forming this research. The goal of field studies of CTEAs was preparation for the subsequent workshop experiments. This preparation included three parts: First, collecting a corpus of images and data, taking notes of observations of CTEAs to establish basic knowledge and collect material for the following workshops. Second, structuring categories of CTEAs which have potential meaningful application for SPD and building a framework of those potential design values by functional, aesthetical, and cultural perspectives. Third, testing and refining the methodology of studying CTEAs which was proposed in the research topic confirmation and which has been improved by this empirical study experience.

Experimental Workshops were the second part of the empirical study. They were conducted over a two-year timeframe from and in six different Chinese design schools located in different cultural regions of China. These six workshops were designed for different research functions to solve particular inquiry tasks according to the progress of the final research result--the I-SPD Method. The fundamental structure of these workshops was built around the initial theoretical model of “Studying CTEAs”, “Abstracting SPD Insights”, and “Interpreting Insights”. This model was then developed alongside the six workshops, each addressing different specific tasks and emergent problems of the application of the theoretical model. As the final research result, the given solutions of the tasks and problems along the application process were composed to a formal and concrete design method for SPD—the I-SPD method which will be illustrated in the following chapter: *Chapter 6. Research Findings*.

5.1 Field Studies of CTEAs

The field study of CTEAs in different cultural regions of China indicated that CTEAs can be organized in categories when various contemporary values are applied. As Forty (1986) addressed, many innovative and mould-breaking products can be identified throughout the history of design. These often become what are regarded as "classic" designs which have a timeless quality. Lawson (2006) also pointed out that these designs are united by the fact that they brilliantly solved the problems posed to the users and that they changed the world irrevocably. They are the one-way values of design history, equivalent to the great discoveries of science.

Some traditional artefacts have been gradually replaced by modern products designed using new technologies or for changing lifestyles. In most circumstances advanced or new technologies can bring better product performance; however, they can also bring negative effects and problems. Investigations of Chinese households in various locations and economic statuses show that some CTEAs are still used in everyday lives. The field studies represent "timeless" functional artefacts in their relevant cultural and economic conditions.

The embedded design values of CTEAs can be classified into three major categories: scientific value, aesthetic value, and cultural value. To develop the structure of CTEAs' embedded design values, this study conducts a review of relevant research to explicate different themes of embedded design value and their meanings for contemporary design practices.

5.1.1 Categorization of CTEAs for This Research

The field studies of CTEAs were conducted over the period 2009–2010 in different regions of China. It aimed to achieve an in-depth understanding of CTEAs that would inspire research ideas informing the main research tasks and also provide materials for the planned workshops. Before the workshops, I visited a number of culturally and geographically distinct locations in the China, including Jiangsu, Hubei, Anhui, and Guangdong provinces, and the Beijing, Shanghai, Shenzhen urban areas, as well as others. In the investigated countryside and urban places, I have visited 20 households, taking photographs and conducting interviews when I found some traditional artefacts at their homes. Additionally, I took notes from interviewing family members and observing their lifestyles. Besides these household visits I also visited museums, markets, shops, and restaurants where there were also opportunities to observe how modern Chinese people use traditional artefacts in their everyday lives. These field studies established a fundamental and comprehensive understanding of how CTEAs are used in contemporary life and people's general understanding of them and their use.

I intentionally compared households in both rural and urban areas in investigating how they use traditional artefacts at their homes. I hypothesized that there would be differences arising from economic, cultural, and other influences.

The following description is a comparative case study of two regions, provided as a representative example:

The two places compared are Taihu in rural Anhui Province, and Shenzhen, the first special economic zone of China and located southern Guangdong Province across the border from Hong Kong. These two case studies were conducted between December 2009 and January 2010. Participant observation and related qualitative investigative methods (such as interviews and semi-constructed questionnaires) were used at the two different investigated sites.

Traditional Chinese culture is composed of a complex and highly diverse system of sub-cultures. Different sub-cultures of China are typically defined geographically, with inherent connections to historical migration routes. This definition represents the nature of continuity, diversity, and interrelatedness that marks Chinese traditional culture. According to Haibin Zhu (1997), a Chinese cultural specialist, there are seventeen cultural districts of China, regionally divided by different historic backgrounds and cultural characteristics. The two places investigated in this case study are Taihu and Shenzhen, which are located in the Central Cultural District and the Lingnan Cultural District, respectively. Beyond their sub-cultural and economic differences, these two places represent the two typical conditions of cultural inheritance and preservation in China. Taihu represents original cultural traditions in historic cultural conditions while Shenzhen represents the modern Chinese city mode with mixed cultural influences.

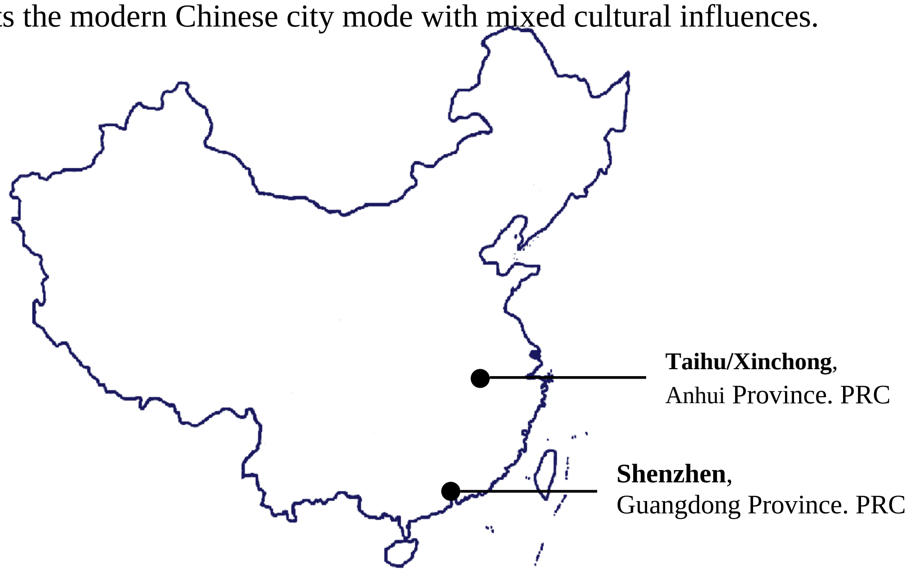


Figure 5.1: Map of the Two Sites of the CTEA Field Studies

Taihu (Anhui Province) and Xinchong Village (Taihu county, Tianhua town)

Cultural and Geographic Overview

Figure 5.2: Image of Taihu

1) Taihu county is located north of the Yangtse River and is noted for Huating Lake and is characterized by mountains and scenic waters. It has a long history of Zen Buddhist practice and influence and was an important tributary of Chinese Buddhism. It has a long history, having existed since 448 AD. The four seasons are clearly differentiated, with the warmest temperatures at 38 degrees centigrade and the lowest temperatures at 3 degrees centigrade. It has plenty of natural resources from nearby mountains and lakes that produce bamboo, wood, and agricultural products. Relative to other areas in China, it has an economic level below the median.

2) Xinchong village is a remote, small village located in the mountains within Taihu county. It does not have any industrial business. Residents are farmers who live on a self-sufficiency model. Traditional lifestyle and cultures are well-preserved.

Shenzhen (Guangdong Province)

Cultural and Geographic Overview

Figure 5.3: Image of Shenzhen

Shenzhen is located in the Pearl River Delta in the south of Guangdong province, just north of Hong Kong. It is the first and most successful special economic zone in the People's Republic of China. The city is quite new, with a short history of about 30 years, as it was not given sub-provincial administrative status until 1980. It quickly developed into an urban environment and experienced rapid population expansion. Most residents are non-local people who have emigrated from different parts of the country, so the city has a mixed cultural identity. It is situated in the subtropical part of China and so has year-long warm and humid weather with less differentiation in the four seasons than Taihu. It represents a typical modern Chinese city, with an economy derived from high-tech and service industries.

Case 1: CTEA Use in the Chinese Countryside: The Taihu Case

In both the town and countryside of Taihu, local economic productivity mainly relies on agriculture, services, craft-making, and small private businesses. Mainstream lifestyle has not been greatly influenced by contemporary industrial and consumer culture. Most of the families investigated maintain a traditional self-sufficient lifestyle with minimum consumption. Family histories and the nature of the material environment create a clear cultural boundary between the rural and the urban family lifestyles. Life in Taihu is less intense. The lower economic status of most of the locals creates a context in which the majority of people focus on ways to carry out everyday activities in a less consumptive manner. Beyond the categories of CTEAs found in urban families, country families use several additional kinds of CTEAs for economic reasons and agricultural activities.

Type 1: Economical and Flexible Energy Consuming Products

The everyday life of most urban Chinese families relies on standard supplies of electricity and natural gas, although some have adopted self-sufficient solar energy systems. Countryside families have different ways of consuming energy that rely less on standard energy supplies. Most of the families in the investigation use charcoal or coal to cook and heat their homes when needed in order to sustain lower energy consumption costs. Charcoal and coal, especially when burned for household use in heating or cooking, are typically low-efficiency fuels and generate particulate pollution with micro and macro-level environmental consequences. There is certainly, therefore, some merit to researching alternative fuel sources, though that is outside the scope of the present topic. What is interesting, and related directly to the present research, is that observed uses of CTEAs using these fuel sources indicate adaptation of intriguing methods of fuel-saving that show some innate understanding of sustainability and provide clues to adapting CTEAs for SPD.

Wisdom 1: Capturing unperceivable energy

Taoists believe that all visible materials and the world are generated by the invisible energy of "the spirit of the world". Visible energy, thermal energy, and light are perceived to be different forms of unperceivable energies. Ancient Chinese people developed methods of capturing those unperceivable energies by various measures, like applying Qigong or Feng-shui. I observed the traditional Chinese cooking stove design implementing a form of this wisdom by collecting and using the leftover heat from cooking to increase energy efficiency. One or several small heating places are fixed around the main stove to boil water or warm food. When the main stove is used in cooking these adjacent pots are heated.

Wisdom 2: Noticing the energy transforming process

Ancient Chinese believed that the human energy system is constantly dynamic—its basic activities comprised of moving and transforming. Balancing this energy system can restore people to health. In Taoism and the Yi-jing (*Book of Changes*), ancient Chinese philosophers emphasized the continued change and moving of energy in the substance of the world. They described an unperceivable universal law that existed to guide the movement, development, and transformation of everything in the world. Energy is also constantly regenerating. It has a lifecycle with different phases. An example of applying this wisdom in traditional Chinese kitchens is the bamboo steamer. Ancient people noticed the energy from charcoal can be transformed into the heat of water vapour. Heated water vapour goes up and flows to heat foods in different bamboo drawers. This is a natural science phenomenon and also reflects traditional Chinese wisdoms.

Wisdom 3: Caring for reactions of different kinds of energies

This principle comes from the traditional Chinese theory of “the five elements”: wind, dynamism, water, heat, and cultivation. Introduced by the Yi-jing, these five different elements are mutually reactive, as are the five reprehensive energies mentioned above. The principle asks people to consider those different energies as a system. Using energy should not break the balance of the system and inner dynamic relations. In traditional Chinese homes, people carefully plan places and types of home settings such as the various facilities, furniture, and spaces. Instead of pursuing extreme comfort and efficiency, ancient Chinese people tried to integrate the natural forms and qualities of these five kinds of energies with their everyday needs.

Those traditional wisdoms affect the design and use of energy producing and consuming products in rural Chinese households. The pictures below show two examples of energy-efficient CTEAs.

Figure 5.4: Flexible Structure Clay Table Stove

Figure 5.5: Energy-Efficient Kitchen

Type 2: Farming Tools and Farming Lifestyle Products

Most of the families comprising the research sample in Taihu are involved in farming and agricultural activities. In other parts of the Chinese countryside, farmers use industrial facilities and motorized equipment. These technologies drastically changed the traditional family-unit way of farming. In Taihu (Xinchong), people rely on individual or family-organized farming models with smaller scales because of the economic status and geographic setting of the area. Basic farming tools are possessed by the family unit and the larger and more expensive tools are shared between families that are either kinship or politically related. The basic farming tools are made, used, and possessed according to traditional designs and craftsmanship.

To support the basic and traditional farming methods and activities, other related traditional products are used by local families. Some of them have flexible and multiple uses, defined by users and contexts.

Figure 5.6: Wood Plough

Figure 5.7: Small Seat for Rice Transplanting

Type 3: Homemade, Handcrafted Products

Many local people make handcrafts at home as a hobby or special skill. Most of the homemade handcrafts are functional products that also represent the maker's aesthetic preferences and skills. Home manufacture of handicrafts is also a lifestyle attribute of

Chinese farming families, not just for economic reasons but also as a continuity of traditions. They make shoes, clothes, and furniture for family and friends. They even build their own houses. Most of them do not plan beforehand their ideas for crafting the products. One interviewee said that he did not even create architectural drawings for the house he built. These products are created based on the past experiences of the individual or others in the community. That causes the styles, designs, and crafting methods of their homemade products to be fairly fixed.

Figure 5.8: Handmade Cotton Boots

Figure 5.9 : Handmade Plastic Vase made of Used Bottles

Type 4: Usable Raw Products and Temporary Solutions

Many of the families used some traditional objects that were not intentionally designed or made for specific functions, but rather satisfy basic functions to the specific contexts. They do not have well-designed shapes and cannot be defined as a final product. They are named "usable raw products" in this research. This kind of artefact was frequently observed during the pilot study.

A similar category to usable raw products is those objects that provide temporary solutions. These are artefacts that were designed for other purposes or were components of other functional products, but people "borrow" them from their original contexts and use them temporarily to solve everyday problems. These kinds of artefacts also appeared in the investigation of urban families, but are more frequently found in the countryside. This use represents a human value and design philosophy that has been abstracted and used in some of the students' design concepts in the workshops analysed as part of this study.

Type 5: Traditional Measuring and Calculating Tools

Many traditional artefacts for taking measurements and making calculations are still used in countryside households. These represent traditional social standards that have been maintained by a consensus of the community.

Type 6: Symbolic Artefacts and Designs on Ancient Human Beliefs and Historical Heritages

Beyond the above categories of CTEAs, there are some artefacts that do not have general practical uses but are related to spiritual values concerning family history or religious or cultural beliefs. Because these types of artefacts are closely related to particular cultural contexts and human values of special groups, they are not included in the systematic CTEAs studies in this research. Culturally symbolic objects, patterns, and forms are frequently used and interpreted in commercial designs, especially in fashion. These patterns and forms are used to create strong symbolic cultural identification to the product. In most circumstances, the forms and patterns are transformed to adapt universal design languages. Studying the cultural symbols used in Chinese traditional objects is another broad and deep topic of design research. Most of these cultural symbols have lost their effective contexts, but reusing these symbols in contemporary designs is a feasible way to remind people of their cultural history to and preserve cultural heritage.

Case 2: CTEA Use in Urban China: Shenzhen Case

The speed of urbanization in China is rapid during the last twenty years. This has greatly altered the everyday lifestyle of city-dwelling Chinese families and led to a modernized and "westernized" way of life. A brief investigation of some urban Chinese families in Shenzhen shows how their preferences in the use of CTEAs differ from more traditional communities.

Type 1: Chinese Style Furniture (bamboo, wood, rattan)

The aesthetic renaissance of traditional style furniture is growing in Chinese urban families as a way to present cultural preference and to interpret oriental style. Besides aesthetic preferences, some families interviewed pointed out that the function and quality of Chinese style furniture made for better usability and durability than other contemporary designs. Hardwood (rosewood), rattan, and bamboo are popular materials for the traditional style, and can be used to make dining tables, chairs, desks, benches, tea tables, rocking chairs, footstools, beds, bookcases, and wardrobes, which are the most commonly used furniture pieces among urban Chinese families. These materials are especially popular in Guangdong province, where the weather is more suitable for using and preserving hardwood and bamboo furniture. The designs of traditional style furniture are modernized through the addition of contemporary design elements in the shape of the feet, the decorations incorporated, and the patterns used. Thus, contemporary furniture designs using traditional styles are not exact approximates of traditional Chinese furniture. There are no rigorous standards or required patterns for design in traditional style furniture. The development of machine crafting capabilities makes it so the quality of details and the complexity of decorations are usually emphasized for better market value. According to market investigations and households investigations, there are three motivations to use traditional Chinese furniture: 1) function, quality, and durability; 2) aesthetic preference; and 3) personal interests in collecting antique Chinese furniture. Pictured below are hardwood and rattan chairs popularly used by urban Chinese families in Shenzhen which suit local climate and cultural requirements.

Figure 5.10: Hardwood Chairs with Tea Table   Figure 5.11: Rattan Chairs with Tea Table

Type 2: Kitchen and Table Wares for Traditional Dietary Habits

Traditional kitchen and table wares can be found in most urban households. They are used to cook Chinese dishes from traditional recipes, which have remained relatively unchanged by modern lifestyles. Traditional cookware can be found in markets, but typically not in stores and supermarkets. Clay pots, clay jars, and bamboo or steel steamers are traditional wares that are used often by Chinese urban families. Certain varieties of Chinese tableware are necessary for every Chinese family, including hardwood chopsticks and porcelain plates, bowls, and spoons. Some families keep superior sets of tableware for festivals and guests. Tableware sets are still popular gifts for weddings and housewarmings as cultural traditions. Traditional Chinese tea sets are also popular in both modern Chinese households and fancy restaurants for cultural uniqueness. The pictures below represent common conditions of traditional cooking and table wares using in kitchens and dining rooms.

Figure 5.12: Single Handle Soup Pot   Figure 5.13: Dish Set in Contemporary Forms

Type 3: Easy-to-Use Tools and Smart Small Products

Traditional tools to be used in the kitchen, bathroom, and bedroom can also be found in urban Chinese households. The most frequently used traditional tools are kitchen tools for cutting or processing foods; tools for cleaning dishes, floors, or clothes; and tools for massaging the body. Some are small and are usually used because they are effective and can be purchased cheaply, such as wood and bamboo clips for hanging clothes, palm-leaf fans, and sponge melon brushes. Some other traditional tools and products are used by elderly people as the result of old habits, like thimbles for sewing. These traditional tools are either easier to use than modern tools with similar functions or else the traditional tools are still the current standard, and haven't been replaced with modern designs. The pictures below show two examples of traditional tools.

Figure 5.14: Basin and Washboard

Figure 5.15: Dish Washing Tools

Type 4: Traditional Learning and Leisurely Tools

Investigations of urban Chinese families show that they use traditional products such as Chinese stationery, musical instruments, chests, and toys. These have become cultural symbols and functions for special activities. The designs of these artefacts are fixed. Material, quality, craft, and brands differentiate the market prices of these products. Aesthetic values are emphasized in this kind of CTEA. The pictures below show two examples.

Figure 5.16 Bamboo Flute

Figure 5.17: Go-Wei Chi

Type 5: Ritual Cultural and Traditional Symbols

Some CTEAs have unique ritual and cultural meaning. They are adaptive in the special cultural context and cannot be replaced by modern substitutes. The artefacts themselves serve as fixed cultural forms and have obvious symbolic meanings which are usually related to specific functions for traditional beliefs. The pictures below show two examples of ritual cultural and traditional cultural symbols.

Figure 5.18: Red Packets[1]

Figure 5.19: Feng Shui Mirror[2]

[1] Red envelopes containing money are gifts for traditional festivals. They are usually sent from older generations to younger generations.

[2] A traditional tool for measuring Fengshui for Chinese homes.

Summary of Field Studies: Categories and Value Focuses of CTEAs

Some CTEAs are still used for cultural and aesthetical preferences while some are used for specific economical or ideological reasons. Some cannot be replaced by better industrial or electronic products created using mass production methods. Some reflect the traditions and culture of the Chinese people. Cultural traditions, economic considerations, and functional performance are three major reasons for the continuity of CTEA use in contemporary times.

According to the investigation of Taihu and Shenzen, the categories of CTEAs can be classified as follows.

Urban Families	▪ Chinese Style Furniture ▪ Cooking Wares and Table Wares for Traditional Dietary Habits ▪ Ritual and Cultural, Traditional Symbols ▪ Traditional Learning and Toys ▪ Easy to Use Tools and Smart Small Products
Countryside Families	▪ Chinese Style Furniture ▪ Cooking Wares and Table Wares for Traditional Dietary Habits ▪ Traditional Learning and Toys ▪ Easy-to-Use Tools and Smart Small Products ▪ Economical and Flexible Energy Consuming Products ▪ Farming Tools and Farming Lifestyle Products ▪ Homemade Products ▪ Usable Raw Products and Temporary Solutions ▪ Traditional Measurement and Calculation Tools ▪ Symbolic Artefacts on Ancient Human Belief and Cultural Heritages

Table 5.1: CTEA Categories

These categories of CTEAs may have embedded values for contemporary designs. Traditional decoration and art pieces are not included in this research as these artefacts represent fixed forms or patterns in certain cultural contexts. The designs of traditional art and decoration can be used or represented in their original or similar forms, but do not have general meanings that can lead to new design thinking.

Concluding Focuses of CTEAs' Design Values

The pilot studies on CTEAs in urban and rural China in both modern and traditional-lifestyle families not only provided a picture of what kinds of traditional artefacts are still used—a more important finding is the answer to why these artefacts were picked to serve these functions in contemporary lives.

By interviewing the users, observing related user behaviours, and analysing personal experiences and contextual inquiry of the artefacts, the case study found different values that the artefacts originally had and still have for contemporary needs.

Some of the categories of CTEAs may have different functional values in different contexts. As some of the homemade crafts can bring the aesthetical value of joy and happiness and the mental fulfilment of personal capability, they can also serve as economic solutions with specific functions.

Design Values	CTEA Categories
FUNCTIONAL VALUE (SCIENTIFIC VALUE)	
Advanced Ancient Technological and Economical Solutions	▪ Farming Tools and Farming Lifestyle Products ▪ Economical and Flexible Energy Consuming Products ▪ Homemade Products ▪ Usable Raw Products and Temporary Solutions ▪ Traditional Learning and Toys ▪ Traditional Measurement and Calculation Tools
AESTHETIC VALUE	
Patterns and Symbols of Traditional Tastes, Customs, and Lifestyles	▪ Traditional Style Furniture ▪ Traditional Learning and Amusement Objects

	▪ Homemade Products ▪ Ritual and Cultural, Traditional Symbols
CULTURAL VALUE	
Approaches and Principles of Traditional Religion and Beliefs	▪ Ritual and Cultural, Traditional Symbols ▪ Symbolic Artefacts on Human Belief and History ▪ Kitchen Wares and Table Wares for Traditional Dietary Habits

Table 5.2: Design Value Focuses of CTEAs

The focus of Functional Value represents that which can be referred to in order to solve certain current problems in designing, making, and using products for functional purposes. It is above specific culture contexts with general scientific and technological means. The focus of Aesthetic Value describes the inherited traditional aesthetic traits of appreciating forms of products or experiences through using the products in a general cultural context. It is the conventional term of specific cultures that developed through social and artefact evolutions.

Cultural customs and beliefs also provide insights into the motivation for making and using the artefacts. In this research, the focus of Cultural Value describes the traditional moralities and values that are reflected from the approaches or principles of how people make, use, or select CTEAs through their everyday activities. These derive from inherited traditional religious, institutional, and philosophical beliefs.

Practical Values of CTEAs in Contemporary Chinese Lives

CTEAs in this research refer to those traditional artefacts used in everyday life that were gradually developed through generations of use and technological breakthroughs. These artefacts were not originally intended to address today's sustainability problems, although they are still used in some places for cultural or economic reasons.

Investigating why the traditional artefacts are still being used in contemporary everyday life attracts designers' interest in discovering the design implications of these artefacts' inherent characteristics. For the specific purpose of understanding the objects' SPD values, the table below reveals the places in which the CTEAs are still used and the reasons behind their continued usefulness. Investigating the amount of use among families in different locations, as well as among families in different cultural and economic conditions, indicates that there are many motivations for using traditional objects. The table focuses on two aspects: cultural influences and, functional and economic considerations.

TWO ASPECTS	VALUE FOCUSES
Cultural Influences	▪ Tradition & Custom ▪ Ritual & Ceremony ▪ Habit ▪ Cultural Symbolic Meanings: ▪ Aesthetic preferences ▪ Representative of different social hierarchies ▪ Embedded cultural diversity
Functional & Economic Considerations	▪ Cheap to Buy or Produce ▪ Cheap to Use ▪ Energy Efficient ▪ Multi-functional ▪ Easy to Use ▪ Simple to Make and Use ▪ Durable ▪ Safe to Use ▪ Manufacture or Use Creates Usable Waste Products

Table 5.3: Practical Values of CTEAs

Investigating the design reasoning behind the practical values of artefacts can help designers position the artefacts on the SPD framework. The design reasoning is how ancient people realized functions of aesthetics and uses by utilizing materials for a certain purpose according to their shape, structure, texture, style, decoration, and pattern, and why these aspects are suitable in the context of use. This also decides the content and aims of further investigations of the selected CTEAs.

5.1.2 Development of Artefacts Study Process and Methods

Another objective of the field studies was to test the research methods for artefacts studies which were proposed in the research topic conformation. The proposed process of CTEAs studies has two steps: 1) select CTEAs, and 2) study CTEAs for SPD insights. The reason for composing the artefacts study process is there is a premise that not every CTEA was designed with SPD thoughts according to the SPD criteria built for this research purpose.

The field studies of the CTEAs were conducted in different areas of China. They were informed by my personal research experiences and guided by the supported investigative knowledge in design, artefacts, and cultural research. As the research purpose is to develop an effective research method for exploring and collecting embedded design values for SPD, I attempted to capture the key SPD attributes and seek information for the attributes' reasoning through the field studies. The study used various techniques for gathering data, including traditional research methods of traditional Chinese artefacts studies and contextual inquiry methods such as participant observation, in order to help the investigators gain a depth of understanding about the investigated artefacts.

Adapting the SPD Framework with Criteria to the Artefact Selection Method during Analysis of the Data from CTEAs Field Studies

The data collected from the field studies of CTEAs included artefacts' images in their original contexts, interviews with local users, field notes of the artefacts' cultural, economic, and geographic backgrounds, and videos for recording user behaviours. The next step was data processing. I served as the key investigator in the field studies, although in some sites, such as Taihu, assistants helped to gather data by taking photographs and conducting interviews. There was thus no actionable process for teaching investigators about SPD knowledge before gathering data in the field studies.

Before entering the site, the SPD criteria framework has been developed in its rough model. As the rough model came entirely from coding and abstracting design principles from the literature and from descriptions of successful design projects, the SPD framework was continually adjusted while investigating the CTEAs. Thus, its adaptive content, form, and structure fit the requirement of searching, sorting, and understanding the nature of the embedded SPD values of the investigated artefacts. The final version of the most effective form of the SPD framework was introduced in chapter three of this thesis.

Through this framework, if the artefact embeds any of the listed sustainable attributes according to my understanding of the criteria, it is deemed a sustainable CTEA, qualifying it for further study. This selection process includes an interpretive action of deductive reasoning for all criteria to the specific context of the observed artefact. This action requires the investigator to understand the framework and criteria in a comprehensive and flexible way. For the other organized workshops, understanding of the SPD framework has been constructed as a separate teaching unit; it also has been continually refined through the workshops. I applied the following methods in the artefact field studies:

Participant Observation

When arriving at the site and finding target artefacts, the first task of the investigation is to try to use those artefacts. The first-hand experience of using the artefact is very important to understanding the design, making, and using as a prerequisite for further investigation. I took notes of the using experience. Record questions of what the researcher wants to know through further investigation.

Contextual observation

Besides participant observation as the key artefacts study method, contextual observation of different people making and using the artefacts has also been adapted to investigate different functional performances, behavior patterns, and aesthetic attributes of CTEAs. Short interviews can be conducted for specific questions emerging from observation. Take pictures and notes of observations; some behaviours can be record by video camera with short descriptions.

Interviews

Semi-structured interviews were conducted. The questionnaire came from participant and contextual observations to investigate the particular attributes and reasons of CTEAs. Product lifecycle analysis and ICB for interpreting cultural behaviors from Xin (2007) are two methods used to develop meaningful questions.

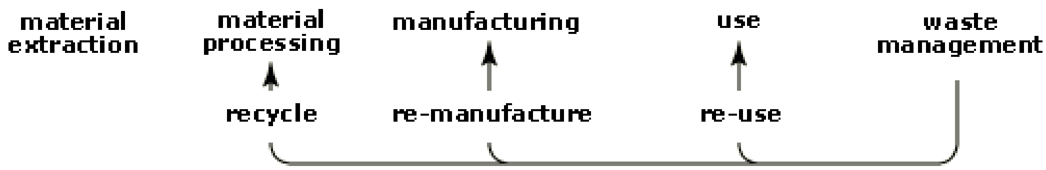


Figure 5.20: Product Lifecycle Analysis

Name of a Cultural Behavior

Observed Behavior	Motivation - Physiological needs - Emotional needs - Symbolic Meanings - Hierarchical Rules	Cultural Influence - SETIG Factors - Traditions - Philosophic Foundation
Description, illustration, or stories of the behavior Behavior Image		

Figure 5.21: ICB--Interpreting of Cultural Behaviors (Xin, 2007)

In this research there was no paper questionnaire for interviewees, as some interviewees were illiterate. The questions should be simple and direct. Every interview of non-specialists should be finished within fifteen to twenty minutes. The quantity of interviewees is also decided by the quantity of new sustainable features and behavior patterns. Besides interviewing ordinary users according to the local situations, I also interviewed “specialists” of CTEAs. Specialists include craftsmen, artefact dealers, and experts in craft and cultural research. The aim of conducting interview of specialists is to discover the deeper reasoning of cultural influence of the investigated artefacts. Digital recorder, high resolution camera, and video camera should be used during interview to record useful information.

Artefact collecting

Besides taking images, videos, and interview notes of many CTEAs, I also collected many material objects. They are examples to inspire workshop participants and also help explain my research ideas.

A Sample Investigation Note: "Charcoal Ashes Warmer"

Description: At left, the researcher (the designer of the project) gains direct experiences of the artefact's function.

Figure 5.22: The Use Process of the Charcoal Ashes Warmer

Artefacts Description

Context: *I found this artefact in Taihu, Anhui, where it acted as a warming mechanism in many households. The artifact holds the remnant heat of charcoal ashes after they have been used in cooking. In traditional China, most people burn charcoal or coal to keep warm in winter, but this charcoal warmer provides a more economical solution as the leftover ashes from cooking, when placed in the receptacle, can be used to keep a person or area warm for several hours. There are different sizes and forms for the warmer, according to its different needs and use contexts. In some households certain warmers are used as pieces of furniture.*

Uses: *The body of this warmer is commonly made of wood and looks like a barrel used for bathing. There is a metal basin in the bottom of the artifact, which holds charcoal ashes, and a semicircular* *wooden board located atop the barrel, which is used for sitting. A round metal grate is fixed just above the ashes' basin, which protects the feet. Some portable warmers have also been developed for warming hands or drying shoes. Some have twin seats to accommodate two people sitting face-to-face, when they want to closely chat.*

Motivation: *This design is initiated from the concept of using the remnant energy of cooking ashes after the charcoal has served its original purpose. This is an inexpensive method of personal heating. Furthermore, charcoal ash releases gentler warmth than burning charcoal or coal directly. After people realized that the cooking ashes could be used for keeping warm, they used creativity to improve the design of the warmer.*

Design Characteristics: *The warmer is a design model for multi-use furniture. It can be used as a seat and also as a warmer, much as a massage recliner is both a comfortable chair and provides a mechanical massage.*

SPD Attributes: *1) Efficient use of remnant energy after its original purpose—promotes energy efficiency. 2) Integrates different functions into one product, providing multiple uses from one item—smart function.*

FIELD NOTES –Selections

"….Ashes are held in a clay or metal basin. After remnant fires are extinguished, the basin can be placed into the body of the warmer for use. (1) Users can stir the ashes with a kitchen hook or a metal stick to make the ashes burn more efficiently and provide more heat. There are some small holes in the seat, which allow rising heat from the ash basin to saturate the user. (2) People can dry their shoes while making themselves warm. Usually, it is used after supper in the evening. That is because there are ashes available after cooking dinner, and people have time to sit and enjoy their leisure time. (3) This artifact reflects a kind of lifestyle that focuses on energy use. In town, I also found that some people make ashes by burning dry leaves or coals to use a similarly-designed warmer. There are also a lot of similar products in mass production that consume electricity. I have tried some of these products and found that they lacked the original experience of the charcoal ash warmer and need to be further developed. (4) I found many different forms of charcoal ash warmers among Anhui Taihu families; the creativity of the local people was exciting. They designed different styles of warmers to fit their family uses, and these products are honest and functional. (5) All shared one single concept: they located and continued using remnant energy. The charcoal ash warmer also acts as a philosophy of energy use in this area. (6) The

warmer is a traditional object and also makes economic use of energy, inherited unconsciously through different generations...”

5.2 Experimental Workshops

As the ICTEA-SPD method was generated through the six workshops as design cases provided theoretical modifications as research was in progress, each of the workshops had distinct functions and roles in the evolutionary process of the theory. The workshops are described in the table below according to their functions in the theory evolution process.

Experiments from the workshops are divided into two parts: 1) the initial workshop, which included a small group of professional designers, including the researcher herself, where the initial theoretical model for interpreting the studied CTEAs was built; and 2) the other five structured workshops, which tested the hypothesis of the detailed method process and also allowed for collection of different application patterns of the method.

The following table records the key points of method development through each stage of the empirical study of the workshops.

Workshop Title	SPD Method in Progress
(Pilot) Workshop-HK	Propose initial model of the SPD method: study CTEAs; abstract design insights; interpret design insights.
Workshop No.1-SC	Specify research and design tasks of each phase of the SPD method: select and investigate CTEAs; abstract inner design reasoning for the SPD traits; design to match the insight to specific design problems.
Workshop No.2-SH	Describe different behaviour patterns of applying the SPD method to studying artefacts, abstracting insights, and interpreting insights to design concepts.
Workshop No.3-SD	Formulate affiliate tools and guidelines to smooth the application of the full process of the SPD method.

Workshop No.4-WH	Compare different paradigms of applying the SPD method: design as a reflection of the insights and design to solve pre-assigned design problems.
Workshop No.5-GZ	The free-style application of the SPD method: applying the method for various purposes.

Table 5.4: Theory Development Progress in Workshops

The research progress of the experiments of the six workshops has been illustrated as "Road-map of ICTEA-SPD Method Development" and attached with the thesis contents as ***Appendix C.***

5.2.1 Propose Initial Model of I-SPD Method: Pilot Workshop in Hong Kong (Workshop-HK)

Describe the Basic Mechanism of Design Reflection from Selected CTEAs through the Pilot Workshop

The pilot workshop was conducted with spontaneous procedures by me and participated by 10 professional designers and product design majored graduate students. We studied, applied and discussed the material and findings of my field studies of CTEAs.

The 10 participants were introduced to the structured knowledge of sustainable product design and the initial SPD criteria framework. Once the participants gained a brief and systematic understanding of the criteria and different approaches of SPD they were able to interpret the abstracted criteria into their own design contexts. There was no structured design process to introduce before each participant started his or her own design project, nor were there any required or appointed design purposes and project titles. The participants were required to create several design concepts that were inspired from their understanding and studying of the given materials about CTEAs. The concepts were represented in sketches, with brief process illustrations to present their design methods or processes.

The fuzzy design process of designing by inspirations from CTEAs, as gleaned from the pilot workshop, is illustrated in the below diagram:

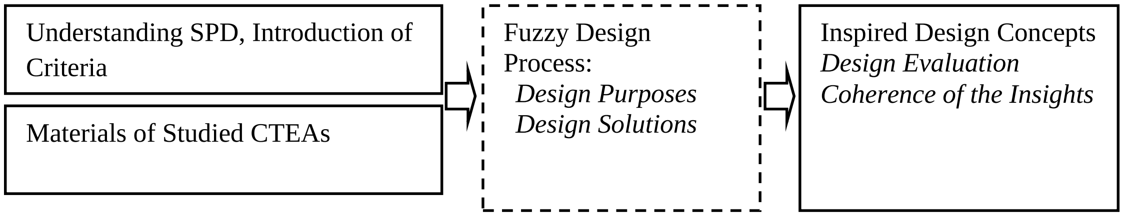


Figure 5.23: A Fuzzy Design Process

According to the investigations of the designers' fuzzy design processes, which they were required to illustrate and record with their final design concepts, abstracting specific design insights occurred according to the designer's understanding, personal experiences, and interests, as well as the designer's methods and capabilities of abstracting meanings for SPD from the studied CTEAs. The participants were inspired in different directions to generate new design concepts, which were represented in the alignment of their given design concepts with SPD purposes and the original inspirations from their studied artefacts. The initial process model can be synthesized into three phases: understanding and selecting CTEAs, getting inspirations from CTEAs, and designing from the inspirations.

Understanding SPD serves as the knowledge background and design evaluation criteria for making decisions in each step of the design process. This understanding ensures that the outcome design concepts serve the purpose of solving sustainability problems in designs or everyday lives.

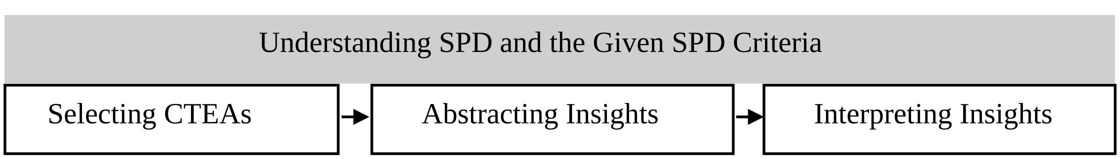


Figure5.24: The Initial Process Model

5.2.2 Develop a Concrete Process: Sichuan Workshop (Workshop-SC) and Shanghai Workshop (Workshop-SH)

1. Specifying the Research and Design Tasks of Applying the SPD Method: Workshop-SC

Workshop-SC was the first workshop with structured contents and it is defined as workshop 1 for this research. The workshop was designed to: 1) understand the project and the SPD framework while introducing basic knowledge of SPD with substantial design examples; 2) select and study artefacts; 3) abstract design insights from collected data; and 4) generate design concepts from the design insights. The method of selecting artefacts was according to SPD criteria; artefact study methods were introduced to help participants more directly access the research targets. The 23 participants were graduate students and senior-grade undergraduate students in product design. They had a level of design and research capability that allowed them to accomplish the research and design tasks of each phase of the workshop.

The workshop is designed to carry out specify tasks for each of the three phases. This organization of the tasks of each phase achieves the purpose of applying the SPD method: using designing solutions embedded in CTEAs to solve contemporary sustainability problems. While electing the adaptable artefacts for their projects, participants were expected to keep in mind that what they selected should have certain applications to contemporary SPD. Without this clear, final goal for the workshop, their resulting design concepts would otherwise lack relevance to the studied artefacts or have no strong influence to SPD.

The specific tasks for each phase of the method are as follows:

1) Specify the SPD traits by investigating the design objective of the selected CTEAs while conducting “blind observation” (direct observation) in the field or conducting related artefacts research (indirect observation).
2) Investigate CTEAs with different methods of artefacts studies to understand the design reasoning of their SPD traits.
3) Abstract the design reasoning from its original design context to create a clear sustainability effect according to the SPD criteria.

4) Design product concepts that realize the sustainability effect to a specific design context.
5) Select the best design concept using the SPD criteria and other required criteria.

These tasks can be arranged within the corresponding phases of the method.

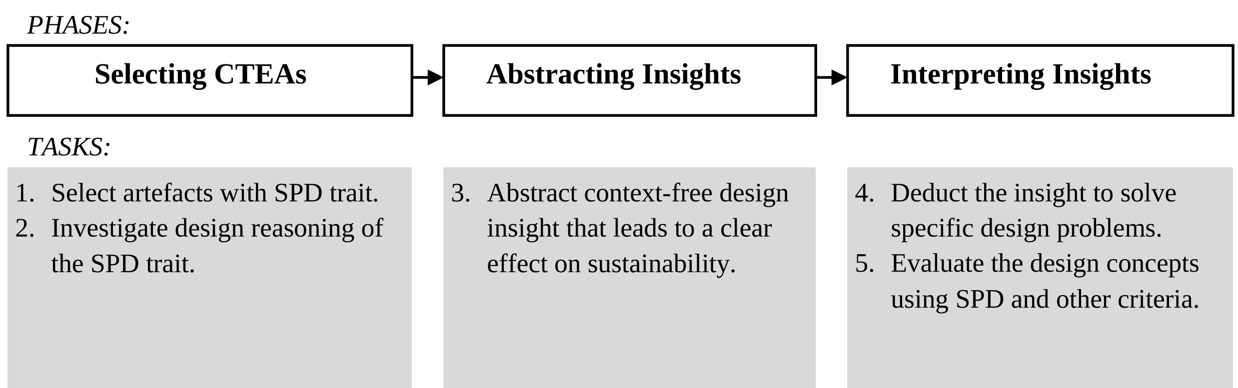


Figure 5.25: Specified Tasks for Each Phase of the Method

Besides fixing clear tasks for each phase of the method, there are also other findings, which included: 1) the fuzzy model of abstract design insights: insights as specific or abstract design solutions to satisfy certain sustainable design effects; 2) the basic pattern of interpreting insight: reflections from the design insight process; 3) related skills and techniques for concept generation; and 4) the method of evaluating design concepts: combining SPD criteria and other required criteria. These findings shaped the outline for theoretical study and the following Shanghai workshop.

2. Describing Different Design Patterns[3] in Applying the SPD Method: Workshop-SH

[3] "A design pattern consists of three essential parts: 1) an abstract description of a class or object collaboration and its structure; 2) the issue in system design addressed by the abstract structure; 3) the consequences of applying the abstract structure to a system's architecture." from Gamma, E., & Helm, R. (1993).

There were 20 participants in workshop-SH, and all are graduate students in product design and some are with engineering backgrounds. They have been well trained with systematic and logical thinking capabilities. The workshop is designed to categorize different participant behaviour patterns while they completed each compulsory task of the method. From group and individual tutorials during different stages of the workshop the objective and subjective situations (dimensions of the tasks and qualities of designers, respectively) of each emerged behaviour patterns were investigated. By describing the found behaviour patterns according to their corresponding situations, the research and design tasks for each phase of the method are made into more concrete illustrations. Furthermore, the quality of the tasks could be controlled by an in-depth understanding of the developed method process.

The identified behaviour patterns are described in the table below according to the three phases of the method:

Selecting CTEAs	1. Select artefacts with SPD trait. 2. Investigate design reasoning of the SPD trait.	Different levels of artefact investigation.
Abstracting Insights	3. Abstract context-free design insights that lead to a clear effect on sustainability.	Different levels of abstracting the design reasoning to the SPD trait.
Interpreting Insights	4. Deduct the insight to solve specific design problems. 5. Evaluate design concepts.	Creative patterns for interpreting design insights: 1) interpret single insight and 2) interpret cluster of design insights.

Table 5.5: Behaviour Patterns of SPD Method Tasks

The behaviour patterns were observed and categorized during the workshop and after-workshop data sorting. Required knowledge of artefact studies and human cognition processes were studied to help understand the relationships between the patterns of behaviours that characterize a given task. These patterns shape the basic descriptions and criteria of each task on the method process, which can provide future users of the I-SPD method with a set of concrete guidelines for their cognitive and design activities. The specific contents of each behaviour pattern category have been explained in previous chapters according to the phase in which they are located.

Besides the findings in different behaviour patterns, the phenomena of abstracting insights and interpreting insights to concrete design concepts have been studied according to participants' practices and applying related psychological theories on the nature of abstractive and interpretive thinking. Fundamental theories on design thinking are also investigated to explain the mechanism of how the inspiration intervenes and connects with the designer's own knowledge while communicating with the design context. The definition and validity of "insight" is given as a linguistic representation of a sentence with a standardized grammatical formula. It contains basic components of abstracted subjects, which can be alternated or inducted by specific subjects to fulfil the SPD purpose. The creative method of "Cluster Design Method" was developed to introduce a structured brainstorming method to assist the concept driving task. This method was also found to be an effective method of training creative thinking.

5.2.3 Formulate Affiliate Tools and Guidelines: Shandong Workshop (Workshop-SD)

Workshop-SD was the third official workshop requiring all participants to finish compulsory tasks within sequential processes. There were 19 participants, all of whom were undergraduate design students from art and design backgrounds. These students were not trained in research methods, but they were quite open and patient when it came to learning the concepts in the workshop. They had all been immersed in local traditional backgrounds through their past studies at school. This workshop benefited from the Museum of Chinese Traditional Everyday Artefacts located on campus. It provided a convenient opportunity for students to study and understand local CTEAs.

Observing and collecting participants' ambiguities and difficulties with the specific tasks and theoretical studies gave rise to some related tools and guidelines to understand those problems and create theoretical proposals. These tools and guidelines were tested and refined during the workshop in order to make the SPD method easier to follow and be integrated with its final purpose. The workshop was organized in three units of tasks following the three phases of the I-SPD method process. There was an introductory session giving project background and plan and a separate study unit for participants to gain knowledge of sustainable design as well as the structure and criteria of the SPD framework. The tools and guidelines were provided during the learning part of each unit, according to the relevant tasks of that unit. Students were divided in groups to work for the tasks in phases. Tutorials were conducted to guide students' works and collect their feedbacks. The tested tools and guidelines from this workshop are sequentially listed in the following table, with brief explanations of their functions in the method applications:

Tasks	Tools/Guidelines (T/G)	Functions of T/G
Phase 1—Selecting and Investigating CTEAs		
1.1 Select CTEAs with SPD attributes	**T1:** Select CTEA by SPD framework. **T2:** Tools for artefacts collecting.	T1: Provide an evaluation method for CTEA selection using comprehensive understandings of the abstracted SPD criteria. T2: A structured method helps method users collect more CTEAs for further selection.
1.2 Investigate CTEAs on design reasoning of the SPD attributes	**T3:** Different levels of artefacts investigation. **G1:** Data collecting structure. **T4:** Deconstruct designs for the SPD attributes.	T3: Help to know which level of artefacts investigation they are doing and what potential results they will get. G1: List categories of possible data from artefacts investigation while providing a data processing structure. T4: Help to organize the information and remind that information should be collected during artefacts investigation.
Phase 2—Abstracting Design Insights		
2.1 Abstract context-free design insights for SPD	**G2:** Check validity of the SPD insights. **T5:** A model for analysing data. **T6:** A tree diagram for coding insights. **T7:** Different levels of abstracting.	G2: Structure the evaluating factors' insights validities. T5: A prescriptive method for processing data for beginning users of the method. T6: Present language syntax of the abstracted insights. T7: Help to understand the domains and contents of different abstracted levels.
Phase 3—Interpret Insights and Evaluate Design Concepts		

3.1 Interpret the insight to solve specific design problems.	**T8**: Identify design problem using the SPD framework. **T9:** Tool for interpreting insight.	T8: Help to identify design problems for the interpreted insights. T9: A tool for interpreting insight by replacing alternatives of the insight schema structure.
3.2 Evaluate design concepts.	**G3:** Constant evaluating during interpreting process.	G3: Evaluating SPD and other required design qualities.

Table 5.6: Development of Tools and Guidelines for the Method Process

5.2.4 Integrate Process into a Design Method: Wuhan Workshop (Workshop-WH) and Guangzhou Workshop (Workshop-GZ)

1. To Develop the Method to Fit the Design Method's Heuristic Nature: Use the Method to Solve Particular Design Problems: Workshop-WH

The fourth workshop was conducted to compare the two different design paradigms: design as a reflection on insights and design to solve pre-assigned design problems. The previous three workshops were created to assess designing through reflection on the insights, which is a deductive thinking process that matches adaptable design problems to interpreted design solutions. In this paradigm, one design insight can lead to multiple possible design solutions. The role of evaluation at the final stage is to select the most adaptable design problems to the deductive design solutions. It is a reverse process of design thinking, as design thinking usually runs from the existence of a problem to the creation of a solution. The observations in this research indicate that training designers to think in this reverse process is part of the difficulty of the method.

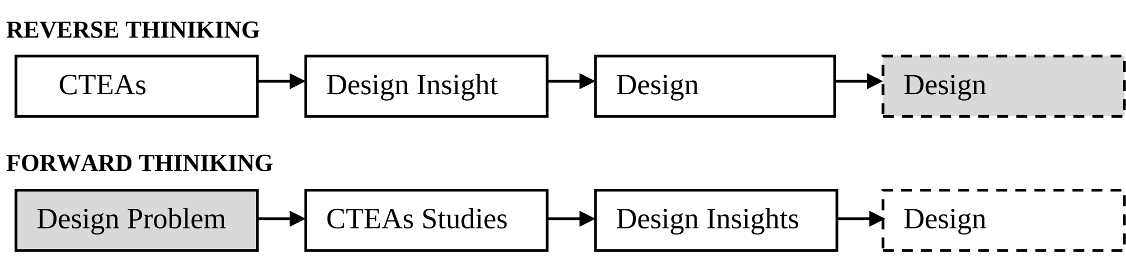


Figure 5.26: Reverse Thinking and Forward Thinking in Method Application

This workshop invited 23 graduate design students with backgrounds in product (industrial) design to explore the possibilities for using the method to solve pre-assigned design problems. The design tasks were not fixed before they began the process of the method, however. In this workshop, the SPD framework was used to search design tasks (find opportunities) according to the designers' understanding of the contemporary world. The framework was designed as a tool to search design opportunities for SPD.

The most difficult part of the forward thinking design process is finding connections between a design problem and the CTEAs, for when the problem is already set, artefacts selection must be guided not only by the SPD framework, but also by relevance to the design problem. Mapping the design problem on the SPD framework is a way to understand the problem. It is also a way to propose a direction to generate design solutions. According to the workshop cases, many students got their initial ideas when they placed the problem on the design criteria that they thought would help to solve the problem. Because they were asked to continue the process of selecting relevant CTEAs and interpreting design insights to fit the design problem, they imposed their final concept relevance onto their selection of CTEAs.

In the end, there were two types of unexpected circumstances: 1) a "fake" process of interpreting CTEAs for their final design solutions and concepts, where participants actually interpreted the SPD criteria into design solutions and then skipped the CTEA inspiration process and 2) an adaptable process, wherein participants changed their original design problem and replaced it with another using what they interpreted from the design insights. There were also some "lucky" participants who were able to build a relatively natural connection from their chosen design problem to some CTEAs.

Here are some field notes for recording the situations of interpreting the insight:

> *"Students worked in groups to brainstorm solutions to their design problems based on their chosen insights. I tutored each group and found that most groups didn't show their insights correctly and didn't follow the method of replacing keywords with insights. I helped some groups to reorganize their analysis of the artefacts and tried to help them find design insights to solve their pre-determined design problems.*

I found that there is a vague/fuzzy logic linking artefacts analysis and design solutions. Some students change artefacts and some change the design problems throughout the process. Some even changed both in order to focus on an idea that came to their mind in a moment, even though it did not quite fit the context of the pre-determined problem, because they considered the idea worth exploring. I was inspired to see that there are so many different ways of applying the method.

During individual tutorial, students exhibited three ways of finding their final ideas: 1) change the artefact they selected to link to the final concept. I think these students may have generated a concept first and then found an artefact to represent the related design insight. 2) Change or specify the design problem to use the found design insight. Students have obvious trouble applying the design insights in specific design contexts. I found that limitations are necessary in this stage. Because there are no limitations in the design process, students find it difficult to link the insights to any specific contexts. I explained the method of making categories and building scenarios in the concepts generating phase. I also suggested the importance of using the SPD framework to evaluate the concepts' degree of sustainability. 3) Some students gave design concepts by the complete method. They were lucky enough to link the two objects in the right way from the start. Except in three circumstances, where students gave ideas that were just design concepts that may be related to their pre-determined design problem. These design works were not generated from the method at all and not considered to be intelligent insights."

In the last context, the insights from CTEAs serve as design references for specific patterns, function plans, product structures, or symbolic meanings. Insights were more likely to be affiliated with the artefact level of abstracted design insights.

2. Explaining Functions of the SPD Method: Applying for Different Purposes for Entry Level Students: Workshop-GZ

The fifth workshop was designed to test the final usability of the proposed ICTEA-SPD method, along with its affiliate tools and guidelines. There were 23 undergraduate students from different areas of the design field (architecture, fashion, fabric, interior, book, exhibition, product, furniture, and design education). Most participants were in their second or third year of undergraduate study, and were art-based design students with strong sketching and form design skills. Rationality and following a thinking process were not emphasized in their past design trainings. This is why these students were suitable for the last workshop in this research—so that the process would be most refined, and could be tested against untrained minds.

This workshop lasted three weeks, which was the longest time span of all the workshops in this research. Half of class time each week was designated for lectures and working in class, while the rest of time they were assigned to perform investigations and work at home. The workshop was organized and conducted as a part of the course entitled: Design Innovation for Everyday Life. This workshop received superb support from the Design School of Guangzhou Fine Art Academy, which is the leading design school in South China.

To create a better understanding of the purpose of the SPD method, participants attended a warm-up session in the first few days of the workshop. This warm-up session provided background knowledge about SPD and explained the SPD framework and criteria. The warm-up assignment from this session required each participant to design a product for everyday use from a CTEA prototype. Other contents of the SPD method were not provided until the warm-up design assignments were completed and evaluated.

Conclusions from the warm-up design assignments are as follows: 1) most of the students' works superficially referred to the visible forms and structures of the CTEA prototypes for designing existing contemporary products; 2) the originality and creativity of the design concepts were strong; 3) the effects of solving everyday sustainability problems were not obvious in the designed products.

After evaluating the warm-up design work, some selected designs from previous workshops were introduced and students were asked to evaluate those works using the SPD framework and their own preferences. Most of the students in the workshop agreed that the designs from previous workshops had more in-depth interpretations of SPD value from their prototype CTEAs, and the designs' effects on solving everyday sustainability problems were more creative and effective. The evaluation made those students who believed that design doesn't require techniques in thinking change their attitude toward the purpose of the workshop. They became more interested in and patient with the new concepts. For most participants, it was their first time designing by using a scientific method. The workshop changed their previous understanding of what constitutes design thinking and design process.

During the rest of the workshop, the SPD method with affiliate tools and guidelines were introduced and applied in three separate parts. The first week was for phase 1: Artefacts Studies; the second week was for phase 2: Abstract Insights; and the last week was for phase 3: Interpreting Insights and Design Evaluation. Each week has a whole-day lecture introducing the method, another whole day for individual tutorial to each student, and a third class day for summarizing and evaluating student work.

For each work unit, the students were not compelled to use the given process and tools. However, to remind them of the process, tools, and guidelines, each student was given a set of "method cards", which were designed to be their "tool box" and could be selected and used at will. Each student was required to keep a journal describing how they completed each part of the tasks and addressing what tools and guidelines they used during their task-finishing process.

According to the findings in the final workshop, gathered from each student's design journal and different stages of tutorials, the users "jump out" of the method toolbox when they pair the insight with a problem. This means that students were more likely to seek out a design problem that can be solved by the insight they found, rather than the other way around.

The method can be modularized in four parts: 1) learn the SPD criteria; 2) select and study CTEAs; 3) abstract insights; and 4) interpret insights. The problem, which is labelled "p" in the below diagram, can appear in any of five different stages. Once the problem co-evolves from the insight interpretation, students will jump out of the "tool box" and focus on realizing the design concept using their personal design methods. This workshop was different from the above four workshops, which required the participants to give as many design concepts as they could think of but did not focus on selecting the best concept and realizing a design.

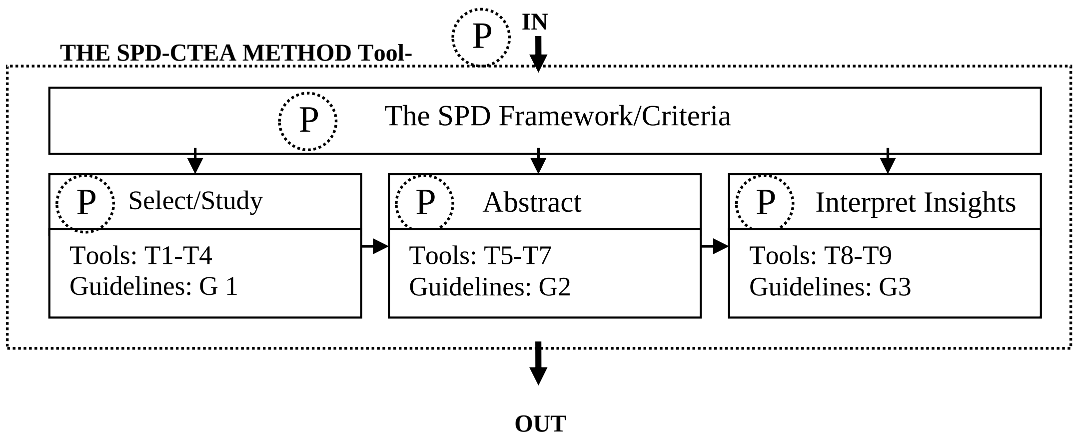


Figure 5.27: Application Patterns of the ICTEA-SPD Method

The investigations in the workshops show that application of the SPD method can have different purposes:

1. Interpreting insights from CTEAs for SPD. This purpose is focused on giving more design ideals from CTEAs studies to serve the SPD purpose. It also can be used as a training course for creativity in design thinking.

2. A quick solution as a design method for SPD when a designer lacks a “sparkling” insight and is willing to seek an insight from traditional design wisdoms.

3. A tentative use for a universal design method for SPD. This has been discussed in the previous workshop, as there is no guaranteed connection from CTEA studies to a given design problem. From a natural, cultural evolution standpoint, this use has possibilities. There were also some successful design examples in the fourth workshop of this research that used this method. The applicability of the method for this purpose is a matter for further investigation by future research.

Further Workshops

Potential workshops could be conducted to continuously develop the I-SPD method in some specified direction or aspect. In this research, the workshops ended after the fifth official one as fundamental problems of the I-SPD method building had been solved. The general uses and values of the method were revealed in different conditions. As time and resources limit this research, it focuses on investigating the adaptation of the method for educational purposes. Further research could develop the theory for professional use. This will be discussed in the final chapter of Conclusion and Discussion.

Summary of Chapter 5

Field studies of CTEAs and experimental workshops serve as the empirical studies of this research. The research process is designed from a qualitative research inquiry paradigm. In-depth analysis of the collected data and constant theoretical inquiry of key theoretical concepts which emerged from empirical studies led to the final research findings. For workshops, each workshop was designed and conducted to fulfil different phases of research goals. As limited by time and resources, the workshops had to be ended after six rounds (one pilot and five official workshops) when the fundamental structure and key variables of the final theory the research aimed to propose could be described. Process, contents, and application meaning of the I-SPD method will be introduced in next chapter, *Chapter 6: Research Findings*.

Chapter 6:

Research Findings

Introduction of Chapter 6

This chapter lists and illustrates key findings from both the empirical and theoretical studies. Key findings include:

1) A full process map of the I-SPD method. This process map is organized to demonstrate the two fundamental paradigms of design methodology: *design as rational problem solving* and *design as reflective practices from design situations*. The full process map is constructed with the three phases for the interpreting process: Selecting and Investigating CTEAs; Abstracting Design Insights; Interpreting Insights and Evaluate Design Concepts. The method paradigm of this process map has been extracted and formed to adapt different patterns of the process applications which I observed from the final workshop. The paradigm model of the interpretive process enriches application possibilities of the I-SPD method.

2) In each phase of the interpretive full process map supporting methods, tools, and guidelines are provided. These cognitive techniques were developed from workshops and theoretical studies. In this research thirteen cognitive techniques were developed. In the workshop experiments these techniques help to elevate the purpose and efficiency of the major tasks of the interpretive process. Theoretical explanation and examples are also illustrated in this section to help understand and learn these techniques.

3) The plan of workshop is another key finding of this research. Besides serving as the empirical research foundation of this research, the goal of the workshop design can be related to cultural artifacts studies in the design discipline. It can also be used to train abstractive and interpretive thinking capabilities. The workshop plan has been tested and developed during the six rounds of workshops. A basic workshop structure is proposed at the end of the research findings section. Ways of managing performance and quality of the workshop have also been noted to guide applications of this workshop plan.

6.1 The I-SPD Method: Interpreting CTEAs for SPD

Roozenburg and Cross (1991) stated that any method for aiding design activities necessarily contains statements or assumptions about the three "dimensions of design activities": the dynamics of a design process, the designer, and the design problem. The presentation of a method is fairly arbitrary. There are various kinds of representation possible, and the taste of the author determines his choice. Whichever representation is chosen—statements in a language, a mathematical model, a diagram, or a physical model—the representation is never the structure itself. The author's choice of structural elements is also rather arbitrary, and the preference of the author is again decisive when it comes to the level of abstraction on which the method is analysed or designed and what elements are relevant to the representation.

The I-SPD method was developed through cycles of empirical and theoretical studies from a proposed structural model to a complete process with affiliate tools and guidelines for specific tasks. The method can be represented in two forms: the full process map and the method diagram for different application situations.

The full process map of the method is a systematic plan of the how the related activities in the interpretive process can be processed toward a central, overarching logic. It programs the practical functions of the SPD method and gives clear orders in each move of applying the method. It also provides technical solutions as tools and guidelines to those difficult tasks that need to be deconstructed or scoped. The method diagram is an abstracted representation of the SPD method to adapt to different application situations. It is a simplified way to represent the I-SPD method. It points to the space where insight meets its final design concepts (SPD solutions).

6.1.1 The Full Process Map of the I-SPD Method

The full process map is a complete description of all cognitive activities required in the interpretive process. It also demonstrates how the research question has been answered through both empirical and theoretical inquiries. The full process of I-SPD method is constructed with three sequential contents: 1) Understanding SPD criteria; 2) The two paradigms of CTEA interpretation; 3) Process and cognitive techniques.

6.1.1.1 Understanding SPD Criteria

Understanding SPD Criteria is the start of the I-SPD Method. Many designers may lack a structured knowledge of SPD or their understanding of SPD could be limited in some particular aspects as “green design”, “environmental friendly design”. The framework of SPD criteria in this study aims to help I-SPD method users to attain a fundamental understanding of different design scopes of SPD so they may make more informed decisions when selecting artefacts from field investigations or other experiences. Although the framework doesn’t cover every existing aspect of SPD research and practice, the SPD criteria are valid in this research and also meaningful in other studies related to SPD and design projects. It is structured by the four fundamental perspectives of how products (artificial objects) can affect human-nature sustainability. This framework is not defined by any particular social, economic, or technological situations.

In the empirical studies, before workshop applicants began their field studies of CTEAs, the framework, with its affiliate criteria and also some design examples, were introduced through initial lectures and organized discussions. Design education in the field of sustainability is still under development in the design schools of mainland China. The SPD introductory lectures were successfully conducted, according to feedbacks from the workshop participants. It helped them expand their ability to define what makes a sustainably designed product and also provided realization that there are many different approaches to and possibilities for SPD. The forms and depths of the introductory SPD lectures were specifically designed according to the experience levels of the different participants. Selected readings and websites on SPD were suggested to the participants to help them better understand the concepts introduced in the lectures. The lectures also include a unit where they critiqued contemporary designs from an SPD standpoint.

Understanding the SPD framework is a subjective activity with different levels of acceptance and comprehension. Understanding is determined by the designer’s background, experiences, interests, and characteristics. Coming to improve understanding is also a practical method to organize a designer's existing knowledge about SPD and compel him/her to reconsider problems of the field. Learning about the SPD criteria could imply a possible approach to an issue, which can then be addressed in the final design concepts. This phenomenon can be explained by the fact that each person attempting to understand the framework will be subjectively interested in certain parts of the criteria, and this personal preference influences how each person processes the method to reach final design concepts.

In this research there is no examination of the comprehensiveness and correctness of the SPD Criteria framework. It is built to assist the construction and efficiency of the empirical studies. Although building a structured criteria framework requires a certain amount of theoretical learning and it is a time consuming process, in the workshops I also encourage each participant to build their own criteria according to their existing knowledge and learning of SPD.

6.1.1.2 The Two Approaches of CTEA Interpretation

Understanding SPD Criteria is the premise of applying the I-SPD method. Realizing how the method can be approached from the two fundamental paradigms of design methodology make the method useful in general design situations.

1. Objective Interpretation for Solving Particular Problems

Design was introduced as a rational problem solving paradigm by Herbert Simon in the early 1970s. In Simon's paradigm, design is viewed as a rational search process: the design problem defines the "problem space" that has to be surveyed in search of a design solution.

If the design problem was already identified before the selection of CTEAs and abstracting of insights, the purpose of interpreting the insights serves the design problem.

In this situation, interpreting insights fits the paradigm of rational problem solving. In the present research, one of the five workshops was required to select artefacts and abstract design insights for their pre-settled design problems. The design problems were identified by participants' understandings of everyday sustainability problems. The SPD framework can be used as a tool to locate the sustainability problems that contradict the SPD criteria.

The precondition of this function is that there are enough design insights to choose from. There is a hypothesis that all identified design related sustainability problems can be solved with a design insight or insights abstracted from traditional wisdom. According to the empirical studies in this research, the condition of the SPD method's general design problem-solving function is tentative, and depends on a scale of CTEA investigations and coherence with specific cultural requirements.

According to workshop experiments on selecting artefacts for specific design, there is a fuzzy connection between the hints and schemes of artefacts selection and the pre-defined design problems. The SPD framework works as a platform upon which SPD attributes can be matched by locating specific SPD criteria. While the problem is defined, the scope and domain for the design solution is also given. This means that having a defined problem using the SPD framework helps to give direction toward a potential solution. Searching adapted CTEAs that contain certain SPD attributes is a method for designers to find specific technologies and patterns that can inspire concrete design solutions. The diagram below describes how workshop participants solve a specified design problem by using the I-SPD method.

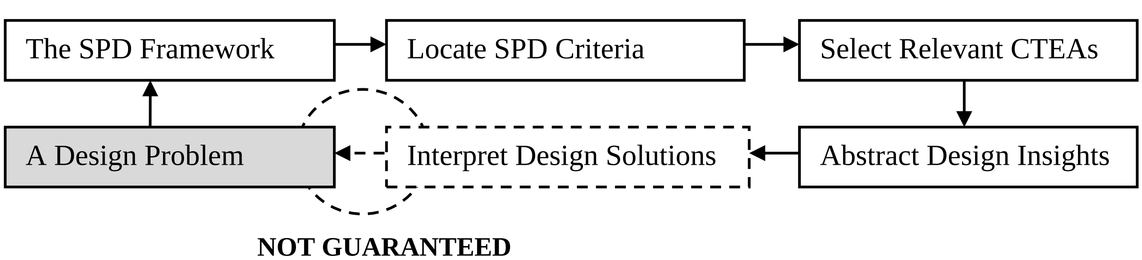


Figure 6.1: Solving Particular Design Problems by I-SPD Method

To solve a particular design problem, the I-SPD method process moves from identifying the design problem, to proposing solution directions by investigating the problem, and to selecting relevant CTEAs according to the solution directions.

Observations from the workshops indicate that interpreting CTEAs as a general design method to solve any design problem can be challenging. In this research, the prerequisites for success with this method are adequate skill and knowledge and a reasonable scale of selected and abstracted artefacts and insights to choose from. The I-SPD is a tentative method to solve general design problems. There is a constant comparison dynamic during this process until the abstracted insights from selected CTEAs match the requirements of the proposed design solution.

2. Subjective Interpretation: Interpreting Insights to Identify Design Problems

Subjective interpretation emphasizes the process of how a designer works on a design project. The designer tries to formulate the design problem and its context according to his reflective thinking about the abstracted design insight. This reflective thinking refers to the meanings of the design paradigm as a reflective conversation with the situation that was presented by Donald Schön, who identified the limitations of the rational problem solving paradigm for design methodology. In this conversation, according to Schön (1982), the structure and scope of the design problem can be reformulated during the design process.

1) Design as a Reflective Conversation with the Situation

A designer makes things. Sometimes, the designer makes the final product; more often he makes a representation—a plan, program, or image—of an artefact to be constructed by others. He works in particular situations, uses particular materials, and employs a distinctive medium and language. Typically his design process is complex and there are more variables to the design process than can be represented in a finite model. Because of this complexity, the designer’s moves tend to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by making new moves. He shapes the situation in accordance with his initial appreciation of it, the situation "talks back", and he responds to the situational feedback.

Indeed, practitioners often reveal a capacity for reflection on their intuitive knowing in the midst of action and sometimes use this capacity to cope with the unique, uncertain, and conflicted situations of practice. Kees Dorst (2007) noted that the design task in any context should be challenging, realistic, appropriate for the subject, not too large, feasible in the time available, and within the sphere of knowledge of the researchers.

2) From Insight to Formulating a Problem

In the I-SPD approach to interpreting design insights the design task and problem are defined during the interpretive process. Duncker (1954) described two methods for reformulating a problem: suggestions from above and suggestions from below. A suggestion from above occurs when the problem solver redefines the goal; in these cases, the problem solver may seek to formulate the functional value of the goal—that is, the general purpose that needs to be satisfied. A typical problem solver first thinks of one way of reformulating the goal, and this initial idea provides some specific solutions. Then the problem solver thinks of another reformulated goal, followed by some specific solutions, and so on. A suggestion from below occurs when a problem solver reformulates the given information in a new way. The idea to reformulate the function of the given objects can come from subtle aspects of the problem situation.

3) Subjective Interpretation: Applying Design Insights in Specific Design Contexts

Interpreting insights is the process of discovering concrete design solutions and defining the adaptable contexts for those solutions where there are sustainability problems to be solved. According to the mode of interpretation, the insights will be introduced in the cognitive techniques of I-SPD method. A method of interpreting insight can be developed to fill the insight schema, or structure, with adaptive alternatives. Each insight is composed with basic syntax and key elements that represent subjects, methods, and SPD effects and attributes. There are two specific factors in the activity of interpretation: 1) the correspondent thinking of the specific SPD effect or attribute and the concrete subjects that can lead to the SPD effect; and 2) the technological rationality and institutional rationality, which determine whether the interpreted design solution makes sense in practice.

From this approach, the I-SPD method is processed from selection of CTEAs, to abstraction of SPD insights from studying selected CTEA, and ends with identification of design problem in insights interpretation. Tools and methods for open selection of CTEAs, abstraction of SPD insights, and identification of design problems during the interpretive process will be introduced in the section detailing cognitive techniques of the I-SPD method.

6.1.1.3 Process and Cognitive Techniques

The I-SPD method is an integrated product design method with a descriptive process, explicit cognitive techniques, and guidelines. It was developed by exploring and describing the cognitive process and techniques of discovering and interpreting design insights from Chinese traditional everyday artefacts (CTEAs). The structure and integrated tasks of the process were innovated, tested, and refined through cycles of theoretical and empirical investigations.

The process of the method is constructed using three general phases: selecting artefacts, abstracting insights, and interpreting insights, with a constant evaluation of SPD criteria underlying and integrated within the whole process. Each phase includes orders of tasks with guidelines to define the tasks and suggested tools to help make the process easier to follow and control.

To clearly define sequential tasks and reduce the difficulties and ambiguities of applying the I-SPD method, cognitive techniques of *ten tools* and *three sets of guidelines* are designed and examined in the empirical studies. They are listed and explained with examples in the thesis according to the appropriate phase of the method process, and are included in the full process map of the SPD method. Following the provided tools and guidelines is not a compulsory requirement of the method. Users of the I-SPD method are encouraged to design their own tools and guidelines from their personal design experiences and understanding as well.

UNDERSTANDING SPD CRITERIA	
↓	
THE TWO PARADIGMS OF CTEA INTERPRETATION	
Objective Interpretation	**Subjective Interpretation**
Solving particular design problems 1) Identify design problem; 2) Propose solution directions; 3) Select relevant CTEAs;	**Co-evolution of design solutions and problems** 1) Open selection of CTEAs; 2) Abstract design insights ; 3) Identify design problems;
↓	

PROCESS AND COGNITIVE TECHNIQUES		
Tasks	**Tools/ Guidelines (T/G)**	
Phase 1—Selecting and Investigating CTEAs		
1.1 Select CTEAs with SPD Attributes	**T1:** CTEA Selection Method	Page. 177
	T2: Tools for artefact collection	Page. 181
1.2 Investigate CTEAs on Design Reasoning of the SPD Attributes	**T3:** Different levels of artefact investigation	Page. 184
	G1: Data collection structure	Page. 189
	T4: Deconstruct designs for the SPD attributes	Page. 190
Phase 2—Abstracting Design Insights		
2.1 Abstract Context-free Design Insights for SPD	**T5:** A model for processing data	Page. 195
	T6: The tree diagram for coding insights	Page. 197
	T7: Different levels of abstracting	Page. 199
2.2 Evaluate Design Insights	**G2:** Check validity of the SPD insights	Page. 193
2.3 Position Design Insights	**The SPD Framework**	Page. 120
Phase 3—Interpreting Insights and Evaluating Design Concepts		
3.1 Interpret Insights to Design Solutions	**T8:** Identify design problem by SPD framework	Page. 203
	T9: Tool for interpreting insight	Page. 203
	T10: "The cluster design method"	Page. 209
3.2 Build Adaptive Design Contexts	Scenario building, storyboard drawing, etc.	
3.3 Visualize Design Concepts	Sketching, modelling, prototyping, etc.	
3.4 Evaluate Design Concepts.	**G3:** Constant evaluation during interpretive process	Page. 210

Table 6.1: Full Process Map of the I-SPD Method

6.1.2 The Method Paradigm

The full process map of the I-SPD method is comparatively long, although inner steps are directly related. This makes the method not be flexible and relatively easy to be applied if only the full process map is represented. A simplified form of the I-SPD method is required to synthesize the possible application situations.

During the first three workshops, students were required to finish the entire process's tasks using the compulsory sequence of the listed tasks. The last two workshops (Wuhan and Guangzhou workshops) were designed to describe how to integrate all the spontaneous applications of the given process and techniques into a simplified method framework.

The I-SPD method is not a fundamental design method which can satisfy the general application contexts. The method works for a particular design situation: finding and interpreting design insights from CTEAs for SPD. This method can be applied in a variety of ways and for a variety of purposes, according to particular preferences and needs. The paradigm of the method was developed by synthesizing different application patterns during the last two workshops. The method of developing the I-SPD method paradigm was quantitative data analysis from structured questionnaires which required workshop applicants to keep a journal of their actual process and actions of applying the I-SPD process and cognitive techniques in the workshop according to their actual design processes.

Based on observations of the last two workshops, workshop participants "jumped in" and "out" of the given process when they applied it to figure out their design solutions. This is also the way they learnt the method, by reflective actions. Designers are usually not used to being aware of their actual design process when focusing on driving the design solution. Accordingly, they often go back and forth to the different phases of the method and select different tools to complete design tasks. The following diagram represents all the possible application patterns of the I-SPD method according to the questionnaire data:

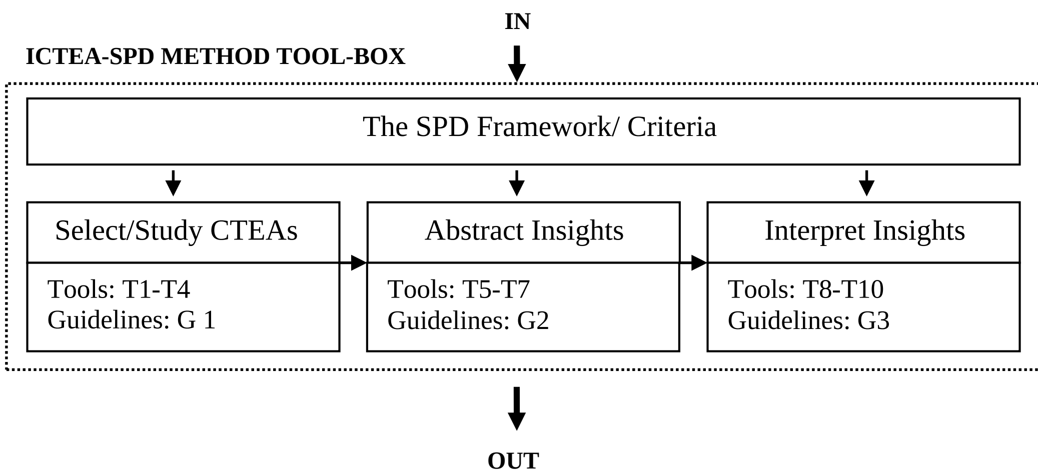


Figure 6.2: The ICTEA-SPD Method Paradigm

When using the I-SPD method to generate SPD concepts the inner structure of the I-SPD method paradigm is like a “black-box”, users do not know their exact paths before they complete all the spontaneous tasks. In this “black-box” four parts of the contents are organized according to mutual relationships. Ideas may be generated in each step of the process. It is a dialogue between the user’s mind and the process. “IN” is the starting point for the process. When a satisfactory idea is generated the process is finished, which is marked as “OUT” in the paradigm diagram. The user keeps the SPD criteria in his/her mind to select CTEAs, abstract insights, and generate ideas or concepts.

6.2 Affiliated Cognitive Techniques and Applications

The following section introduces and explains the cognitive techniques of the I-SPD Method and how they can be applied. The sequence of presentation of each technique is arranged according to the structure of the full process map. They were proposed and refined in my research process. These cognitive techniques have been tested and refined during workshop experiments.

6.2.1 Selecting CTEAs for SPD

Different kinds of design insights relate to different SPD criteria. Visual forms and structures are more relevant to aesthetics-related criteria; advanced techniques and functions reflect product functionality and ecological efficiency. Ecological lifestyles may contribute to human values and humanity. To select relevant CTEAs requires in-depth understanding of the SPD criteria, not only the abstracted means that the words represent, but also meaningfulness of interpretations of SPD in specific contexts.

6.2.1.1 Selection Method: The SPD Criteria Framework

CTEAs are selected for the purpose of assessing embedded design values for SPD. The CTEAs considered valuable should satisfy some of the criteria of SPD, or at least one of the criteria. As the SPD criteria are abstracted and designed to contain general meanings of sustainability through design to satisfy criteria, a CTEA's embedded SPD value is an interpretation of the criteria according to the interpreting designer's individual knowledge. Those CTEAs observed in the initial field studies revealed different degrees of sustainable design values which are weighted by factors and effects on the sustainable existence of humans in nature. Some have obvious connections with SPD and can be collected for further studies. Some may seem less connected or have less obvious connections to SPD but have meanings toward other evaluation criteria. According to the SPD criteria built for this research some CTEAs have a higher degree of SPD value and some have a lower degree, although these designations are relative to the extent to which the artefacts are understood. These experiences, knowledge, and observations are defined as the researcher's "immediate understanding" of the CTEAs in this research. When CTEAs are observed, immediate understanding helps the researcher to quickly decide whether to include certain items as research targets for further investigations.

CTEA Selection Method: the SPD Criteria Framework (Tool No.1)

Product Perspective	Human Perspective
☐ Design Multifunctional Products ☐ Provide Durable and Direct Functions ☐ Involve User as a Part of the Design to Simplify the Product ☐ Involve Recycle Plans in Design Solutions ☐ Design Contextually Appropriate Products	☐ Use Safe and Non-toxic Design Solutions ☐ Design for Poverty and Equity ☐ Emphasize Nature and the Rules of Human Life ☐ Design Sustainable, Everyday Life Patterns ☐ Design for Emotional Well-being
Natural Environment Perspective	**Social Perspective**
☐ Minimize Environmental Impacts along the Product Lifecycle ☐ Design for Energy Efficiency ☐ Respect Rules and Principles of the Natural World ☐ Design for Waste Minimization ☐ Select Materials for Function and Economical Efficiency	☐ Encourage Long-Term and Holistic Considerations ☐ Respect and Develop Local Cultural Heritage ☐ Cultivate Modest Desire and Taste ☐ Adopt Indigenous Design Solution ☐ Be Aware of Socio-economic Factors

Table 6.2: Select CTEAs by the SPD Framework

Approach 1: Open Selection: Selecting through Immediate Understandings of the Observed CTEAs

At the beginning of the artefact selection process, researchers must decide how they will focus their attention on the CTEAs. Researchers' past experiences with the artefacts will be remembered, while the immediate information related by the observed artefacts will be organized to extract their SPD attributes according to the selection criteria. This is a prompt mental process, which is described in the following diagram:

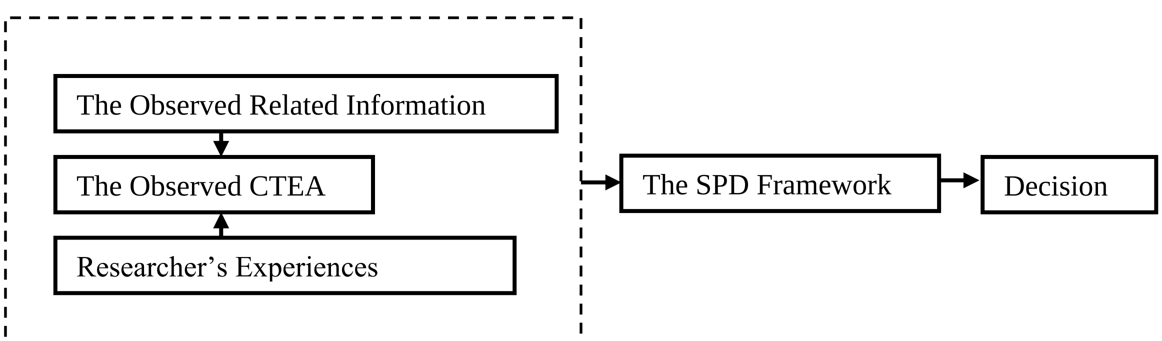


Figure 6.3: The Process of Deciding for Target CTEA

Sorting through second-hand information and the researchers' memories bases the decision on both existing and newly-built understandings of the artefacts' SPD attributes. If the artefacts are observed in their original contexts there will be first-hand information about user behaviours, the artefacts' functional performance, and their relationships to other artefacts in the same context. More information can be collected by investigating artefact users, analysing artefact contexts, and remembering direct experiences with artefacts. When observing artefacts in their original contexts, researchers will have a deeper understanding from which to select CTEAs for SPD. For an example of open selection see *Appendix E: An Example of Open Selection of CTEAs*

Approach 2: A Tentative Approach: Selecting CTEAs for Specific SPD Purposes

There are no obvious correspondences with or connections to the design problem that relate contemporary everyday life to traditional Chinese everyday artefacts designed in vastly different contexts and for different purposes. Except for helping to judge the observed CTEAs, the SPD framework was also the "platform" from which potential design inspirations sprung.

A Method for Selecting when Given a Design Problem: Mapping Design Problems and CTEAs on the SPD Framework

Mapping the specific design problem in the SPD framework connects the relevance of artefact selection to design problem solving. While the designer enters the field to observe and select target artefacts, the scope of selection is limited by geography; a lack of open selection can involve every aspect contained in the framework. Designers can select the artefacts placed in the same area as potential references for solving similar design problems. That means only the observed artefacts that satisfy the criteria addressed by the design problem can be involved in the further investigation of the embedded design inspirations. An example of "Selecting Artefacts with a Design Problem" to see ***Appendix F.***

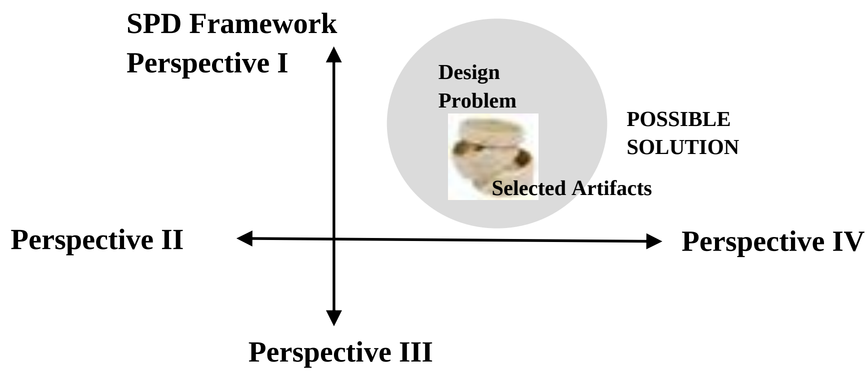


Figure 6.4: Mapping Design Problems and Artefacts on SPD Framework

Fuzzy Connections between the Design Problem and Artefact Selection

Selecting adaptive artefacts from a specific scope is more complicated and challenging than open selection. When the users define the design problem to be assigned or investigated different aspects and directions of the potential and possible solutions often come to their minds. Design problems and possible solutions are not linearly related. While users define the design problem, the primary ideas behind design solutions are already being created based on personal design experience and interests. Further studies are needed to discern the extent of CTEAs' ability to give references or inspirations in realizing design ideas in functional, material, or structural ways.

A model of the selection process is illustrated in the following diagram.

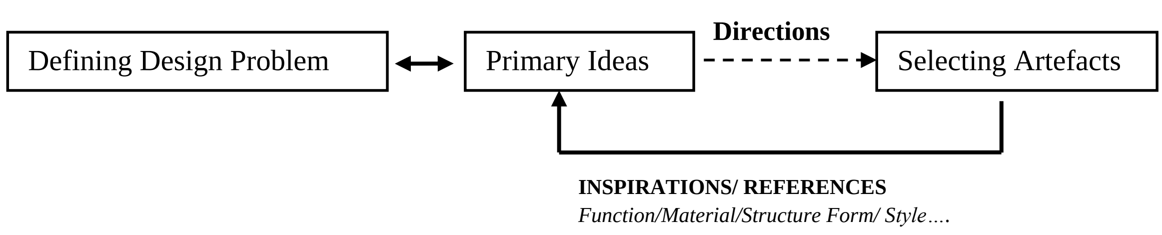


Figure 6.5: A Process Model of Selecting CTEAs for Specific Design Problems

6.2.1.2 Tools for Artefact Collection (Tool No. 2)

The method includes a set of tools to help to collect artefacts from which to select inspiration: 1) collect artefacts in different categories; 2) collect artefacts based on different geographic locations; 3) collect artefacts using the "Artefacts Network"

Artefacts in Different Categories (Checklist)

☐ Completely Traditional: handmade/semi-industrial/crafts/standard/temporary solutions
☐ Contemporarily Interpreted: pattern/form/structure/solutions/method/concept/ philosophy/ideology

Artefacts in Different Places (Checklist)

☐ Home: living room/washroom/kitchen/bedroom/reading room/courtyard/storage room/ other
☐ Outdoors: farm lands/markets/streets/other
☐ Institutes: museums/private collections/research institutes/other

Artefacts Network (Method)

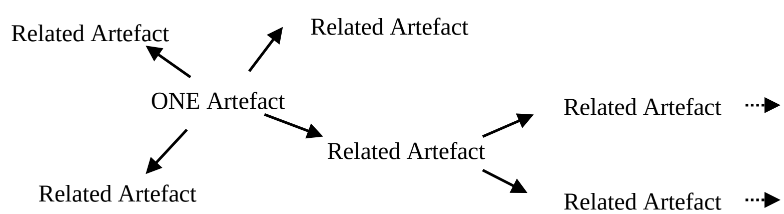


Figure 6.6: Tools for Helping Artefacts Collection

There are also different conditions of artefact observation: 1) for a purpose; 2) without a purpose; and 3) to collect artefacts in field studies. If users collect artefacts for a certain purpose, the collected artefacts may have certain common elements; for example, if the investigator is looking for inspiration to solve a design problem, the artefacts might all have similar elements that solve the design problem. If users collect artefacts without a certain purpose, they might search for artefacts based on their own experiences or else memories from field observations of traditional/interpreted artefacts. Collecting artefacts from field studies visiting the original contexts of the artefacts can provide more complete and contextualized data. Investigators can take pictures and video, and conduct interviews and other contextual inquiry methods to get first-hand data to help them make selection decisions.

6.2.1.3 Summary of Selecting CTEAs

There are two approaches to selecting relevant artefacts to study for SPD: open selection, where the designer identifies the design problem while studying artefacts; and directed selection, where the designer identifies the design problem before selecting artefacts. The first approach can tend to be more creative and productive as the design insights can be applied by addressing related design problem during the investigation. The second approach contains uncertainty in finding suitable CTEAs for giving inspirations to solve the pre-settled design problem.

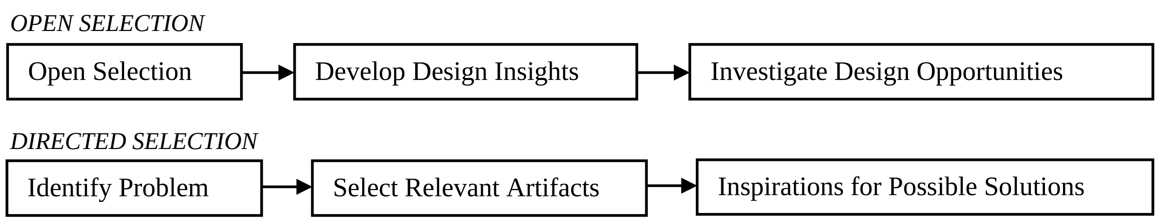


Figure 6.7 Two Approaches of Artefact Selection

Subjectivity and Objectivity in Artefact Selection

Because of the comprehensive nature of the SPD framework, different users of the method will have their own understanding and interpretation of the selection criteria when selecting from among their collected artefacts. The subjectivity of the selection is due to the fact that different people have different opinions about the value of various factors of the design and manufacture of artefacts. The objectivity of selecting the artefacts is mentioned in previous chapters and through the whole thesis. The artefact should satisfy at least one criterion of the SPD framework in any of the four approaches to ensure that the found inspirations will contribute to generating sustainable design concepts. Satisfying the criteria defines the artefact as having SPD attributes.

6.2.2 Studying CTEAs: Investigating the Design Reasoning of Their Embedded SPD Attributes

6.2.2.1 Specifying the Objectives of Artefact Studies

To find meanings for SPD, artefacts investigation must: 1) understand the design reasoning of the SPD attributes that are structured according to the satisfied SPD criteria and 2) discover more valuable design inspirations while analysing the collected data of the selected artefacts to find more SPD attributes.

After the artefacts have been selected according to their SPD values, the method suggests that the designer conduct a systematic investigation to get a better understanding of the design reasoning behind the selected artefacts and also to retrieve more useful insights for SPD. The investigation should focus on how the artefact's SPD attributes are realized by its design.

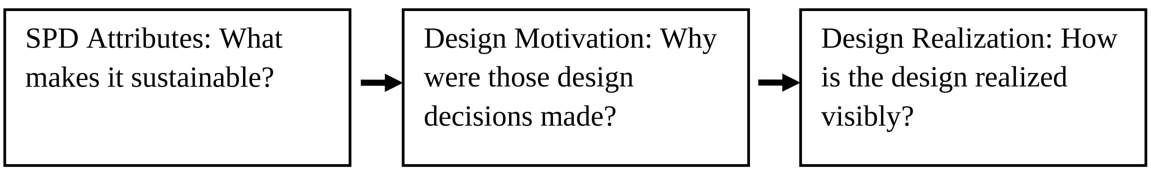


Figure 6.8: Logic of Artefact Investigation

6.2.2.2 Artefact Studies: A Systematic Plan

The Cycle of Artefact Investigation

Initial investigations of artefacts may be conducted during the selection phase. Users should at least understand the function and design of the artefacts under consideration before making their selections. During the deeper investigation that follows, the designer can explore the motivations and realizations behind the initial sustainable design attributes. In addition, more sustainable design attributes may be discovered that make the selected artefacts more significant to the study. It is also possible that some of the collected artefacts would not be included if it were not for the findings of deeper investigations. The investigation process may be conducted by following the diagram below:

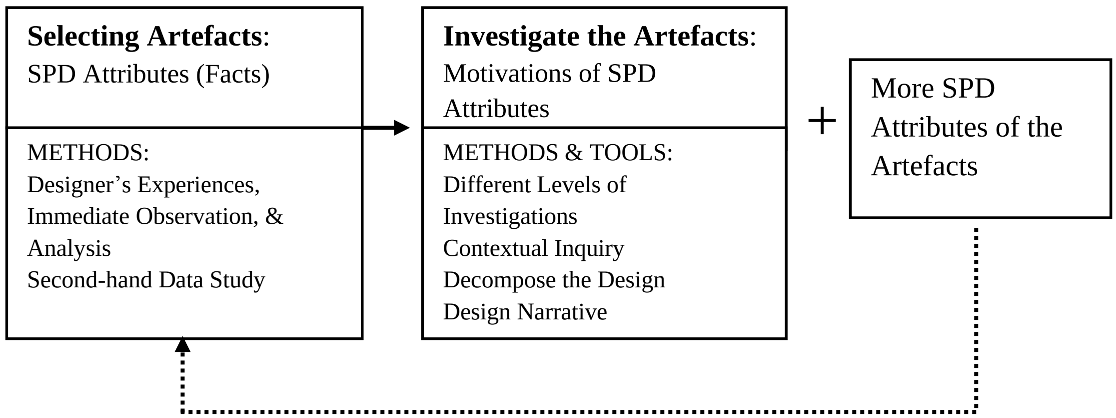


Figure 6.9: The Artefacts Investigation Cycle

Investigating through the Artefact's Lifecycle

Another approach that has been suggested for artefact investigations is to consider the artefact's lifecycle. This approach suggests that investigators observe their potential artefacts and collect useful data from their whole lifecycles, which last from manufacture, through use, and end with disposal. During these three stages of the artefact's lifecycle investigators should observe different SPD attributes of the artefact. The SPD attribute may also be reasoned out by enacting a design plan through different stages. For an example see *Appendix G: An Example of Investigating Artefacts through Lifecycle*

6.2.2.3 Different Levels of Artefact Studies (Tool No.3)

For the purpose and requirements of artefact studies, there are three levels of investigation, as illustrated below:

Immediate Understanding	Contextual Inquiry	Artefacts Comparison
▪ Designer's Previous Understanding ▪ Immediate Observation and Analysis ▪ Secondhand Data Collecting	▪ Observation ▪ Interviews ▪ Participant Observation	▪ Compare similar artefacts in different geographical and cultural contexts ▪ Compare related artefacts

Immediate Level: get quick insights →

Contextual Level: get deeper insights →

Methodological Level: get design methods →

Figure 6.10: Different Levels of Artefacts Investigation and Purposes

The First Level: Immediate Understanding

Immediate understanding is the lowest level of artefact investigation. It can be conducted in a short time with limited resources. According to quick and direct observations, which are taken during the artefact selection process, investigators find the most obvious SPD attributes and can give reasons to explain the designing, making, use, and disposal of the artefacts according to their experience and prior knowledge.

At this level, investigators can also learn about the lifecycle of the studied artefacts using desktop research tools that have been taken and adapted in some workshops in this study. These workshops were designed to emphasize interpreting artefacts and applying design insights, so they make more thoroughly investigations. Furthermore, students were required to select many artefacts in these workshops according to their immediate understanding of the artefacts.

Possible methods for gaining immediate understanding of artefacts include: investigation from personal experiences and culture background; investigation using immediate observation and analysis in places where suitable artefacts might be found; investigation by desktop research from the literature or online resources; investigation by organizing study groups or interviews to learn about other people's experiences. In most circumstances, designers and practitioners prefer using this level of artefact research to find quick inspiration or ideals for new products.

Designers' immediate understanding of artefacts helps them select what artefacts to analyse further. To complete the immediate understanding investigation level, second-hand data from other forms of organized information pertaining to the chosen artefacts should also be collected and reviewed. These are the study methods used for the first level of artefact investigation according to the practices of the field studies and workshops in this research.

The Second Level: Contextual Inquiry

Contextual inquiry is an adaptation of field research techniques taken from psychology, anthropology, sociology, and interpretive hermeneutics (Glaser & Strauss, 1976). In the contextual inquiry process, the selected artefacts are investigated through observation, interviews, and participant observation.

Participant observation refers to a form of sociological research methodology in which the researcher takes on a role in the social situation under observation. Participant observation is an important investigative method that allows designers to attain direct use experiences of the artefacts in their original contexts.

In this research, contextual inquiry refers to the investigation-related user behaviours and product conditions that can be observed in the places where the selected artefacts are made, distributed, used, stored, or disposed. There is no set process of contextual inquiry. Researchers can investigate related user or maker behaviours that may reveal or explain the artefacts' SPD traits. It is thus a mode of investigating the design reasoning of artefacts' SPD attributes. The researcher can also conduct contextual inquiry of the artefacts' accessible contexts, which may bring more SPD attributes to light.

Participant Observation as an Effective Investigation Method for CTEA Studies

Participant observation is an effective investigation method for the CTEA studies. It requires the researcher achieve personally experiences of the artefacts in their original contexts. By noting useful data from their personal experiences, researchers can describe in-depth understandings of the artefacts in various forms. They will have a more direct and accurate understanding than that gained through second-hand data or interviews.

In the participant observation method, the researcher takes a role among those who relate to some aspect of the artefacts' functional performance. Beyond the researcher's personal experience, discussions and interviews can be conducted while observing other related behaviours in the artefact's original context. This is a more synthetic investigative method for CTEA studies. This method gains a more comprehensive understanding of the artefacts. Duration of the investigation is determined by the researcher's investigating scope and purposes, as well as the artefacts' degrees of complexity and amount of SPD values. With some very simple artefacts, the investigation process can be quite short. An example of Participant Observation is illustrated in *Chapter 5: Empirical Studies and Experiments.*

The Third Level: Artefacts Comparison

To investigate artefacts for the purpose of understanding their philosophic roots, researchers can also compare a group of selected artefacts to investigate their cultural roots, design motivations, and philosophic meanings. Such a comparison could inspire more abstracted design insights and design approaches and methods. There are three approaches to artefact comparison in this study:

1. Comparing Similar Artefacts in Different Cultures

Artefacts that share the same basic functions for everyday life could have different designs in geographically disparate cultures. These differences may be caused by aesthetic traditions or contextual differences in the artefacts' use. Traditional everyday artefacts were mostly designed as indigenous solutions to geographic conditions, using idiosyncratic natural resources and ideological traditions.

The photographs below are examples of artefacts that share the same function in different cultures:

Figure 6.11: Examples of Charcoal Ash Hand Warmers in Different Cultures

2. Comparing Related Artefacts in Single Place or Use Context

By studying a group of artefacts that are all involved in a similar context, the researcher can investigate how the embedded SPD values of the artefacts are connected. Such understanding can provide inspirations for designing sustainable products from a systematic approach. For example, researchers can investigate how traditional Chinese cooking appliances are used with each other to work for the purpose of cooking.

3. Comparing Artefacts That Satisfy the Same SPD Criteria

Some of the observed and selected artefacts satisfy only one SPD criteria of the framework. The researcher can compare artefacts that satisfy the same SPD criteria in order to see if there are common patterns in function or aesthetics. The common pattern can be described and applied as a design method for developing contemporary sustainable products.

6.2.2.4 Data Processing

The artefacts' investigation provides data through various research methods:

- Field Notes: first-hand experience, observation
- Images: first-hand experience, observation, and interview
- Video images: recorded observation, interview
- Sound records: interview
- Questionnaire: interview
- Artefact samples

Categorize these data into different archives of artefact related sustainable design attributes. The structure of the investigation for discerning the design reasoning of SPD attributes is as depicted in the following chart. (Guideline No. 1)

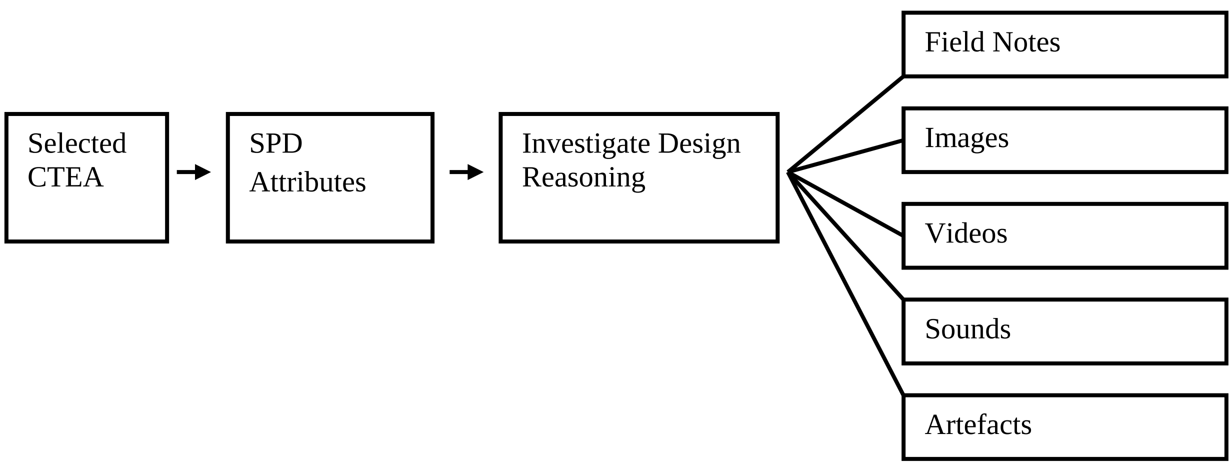


Figure 6.12: Data Collecting Structure

Concluding Data

To draw conclusions from the data collected during artefact investigations, the researcher should summarize the information that could help abstract some applicable and effective design insights for SPD. This information can be recorded by random sequence or by some organized structure. There is no fixed structure for concluding the artefact studies. It is suggested that the researcher provide a profile that gives a brief description of the artefact, including its context, uses, and motivations for the design. The researcher can also describe the manufacture, distribution, use, and disposal sequences of the product lifecycle.

A Tool: Deconstructing Designs for SPD Attributes (Tool No. 4)

Investigations of the selected artefact for its SPD attributes can explain the design of the artefact in a structured way. According to the tests of several suggested patterns of design explanation, a suggested pattern is introduced as a tool for "design deconstruction". This tool reminds the investigator of the necessary information of the investigated artefact while suggesting an easy way to structure the design reasoning by listing the key factors of designing the artefact. This is the process of "decomposing the artefact". To review all the data collected about the design, manufacture, and use of the artefact, some aspects and design elements are main factors of SPD attributes. It may be not be singly from one aspect of the designing of the artefact. In some cases, there are several design factors that contribute to an SPD attribute. To see how these aspects relate and cooperate is also necessary in the process of data analysis.

(Artefact Image)	**Brief Description of the Artefact:** context, uses, motivations, SPD attributes….
SPD Attribute:	That Approach the SPD Framework: **Satisfied Criteria:**
Design Motivation	
Design Purposes:	
Use/Design Context:	
SETIG[1] Influences:	
Function Realization	
User Behaviours when Using the Artefact:	
Product Performance:	
Ergonomic Performance:	

[1] SETIG is an abbreviation for the Social, Economic, Technological, Ideological, and Geographic factors that influence artefact design. This structure comes from the book *Product Innovation in A Cultural Context*. Xin, X. Y. (2007). *Product innovation in cultural context: A method applied to Chinese product development*. PhD thesis. School of Design. Carnegie Mellon University.

Function and Economic Efficiencies:	
Aesthetical Performance:	
Product Lifespan and Disposal:	
Designing and Making the Artefact	
Material Selection and Processing:	
Structure/Components:	
Form, Style, Decoration:	
Dynamic/Energy Solutions:	
Functional Technologies Solutions:	
Cultural and Symbolic Meanings:	

Table 6.3: Deconstructing Designs for their SPD Attributes

This tool was designed using the logic of artefact investigation outlined in this research and constructed using fundamental aspects and elements of product design from four perspectives: 1) design as problem solving, 2) design as function realization, 3) design as product realization, and 4) design as a reflection of product performance. This structure means that each of the SPD traits embedded in the selected artefact should have some design reasoning as gleaned from the researcher's understanding of the artefact and the analysis of the collected data.

6.2.3 Abstracting Design Insights

6.2.3.1 Language Structure of Abstracted Design Insights

In linguistics, syntax is the study of principles and rules for constructing phrases and sentences in modern languages. The language of design may describe a rich diversity of designs, but all the designs expressed in a language share a common syntactic structure (Weissman, 1981).

In language, nouns often occur in adjectival constructions. The idea that objects have properties is neither natural, culture-free, nor universal. Nouns are the result of linguistic attributions. Attributions are acts performed in language, and they reflect perceptual, emotional, or experiential coordination in a particular community. Attributions reveal what people sense and feel, and what they believe other people sense and feel (Krippendorff, 2006).

The syntax of the abstracted design insights requires that each insight should contain a subject, verb, and object. The subject should be the elements of design, the verb should be the method of design, and the object should be the purpose of design. Each of the abstracted design insights represents a way of planning the specific design element to fulfil a certain design purpose. Thus, the interpretation of design insights means the fitting of insights into adaptable design contexts to solve a specific design problem. This "fit" can be referred as the "key" to the solution. The "key" is abstracted with general meanings. It can be adapted to a series of similar or related design contexts.

In his article, *The Core of "Design Thinking" and Its Application,* Kees Dorst (2011a) pointed out that, to get to the heart of design thinking, we build fundamentally different kinds of reasoning using formal logic. We describe the basic reasoning patterns that humans use in problem solving by comparing different "settings" of the known and unknown elements of the equation:

WHAT	+	HOW	=	RESULT
Thing		Working principle		Observed

Figure 6.13: Basic Design Reasoning Pattern Equation (Dorst, 2011a)

He explained that this form of reasoning is absolutely core to the "context of discovery" in the sciences; this is the way hypotheses are formed. Within the sciences, formed hypotheses are subjected to critical experiments in an effort to falsify them. These rigorous tests are driven by deduction. Thus, in the sciences, inductive reasoning informs "discovery", while deductive reasoning informs "justification". These two forms of analytical reasoning help us to predict and explain phenomena in the world.

The abstraction of the design insight leads to an abstracted SPD attribute, which fits the requirements of certain design contexts. When interpreting the insight, we can use induction to form the equation. The design insight provides the result, and we search for particular “what” and “how” situations to realize the meanings of the insight. This equation serves as a basic language structure to the insight for meeting the interpreting method of the next phase of the ICTEA-SPD method. This structure requires that the abstracted design insights should be written in a simple and clear syntax, which can be an artificial language, such as programming.

6.2.3.2 Validity and Utility of Design Insights

1. Validity of the Insights

The explicated insight represents an abstracted design pattern that causes an interpretation of SPD criteria. It is generated by logical abstractions, from the sentences of design reasoning to the final, found SPD attribute. The insight should be examined in two situations: the logical rationality and SPD validity.

A Guideline to Check the Validity of the SPD Insights (Guideline NO.2)

- Check Technological Rationality
- Check Institutional Rationality
- Check SPD Validity According to the SPD Framework

Logical Rationality: Technological Rationality and Institutional Rationality

The view that language is a medium of interpretation looks for meanings in the possible re-articulations of forms (or texts). It relies on a community to determine the legitimacy of the interpretations offered by its members (Hirsch, 1967). According to the basic design reasoning pattern referred to in this research, three elements must be abstracted from the artefact’s original context to form the specific SPD solution. These three elements are abstracted individually by giving each specific aspect a general meaning. During the process, logical examinations are performed by the person who is doing the abstracting.

First, the person checks to see whether the grammar is logically correct and then he examines rationalities to ensure that the statement makes sense in the real world.

Technological rationality is viewed by many as a lower form of rationality that needs to be supplemented and overseen by genuine philosophical, dialectical, or other higher rationality. Arthur (2009) demonstrated that good design in fact is like good poetry—not in any sense of sublimity, but in the sheer rightness of choice from the many possibilities for each part. Each part must fit tightly, must work accurately, and must conform to the interaction of the rest. The beauty in good design is that of appropriateness, of least effort for what is achieved. Throughout the analysis, rigor should be maintained using the criteria of coherence, contextuality, comprehensiveness, and thoroughness described by Plager (1994). The abstracted insight should be based on technological rationality while providing effective and integrated solutions to SPD.

Meaning is making sense in specific contexts. Beyond technological rationality, institutional rationality must be examined. Cultural beliefs, ethical principles, social institutions, and specific policies are all cultural considerations in the context to which the insight may be applied.

SPD Validity: Mapping the Insight on the SPD Framework

Abstraction is a process of reframing meaning according to individual understanding and personal knowledge. There is a need to examine whether the insight leads to a true value toward SPD. A simple solution is to map the insight on the SPD framework to check if it reflects the criteria that the artefact satisfied. It is also a method of mapping the abstracted insights on the SPD framework, which can help to connect insights to specific design problems and apply insights by matching a design problem placed on the same SPD criteria quadrant.

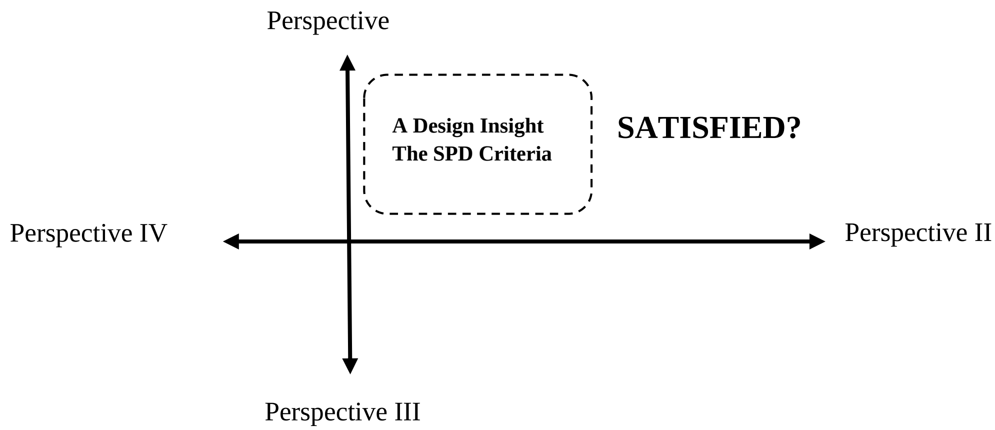


Figure 6.14: Mapping Design Insights on SPD Framework

2. Utility of Insight

The utility of the design insight is the degree to which the insight could be used to inspire or reflect new design concepts. Designers check the design elements, modes, and methods, and also make sure that the design purpose is fulfilled, as part of their conceiving process, which can be very quick. A more experienced designer or design researcher may be able to more quickly check the utility of the abstracted design insights than a less-experienced designer.

The check of validity and utility of the design insights reveals one studied artefact to have the best insight. The best design insight may be interpreted to more useful SPD concepts and also make an obvious reference to the generated design concepts and the original artefact.

6.2.3.3 A Model for Processing Data (Tool No. 5)

Data Sorting

In order to screen data for useful information, investigators must reread and mark the meaningful and relevant contents of the collected information on the deconstruction table. The useful information is called “key notes”, and is selected to clarify the SPD meanings.

In one artefact, different design factors may cooperate to realize a certain function or characteristic that leads to the SPD attribute.

Design is the organization of different resources for accomplishing certain functional or aesthetical purposes. Thus, SPD attributes may be realized through a series of design decisions. These design decisions realize the presentation of the artefact using a certain kind of material or structure, while using specific technologies to create new values in functions, economy, or aesthetics. Sometimes, it is more important to find reasons for the SPD attributes of the selected artefacts than to select the best design approach. Finding reasons for the SPD attributes will inspire a new approach to designing a sustainable product. We should deconstruct the design of the artefact and also depict the organizations of those connected design elements and decisions.

In many circumstances, one selected artefact may satisfy several SPD criteria. In these cases, the investigator has the opportunity to discover how these different SPD attributes are connected. All the design aspects and elements are made to fulfil a single design purpose. For an example of data processing of CTEAs investigation see *Appendix H: Data Processing of Artefact Investigation*

6.2.3.4 Extracting General Meaning

The design values embedded in the artefact is based on the specific design context and the material used to make the artefact. For flexible applications in contemporary design, these values should be abstracted to context-free and object-free insights. When connected with different concrete design elements, the abstracted design insights will have different interpretations in various design concepts as solutions for certain purposes.

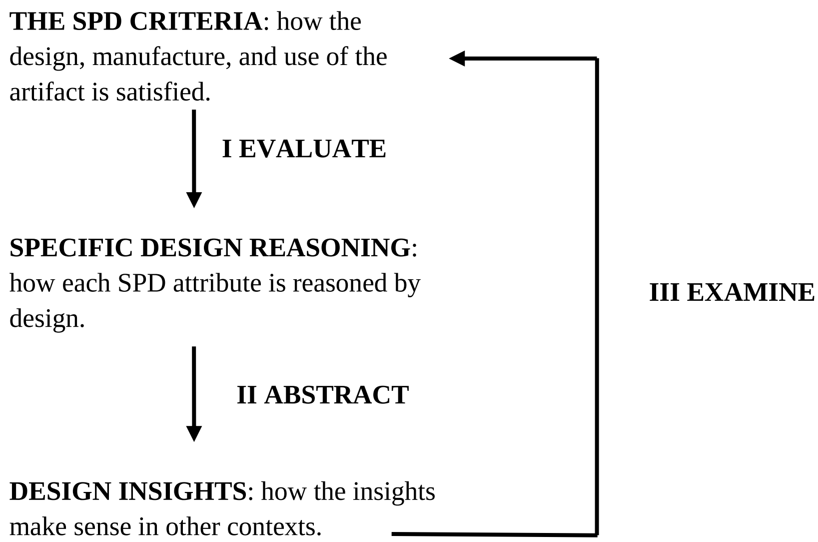


Figure 6.15: The Logic of Abstracting SPD Insights

Abstract Design Insights: The Tree Diagram for Coding General Patterns (Tool No. 6)

Krippendorf (2006) argued that the semantic turn is supposed to do for design what the linguistic turn did for philosophy in the twentieth century. The linguistic turn in philosophy involved a re-orientation toward language as a source of insight into philosophical problems. The process of abstracting is a comprehensive and complex cognitive process of data reorganization, which occurs through comparison with the existing knowledge of the abstractor. In this way, the specific design reasoning of how the artefact is designed by its specific design factor is an “insight” that initiates designers to compare with their existing knowledge to find a general pattern. That means that if there are no similar design solutions stored in the investigator’s experiences, he will not find a general pattern of design solutions. A more experienced designer will be more likely to abstract the insight in a quick and effective way.

The designer will be generalizing and seeking common patterns of all the related ideas or solutions that the information delivers. To give a simple and direct design meaning, the insight can be structured as a short sentence with simple grammar: what factors (design elements) are processed in what ways (methods) to make what SPD qualities (purposes).

Those specified design elements, methods, and purposes are noted as symbolic elements of the insight, which help users to easily abstract meaning.

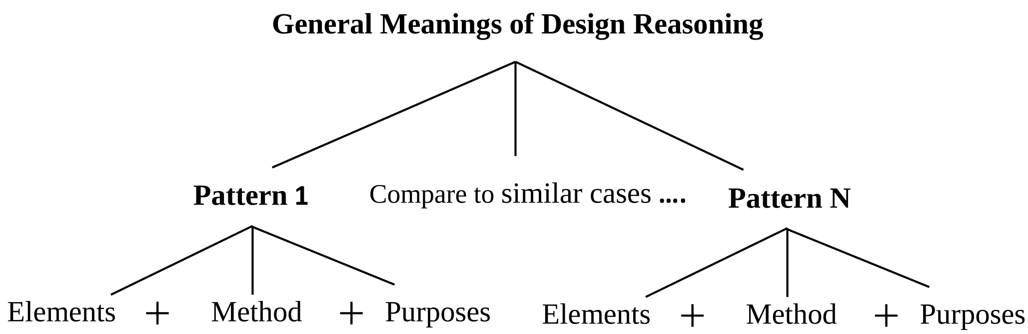


Figure 6.16: The Tree Diagram for Coding Insights

6.2.3.5 Explicit Design Insight

The insight is a simple grammar sentence describing the general pattern of the abstracting process. In the ICTEA-SPD method, insight is an idea abstracted to solve some design problem. It can be: a solution, method, philosophy; a specific scientific or technological form, structure, function, or plan; or a way of using and processing material. The abstracted insight sentence represents a way to organize and process certain design factors listed in the decomposing design of the artefact table to fulfil an abstracted SPD purpose through the SPD criteria. It can also be defined as an abstracted design pattern that has applicable values according to the designer's experiences and knowledge.

A design pattern must explain why a particular situation causes problems, and why the proposed solution is a good one. Alexander (1977) stated a pattern must also explain when it is applicable. Studying traditional everyday artefacts and abstracting embedded design insights is significant for interpreting applications to contemporary product designs. The method suggests that abstracted insights be written in simple and concise language, and that insights maintain reference to the original data revealed by the artefact studies. Here is an example of explicating such insight:

Field Notes: From field studies of the bamboo steamer, the researcher found that most of the observed households make temporary use of a generic steel pan to generate steam. They don’t keep a specific steel iron pan especially for the bamboo steamer.

Abstracted Insight:
Two or more products can temporarily work together to reduce product components.

In the above example of a design insight, three parts can be replaced by specific objects and become specific solutions for certain design contexts.

Figure 6.17: Example of Explicated Design Insights

6.2.3.6 Different Levels of Abstraction: Coherence of the Original Context

According to the patterns categorized from abstracting personal practices and workshop practices, there are three levels of abstracting design insights: the artefact level, the method level, and the philosophy level. The artefacts level of design insight refers to the insights that are directly reflected from the visible design patterns of the artefacts. The method level insight occurs when the abstracted design insights are extracted from specific problem solving methods and strategies. Philosophic or strategic level insights are highly abstracted insights that can be viewed as design methodologies or new approaches that reshape human understanding of everyday artefacts.

These levels represent the degree of generalities that define a given insight. The higher level of abstracting creates insights that are more flexible to apply in design practice; these also have the risk of leading to a “common sense” solution when representing a very broad meaning. (Tool No.7)

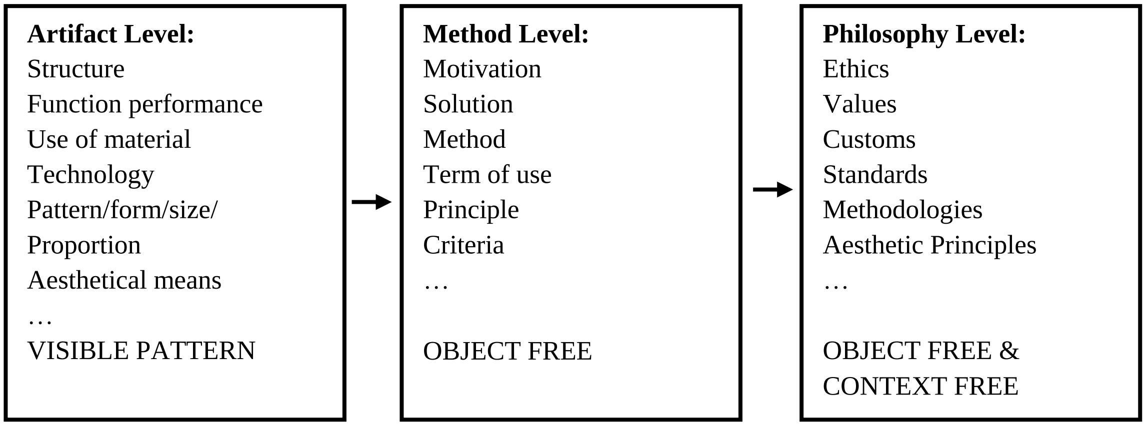


Figure 6.18: Different Levels of Abstracting

Design Insights from the Artefact Level

Design insights at the artefact level tend to be gleaned from visible design patterns that are concrete design plans to make the artefact fulfil its functional or aesthetical purposes. The related aspects may make use of material, structure, functional performance, technologies, form, or size of the product, as well as symbolic or aesthetic meanings of the whole or parts. These patterns have symbolic meanings that agree in other design contexts by their scientific or conventional proofs. This level of design insight can bring more relevant and direct design reflections and inspirations to the new concepts. It is also more direct in its interpretation and makes a visible connection with the original CTEAs. In this research, the artefact level of design insights has the largest quantity of design cases generated in workshops, perhaps because successful patterns in making and designing the artefacts to achieve SPD qualities that are more visible, easier to notice, and simpler to generalize by beginning users of the given method.

Design Insights from the Design Method Level

Design method level insights are related to design patterns that are somewhat invisible but more applicable than artefact-level insights. They represent strategic design solutions that create successful and effective design principles, methods, new approaches, and criteria for evaluating functional efficiency and effectiveness. These insights are achieved by finding a general pattern from the specific elements of the original artefact. All symbolic elements of the design insight sentence are of a higher level abstraction than the visible elements from the artefact level. Having a higher level of abstraction means that design method level insights help create a successful rule of organizing certain design factors.

This level of insight emphasizes the practical rules by understanding the world. The rules may be intrinsic or interpreted by human knowledge. They aim to provide more efficient, more intelligent, more experienced design solutions to contemporary, everyday issues of sustainability. It also represents those intrinsic rules, based on the understanding and accumulated knowledge of human beings, concerning design's physical and psychological characteristics and limitations.

Design Insights from the Philosophy Level

Philosophy-level design insights are the most abstracted ones. They relate to human values, aesthetics, morality, beliefs, customs, and approaches to the sustainability problems of everyday life. These insights are more directly relevant to the context of socially defining a design problem. They are also culturally-based design solutions, meaning that they are relevant to similar cultural and ethical systems and perhaps are not relevant in other cultural contexts. These philosophic ideas can also provide a broad picture of understanding the nature of the world.

This level of design insight requires in-depth experience and knowledge toward understanding design and the world. The most difficult and challenging part of the workshop was the one that required students to abstract philosophic insights.

6.2.3.7 Abstracting Design Insights as a Training Exercise

Perception and similarity are the two basic senses of the cognitive process of abstraction. The ability to perceive the particular meaning of the contents for abstracting relies on logical thinking. The ability to find similarity between concepts or objects depends on the existing knowledge system of the person who is abstracting.

Intelligence is the ability to comprehend information, solve problems, and make decisions in a variety of situations. Highly intelligent people spontaneously apply the processes of selective encoding, selective combination, and selective comparison. On the other hand, subjects of average intelligence do not seem to apply these insight processes spontaneously to problems. Logical thinking, knowledge storage, and intellectual ability can't be advanced in a short period of time. However, applying the inner process of abstracting insights can be trained in the workshops in many ways. At the beginning, students in workshops were not familiar with the abstracting method. They were required to practice individually and in groups to speed their cognitive responses to the process.

The training also included many abstracting activities. Each student in the workshop was required to give a certain amount of abstracted insights as part of in class exercises. This was an effective way to build students' inductive and deductive thinking ability in a short time. Once their logical thinking processes were built through class training they were able to apply the thinking process naturally in their everyday lives. Because of this thinking habit, students can become more sensitive to the information and messages they receive in a number of contexts. According to the questionnaire feedbacks from the workshops, most students considered the abstracting and interpretive training to be very helpful for their future design studies. They were able to think more directly and efficiently when doing specific design work and research following the workshop training.

6.2.4 Interpreting and Evaluating Generated Design Concepts

6.2.4.1 Objective Interpretation for Solving Particular Problems

Based on the SPD framework, designers can check their everyday life experiences to define sustainability problems that can be improved by redesigning everyday products. These redesigns can occur as the result of one of four approaches: 1) product perspective, which aims to build the sustainability of the artificial world; 2) human perspective, which aims to promote individual human well-being; 3) natural environment perspective, which emphasizes sustaining the natural environmental; and 4) social perspective, which targets a remodelling of group human values and aesthetics for the greater good. This framework can be used to evaluate existing conditions from the four perspectives and find problems that can be considered the sustainability problems of everyday life. Designers can often quickly define the problem and can immediately make connections to related design problems from their understanding and contextual interpretations of SPD criteria. For an objective interpretation design case see *Appendix J: An Example of Interpreting Insight for Solving a Particular Problem*

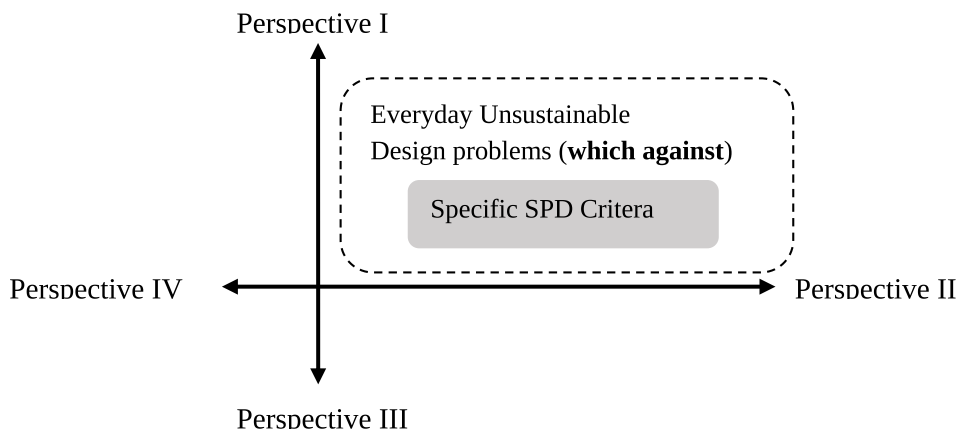


Figure 6.19: Identify Design Problem by the SPD Framework (Tool No.8)

6.2.4.2 Subjective Interpretation for Identifying Design Problems

There is a tool of interpreting design insight, which was developed for quick and effective interpretation. (Tool No.9)

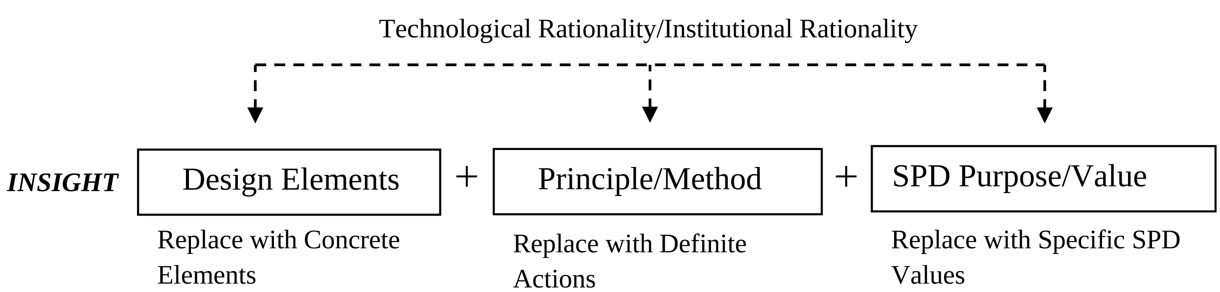


Figure 6.20: A Tool of Interpreting Design Insight

An example of applying the tool of interpreting insight is depicted below:

Bamboo Steamer

Abstracted SPD Insight:

Two or more objects can temporarily work together to reduce product components.

Two or more objects		Temporarily work together		To reduce product components
▪ Television and Mobile Phone ▪ Bed and desk ▪ Book and a cup noodle ▪ Toothbrush and coffee cup ▪ Umbrella and table …	+	▪ Control television ▪ Place together ▪ Place on noodle cup ▪ Use tooth brush handle ▪ Open and place on table …	+	▪ Project pictures, play videos ▪ Extend the bed size ▪ Cook noodles ▪ Stirring coffee/clean the cup ▪ Create an outdoor eating place …

Figure 6.21: An Example of Applying the Tool of Interpreting Insight

The above example shows how each abstracted insight can bring many concrete design solutions. After concrete design solutions have been created, the next step is to realize the design concepts by defining design contexts where the solution is applicable.

6.2.4.3 Interpreting Design Insights on the Three Levels of Abstraction

An artefact that supports multiple layers of meanings does not merely support being looked at from different perspectives. It becomes something different in each semantic layer. There are three levels of insight abstraction, as introduced in chapter five: 1) the artefact level, or low level of insight; 2) the design method level, or medium level of insight; and 3) the philosophic level, or high level of insight. This section explains how to interpret design insights on the three levels of abstraction.

Interpreting Insights on the Artefact Level

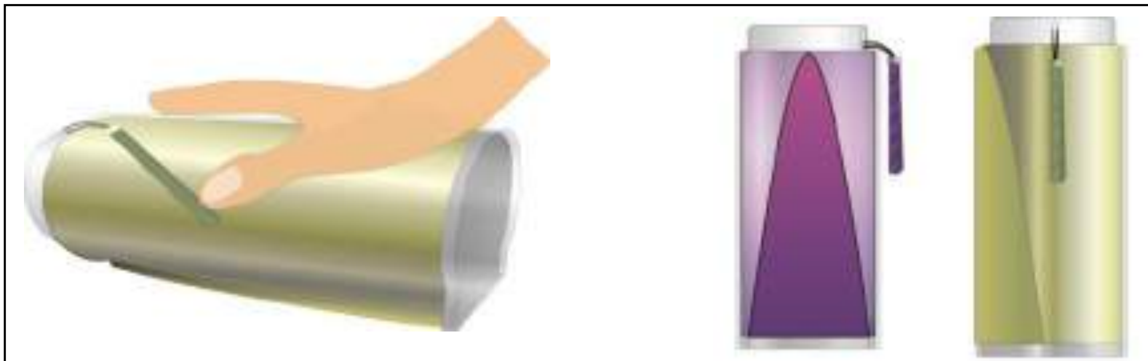
Artefact level insights are directly related to the visual design elements of the studied artefacts; these elements can include product structure, function process or performance, uses, production of the materials, implied technologies, patterns, styles, colours, proportions, style plans, and forms of the artefacts. They can also be symbolic and aesthetical meanings that affect the product's values.

Many existed designs and products that are seen as traditional cultural elements inspire designs that interpret the insight on the artefact level. These newly inspired designs adapt the valuable and typical traditional design plans to the related elements to serve other design purposes. At the artefact level, the new designs are obviously related to or are simulations of their original prototypes. Here is an example of artefact level interpretation:

Charcoal Iron

Abstracted Design Insight (Artefact Level):

The heated flat bottom of a container can be used as a clothes iron without using electricity.



Design Concept: "*Thermos Iron"*

The thermos iron is a convenient solution for users in a travel situation; the object provides the direct functions of heating water and ironing clothes.

Figure 6.22: An Example of Interpreting Insights on the Artefact Level

According to statistics from the six workshops, more than half of the final design concepts were generated by interpreting design insights from the artefact level. A review of these design concepts indicates that most of the students can apply the abstracted design attributes to generate creative solutions to the sustainability problems reflected in their everyday lives or their understandings of the broader scopes of everyday sustainability issues.

Interpreting Insights on the Method Level

This research gives a structure of the artefact-related design elements, which can not only be visual and material elements, but can also be the abstracted elements of the meanings and laws of planning those visual and material elements. By following these laws, or languages, of form and function, certain physical or psychological effects of the design can be delivered to users of the designed product. Insights from the design method level are about the invisible design languages embedded in the selected and studied artefact; these languages refer to the approaches, scopes, and methods used to solve sustainability related design tasks.

Flour Stick

Abstracted Design Insight (Method Level):

Manipulate simple tools using human skills to accomplish complex tasks.

Design Concept: "*Weight Reader"*

It reads the weight of what people are carrying by taking a digital measure of the user's muscle tenseness. Long-term use builds the user's physical sensitivity to weight.

Figure 6.23: An Example of Interpreting Insights on the Method Level

Interpreting Insights on the Philosophic Level

Some insights can have general meanings to users from different cultural backgrounds. Those reflect universal design laws and languages that have close connections with the biological and psychological attributes of human nature. These rules and languages are evolved and described in design histories and design research. The aesthetically related universal insights are gradually formed by symbolic and psychological means through human understanding of the artificial world. The functionally related universal insights can be synthesized in categories of structure, material, dynamic, ergonomic, and technological design patterns and models.

Flour Lamp

Abstracted Design Insight (Philosophic Level):

Extend the life of a product by discovering its whole life performance.

Design Concept: “*Magnet Wall”*

This product concept redesigns our conception of home space planning by providing an applicable solution that makes walls easy to shape according to the user’s immediate needs. Users can quickly change the space plan of their home while using the wall to provide furniture functions.

Figure 6.24: An Example of Interpreting Insights on the Philosophy Level

One artefact can inspire several design insights. There could be at least one insight that makes the artefact more visually relevant to the generated design concepts. Such insights are called direct interpretations. The interpretation of philosophic level or method level, insight will not be so obviously related to the original artefacts. The significance of applying the insights is not evaluated according to the relevance of the insight to the original artefacts, but rather by the resulting product's alignment with the criteria of the SPD framework.

Invisible Connections with the Original Artefact

Visible connection with the original artefact is not a required quality of interpretation. The method and philosophical levels of interpretation usually share invisible meanings with the original artefacts. The examples presented above, which supported the idea that interpreting artefacts means the artefacts and resulting design concepts share not only visible symbols, but also have similarity in deeper meanings.

6.2.4.4 Enhance Interpretation Capacity: Cluster Design Method (Tool No.10)

Elements that share a common purpose group together. Elements that share common physical strength and scale characteristics also group together. Sometimes, elements cluster because they share a common theory. What delineates a cluster of design ideas is some form of commonality, some shared and natural ability of components to work together. Such clusters, or bodies of technologies (design solutions), can be called a domain. A domain is any cluster of components that one conceptualizes in order to form devices or methods, along with the cluster's collection of practices and knowledge, its rules of combination, and its associated way of thinking. Design begins by choosing a domain or, in other words, by choosing a suitable group of components to construct a design solution.

Of designing, technology expert James Newcomb (2010) said, "Doing it well entails knowledge of literally thousands of individual technologies, together with the capability to assimilate and optimally combine these technologies in particular applications." The theme of a combined cluster represents a basic principle of the domain. Design starts from a purpose to find the solution to some perceived need. The need does not necessarily originate from an outside stimulus, but can also originate from within the basic natural principles of the world.

Abstracting design insights and interpreting design insights are controlled by the SPD criteria framework. The given tools and guidelines serve as technique solutions for the abstracting and interpretation processes. They are also effective and usable methods of identifying different levels of interpretive abilities. In workshops, students have to understand why the process and the tools were designed and what functions they serve. An easy way to help them understand the functions of the method is to encourage them to try the abstracting and interpreting experiences without the method first, and then have them try the method.

The “Cluster Design Method” is a method developed under a particular training of interpreting SPD insights for the purpose of training designers’ creative thinking ability. There is a process by which beginning users of the method can come to understand and more efficiently practice the method.

Figure 6.25: Practicing the Cluster Design Method in Workshop

6.2.5 Constant Evaluation during the Interpretive Process (Guideline No. 3)

After defining the scope and approach to solve the problem, designers should give as many possible solutions as they can conceive, based on their analysis of the users' physical, psychological, and sociological contexts. They should also consider multiple business-related factors, such as costs, margins, branding, and significant competition. Analysing a design problem is a very comprehensive situation. In the evaluation phase, evaluating criteria should be pre-set, or else best solutions should be selected as design tasks.

6.2.5.1 Evaluating SPD Significance

Defining the design problems, interpreting design insights in design contexts, and generating design concepts are all guided by SPD criteria framework to ensure the sustainable attributes of the final design concepts. One design insight can generate many design concepts, even in one design context. Designers can select the best concepts using the SPD and other required criteria. The abstracted SPD criteria have to be flexibly interpreted based on the design context, which requires designers using the ICTEA-SPD method to have an in-depth understanding of the meanings of the criteria which associated with their personal knowledge.

Evaluating the SPD significance of the interpreted design solution not only determines whether the criteria have been satisfied, it also determines whether the criteria are satisfied concerning the practical values of the design problem. There is no scientific way to examine the practical significance of the design problem. The generated design solutions are evaluated using a mathematic evaluation that weighs the degrees of SPD significance according to the SPD criteria.

6.2.5.2 Evaluating Other Design Qualities

Gruber (1993) noted that there are three aspects of the aesthetic experience: the subjective experience of appreciating beauty, the properties of objects, and the form or medium in which the contemplated object is represented. He also listed two sets of attributes of the aesthetic experience, one for the experiencing subject and one for the contemplated object.

There can be specific qualities other than aesthetic qualities in design as the designs should account for cultural, social, and economic considerations. The specific criteria for those qualities can be developed according to the design purposes and use contexts.

6.3 A Workshop Plan

6.3.1 A Workshop Model as a Representation of the Method

In this research, the workshop is the research method by which I developed the final theory by empirical testing and defining new problems. It can also be a way to represent the method to both educational and academic purposes.

Some of the schools in which this workshop was conducted have integrated this workshop into some of their related curriculum for undergraduate or graduate students. In the Guangzhou Fine Arts Academy, they use this workshop structure in their "Design Innovation of Home Products" program to train their students' logical and design thinking capabilities. In Shandong University of Art and Design, where the study of traditional crafts is an existed education focus, the workshop has been conducted several times to provide more students can have opportunity to develop design ideas from interpreting their local artefacts. This workshop is the first workshop to operate on a broad cultural scale in China. It is also the first design workshop that specifically aims to interpret traditional Chinese design thinking in everyday artefacts by following a scientific method.

In order to encourage further workshops utilizing the ICTEA-SPD method, a workshop model is proposed at the end of this research. The conducting of these workshops is an on-going project for the researcher, and networking with the design schools for the purpose of conducting further research and educational workshops is under development.

6.3.2 Different Directions of Workshop Purposes

According to the motivation and history of the workshop, there are three potential directions for workshop purposes: 1) to integrate logical design thinking training to the interpretive process; 2) to reveal the effects of understanding and collecting design values of CTEAs for SPD; 3) to introduce the SPD method as an effective and efficient way to attain quality design ideas from CTEAs.

For Training Intelligent Capability of Abstraction and Interpretative Thinking

Most participants of the workshops gave positive feedback on the workshop's introduction of a scientific way of approaching design thinking. In fact, the method did not introduce a logical process into their design thinking. It merely explained what naturally occurs during the inspiration process. A significant part of the logical process is that it establishes the SPD criteria before designers process data from the artefact studies and match their findings with past design experiences and existing knowledge.

To this end, the workshop instructor explains the logic and reasons behind each process and tool designed, as well as how the SPD framework controls each phase of the method. The objective of participants' practicing of the SPD method is to enhance their creativity as a trained skill. The method reveals the conscious logic of insight and introduces techniques to clarify the mind's vague relations. The method requires quick and meaningful reactions to the process and tools, while accumulating the participants' intelligence in inductive and deductive thinking. This can be built through group work on quantities of abstracting and interpreting activities that require students to give as many design ideas as they can and also requires them to abstract different levels of insights to enhance their in-depth thinking skills.

For Collecting SPD Insights from CTEAs

The purpose of the workshop was to glean design value from CTEAs and collect design insights for SPD. The design value of CTEAs has been generally agreed-upon among different cultures. Many Chinese designers, researchers, and design students have passions for studying and interpreting traditional cultural objects. The workshop introduces a systematic way to collect SPD insights from CTEAs. It is also an educational measure that introduces local cultural heritage and encourages the development of culturally related products.

Besides workshop participants understanding the SPD criteria and the whole process of the I-SPD method, in-depth artefact investigations and field observations can be designed to use more time and resources input. Participants should be encouraged to retrieve first-hand CTEA data and record their experiences from different perspectives. This will provide resources from which to generate design insights. Each participant is required to select and analyse a certain number of CTEAs to obtain more insights. The generated insights can be collected as final outputs of the workshop. Collaborative workshops in different places can help each other understand cultural uniqueness by comparing their insight collections. Interpretations of CTEAs can also be accumulated to establish a database for further workshop and research purposes.

To Introduce a Structured Design Method

The workshop aims to teach the participants the ICTEA-SPD method by creating an understanding of how the method is developed and applying the method to generate quality design concepts. Workshop instructors should explain how the method can assist the design process, and how the suggested tools and guidelines will contribute to the different phases of the method. Participants should understand that the method is not a general design method for SPD. This understanding will require them to stay flexible when selecting insights to work on and setting design topics that inspire a natural interpretation of the selected insight. Personal factors of interest, design skills, and creativity capability largely determine the condition of final design concepts, along with degrees of understanding and applying the method.

6.3.3 A Basic Structure of the SPD Workshop

The basic structure of the SPD workshop can be modularized into four parts: 1) understanding SPD framework and criteria; 2) learning the process of the SPD method, including tools and guidelines; 3) practicing the method; 4) evaluating and supervising students' work in different phases.

STRUCTURE	SUGGESTED TASKS
Understanding SPD Framework and Criteria	▪ Introduce background knowledge of SPD. ▪ Explain the structure of SPD framework and give examples to illustrate every criterion. ▪ Introduce design examples that satisfy the SPD criteria.
Learning the SPD Method and Tools	▪ Introduce the main process of the method. ▪ Explain the tools and guidelines. ▪ Introduce examples of applying the method.
Practicing the Method	▪ In-class exercise of abstractive thinking practices. ▪ Group work on CTEA collection and selection. ▪ Group work on abstracting design insights. ▪ Group/individual work on interpreting design insights. ▪ Individual work on realizing design concepts. ▪ Middle term presentation and final presentation.
Evaluating and Supervising	▪ Evaluate CTEA selection and studies. ▪ Evaluate validity and quality of design insights. ▪ Evaluate quantity and quality of design ideas from the insights. ▪ Evaluate group project and individual design projects. ▪ Evaluate workshop effects on students' reflections.

Table 6.4: Basic Tasks of the SPD Workshop

Time duration and scale of the workshop can be flexible according to the workshop conditions. The workshop can be designed to fit different purposes by emphasizing certain parts of the workshop structure.

6.3.4 Workshop Performance Evaluation

The workshop's performance can be measured through**:** 1) the quality of the student work, which is determined by the goals of the workshop; 2) the workshop conditions, which include participants' reactions and collaborations and the productivity of each part of the workshop contents; and 3) participants' feedbacks on organization and performance of the workshops and the SPD method, as collected through structured questionnaires and focus groups.

Summary of Chapter 6

To conclude and illustrate the key research findings, this part of the thesis introduces the comprehensive investigative results and interpretive meanings that serve as evidence for the research potentials. The I-SPD method can be represented in four forms: 1) the full process map; 2) the method paradigm; 3) sequential task lists with cognitive techniques; 4) the construction of the workshop. These representation forms illustrate different application possibilities and scopes. These findings were generated from empirical studies and their supported theoretical investigations. The I-SPD method is not a formal method for solving fundamental design problem. It is from a unique approach which addresses the importance of studying ancient wisdom for SPD innovation. Besides the I-SPD method and its related contents, the substantial data from CTEA studies in this research, including a list of investigated CTEAs with their general design values, were also built as a database for supporting further studies.

Chapter 7:

Conclusion and Discussions

Introduction of Chapter 7

This research is motivated by my belief in the importance of seeking out and applying insights from traditional Chinese design wisdoms to solve contemporary sustainability problems. The research involves a methodological inquiry into how those valuable insights from Chinese traditional everyday artefacts (CTEAs) can be interpreted into meaningful sustainable product design (SPD) concepts which are adaptable to contemporary situations. There are three frameworks related to this research: defining criteria for SPD, structuring design knowledge from traditional artefacts, and describing the process of interpreting insights. As this is a PhD project with strict time and resource limitations, I chose to make the research goal the description of the process of interpreting insights from CTEAs as a particular scope for design insight interpretation. The conceptual framework is shaped by investigating existing theoretical ideas of design methodology, creative techniques for idea generation in the design process, and the cognitive psychology of insightful design interpretation. In taking this approach I combined the related theoretical concepts in insight interoperation with the fundamental paradigms of design process. The main research methodology applied is modified analytic induction inquiring through empirical studies and theoretical reasoning. To support the empirical experiments of the workshops I also worked on providing temporary theoretical solutions to the problems of SPD criteria and the structure of design knowledge of CTEAs. These are important to help workshop participants conduct their tasks efficiently and move toward the research goal.

This final chapter of the thesis is written with the following goals in mind. 1) To synthesize findings and answer the research question according to the theoretical framework and research methodology; 2) To discuss how the key findings are theoretically related and contribute to existing knowledge; and 3) To discuss the limitations of the research and possible future research directions.

7.1 Conclusion

Although many scholars and design practitioners advocate the importance of applying traditional design wisdom to solve contemporary design problems, formal researches aimed at developing practical methods to guide design practices using this approach for SPD innovations are relatively rare. This research project combines several intrinsically complex cross-disciplinary concepts in its investigation and representation. It aims not only to provide a framework for the proposed method of interpreting CTEAs for SPD but also investigates and examines practical solutions to illuminate the complexity and dynamism of this interpretive process. Instead of studying criteria and strategic solutions, the research investigated possible applications for SPD innovation from a methodological approach to compare how the process is discretely different from the general design process.

7.1.1 Synthesized Answer to the Research Question

Research question: Is there any design method of interpreting design insights from Chinese traditional everyday artefacts (CTEAs) for contemporary sustainable product design (SPD)? What is the process of the method? Are there any thinking techniques that can assist the process?

Objective of the research: To investigate the general process, required thinking (cognitive) techniques, and to define possible applications.

The theoretical framework of the research is constructed with a basis in foundational knowledge proceeding to a logical inquiry into the research question, and it answers the research question in 3 steps: 1) What are the fundamental cognitive patterns and process of insight interpretation? 2) How can these fundamental patterns and process be integrated into a design method? 3) How can the design method of insight interpretation specifically be applied to interpret insights from CTEAs for SPD?

The research methodology is also designed and conducted according to this framework. To answer the first and second questions I carried out a theoretical investigation using cognitive psychology and design methodology knowledge to understand the scientific findings and theoretical explanations of insight interpretation processes and patterns and how these theoretical findings can be applied in building design methodologies. Through both the theoretical studies and initial design experiments I developed an initial insight interpretation method-model which was then combined with four processes: 1) building design criteria; 2) obtaining insight from selected data; 3) articulating insight in design language; 4) applying the insight in other design contexts. From the theoretical studies I also developed the two fundamental approaches of insight interpretation, namely "objective interpretation" and "subjective interpretation", which are based on the studies of functions of insight interpretation in both philosophy and design methodology studies (Gadamer 1986; Dorst, 1997; Dorst, 2007).

These two fundamental approaches of insight interpretation, together with the four sequential processes of the basic structure of the insight interpretation method, answer the second sub-question of the research project. From a theoretical standpoint the first sub-question of the research is answered by using the applicable cognitive techniques which have been applied in the workshops and have been developed with specific tools and guidelines to assist the interpretative process.

To provide a solution to the final sub-question, the key research question, the basic model of the insight interpretation method and the cognitive techniques described above have been applied and contextualized in the specific insight interpretation context of six design workshops with 119 participants. The six workshops were designed with two types of applications of the interpretation method model with cognitive techniques in mind. First, compulsory applications (workshop 1-4), which specified the method model by restricting it to concrete tasks along the method process. Second, spontaneous applications (workshop 5-6), which synthesized its application possibilities and patterns according to different design situations.

The key research objective has been reached by presenting the I-SPD method (ICTEA-SPD Method). This method is developed by exploring, describing, examining and synthesizing possible approaches, steps, tasks, and patterns from the interpretive process. The importance of building and understanding SPD criteria has been addressed by the I-SPD method. Structured knowledge of SPD is the prerequisite of applying the I-SPD method. It has been discussed in Chapter 4 of this thesis. To fit its purpose of guiding design practice the method can be approached in two ways: 1) Solving particular design problems, which is defined as objective interpretation according to the design methodological paradigm of "design as rational problem solving" (Simon, 1972; Dorst, 1997, 2007), or 2) Interpreting insights to meet contemporary design problems, which is defined as subjective interpretation according to the other dominant design methodological paradigm of "design as reflective activities according to design situations" (Schön, 1983; Dorst, 1997, 2005). These two approaches of practicing the I-SPD method have been examined in different workshops situations. Performances, capabilities and characteristics of these two approaches have been discussed in Chapter 6, page 169. From these two approaches, the interpretive process can be roughly structured in three phases: 1) Selecting and investigating CTEAs for SPD; 2) Abstracting SPD insights; 3) Interpreting insights and evaluating design concepts by the SPD criteria. The structure of the I-SPD method can be illustrated using the diagram below:

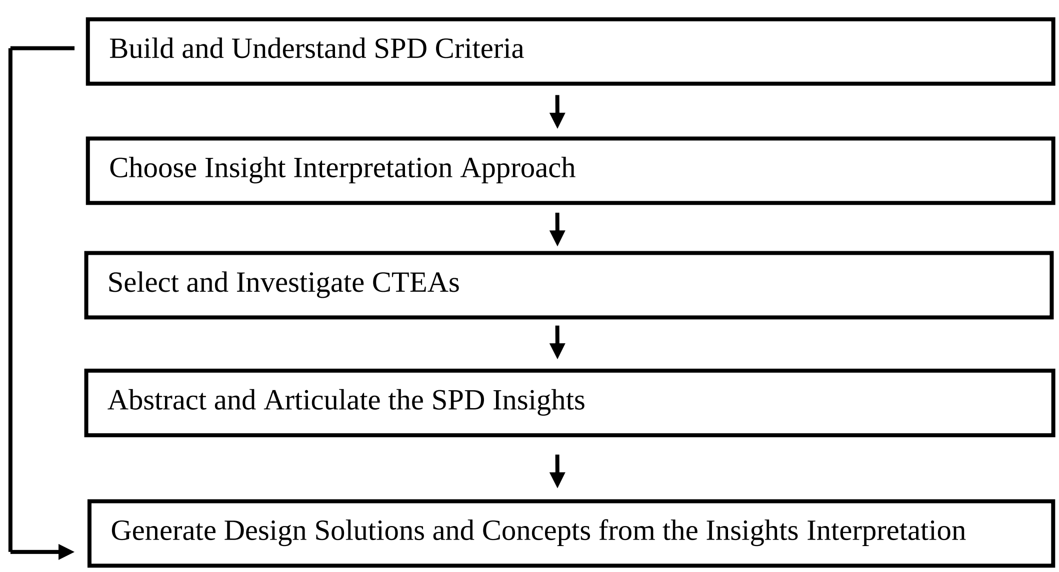


Figure 7.1: Structure of I-SPD Method

The research findings provide two forms to represent the I-SPD method: 1) a full process map which is a complete process of interpreting CTEAs for SPD. This full process map has been illustrated in Chapter 6, page 174. 2) A method paradigm which is a comprehensive description of the method and provides possible flexible applications. The method paradigm has been illustrated in Chapter 6, page 176. The full process map is developed to guide users in how to derive the largest potential from a CTEA which contains meaningful SPD insight (insights) to solve contemporary design problems. The abstracted paradigm of the I-SPD method addresses its nature as a design method which aims to provide efficient technological solutions to meet different interpretive conditions.

Besides describing the inner structure of the interpretive process, the key research question and sub-questions have also been solved by providing thirteen cognitive techniques to help reduce difficulties and ambiguities encountered during the interpretive process. Significant ones are: How to determine which CTEAs contain SPD insights by using the SPD criteria; the different levels of artefacts studies and effective research methods; the organization and analytical processing of investigated design information from CTEAs studies; the tree diagram for insight abstraction; the standard language structure of SPD insights, the three levels of abstraction and interpretation; a method of interpreting SPD insight by using variations of the insight sentence to realize contextual meanings for specific design situations; implying technological and intuitional rationalities in insight interpretation. These cognitive techniques explained detailed tasks along with the three phases of the I-SPD method process. They were built through theoretical hypotheses and empirical tests. Representations, theoretical foundations, and applied meanings of the interpretive process of these cognitive techniques have been illustrated in Chapter 6. Places and functions of these cognitive techniques have been listed in the full process map of the I-SPD method as *Appendix C*.

The research also addresses the requirements of particular knowledge for interpreting CTEAs for SPD. These include criteria of SPD, fundamental knowledge of design practice, intellectual capability of logical thinking, and general knowledge of science and understanding the world. Learning and practicing the I-SPD method can be an effective way to train logical and interpretive thinking capability.

7.1.2 Key Insights from Research Findings

1. Holding the SPD Criteria for Constant Evaluation during the Whole Process

Building criteria is important for the interpretation of CTEAs. In general, interpreting CTEAs means finding embedded universal or contextualized design values and realizing those values in different contexts. Those design values are defined as “design insights” in this research. They are generalized in rational analysis of the design reasoning of the studied CTEA. Without an objective method and attitude to identify and evaluate the embedded design value of the CTEA, the designer or practitioner may focus on something “impressive”, “touching”, “good”, or “interesting” from their personal interests or preferences. But when it comes to product design, the design is examined by the degree to which it achieves market acceptance. This requires designers to have well-informed knowledge of the real needs of people, society, and the world. Designers who intend to interpret “old design ideas” for new uses need to develop well-investigated and confirmed criteria describing the quality of particular design purposes.

This research is designed to interpret CTEAs from a particular scope: design for sustainability. It is meaningful and crucial to the future well-being of humankind. To reduce the difficulty of understanding SPD, I built abstracted and applicable SPD criteria for the workshop participants to inspire them to derive design solutions. These criteria also remind them that the results from each phase of the interpretative process should be guided and evaluated by the criteria to reach the goal of sustainability. The given SPD criteria framework is a way to maintain a rational understanding of each particular requirement while there is no strict boundary curtailing creativity in workshop design situations.

2. Methodology of Interpreting CTEAs: Subjective and Objective Interpretation

Herbert Simon and Donald Schön established the theoretical foundation for the science of design methodology. “Design as rational problem solving” by Herbert Simon in the 1960s and “Design as reflective conversation with the situation” presented by Schön

(1983) are the two fundamental paradigms of design methodology. Dorst (1997) compared these two paradigms by using empirical experiments to describe the qualities and characteristics of using these two fundamental paradigms to explain design practices. These two paradigms represent two different ways of processing design thinking. They are also mutually related. Dorst also developed the theoretical concepts of the two interpretive thinking models in the design process: “objective interpretation”, adaptive for particular design problems and goals, and “subjective interpretation”, a co-evolutionary process of creative problem solving. These two models directly relate to the two fundamental paradigms of design methodology.

These theoretical ideas are important to the derivation of the ultimate research findings. This research uses empirical studies to illustrate how these two models of interpretive thinking can be applied in this particular design situation. For objective interpretation, participants were required to use CTEAs as the source of design inspirations to solve particular design problem. They had to understand the design problem to select meaningful CTEAs and insights. There is a fuzzy dialogue of understanding the design problem and selecting adaptive artefacts and insights in the participant’s mind. The empirical research clarified that there is no guaranteed result from using CTEAs for inspirations as a general method to solve particular design problems, even surveying a large number of CTEAs. The other concept, subjective interpretation, is to use insights from CTEAs to search for potential uses in contemporary design situations. This is more straightforward to conduct as it provides larger creative space and the logic is typically more direct. That said, it is demanding on the interpreter’s intellectual capability and empirical knowledge to process information from open brainstorming. This is also the reason why I developed some cognitive tools to help the workshop participants to structure their thoughts toward making quality decisions during this process. The goal of objective interpretation is to search for one or several quality design solutions inspired by the design of the CTEA and applicable toward a particular design problem. The goal of subjective interpretation is to explore the potential of a particular design insight or many insights attained by investigating the designs of CTEAs.

3. Heuristic Nature and Abstractive Representation of the I-SPD Method

The I-SPD method is a heuristic method established on the foundation of rational thinking and used to explore design possibilities. In this research the activity of design is to find a solution or solutions to specific design problems and also to use abstracted design solutions to address possible design problems. Heuristic design methods have psychological bases that describe the general patterns of designers' effective cognitive processes. This makes it more possible for designers to reach sound, valuable, and creative design solutions by applying the cognitive techniques to help them process information more efficiently. The method optimizes the decision making structure and provides criteria to select and construct information so as to reduce the complexity and ambiguity of the interpretive process. This effect has been examined and confirmed by empirical data from workshops.

Design methods are heuristic methods based on weak-form knowledge and ill-defined rules. They do not guarantee a result but do increase the chance of achieving a result. Design methods should therefore be applied sensibly and with an understanding of the limitations involved. The I-SPD method is represented in two forms: a full process map and an abstracted method paradigm.

The full process map is adaptive to guide users who intend to explore the potential of CTEAs toward solving contemporary sustainability problems by design. Every addressed step and cognitive technique helps to collect and process information.

The heuristic nature of the design method leads to optimized decisions during the design process by informing the designer's own individual interpretation of the rules of design and understanding of the design situation. As a design method, the I-SPD method should be represented in a way fitting to its nature as a heuristic with general applicability to possible design situations. That means that if the I-SPD method is defined as a design method for interpreting CTEAs for SPD concepts it should deliver this function directly and effectively.

The abstracted method paradigm restructured the sequential process into a free-form, improvised process. This method structure is based on the synthesis of different application situations observed from the last two workshops. Participants in these two workshops were required to provide their satisfactory SPD concepts inspired by CTEAs. The experiments indicated that the full process of the I-SPD method is not the necessary condition to reach a good design concept inspired by CTEAs. In fact a good design concept can be generated at any phase of the process. The form of representing a design method can vary from condition to condition. This research shows that the representation of a design method should be in accordance with the basic purpose it is fulfilling.

4. Articulating the Insight by Symbolic Linguistic Representation

Interpretation originates from human linguistic activities used to convey symbolic meanings in different language contexts. Linguistic representation is adaptive, describing designers' cognitive various processes and patterns. Designer's minds work using both rational and inspirational thinking during the design process. Linguistic thinking and visual thinking are equally important as required intellectual skills for designers. Human beings do not rely solely on language to process their cognitive activities, but language is the essence of human communication and also important to carry out intellectual activities. Insight is the driver for designers to make breakthrough decisions toward reaching their design purposes. It can be descriptive or non-descriptive. Design emphasizes its utility toward particular purposes. Clearly defined design insights and design purposes enable effective and inspirational thinking. Symbolic linguistic reorientation is a tool to help designers to articulate insights and also to think. It is therefore an essential task during the interpreting process. In this research linguistic representation of design insights is meaningful in two ways: 1) it structures information and optimizes information processing; and 2) it facilitates cooperative group work.

The empirical experiments of the present research examined the symbolic linguistic representation of the SPD insights. Workshop participants confirmed the formal logic pattern of design reasoning defined by Dorst (2011). I referred to this logic pattern to develop the syntax of the insight language structure: "Elements + Method = Purpose", as the basic language structure of the "insight sentence". I also provided a method to apply the insight sentence and address its satisfaction of both logic and scientific rationalities. In other words, the insight sentence reveals a contextual fact which makes sense of both where the CTEA is originated and also the context in which it can be applied. The activity of abstracting insights is based on the written description arising from CTEAs design investigation. It is an effective form to analyze information and select meaningful information using the SPD criteria.

5. Logical Reasoning in the Interpretative Process

Logical reasoning is the mechanism of interpretation. Inductive, deductive, and abductive reasoning are the three fundamental logical reasoning patterns involved in the interpretative process. Inductive reasoning abstracts and articulates SPD insights from artefact investigations and design descriptions. Deductive thinking interprets the articulated SPD insights into different adaptive design situations. Abductive reasoning is conducted when we understand the design problems and propose possible design solutions or directions of solutions. As Buchanan notes, "Design is the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes". It is a process of understanding design problems and tasks, learning and communicating with design contexts, constantly evaluating each step, and discovering the final design solution. The interpreted design insight serves as a design solution, or the essence of an idea. To interpret design insights is to find the adaptive design situations and explore potential abstractive meanings from the design of CTEAs. In other words, interpreting design is to find a design problem that can be solved by inspirations drawn from the evidence and ideas provided by the traditional artefact.

Addressing Rationality in Insight Interpretation

The "Logical Centre" of interpreting CTEAs is the result of referring to those embedded (concreted, systemized, or abstracted) design insights to create values (functional or aesthetical design attributes) through new products (or improved existing products) to better fulfil the requirements and desires of contemporary users.

Central to Buchanan's (2001) argument on expanded practice is his conviction that design is a new liberal art of technological culture and has the capacity to create connections and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present. When it comes to the purposes of product design, a designer's decision concerning how or if the embedded design value can be interpreted in contemporary design contexts should be objective and pragmatic. Seeking technological, institutional rationality is very important in the interpretative process. It also requires a rigorous use of meaningful, divergent, and compressive thinking capabilities in the cognitive process of design.

6. The Three Levels of Interpretation

One of the most significant insights of the research findings is proposing the three levels of interpretation: artefact level, which is mimic product creation; method level, which seeks technological readaptation; and philosophical level, which moves toward a unified paradigm of human understanding (knowledge). In this research the difficulty of conducting the three interpretive levels increases from the artefact level to the philosophical level. These three situations are determined by the nature of the particular insight and also different abstractive layers of articulating the insight. Artefact-level interpreted design has obvious similarity with the original artefact. Method-level interpreted design relies on technical explanation to link to its original artefact. Philosophic-level interpreted design makes sense by using general logical and ideological agreement. Philosophic interpretation has the greatest power of design innovation but requires both solid knowledge of design and also knowledge of the world. The proposal of the three levels of interpretation helps users of the I-SPD method to be aware of how they want to interpret the insights from CTEAs and also helps them to evaluate if the interpretation is rational and logically related to the insight.

7. Intellectual Capability Influences Insight Interpretation

Empirical experiments of insight interpretation directly reveal individual differences when comparing a group of workshop participants who worked on the same interpreted subject. Required intellectual capabilities may include logical thinking, reflective thinking, as well as design and general knowledge. People who have better knowledge of the world from education or practical activities can be more skilled in rational reasoning and also divergent and convergent thinking. Efficiency and productivity can be two indicators to evaluate insight interpretation performance. Efficiency means the speed of generating good design concepts or solutions which satisfy objective evaluation criteria and professional standards. Productivity means the quantity of workable design concepts or solutions generated from interpreting one particular design insight. Empirical data from this research indicates that learning and practicing the I-SPD method can motivate and enhance workshop participants' intellectual capabilities, which is supported by their improvement of efficiency and productivity in insight interpretation. It can be viewed as a regular intellectual training method.

7.1.3 Evaluation of the Method Performance in the Workshops

The research findings related to cognitive techniques of the I-SPD method were generated from a proposed theoretical model that was refined in the course of the six design workshops. The empirical experiments of the workshops were not aimed to build an accurate or definite method of interpreting CTEAs for SPD. Rather, the nature of the research methodology is to describe the phenomenon and patterns of conducting related research and design tasks in different design situations. It is a way of developing and describing a logical thinking method to assist research and design activities aimed toward the particular task of interpreting CTEAs for SPD purposes. The I-SPD method was proposed by both qualitative analysis and quantitative evaluation to fix each specific task and cognitive technique together with the methodological process. I also encouraged each participant to integrate the method with their own analytical structure and personal knowledge of design and insight interpretation.

I designed several evaluation techniques to measure the performance of the I-SPD method's cognitive techniques at different stages of its development. Open discussions, group discussions, individual tutorials, and questionnaire investigations are the four methods of collecting workshop participants' reactions and opinions from their experiences. Field notes, workshop memos, interview data, and questionnaires have also been collected through multiple channels.

I understand the questionnaires and participants' feedbacks can be quite subjective and closely related to the specific situation of each workshop, with possible interference from students' individual student status, current state of mind, and knowledge of the field. In addition, the quantity of questionnaires is not sufficient to allow strong evaluative statements. That said, the results from quantitative analysis of the participant investigations still can reveal some of the practical effects of the I-SPD method. According to the 110 questionnaires collected, which were designed to evaluate the comprehensive functions of the I-SPD method, I found the following results:

Evaluated Qualities of the I-SPD Method	**Weighting**
Functionality of the I-SPD Method	100%
Systematic Understanding of the Process of Interpreting CTEA for SPD	95%
Enhance Design Thinking Capability	76%
Thinking Techniques are Helpful	94%
Structured Knowledge of SPD	87%
The Method with Tools are Helpful to Future Design Works	93%

Table 7.1: Evaluations of the I-SPD Method

Aside from the quantitative evaluation result, many collaborating design schools also gave positive feedbacks of the workshops in their reports on the workshop in formal media channels.

7.2 Significance of the Research

7.2.1 Knowledge Contribution

The research contributes to two fields of knowledge: design methodology studies and sustainable design studies. It contributes to the field of design methodology from several different perspectives:

1. To Describe the Process of Insight Interpretation for Design Methodology

Existing research on design methodology and design process have been undertaken from many perspectives such as process management (Cross, 1984; Roozenburg, 1995), human cognition (Simon, 1972; Norman, 1988) value creation (Cagan & Craig, 2001; Ouden, 2012) and professional knowledge and skills (Lawson & Dorst, 2009). This research investigated the process of design from the scope of how design concepts are generated by interpreting insights from particular references (CTEAs). It is a scope of studying design methodology that specifically addresses the cognitive process and techniques of interpretive design thinking. Briefly, the research discussed a new perspective of design methodology of design as an act of interpreting insights. The significance of the insights and interpretive thinking during the design process has been demonstrated by many previous endeavors in design research (Cross, 1997; Kelly & Gero, 2011). To design is to interpret (Snodgrass & Coyne, 2006). The research findings illustrate the basic structure of the interpretive process and also propose key cognitive techniques. Although it is not a fundamental design method, philosophic ideas of the method can be used to explain how design is generated by interpreting shared features from other designs in general design situations.

2. To Compare the Two Fundamental Design Paradigms from Insight Interpretation

To build a method for design practice, the research applied the two fundamental paradigms of design as problem solving by Simon (1972), and design as reflective practice by Schön (1983). Dorst (1997) compared the two fundamental paradigms of design by looking into how different situations of design practice reflect the two approaches. This research also compares the two fundamental paradigms by adapting their interpretive purposes for design. There are two kinds of interpretation according to these two design paradigms: objective interpretation for solving specific design problems, and subjective interpretation for defining reflected design problems. Objective interpretation is forward design thinking logic that moves from understanding design problems to proposing design solutions. Subjective interpretation is reflective thinking that builds conversations between interpreted design solutions and adaptive design purpose es. The I-SPD Method can be seen as a theoretical application of the two fundamental design paradigms and focuses on describing how inspirational thinking works in these two paradigms, how inspirational problems solving can be connected with rational problem solving processes, and how reflective decision making is guided by rational problem solving thinking .

3. To Develop the Analogical Creative Techniques for Design Idea-generation

In general design theories design appears to be creative activity by involving designer's subjective attributes of intuition, experience, feelings, and style with objective standards and requirements. Creative thinking is different from rational thinking. Interpreting insights is directed by inspired rational thinking. Interpreting insights to generate new ideas is a kind of structured creativity technique. Structured (logical) creativity techniques analyse functional requirements and generate solutions based on logic and practical rationalities. Interpreting insights is a method for analogic creativity. It focuses on the use of analogies in proposing candidate designs appearing to be a result of the traditional characterization of analogical reasoning. Analogical design involves memory and transfer of elements of a solution for one design problem to the solution for another design problem (Goel, 1997). The I-SPD method is a context-based (interpreting CTEAs for SPD) analogical creative technique. In a broad sense, it also contributes to general creative techniques with other intuitional and heuristic techniques.

The I-SPD method is proposed as an analogical creative thinking method for new design concept generation. It has application value in the particular condition of seeking and interpreting insights from Chinese traditional design wisdoms. Chinese Traditional Everyday Artefacts (CTEAs) are the material objects carrying these traditional design wisdoms. Sustainable Product Design (SPD) is the selected particular aspect to analyze and apply these wisdoms in this research. CTEAs and SPD contextualize the interpretive method and draw a boundary of applications around the I-SPD Method. Above the context of interpreting CTEAs for SPD, the theoretical backgrounds and methodology of this research can also be meaningful for similar scientific research which aims to explore human-being's cognition of insight interpretation and idea generation.

4. To Elaborate the Core of Design Thinking

The "Core of Design Thinking" is proposed by Dorst (2011a). He used a simple equation to describe the core of design thinking: WHAT + HOW = RESULT. WHAT represents the elements of design, HOW represents design principles, and RESULT represents the observed effects of design. This theoretical model is developed by his theoretical ideas of patterns of design reasoning (Dorst, 2011b). He provided a synthetic representation of the patterns of design reasoning. I referred to "the core of design thinking" to build the language structure of the SPD insight. Design reasoning is the fundamental thinking strategy for the interpretive process. It is guided by technological and intuitional rationalities. The insight is required to be clearly defined by this language form. Abstracted elements of the equation can be interpreted and replaced by substantial elements in particular design contexts. This is the key mechanism of insight interpretation. Dorst (2011b) proposed the equation model to describe the essential logic of design reasoning. I developed this theory by exploring its capability in idea generation: the meaning of equations can be realized by observing technological or intuitional rationalities and applying them in substantial design contexts. The research also develops the theoretical idea of "the core of design thinking" by proposing different levels of abstraction and interpretation of the insight sentence (insight equation).

5. To Develop the Systematic Approach of Interpreting Cultural Artefacts

Xin (2007) proposed a systematic tool of ICA: Interpret Cultural Artefacts for Product Innovation. It is a structured method to analyze the design reasoning of cultural artefacts. This research realized and developed his idea of using cultural artefacts as inspirations for product innovation by exploring and describing an applicable process of interpreting insights from cultural artefacts for contemporary design concepts. Interpreting traditional artefacts involves complicated cognitive tasks and restrains from contextual differences and comparisons (making sense from old contexts and new contexts). Research outcomes of the interpretive process, approaches, and cognitive technique aids in this research are also meaningful for interpreting cultural artefacts or behaviors for product innovation from other scopes than SPD.

6. To Suggest a New Approach for Sustainable Product Design (SPD)

As I discussed in Chapter 4: Building SPD Criteria, the framework and criteria together with the collected design principles (*Appendix A*) contribute to the general knowledge of SPD in some way. But as these criteria are built for the particular purpose of this research to support the empirical experiments as workshops they may not be satisfactory for all design situations. The more meaningful contribution from building the criteria is the articulation of two important issues of SPD criteria building. One is the development of a framework according to the nature and requirements of the design situation the designer is working on; the other is addressing the importance of updating the criteria from time to time according to the development of knowledge in the field of sustainable product design. In fact, as sustainable design, or "design for sustainability", is a topic likely to have everlasting significance to both theoretical study and design practice. Approaches, perspectives and study methodologies are consistently redefined according to the changes of design needs, situations and supported social, economic, and technological conditions.

The research also provides a new approach for SPD creativity. SPD requires designers to derive creative solutions toward contemporary sustainability problems. For SPD innovation there are several approaches that have been taken, such as redesigning artificial systems (McDonough & Braungart, 2002), promoting ecological literacy (Orr, 1992), learning from natural principles (Mollison, 1988), redesigning fundamental paradigms of industrial production (Tischner & Charter, 2001), and indicator development (Datschefski, 1998). This research is the first research to develop a specific design methodology from the approach of learning and interpreting traditional design solutions to solve contemporary sustainability problems. The idea of taking a retrospective view of traditional wisdom has been addressed in many theoretical writings. This research utilized this approach for the purpose of application toward design practices. This is also a meaningful contribution to the field of sustainable design.

7.2.2 Practical Applications

1. A Method for SPD Innovation

The I-SPD method is a design method for SPD innovation. It addresses possibilities and the significance of seeking SPD solutions from ancient design wisdoms. As William McDonough (2002) pointed out, "sustainability" should be local. The I-SPD method guides SPD practices from an indigenous approach by investigating and applying timeless design solutions from CTEAs. It provides two approaches for empirical application: 1) for solving particular SPD problems; 2) to explore the potentials of particular CTEAs to solve contemporary sustainability problems.

The application of solving particular design problem (objective interpretation) is defined as a tentative function for I-SPD method. The method cannot guarantee that insights from CTEAs can be interpreted to solve every SPD problems. According to the empirical data there is still a possible connection between contemporary SPD problems and traditional design solutions. The possibility can be increased by adopting a longer process of seeking and interpreting design insights to meet particular design problems.

Applying the method to explore potentials of the SPD insights from CTEAs in contemporary contexts has been examined and confirmed in the workshop experiments. Every selected CTEA may contain one or more than one SPD insights according to the SPD criteria. Each insight can be abstracted and interpreted in multiple ways. The "tree structure” of insight abstraction and interpretation provides designers with the capability to produce certain quantities of design concepts. Designers can evaluate and select these design concepts according to specific requirements and criteria.

2. The Workshop Model and Educational Functions

The designing of, conducting, and reflecting on the six workshops for this research have been described and analysed as empirical data. All these data and materials, including images, videos, and cases of student projects, have been sorted. Information and analysis of a large number of CTEAs have also be collected and sorted for further educational and research purposes.

The workshop model is an important research outcome of this research. It has both research and educational functions. The model has been tested and improved during the six rounds of workshops. It can be applied to similar educational activities by referring to the workshop design, materials, contents and management. It also can be developed as a subject model for longer term learning and practicing.

3. Interpretive Thinking Techniques for Designers

Product and industrial designers require creative thinking techniques. Established design thinking techniques are helpful in developing both creativity and working efficiency. The suggested cognitive techniques affiliated with the I-SPD method can be learnt and practiced by designers to develop reflective and logical thinking capabilities. Many of the cognitive tools in this research are designed to reveal fundamental knowledge of human understanding and design thinking as “the three diagrams of insight abstraction”, “alternative elements of the insight equation” and “the cluster design method”. They are helpful to enhance creative thinking abilities and building efficient design thinking patterns by learning and practicing these cognitive techniques.

4. Building the Identity of Chinese Design and Emphasizing Cultural Significance

For the industries which aim to use Chinese cultural identities in their products or for corporate cultural images, interpreting insights from CTEAs is a feasible design and business strategy. Most of the designs with Chinese cultural identities were designed from artefact level interpretation according to the I-SPD design method. Method and philosophic levels of interpretations have potential to make wider cultural and market influences as they have better contextual flexibility to fit particular design or market requirements. From visual identity building to cultural and human value identity building, cultural understanding and interpretive skills are necessary for those companies and individual designers. Business opportunities and better design qualities can both be achieved by acquiring specific knowledge of interpreted cultural symbols and interpretive design techniques. This knowledge can be learnt from the thesis.

7.2.3 Possibilities of Applying the Method in Other Cultures

The I-SPD method was developed by investigating existing theories of the cognitive process of insight interpretation and design methodology, and by conducting empirical studies in Chinese design schools. According to the research methodology, the proposed general theoretic model of insight interpretation with fundamental cognitive techniques definitely can be referred to and applied in general cultural contexts to guide understanding of the insight interpretation process for design purposes. In regards to the specific research goal of this particular project, the presented I-SPD method is generated based on empirical experiments in the Chinese context of studying Chinese traditional objects by Chinese design students. For different cultures the contents of traditional objects and backgrounds of design students can be different from the Chinese situation. Other cultures may have different approaches to reapplying traditional design wisdoms to solve contemporary sustainable design problems.

China is a quickly developing country with a large population. This rapid economic growth and concomitant vanishing cultural traditions makes this approach of respecting and reapplying indigenous traditional wisdom to solve local problems especially meaningful. In some other cultures, such as in Japan or parts of Africa, there has been stronger cultural continuity from pre-modern to contemporary times, at least relative to China. Many traditions continue to be applied and respected by contemporary people. Those traditional wisdoms not been separated from their traditional design origins and are still significant influences on modern designs.

Despite these differences in social, cultural, and economic backgrounds, the general process and tools of the I-SPD method can still be transferred to guide research and design practices in other cultural contexts as its theoretical foundation and the research methodology are not necessarily specific to any particular culture. Although there is no sound proof and solid data to support this assumption, from my communications with professionals and scholars outside of China, there is approval of the general function of the I-SPD method according their knowledge and also belief on their part that the method can be valuably applied in design practices in their own contexts.

7.3 Limitation and Recommendation for Future Research

7.3.1 Limitation of the Research

The research is carried out using a particular approach of design methodology study. It is aimed at providing a structured method to get and apply meaningful design insights from CTEAs to SPD. It is not a fundamental design methodological study to solve general problems of design method, process, and techniques. The result also has limited use in solving general design problems.

Although the research has been carefully designed and managed, time and resources were quite limited during the different phases of research owing to its complex knowledge background and the long process of the research methodology. As my first independent research project, the process of conducting the research is also a process of developing specific knowledge concerning scientific research methodologies. This made some of the theoretical statements and research findings may lack sound theoretical and analytical supports.

The quantities of workshops and participants were also influenced by the limited amount of time and resource of available for the research project, however the empirical data from observations and workshops are enough to examine the key theoretical ideas and assumptions in the thesis. For the suggestions of cognitive techniques they are lacking sufficient empirical evidences to prove their accuracy and effects. The condition and quality of workshops were also influenced by many uncontrolled factors such as timing, available resources, and constraints resulting from cooperation with the participant schools.

The research context is directly related to cultural, geographical, and historical diversities, bringing a level of difficulty and complexity to the research on CTEAs. Although I attempted to include different cultural regions and categories of CTEAs in the empirical studies, the research on CTEAs is far from complete. This also makes space and opportunity for further investigations.

The SPD criteria were built on an ad hoc basis for use in this specific research context. It is not a formal theoretical framework for existing SPD knowledge. It is not designed to cover all the fundamental aspects and factors of sustainable design theories as many of the aspects and factors show no direct relationship with the studies of CTEAs. The projects and theoretical ideas studied in this research for building SPD criteria were published between 1970 and 2012, a watershed period for knowledge of sustainable design.

7.3.2 Directions of Future Research

1. Addressing Specific Concepts of the Design Interpretation Process

The field of design methodology is based on empirical and theoretical studies of design contents, activities, contexts and designers' explicit knowledge. Studying design thinking processes and techniques is a fundamental research area of design methodology studies. It does not have as long of a tradition as studies of artificial intelligence (AI), which arose out of the field of computer science in the 1960s. In this research I have also referred to a number of studies and theoretical ideas from the field of artificial intelligence. As my research interest is related to studying and applying knowledge from cognitive psychology towards design methodology, I made an effort to develop my knowledge foundation in both cognitive psychology and design methodologies. In this research I built a basic structure of the insight interpretation process for design innovation methodology. Given more time and resources, I would like to explore more deeply some specific concepts which are significant in the design interpretation process such as "abstraction", "heuristics", and "syntax", to develop their use in general theories in the field of design methodology.

2. Developing Methods for Industrial Purposes

The purpose of building the I-SPD method is to guide design practices. Because of the limitations of time and resources for the research project, and those specifying the scope of empirical studies, the workshops focused only on design students in an educational context. The research conditions would be different if professional designers were involved as workshop participants. Or, when it focuses on particular industries. Thus, it is unknown whether the expected effects and functions of the method and the proposed tools and guidelines would apply to the experience of professional designers using the method.

3. Investigating Other Asian Cultures

There is potential for research related to design practices and methodologies of interpreting traditional design insights in the other major East Asian countries outside of greater China, such as Japan and South Korea. These Asian cultures are more superficially similar than truly alike, but the fact remains that each has shared at least some aesthetic and philosophical influence that ought to be considered. Investigation of how traditional design insights can be interpreted in other similar cultures can also be meaningful as a future study direction.

4. Investigating Traditional Cultural Behaviours: From Designing Products to Designing Services

While investigating material traditional artefacts, many interesting artefacts-related traditional user behaviours also caught the attention of the workshop participants. Xin (2007) argued that studies of cultural behaviour are presented as cultural user insights that illustrate the relationships between the motivation and cultural influences of cultural behaviours. Cultural user insights provide a structural guideline to verify the appropriateness of new product or service concepts. If a new product supports or stimulates the user behaviours studied, most likely it will be a culturally appropriate product concept. Studies on sustainable traditional user behaviours can also be a direction for further research on designing sustainable product and service systems.

Summary of the Chapter 7

The goal of building the ICTEA-SPD method is not only to guide design practices and promote creativity for SPD. It also aims to contribute to design knowledge and the understanding of intrinsic thinking patterns and processes of insight interpretation. As one of the fundamental creativity techniques used in the practice of design, insight interpretation is meaningful for studying and developing design processes in different contexts. This research investigated the related meanings and applications of these techniques from the particular scope of how to transfer traditional design ideas for use as solutions to contemporary design problem. During the years of conducting the research and writing this thesis, I received significant support and collaboration from many different sources. I deeply appreciate the many people and resources that contributed to this research. There remains significant room to improve and develop the research. I hope that my work not only can contribute to academic knowledge in the field of design but also can inspire professionals and non-professionals to build a structured way of considering design as a natural human capability.

Appendices

Appendix A:

Collected SPD Principles and Initial Coding

(Updated to December, Year 2011)

1. Product Perspective: Toward Sustainability of the Artificial World

Collected SPD Principles	**Categories**
▪ Greater durability of products(Paul Hawken, Lovins, L. Hunter 2008) ▪ Create safe objects to long-term value (William McDonough."Hannover Principles" .2000) ▪ Good design means durability (Dieter Rams 1998) ▪ Increase product life time （McDonough）	Design for Durability
▪ Incorporate Biology and Physics into Designs. (David Wann, 1996) ▪ Design with Nature (Sim Van der Ryn, Stuart Cowan 1995） ▪ Work with nature. (Mollison 1988) ▪ Cooperative anarchy (Art Ludwig 2003)	Corporative Design
▪ Clarify core functions (Gertsakis et al 1997) ▪ Simplify products(M. M. Kostecki 1998) ▪ Intervene as little as possible (Art Ludwig 2003) ▪ Concentration on the product functions (Frei 1998)	Design for Simplicity
▪ True progress (Art Ludwig. 2003) ▪ True comfort (Art Ludwig. 2003) ▪ Good design means honest. (Rams 1998) ▪ Good design means usefulness. (Rams 1998) ▪ Ask stupid questions （McDonough）	Honest Product
▪ Product Services Systems (Tom Greenwood 2004) ▪ Sharing not buying (Victor Papanek 1995) ▪ Do not design products, but services （McDonough）	Establish Product Service System
▪ Use design solutions that accomplish three or four things at once. (David Wann 1996)	Design for Multi-functionalism
▪ Understand the limitations of design. (William McDonough."Hannover Principles" .2000)	Design for Contexts

▪ Design using systems and materials that are flexible ▪ enough to accommodate improvements and retrofits. (David Wann 1996) ▪ Alternatives to the conventional score (Art Ludwig 2003)	
▪ Good design means innovation. (Rams 1998)	Innovative Solutions
▪ Soft-energy production alternatives work with the cycles of the sun, water, wind, and geothermal energy rather than depleting finite resources that can be more effectively used elsewhere. (David Wann 1996)	Using Renewable Energy Resources
▪ Look for synergies in systems (Gertsakis et al 1997) ▪ Aim for maximum efficiency (Gertsakis et al 1997) ▪ Design for part load operation (Gertsakis et al 1997) ▪ Specify low energy process(Tom Greenwood 2004) ▪ Specify low waste process (Tom Greenwood 2004) ▪ Plan for ongoing efficiency improvements in energy consuming products (Tom Greenwood 2004) ▪ Minimize leaks (Lewis et al. 2001) ▪ Minimize standy energy ▪ Minimize cycling losses (Lewis et al, 2001) ▪ Use renewable energy (Tom Greenwood 2004) ▪ Use cleaner fuels (Tom Greenwood 2004) ▪ Avoid use of batteries (Tom Greenwood 2004) ▪ Supply battery powered products with a battery charger(Tom Greenwood 2004) ▪ Use feedback mechanisms (Tom Greenwood 2004) ▪ Minimize transportation distances (Tom Greenwood 2004)	Select Appropriate Energy
▪ Design to take maximum advantage of existing infrastructure and recyclable resources. (David Wann 1996)	Use Recycling Resource
▪ Good design means consistency down to the last detail. (Rams 1998) ▪ Good design explains a product and its function. (Rams 1998)	Design for Details
▪ Create closed-loop biological and Technological cycle (McDonough & Braungart 2002)	Build Closed-loop biological and Technological Cycle

▪ Select appropriate technologies, regenerative agriculture, and minimal-impact waste strategies for radiation by-product and unrecyclable waste (David Wann 1996) ▪ Use the right tool for the right job. (David Wann 1996) ▪ Appropriate technology (Art Ludwig 2003)	Select Appropriate Technologies
(G. Seliger 2008) ▪ Implementation of innovative technologies ▪ Improving the use-intensity of products ▪ Service-oriented business model ▪ Distributed use of products and components ▪ Extension of product life span ▪ Choosing cleaner production processes(Helen Lewis and John Gertsakis 2001) ▪ Select environmentally responsible manufactures and suppliers (Tom Greenwood 2004)	Sustainable Manufacturing
▪ Select low-impact materials(Helen Lewis and John Gertsakis 2001) ▪ Avoid toxic or hazardous materials(Helen Lewis and John Gertsakis 2001) (M. M. Kostecki 1998) ▪ Minimize toxic chemical content ▪ Incorporate recycled and recyclable materials ▪ Use more durable materials ▪ Reduce material use ▪ Standardize material types	Select Appropriate Materials
▪ Good design is unobtrusive. (Rams 1998)	Unobtrusive Function Realization
(Chapman 2009) ▪ Emotional Durability ▪ Narrative: Users share a unique personal history with the product; this often relates to when, how, and from whom the object was acquired. ▪ Detachment: Users feel no emotional connection to the product, have low expectations, and thus perceive it in a favorable way due to a lack of emotional demand or expectation.	Promote Emotional Durability

▪ Surface: The product is physically aging well and developing a tangible character through time and use (and sometimes misuse). ▪ Attachment: Users feel a strong emotional connection to the product, due to the service it provides, the information it contains, and the meaning it conveys. ▪ Users are delighted or even enchanted by the product as they do not yet fully understood or know it, especially with a recently purchased product that is still being explored and discovered. ▪ Consciousness: The product is perceived as autonomous and in possession of its own free will. It is quirky and often temperamental, and interaction is an acquired skill that can be fully acquired only with practice.	

2. Human Perspective: Promote Sustainable Human Living Conditions

Collected SPD Principles	**Categories**
(Dan Lockton , David Harrison 2009) ▪ Architectural patterns ▪ Error proofing patterns ▪ Persuasive patterns ▪ Visual patterns ▪ Cognitive patterns ▪ Security patterns (Debra Lilley 2009) ▪ Make resource use and resulting waste visible ▪ Be coupled with eco-efficiency improvements ▪ Provide tangible incentives and measurable outcomes ▪ Use predominately positive, rather than negative, reinforcements ▪ Avoid competing with other values ▪ Provide feedback in real-time ▪ Ensure reinforcements are varied in frequency and modality ▪ Adjust to respond to changes in user behaviors ▪ Not compete with, but be supported by, and support, the context of use	Design for Sustainable User Behavior

▪ Be, as far as possible, ethical in their intent and predicated outcomes	
(Angharad Thomas 2006) ▪ Design and production of goods by poor people for poor people ▪ Design for poor markets ▪ Design for poverty reduction ▪ Equity (Demi Principles)	Design for Poverty and Equity
▪ Insist on the right of humanity and nature to co-exist in a healthy, supportive, diverse, and sustainable condition (William McDonough."Hannover Principles" .2000) ▪ Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems, and their right to co-exist. (William McDonough."Hannover Principles" .2000) ▪ When designing, think about whether the user will be able to understand the result, maintain it, and feel satisfied with it. (David Wann 1996) ▪ Design to enhance user’s self-reliance and self-worth, rather than dependency and insecurity. (David Wann 1996) ▪ Enable people to live as they like , in a sustainable way (Ezio Manzini 2006)	Emphasis Humanity
▪ Design to accommodate household hazardous-waste products. (David Wann 1996) ▪ Design for a safe future (Victor Papanek 1995)	Safe Solutions
(Martin Charter and Ursula Tischner 2001) ▪ Consumer Information: Eco-labels ▪ Product profiles ▪ Product guidelines ▪ Information centers ▪ Indirect taxation ▪ Public purchasing ▪ Deposit/ refund schemes	Design for Sustainable Consumption
▪ Follow nature’s example (Art Ludwig 2003) ▪ Green living inspiration (Art Ludwig 2003)	Follow Nature’s Example

(Victoria J. Gallagher 2011) ▪ Expression of virtue ▪ Enriching activities, of vitality, in people who live in groups ▪ Personal expressiveness of deeply held values ▪ Fulfillment ▪ A condition for human flourishing ▪ Inherently culturally rooted ▪ Focuses on meanings and self-realization	Design for Visual Well-being
▪ Form follows fun (Victor Papanek 1995)	Design for Pleasure

3. Natural Environment Perspective: Emphasize Natural Environment Sustainability

Collected SPD Principles	**Categories**
▪ Account for cost with in the full lifetime of the product in mind. (David Wann 1996) ▪ Design to minimize the environmental contamination and energy/ resource consumption along the entire lifecycle. (David Wann 1996) ▪ Make your product recyclable (McDonough） ▪ Do not design products, but life cycles (McDonough）	Product Lifecycle Assessment
(McDonough & Braungart 2002) ▪ Purifies air, water, and soil ▪ Retains valuable materials for perpetual, ▪ Productive reuse ▪ Requires no regulation ▪ Creates positive emissions ▪ Celebrates an abundance of cultural and ▪ Biological diversity ▪ Enhances nature's capacity to thrive ▪ Generates value and opportunity for all stakeholders. ▪ Waste equals food ▪ Use current solar incomes ▪ Celebrate diversity ▪ Ensure quality before quantity (Jason F Mclennan 2004)	Respect to Environmental Principles

▪ Respect for the wisdom of natural system- the biomimicry principle ▪ Respect for place-the eco-system/ bio-region principle ▪ Respect for energy and natural resources-the conservation and renewable resources principle (Michel.K. 1998) ▪ Balancing environmental, economic, ethical and social factors ▪ Generating eco-solutions, solving eco-problems ▪ Reduced and more efficient use of resources: eco-efficiency ▪ Work with nature, not against it ▪ Minimizing environmental impact across the product's life cycle ▪ Aiming for zero emissions ▪ Less waste means less cleanup, less conflict, and fewer cost. (David Wann 1996) ▪ Creating better products and process such as improved quality housing, pollution-free manufacturing. (David Wann 1996) ▪ Good design means respect for the environment. (Rams 1998) ▪ Consider environmental impact (Frei 1998) ▪ Considering environmental requirements (Frei 1998)	
▪ Ecological Accounting informs design （Sim Van der Ryn, Stuart Cowan1995） ▪ Energy consumption: often underestimated （McDonough ） ▪ Measures prosperity by natural capital productively accrued	Account Ecological Capitals
▪ Efficiency (disassembly, substitution, lifecycle thinking, reduce, dematerialization, durability, cascading, recycle) (Demi Principles) ▪ Everything gardens, all nature should be used to a maximum. (Mollison. 1998) ▪ Use minimum effort for maximum effect. (Mollison 1998) ▪ Maximize energy and waste efficiency(Helen Lewis and John Gertsakis 2001) ▪ Moderate and efficient resource use (Art Ludwig 2003)	Design Resources Efficient

▪ Outputs become inputs. (Mollison 1998) ▪ All releases to air, water, land or space are food for other systems. (Edwin Datschefski 2001)	Waste Equals Food
DfDs (Helen Lewis and John Gertsakis 2001) ▪ Design for Disposal ▪ Design for Disassembly ▪ Design for Durability ▪ Design for Dematerialization ▪ Desing for Degradability (Packaging) ▪ Design for Upgradability ▪ Design for Minimal consumption 3Rs (Helen Lewis and John Gertsakis 2001) ▪ Recycle& Remanufacturing ▪ Reuse & Refurbishment ▪ Reduce—Minimize weight, size, volume ▪ (Tom Greenwood 2004) ▪ Eliminate unnecessary components ▪ Minimize packaging requirements ▪ Use strong lightweight materials ▪ Maximize durability of low or non-energy consuming products ▪ Design product for misuse ▪ Design for easy maintenance and repair by user ▪ Design to encourage users to keep products long term ▪ Design to meet the consumers changing needs ▪ Design packing for reuse or refilling ▪ Design "Slow change" products for remanufacturing ▪ Design for disassembly ▪ Design to make repairs economically viable ▪ Minimize or eliminate use of consumables ▪ Offer maintenance feedback ▪ Design consumable materials to be reusable ▪ Integrate disposal instructions into the products ▪ Use waste products ▪ Design for a closed lifecycle(McDonough and Braungart, 2002) (M. M. Kostecki 1998) ▪ Minimize packaging ▪ Ensure easy disassembly ▪ Design for remanufacture	Design for Waste Minimization

▪ Design for upgrade ▪ Make parts accessible to facilitate maintenance and repairs ▪ Incorporate reconditioned parts or subassemblies (Lovins, L. Hunter 2008) ▪ A reduction in the material intensity of goods or services ▪ A reduction in the energy intensity of goods or services ▪ Improved recyclability ▪ Maximum use of renewable resources ▪ Increased service intensity of goods and services ▪ Eliminate the concept of waste. (William McDonough."Hannover Principles" .2000) ▪ Design to allow point-of-sale recovery of packaging materials. (David Wann, 1996)	
(Tom Greenwood 2004) ▪ Minimize the variety of different materials ▪ Lightweighting—use minimum amount of material ▪ Select recyclable material ▪ Use recycles material ▪ Consider home compostable material ▪ Use renewable materials when virgin materials is required ▪ Limit use of composites ▪ Avoid use of hazardous and toxic materials ▪ Ensure that label materials are compatible with main product ▪ Consider in-mould labeling Use non-hazardous paints and adhesives ▪ User non-hazardous coloring ▪ Use low embergy materials … ▪ Incorporate recyclable materials (M. M. Kostecki 1998) ▪ Reduce materials diversity(M. M. Kostecki 1998) ▪ Label parts (M. M. Kostecki 1998) ▪ Reduced dispersion of toxic materials (Lovins, L. Hunter 2008) ▪ Use a minimum of material （McDonough） ▪ Use recycled materials （McDonough） ▪ Natural materials are not always better （McDonough）	Material Selections

▪ Rely on natural energy flows. (William McDonough."Hannover Principles" .2000)	Rely on Natural Energy Flow
▪ Solar—The product manufacture and use consumes only renewable energy that is cyclic and safe. (Edwin Datschefski 2001)	Use Renewable Energies and Resources
(David Wann 1996) ▪ Live within the ecological and resource limits of the planet. ▪ Apply technological knowledge to the challenge of an energy-efficient economy. ▪ Built better relationships between different communities/ groups of people. ▪ Guarantee the rights of non-human spices. ▪ Promote and respect self-regulating natural systems. ▪ Respect relationships between spirit and matter. (William McDonough."Hannover Principles".2000)	Respect Ecological Wisdoms

4. Social Perspective: Remodel Human Value and Aesthetics

Collected SPD Principles	**Categories**
▪ Create product services system (McDonough & Braungart 2002) ▪ Respect for process-the holistic thinking principle(Jason F Mclennan 2004) ▪ Functionality (Michel.K.1998) ▪ Longevity (Michel.K.1998) ▪ Systems-oriented Innovative (Michel.K.1998) ▪ Holistic (Michel.K.1998) ▪ Systems (cause and effect, ecosystems, energy and resource transformation, industrial ecology, lifecycles, premaculture) (Demi Principles) ▪ Each function should be supported by many elements. (Mollison 1998) ▪ Each element performs several functions. (Mollison 1998) ▪ Cyclic—The product is made from compostable organic materials or from minerals that are continuous recycled in a closed loop. (Edwin Datschefski)	Long Term and Systematic Consideration

▪ Recognize Interdependence. The elements of human design interact with and depend on the natural world, with broad and diverse implications at every scale. (William McDonough."Hannover Principles".2000) ▪ Consideration of the whole product system (Frei 1998)	
(David Wann 1996) ▪ Honor cultural, ethnic, racial, sexual, religious, and spiritual diversity of all beings within the context of individual responsibility. ▪ Respect and maintain biodiversity, or diversity of living species. ▪ Everyone is a Designer (Sim Van der Ryn, Stuart Cowan1995） ▪ Design to increase rather than limit people’s options. (David Wann 1996) ▪ Design to enhance the educational possibility. (David Wann 1996) ▪ Respecting the global cultural diversity (Yrjö Sotamaa 2006)	Respect Diversity
▪ Global responsibility. Maintain awareness of the impacts of our actions on global, ecological, economic, and social systems. (David Wann 1996) ▪ Inter-relatedness, interdependence, and natural process learn these lessons from the ecosystems we are a part of. (David Wann 1996) ▪ Design to enhance creative thinking. (David Wann 1996) ▪ Context is everything (Art Ludwig 2003) ▪ Individual thought and action (Art Ludwig 2003) ▪ Integration into the design process (Frei 1998)	Holistic Thinking
(David Wann 1996) ▪ Help institutions and individuals think in terms of the long-range future, not just short term selfish interests. ▪ Make quality of life, rather than merely open-ended economic growth, the focus of future thinking. ▪ Design for the future, think about future use, reuse, or disposal requirements of given material when designing it.	Focus on Future

▪ Solutions grow from place（Sim Van der Ryn, Stuart Cowan 1995） ▪ Relative location: each element in the system should be located in the most beneficial place for the whole system. (Mollison 1998) ▪ Design with consideration for the specific site—existing ecosystems, location relative to transportation systems, proximity to community environmental infrastructure, etc. (David Wann1996)	Local Solutions
▪ Preserving our legacy of ancient (Art Ludwig 2003) ▪ Respect traditional wisdoms (Art Ludwig 2003)	Respect Traditional Wisdom
▪ Proper convenience (Victor Papanek 1995)	Design for Appropriateness
▪ Respect for people-the human vitality principle(Jason F Mclennan 2004) ▪ Respect for the cycle of life-the seven generations principle(Jason F Mclennan 2004) (Michel.K.1998) ▪ Needs vs. wants ▪ Human health and toxicity issues ▪ Stakeholder-orientated	Design for Future Generations
(Seyed Javad Zafarmand 2002) ▪ Aesthetic durability ▪ Local aesthetic and cultural identity ▪ Individuality and diversity ▪ Logicality and functionality ▪ Aesthetic upgrade-ability and ▪ modularity ▪ Simplicity and minimalism ▪ Natural forms and materials ▪ Make Nature Visible（Sim Van der Ryn, Stuart Cowan 1995） ▪ Good design means aesthetic design. (Rams 1998) ▪ Recreate new aesthetic (Victor Papanek 1995)	Design for Sustainable Aesthetics
(M. Nadarajah, Ann Tomoko Yamamoto 2007) ▪ Transforming cultural heritage into Sustainable future ▪ Creating cultural identity for Sustainability	Design for Culture Sustainability

▪ Make urban cultural mode of production ▪ Develop cultural Indicators for Sustainable urban development ▪ Transcend market culture (Art Ludwig 2003)	
(Martin Hawes) ▪ One people ▪ One planet ▪ Responsibility ▪ Make a difference ▪ Learning ▪ Seeing ▪ Self-awareness ▪ Global awareness ▪ Respect ▪ Simplicity ▪ Love ▪ Integrity ▪ Product manufacture and use supports basic human rights and natural justice(Edwin Datschefski 2001) ▪ Addressing community issues. (David Wann 1996) ▪ Enhance social innovation, and steer it towards more sustainable way of living. (Ezio Manzini 2006)	Design for Social Ecology
▪ Slow is beautiful , Too wealthy is unhealthy. (David Wann 1996) ▪ Good design means as little as possible. (Rams 1998)	Design for Sufficient& Appropriateness
▪ Toward the spiritual in design (Victor Papanek 1995)	Toward Spiritual in Design
▪ Developing better business methods. (David Wann 1996) ▪ Exploring innovative uses of profit. (David Wann 1996)	Use Better Business Methods
(Fan Shu-Yang; Bill Freedman; Raymond Cote 2004) ▪ The need to meet the inherent needs of humans and their economy ▪ The requirement to sustain the integrity of the structure and function of both natural and managed ecosystems ▪ The appropriateness of emulating the inherent designs of nature in anthropogenic management systems	Support Sustainable Economy

▪ The need to make progress to a sustainable economy through greater reliance on renewable resources and more focus on recycling, reusing, and efficient use of materials and energy ▪ The use of ecological economics (or full-cost accounting) to comprehensively take resource depletion and environmental damage into consideration and thereby address issues of natural debt ▪ From stakeholders and the company (Frei 1998) ▪ Be open and honest with our clients and suppliers (Ian Grout 2006) ▪ Prevent waste by educating clients about efficient and low-impact printing methods (Ian Grout 2006)	
▪ The biotechnology of communities (Victor Papanek 1995) ▪ Become an O2 member (McDonough 2002）	Building Sustainable Technological Communities

Appendix B:

A Sample of Workshop Plan

Workshop Title:

ICTEA-SPD WORKSHOP:

Interpret Chinese Traditional Everyday Artefacts for Sustainable Product Design

Time:

Year 2011, April.16th—22th (Saturday--Thursday)--6 days workshop, the final day for interviews (Total 25-30hrs)

Place:

School of Design, Wuhan University of Technology

Wuhan, Hubei, China

Material Preparations:

1) Projector Classroom for 30 people
2) Nominate group leaders and workshop assistant
3) Student contacts and list
4) Documents and Materials for Class
5) Stationeries—mark notes in 4clours, A4 papers, A0 card board (2*5)
6) Camera, digital recorder, laptop
7) Poster for final presentation
8) Flash for workshop images for final presentation
9) Remind students should bring their sketching tools and laptops
10) Coffee and Snacks
11) Place for focus group and questionnaires for workshop reflection

Objectives:

This workshop is designed to explore more ideas and patterns of interpreting, designing and assessing the design concepts from participants. The workshop in Wuhan University of Technology in three parts: 1) knowledge buildings; 2) I-SPD Method application and development; 3) workshop reflection.

Workshop Assessment Criteria:

1) SPD knowledge building from the SPD framework. The SPD framework with criteria will be explained and illustrated with design examples to the students.
2) Outcomes of studying the collected traditional artefacts. Analyses the artefacts, abstract design insights and interpret the design insights are basic tasks in this phase. Students should be easily and effectively using the given tools to find out more valuable design insights as possible. The abstracted insights are suggested to be more related to the artifact level and method level.
3) Significance, practical value and originality of the generated design concepts. Priory criteria of assessment for the final design concepts for each group--effectiveness of sustainability and practical significance.
4) Apprehension and application of the whole I-SPD process. The form of representing the I-SPD method should be easy to understand and implied. Provide clear instructions and flexible way of using the affiliate tools.

Workshop Schedule:

lecture giving, handout, students works/ presentation, focus group

Day one: April 16th .2011

▼ (Morning)

- Workshop Brief—significance, plan, requirements (ppt. brief, handout-time plan)
- Understanding Sustainable Product Design (SPD)—development, approaches, and the framework (ppt. SPD-a)
- Team Building—4 students in a group and make 5 groups Cultural Innovative Sustainable Design—background of the method(ppt. CISD)
- Non-disclosure Agreement
- Identify Design Problems—each team gives 4-5 problems of everyday unsustainable problems

▼ (Afternoon)

- Students Presentation 1—Design Tasks Brief: Identify Unsustainable Problems （10mins for each group）
- The I-SPD METHOD: Phase Artefacts Collect and Select(ppt. SPD-TCW-I) *(Groups work: find and analysis relevant traditional everyday Chinese artefacts)*

Day Two: April 17th .2011

▼ (Morning)

- Students Presentation 2—Identify Relevant Objects （10mins）

- The I-SPD METHOD: Interpreting and Abstracting the Embedded Design Insights (ppt. SPD-TCW-II, handout-interpreting tools)

▼ (Afternoon)

- Group Work and Tutorial—each group choose 2 artefacts to study
- Students Presentation 3—Artefacts Interpreting and Design Insights will be applied to solve the design problem (15mins for each group)

Day Three: April 18th .2011

▼ (Morning)

- The I-SPD METHOD: Applying the Design Insight (ppt. SPD-TCW-III, handout-design tools)
- Group Work and Tutorial—Brain Storming the Design Solutions（20mins for each group）

▼ (Afternoon)

- Students Presentation 4—The Insights and Possible Solutions（20mins）
- Sustainable Product Design in Practice
- Assessing the Design Concepts
- Individual Work on Design Concept (in Sketching) and Tutorial (Make every student 15mins tutorial) Arrange tutorial time the next day.

Day Four: April 19th .2011

▼ (Afternoon)

- Final Presentation —The Complete Work with Individual Concepts（30mins for each group）
- Questionnaire Investigation
- End the Workshop

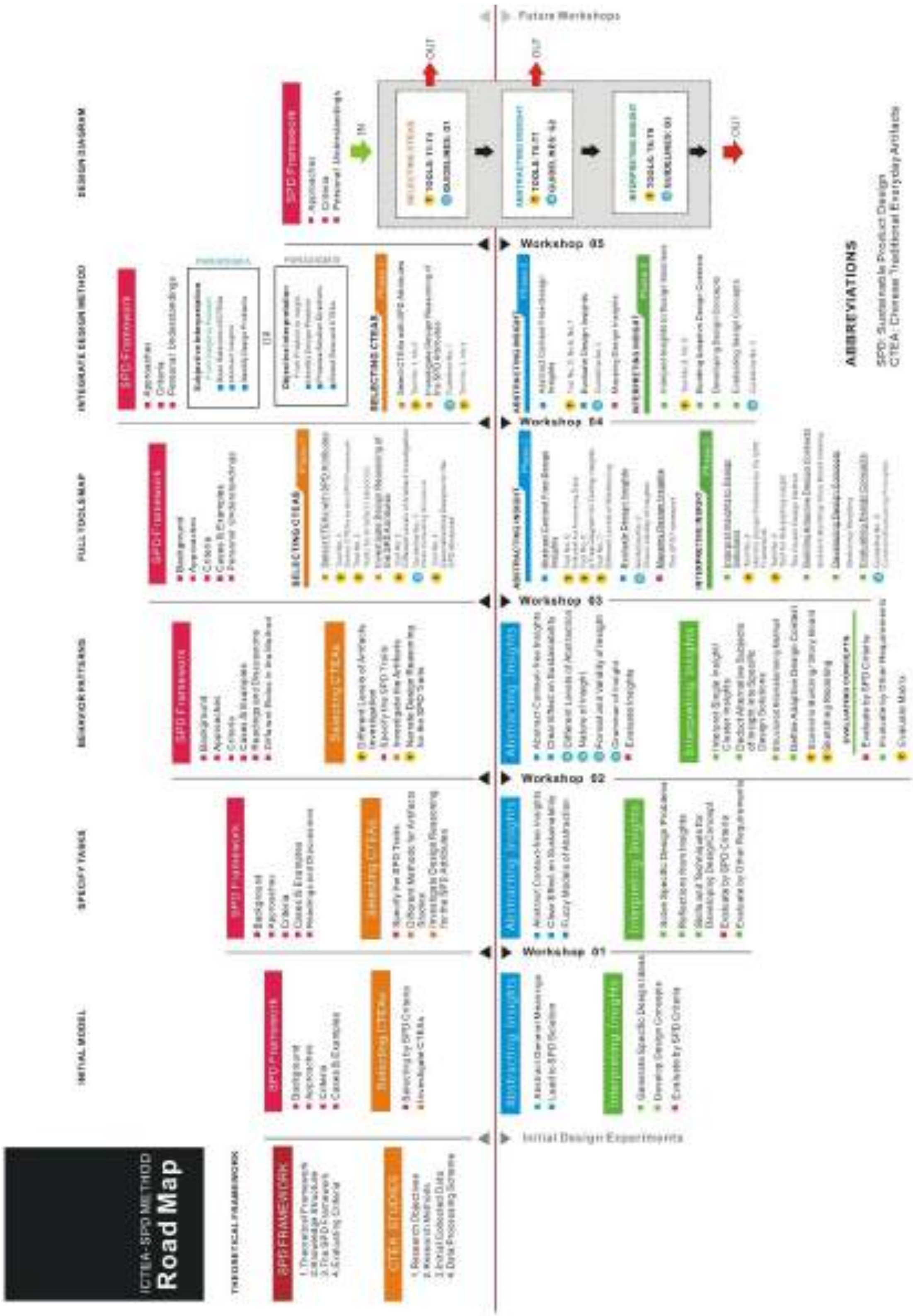
Day Six: April 17th .2011

▼ (Morning)

Workshop Reflection—Interview/ Focus Group (3 hours)

Appendix C:

Road-map of ICTEA-SPD Method Development


ICTEA-SPD METHOD
Road Map
THEORETICAL FRAMEWORK
INITIAL MODEL
SPECIFY TASKS
BEHAVIOR PATTERNS
FULL TOOLS MAP
INTEGRATE DESIGN METHOD
DESIGN DIAGRAM
SPD FRAMEWORK
1. Theoretical Framework
2. Knowledge Structure
3. The SPD Framework
4. Evaluating Criteria
CTEA STUDIES
1. Research Objectives
2. Research Methods
3. Initial Collected Data
4. Data Processing Scheme
SPD Framework
Background
Approaches
Criteria
Cases & Examples
Readings and Discussions
Personal Understandings
Selecting CTEAs
Selecting by SPD Criteria
Investigate CTEAs
Specify the SPD Traits
Investigate the Artifacts
Abstracting Insights
Interpreting Insights
Generate Specific Design Ideas
Develop Design Concepts
Evaluate by SPD Criteria
Evaluate by Other Requirements
SELECTING CTEAS
ABSTRACTING INSIGHT
INTERPRETING INSIGHT
EVALUATING CONCEPTS
Evaluate Matrix
TOOLS: T1-T4
GUIDELINES: 01
TOOLS: T5-T7
GUIDELINES: 02
TOOLS: T8-T9
GUIDELINES: 03
IN
OUT
Initial Design Experiments
Workshop 01
Workshop 02
Workshop 03
Workshop 04
Workshop 05
Future Workshops
ABBREVIATIONS
SPD: Sustainable Product Design
CTEA: Chinese Traditional Everyday Artifacts

Appendix D:

Workshop Participants and Design Outputs

Online Reports of Some Research Activities:

http://www.sdada.edu.cn/gongye/show.php?id=582263

http://www.dl0086.com/content/dispdetailcoinfo-4297.html

http://yjsh.whut.edu.cn/uploadfiles/printpage.asp?ArticleID=9341

<table>
<tr><td colspan="4">Sichuan Workshop Sichuan Fine Arts Institute, School of Art and Design</td></tr>
<tr><td colspan="4">23 participants/ Time: 2010.September 13-18</td></tr>
<tr><th>Name</th><th>Background</th><th>Interpreted CTEA</th><th>Final Design Concept</th></tr>
<tr><td>曾增
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Industrial Design</td><td rowspan="6">
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<tr><td>何媛媛
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Visual Communication</td></tr>
<tr><td>柴皓杰
Haojie Chai</td><td>Year 4 undergraduate
Industrial Design</td></tr>
<tr><td>王威
Wei Wang</td><td>Year 2 graduate
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<tr><td>陈梦秋
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Industrial Design</td></tr>
<tr><td>李萍潇
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<tr><td>程晗娟
Hanjuan Cheng</td><td>Year 2 graduate
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Pickle Jar</td><td rowspan="3">
Air Leakage Sofa</td></tr>
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<tr><td>曹智全
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Industrial Design</td></tr>
<tr><td>廖华
Hua Liao</td><td>Year 1 graduate
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Bamboo Pack Basket</td><td rowspan="3">
Water Pipe Screen</td></tr>
<tr><td>郭雅琴
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<tr><td>高瑞敏
Ruimin Gao</td><td>Year 1 graduate
Industrial Design</td></tr>
<tr><td>程艳
Yan Cheng</td><td>Year 4 undergraduate
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<tr><td>江颖
Ying Jiang</td><td>Year 3 graduate
Interior Decoration</td></tr>
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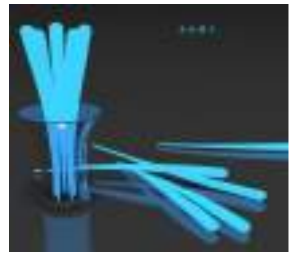
Water Well</td><td>
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Rice Thresher</td><td rowspan="3">
Grip Microphone</td></tr>
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<tr><td>杨嘉宏
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<tr><td>刘海军
Haijun Liu</td><td>Year 2 graduate
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Charcoal Iron</td><td rowspan="3">
Iron Cup</td></tr>
<tr><td>武强
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Visual Communication</td></tr>
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<tr><td>蒋翀
Chong Jiang</td><td>Year 1 graduate
Product Design</td><td rowspan="4">
Leather Water Jug</td><td rowspan="4">
Flexible Home Plan</td></tr>
<tr><td>李德耀
Deyao Li</td><td>Year 1 graduate
Product Design</td></tr>
<tr><td>苗春挺
Chunting Miao</td><td>Year 1 graduate
Product Design</td></tr>
<tr><td>张明华
Minghua Zhang</td><td>Year 1 graduate
Product Design</td></tr>
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Shifeng Gao</td><td>Year 1 graduate
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Thimble</td><td rowspan="2">
Fireproof Fabric</td></tr>
<tr><td>陈亚锋
Yafeng Chen</td><td>Year 1 graduate
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<tr><td>缪璐璐
Lulu Miao</td><td>Year 1 graduate
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<tr><td>炎晶晶
Jingjing Yan</td><td>Year 1 graduate
Product Design</td></tr>
<tr><td>陈沁丛
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Finger Exercises Ball</td><td rowspan="3">
Baby Crawler</td></tr>
<tr><td>刘蕙
Hui Liu</td><td>Year 1 graduate
User Studies</td></tr>
<tr><td>史文雅
Wenya Shi</td><td>Year 1 graduate
Product Design</td></tr>
<tr><td>孟圆
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<tr><td>王艳池
Yanchi Wang</td><td>Year 1 graduate
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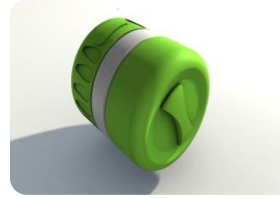
<tr><td></td><td></td><td>kerosene Lamp</td><td>
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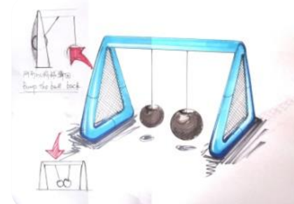
Steelyard</td><td rowspan="3">
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<tr><td>王雅楠
Yanan Wang</td><td>Year 1 graduate
Handicraft</td><td rowspan="2">
Stone Mill</td><td rowspan="2">
Sand Glass Lighting</td></tr>
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Wenting Song</td><td>Year 3 undergraduate
Product Design</td></tr>
<tr><td>陈亚琳
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Folding Fan</td><td rowspan="3">
Office Emotion Forecast Interface</td></tr>
<tr><td>李萍
Ping Li</td><td>Year 3 undergraduate
Product Design</td></tr>
<tr><td>梁爽
Shuang Liang</td><td>Year 3 undergraduate
Product Design</td></tr>
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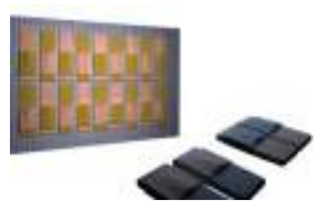
申建群 Jianqun Shen	Year 3 undergraduate Tourist Product Design	 Bottle Gourd	 Foldable Basin Frame
黄韶枫 Shaofeng Huang	Year 3 undergraduate Tourist Product Design		
张杰 Jie Zhang	Year 3 undergraduate Tourist Product Design	 Scissors	 Convenient Slipper
任晓飞 Xiaofei Ren	Year 3 undergraduate Tourist Product Design		
曹乐 Le Chao	Year 3 undergraduate Product Design		
徐潇潇 Xiaoxiao Xu	Year 3 undergraduate Product Design	 Rattan Chair	 Book Furniture
程娟娟 Juanjuan Cheng	Year 3 undergraduate Product Design		
潘丽莎 Lisa Pan	Year 3 undergraduate Product Design	 “连枷” Pat	 Unfinished Design
刘悦 Yue Liu	Year 3 undergraduate Product Design		
李娜 Na Li	Year 3 undergraduate Tourist Product Design		
葛明媚 Mingmei Ge	Year 1 graduate Product Design		

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Zheng</td><td>Year 3
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Rolling Pin</td><td>
Library Private Room</td></tr>
<tr><td>盖玉倩
Yuqian Gai</td><td>Year 3
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Magnet Transformable Wall</td></tr>
<tr><td>鞠磊
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<tr><td>曾翔
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Fire Extinguisher with Decorative Function</td></tr>
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Pengfei Jing</td><td>Year 1 graduate
Product Design</td><td>
Exercise/ Escape System</td></tr>
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邱金 Jin Qiu	Year 2 graduate Product Design		 Floating Sofa for Emergences
黄路 Lu Huang	Year 1 graduate Product Design	 Flat Bamboo Basket	 Safe Thermos Cover
肖宽 Kuan Xiao	Year 1 graduate Product Design		 Fire Extinguish System
齐建春 Jiancun Qi	Year 3 graduate Product Design	 Medicine Cabinet	 Assembled Refrigerator
郭建伟 Jianwei Guo	Year 1 graduate Product Design		
段行行 Hanghang Duan	Year 1 graduate Product Design	 Chinese Abacus	 Emergency Package
鞠金梁 Jinliang Ju	Year 3 graduate Product Design		
游欢 Huan You	Year 2 graduate Product Design	 Go-Wei Qi	 Plastic Bottle Collector
陈利 Li Chen	Year 1 graduate Product Design		

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Xiaofang
Song</td><td>Year 1 graduate
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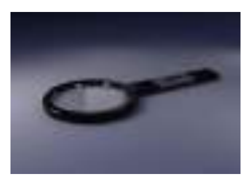
Sand-fired pot</td><td rowspan="2">
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With Automatic Lighting</td></tr>
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Flexible Bamboo Bench</td><td rowspan="2"></td></tr>
<tr><td>冯维
Wei Feng</td><td>Year 3 graduate
Product Design</td></tr>
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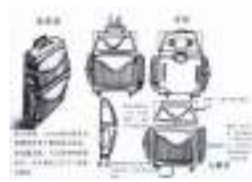
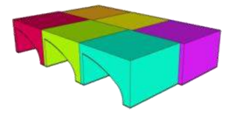
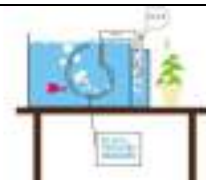
			Transformable Desks
田培 Pei Tian	Year 1 graduate Product Design		 Flexible Floor Furniture
李丽丽 Lili Li	Year 1 graduate Product Design		
杜丹 Dan Du	Year 1 graduate Product Design		

Guangzhou Workshop Guangzhou Academy of Fine Arts. School of Design			
23 participants/ Time: 2011.June9-25			
黄宇剑 Yujian Huang	Year 2 undergraduate Textile Design	 Assembly Bamboo Steamer	 Assembly School Bag
郑邦明 Bangming Zheng	Year 2 undergraduate Industrial Design	 Lantern	 Vase Design
任婷慧 Tinghui Ren	Year 3 undergraduate Fashion Design	 Ink Brush Pack	 Newspaper Pack
黄兆康 Zhaokang Huang	Year 3 undergraduate Visual Communication	 Bamboo Steamer	 Assembly Speaker

陈倩图 Qianling Chen	Year 3 undergraduate Architecture Design	 Tangram	 Children Furniture Lego
柯慧 Hui Ke	Year 2 undergraduate Textile Design	 Drum	 Watermelon Drum
麦子杨 Ziyang Mai	Year 3 undergraduate Interior Design	 Stone Mill	 Mill Juicer
何绮珊 Qishan He	Year 2 undergraduate Book Design	 Water Smoke Pipe	 Automatic Clean System for Goldfish Bowl
谢子媚 Zimei Xie	Year 2 undergraduate Exhibition Design		
吴燕红 Yanhong Wu	Year 2 undergraduate Chinese Painting	 Comb	 Postcard Holder
冷丽坤 Likun Leng	Year 3 undergraduate Water Color Painting	 "Ding"	 Pattern Design

刘桢祥 Zhenxiang Liu	Year 3 undergraduate Design Studies	 Cloud Pattern	 Cloud Style Book Frame
谢俊尧 Junrao Xie	Year 3 undergraduate Industrial Design	 Tea Sets	 Lighting Wine Glasses
李宗杰 Zhongjie Li	Year 3 undergraduate Industrial Design	 Folding Fan	 Auto-induction Faucet In Folding Fan Shape
柳毅 Yi Liu	Year 3 undergraduate Industrial Design	 Revolving Scenic Lantern	 Wind Dynamic Public Sculpture
黄文欢 Wenhuan Huang	Year 3 undergraduate Industrial Design	 Assembly Bamboo Steamer	 Table Lamp
李蔚楠 Weinan Li	Year 3 undergraduate Design Education	 Fire Wood	 Emergency Pendant

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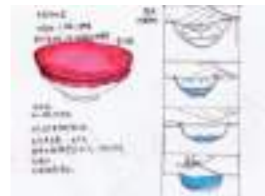
Furniture Design</td><td rowspan="2">
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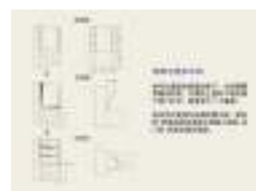
Bamboo Pillow</td><td>
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Shilan Wen</td><td>Year 3
undergraduate
Furniture Design</td><td>
Chicken Cage</td><td>
Leather Bag Design</td></tr>
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Appendix E:

An Example of Open Selection of CTEAs

Holistic Considerations of Consuming Energy: A Group of Traditional Home Appliances

Six everyday Chinese objects were selected as meaningful to SPD. Some of the objects are traditional home appliances and others are contemporary appliances or immediate solutions that reflect traditional wisdoms. Some of them have fixed names, while others are spontaneously named according to their function. The following photographs, marked with numbers, are of objects and were taken in the objects' original use contexts in field studies in different Chinese families. They are organized as a group of artefacts, which represent a holistic concept of energy consumption. They all satisfy some of the criteria from the SPD framework.

Figure 1: CTEAs that Imply Holistic Considerations of Energy Consumption

1) **Chinese Kitchen Stove:** The everyday object labelled "1" was found in the home of a Chinese family in the countryside of the Anhui Province. It is an integrated stove with a fixed iron, rounded

bottom pan that is heated by firing wood and charcoal beneath. The biggest, iron pan is directly heated by firing fuel and the small one is heated through the transmission of leftover heat from the main pan. The small pan can be used to boil a small amount of water or soup while cooking occurs in the main pan. This integrated kitchen stove is popularly used in the countryside areas of northern and central China. Its sustainable attributes include: 1) systematic thinking that provides a holistic cooking solution and 2) promotes ecological efficiency by locating and making use of leftover energy.

2) **Roasting System:** The image labelled “2” depicts an immediate solution for the baking of melon seeds by using the leftover heat from the metal surface of a modern day gas stove. This solution was found in the household of an urban family in Shenzhen, which is in southern China. The method was invented by a retired housewife and was inspired by her former experience baking sweet potatoes on traditional stoves using leftover heat. Its sustainable attributes include the promotion of ecological efficiency by using leftover energies.

3) **Charcoal Ashes Warmer:** The everyday object labelled “3” is both furniture and a home appliance. It is a place to keep the remnant heat of charcoal ashes after coal has been used for cooking. In traditional China, most people burn charcoal or coal to keep warm in winter. This warmer provides a more economic heating solution. The artefact is made of wood, except the removable metal grate placed within the barrel, which props up the user’s feet. In the bottom of barrel, under the metal grate, a brazier is filled with leftover charcoal ashes as the source of heat. The heat can last more than five hours; after that, the ashes can be used as fertilizer for framing. The warmer can be made in different sizes and forms to satisfy different needs and use contexts. Some are used as necessary furniture items. This object is popular among Anhui rural families. Its sustainable attributes include: 1) promoting ecological efficiency by making use of remnant energy from charcoal ashes used in cooking; and 2) systematic thinking, in that the artefact is simultaneously used as furniture and a radiator.

4) **Table Clay Stove:** The small clay stove labelled “4” was found in a country market. It can be used to heat a hot pot or a standard sized soup jar. The heating resource is burning charcoal. This simply-made stove can provide three levels of heating power by adding two inner frames to the stove body. It is portable and highly energy efficient. Its sustainable attributes include: 1)

promoting ecological efficiency by choosing an appropriate material for product function and form, providing a flexible and efficient way of heating food; and 2) systematic thinking, as indicated by the object's integrated product structures.

5) **Group of Soup Jars:** The item labelled "5" is not a single object but is composed of a group of two or more soup jars. It is often found in Chinese kitchens. This group of different sized soup jars represents an economic energy use system. People choose different sized jars to boil different amounts of soup. When the amount of soup fits the jar size, heat is concentrated in the soup. This is more efficient in both cooking and energy use. Its sustainable attributes include promoting ecological efficiency by providing flexible choices for economically and efficiently heating foods.

6) **Bamboo Steamer:** The object labelled "6" is a typical, traditional piece of Chinese kitchenware, which is widely used in China and abroad. The bamboo steamer cooks food by thermal steaming, which saturates through the different layers of the steamer. It is traditionally made of bamboo and contemporarily made in alloy. It's used to cook traditional Chinese dishes and snacks. Eating steamed foods is better for people's health than eating foods made by other modes of cooking. Steamed foods also represent a cultural aesthetic in China; many Chinese festivals are celebrated by the eating of traditional, steamed foods. Its sustainable attributes include: 1) promoting ecological efficiency by having high energy efficiency through its ability to cook multiple foods at one heat source; 2) contributing to human ecology by providing healthy and low-calorie steamed recipes; and 3) encouraging ecological aesthetics, by representing a natural, traditional flavour that is geographically distinct.

Appendix F:

An Example of Selecting Artefacts with a Design Problem in Mind

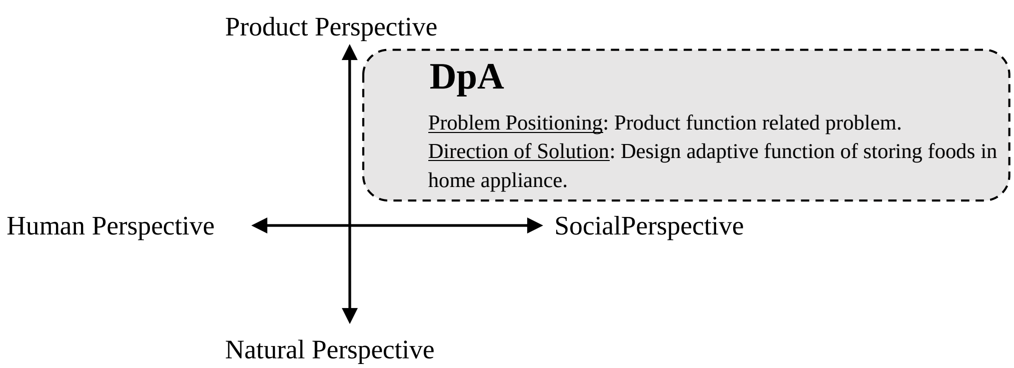
In the fourth workshop organized for this research, the participants were first- and second-year Master's students in the field of product design. This workshop is designed to observe and test the possibilities when studying traditional everyday artefacts in a given place (in this case the city of Wuhan, the capital city of Hubei Province, in China) for specific, sustainable design purposes. After giving lectures on SPD framework and related knowledge, the students were required to define one or two design problems that reflected unsustainable, everyday issues.

Two example design problems proposed by students in the fourth workshop are described below.

Design problem A: How to fetch foods stored in a nearby refrigerator when people are trapped in ruins following an earthquake. (For Team 1)

Design problem B: How to design a more hygienic and effective way of disposing everyday rubbish in homes. (For Team 2)

The students generally mapped the two questions on the SPD framework according to their subjective understanding of the framework and the scope of the questions, particularly concerning what kinds of unsustainable problems the questions represent.



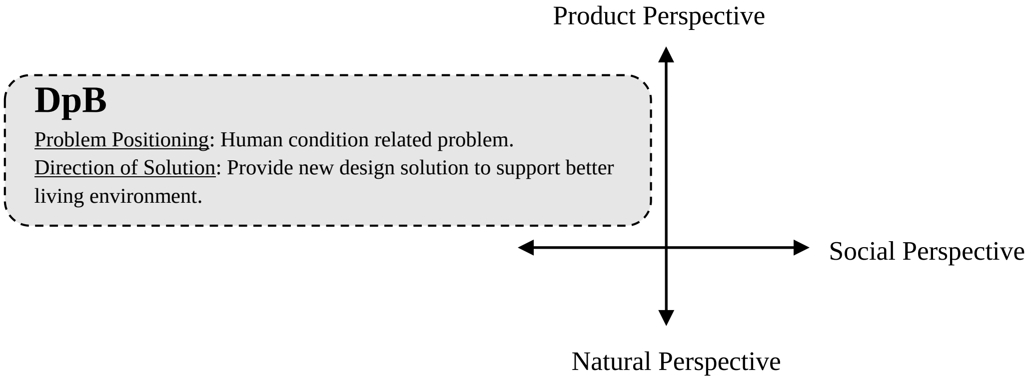
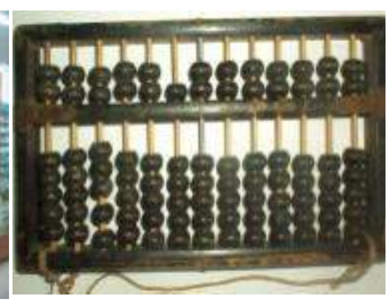


Figure 1: Examples of Mapping Design Problems on the SPD Framework

These two teams went back to search related CTEAs according to their understanding and definitions of the design problems. Team 1 emphasized searching for artefacts with flexible structures and functions when it came to storing foods. Team 2 focused on collecting different kinds of containers and traditional home architecture structure models in order to find some inspirations for redesigning the garbage storing system. Below are depicted some selected CTEAs for the two design problems.

Paper Umbrella

Medicine Box



Counting-frame

Game of Go

Spinning Top

Leather Jar

Figure 2: Collected Artefact Examples for *Problem A*

Traditional House: Miao Minority

Traditional House: River South

Traditional House: Cave Dwelling

Bamboo Baskets

Bamboo Griddle

Pickle Jar

Figure 3: Collected Artefact Examples for *Problem B*

Appendix G:

An Example of Investigating Artefacts through Lifecycle

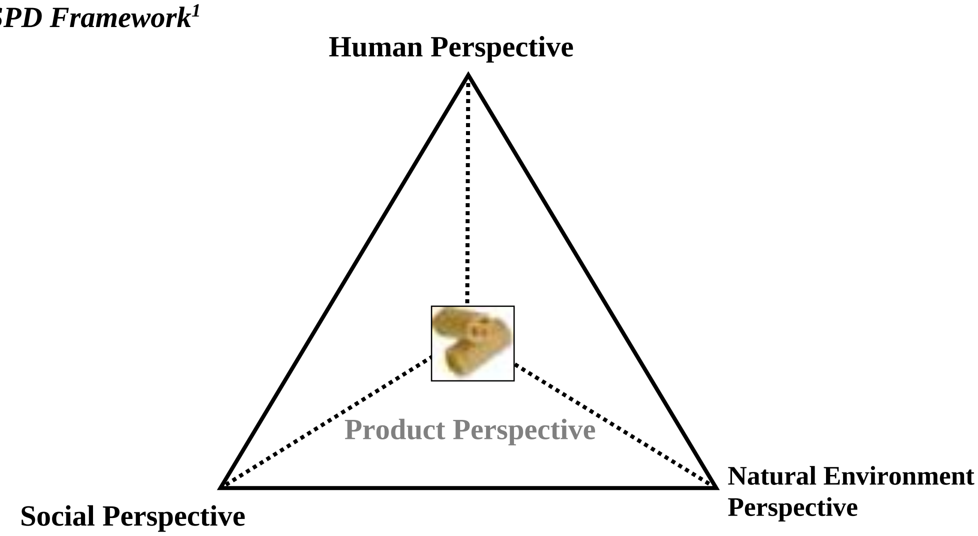
Investigating Loofah Sponge Brush

A Brief Description

The loofah sponge brush is a very popular traditional everyday artefact that is still used in both urban and countryside Chinese homes as a cleaning tool in the kitchen, and contemporary use has translated the tool to bathing, as well. A loofah sponge brush can be easily homemade or cheaply purchased at a market.

SPD Attributes: 1) Contributes to human ecology by improving human health and 2) Promotes ecological efficiency, as it makes best use of the material.

Located in SPD Framework[1]



[1]The attributes can be illustrated as a pyramid model of the SPD criteria.

Figure 1: Placing the Loofah Sponge Brush on the SPD Framework

Producing the Product

Figure 2: Producing the Loofah Sponge Brush

Motivation:People found that the delicate reticulate veins of the inside of dried loofah plant can be used to easily clean the oily surfaces of tableware, when wetted. People then designed loofahs into many different shapes for multiple uses. This artefact is designed according to the physical characteristics of the material, which is natural and non-toxic.

Processing Material: Investigated in the context of Anhui and Hubei rural families, dry loofah are stored all year round in different parts of the home. This storing constitutes the main processing of the product, and emulates the natural process of the loofah's lifecycle.

Figure 3: Material Processing of Loofah Sponge Brush

Making Process: The process of making a loofah sponge brush is as follows: 1) crack the outside of the dry loofah sponge; 2) shake the loofah sponge to take out the seeds; 3) cut the loofah sponge apart using scissors, or chop into sections.

Material, Form, and Structure: Loofahs are made of asingle material: the loofah sponge, which grows naturally into its usable form. One dry loofah sponge can be cut to two to four brushes. Commonly, 15 to 20 cm lengths are used for washing dishes, while longer than 20 cm lengths are used in the bath. The natural textural and colour of the loofah sponge are exhibited in the final product.

Using the Product

Figure 4: Use Contexts of Loofah Sponge Brush

How to Use: Wet the brush to make it soft, and use the loofah like a commercial sponge. Hot water can make the cleaning performance batter. Most of the time, it is not necessary to use soap to clean the stains and oil that remain from cooking. Squeeze excess water from the sponge and store in a well-ventilated and dry place. It can also be used as a bath brush or facial scrubber.

Use Contexts: Both rural and urban Chinese families use loofah sponges in the kitchen, placed with other cleaning tools and detergents, and in the bathroom, hanging with towels or toiletries.

Disposing of the Product

Cost and Duration: The usual price for a loofah sponge is less than 10 RMB, and the cost is even cheaper if the sponge is made at home. One loofah sponge brush can be used for three to six months in common circumstances before being replaced.

Summary: The above case study indicates that, during systematic investigation of the selected artefacts, more SPD attributes could be discovered than revealed by first impressions of the artefacts. Some selected artefacts may have more sustainable attributes to be further investigated, although some may just have the original attributes that caused them to be selected. Those embedded SPD attributes may be connected to serve a design philosophy, or used separately to form other advantages to human and environmental sustainability.

Appendix H:

Data Processing of Artefact Investigation

The following is an example from the loofah sponge brush artefact, and illustrates the data processing system of the ICTEA-SPD method.

1. Deconstruct the Artefact:

<table>
<tr><td></td><td colspan="2">Brief Description:
▪ This artefact is collected and its use and making are observed in both cities(Shenzhen, Shanghai) and also in some remote areas (Taihu, Anhui).
▪ It is primarily used in kitchens to clean dishes and pots after cooking and sometimes used in the bathroom for personal hygiene.
▪ The artefact is very easily made and requires no specific techniques.</td></tr>
<tr><td colspan="2">SPD Attribute:
1. It's a very inexpensive solution to clean kitchenware.
2. It is a safe, non-toxic, and natural product.
3. It is not a pollutant and does no harm to the environment.
4. It is an appreciable natural form that assists the living of a healthy lifestyle.</td><td>From Which Aspect(s) of the SPD Framework: Human or Natural?

Satisfied Criteria:
1) Non-toxic, inexpensive solution that benefits human health;
2) Designed for waste minimization and exemplifies best use of material to benefit the natural environment.</td></tr>
<tr><td colspan="3">Design Motivation</td></tr>
<tr><td>Design Purposes</td><td colspan="2">To provide an effective and economic solution to clean dishes and other items in kitchen. Sometimes also used to clean the body.</td></tr>
<tr><td>Use Context</td><td colspan="2">Both rural and urban Chinese families use the loofah sponge. In the kitchen, it is placed with other cleaning tools and detergents; in the bathroom, it is hung with towels or among toiletries.</td></tr>
<tr><td>SETIG Influences</td><td colspan="2">People found that the delicate reticulate veins of the inside of dry loofah can be used to easily clean the oily surface of tableware, when wetted. Then people manipulated the loofah into different shapes for multiple uses, so it is now also used as a non-toxic, natural, beauty care product. The SPD value of this artefact relies on the physical characteristics of the material.</td></tr>
<tr><td colspan="3">Function Realization</td></tr>
</table>

User Behaviours Concerning the Artefact	The process of washing dishes and pots with the loofah sponge brush is as follows: 1) soak the brush in water to soften it; 2) scrub stains with the wet loofah sponge brush, adjusting the contact area of the brush and scrubbing motion as necessary; 3) use clean water to rinse the object being cleaned; 4) rinse the brush and shake off the remaining water; 5) store the brush in a well-ventilated and dry place to avoid the growth of mildew. The loofah sponge will become softer after several uses.
Product Performance	The loofah sponge has been an item whose use has undergone continuous discovery and evolution. It can be used to wash objects that need to be carefully cleaned, and in that way has direct relations with human hygiene and food safety. Once people discovered the physical characteristics of the material, they used it to fit their daily needs.
Ergonomic Performance	The loofah can be made into a number of shapes and sizes. During use, the loofah is soft as cloth and easy to dry and store.
Function and Economics Efficiencies	It's quite easy to clean dishes and oily kitchenware with loofahs, especially with the addition of warm water. Usually, one loofah sponge can be used for a couple of months of continuous use. It is used frequently during everyday life but costs very little to buy or make.
Aesthetic Performance	N.A.
Product Lifespan and Disposals	Usually can be used for 3–6 months and disposed of with no pollution.
Designing and Making the Artefact	
Material Selection and Processing	It is made of a single material—100% natural dry loofah sponge. In Anhui and Hubei rural families, dry loofah are stored year-round in different parts of the home. Drying the loofah is a processing method that also occurs naturally for loofahs. The process of making the loofah sponge brush is as follows: 1) crack the outside of a dry loofah sponge; 2) shake the loofah sponge to remove the seeds; 3) section the loofah sponge with scissors or a knife.
Structure/ Components	One dry loofah sponge can usually be cut into 2–4 brushes. They are commonly shortened to 15–20cm in length for washing dishes, and to longer than 20cm in length for use in the bath. Most processes keep the natural texture and colour of the original loofah sponge in the product.
Form, Style, Decorations	One dry loofah sponge can usually be cut into 2–4 brushes. They are commonly shortened to 15–20cm in length for washing dishes, and to longer than 20cm in length for use in the bath. Most processes keep the natural texture and colour of the original loofah sponge in the product.
Dynamic/Energy	N.A.
Functional Technologies	N.A.
Cultural and Symbolic Meanings	The artefact represents a natural lifestyle with simple solutions, by its use of original natural material.

Table 1: An Example of Deconstructing the Artefact

The above table represents the initial analysis and information organization that occur in artefact studies. Within the table is organized all the possible useful information of the design, manufacture, and use of the artefact, any of which may lead to its SPD attributes. During the initial analysis of the data, the design reasoning behind the SPD attributes may not be clear. Some of the information recorded may not be relevant to the design reasoning. To make clear the logically related design reasoning of each of the SPD attributes, it's necessary to perform a second analysis of the organized data. The second analysis clarifies the SPD attributes and design reasoning. In this analysis, the investigator marks related contents of the design decomposition by their different aspects according to the mark number of the SPD attributes.

2. Highlight Keynotes:

	SPD Attribute: 1. It's a very inexpensive solution to clean kitchenware. 2. It is a safe, non-toxic, and natural product. 3. It's a non-pollutant and does no harm to the environment. 4.It is an appreciable natural form that assists in the living of a healthy lifestyle.
Design Motivation	
Design Purposes	To provide an effective and economic solution to clean dishes and other things in the kitchen. Sometimes also used to clean the body.
Using Context	Used in both rural and urban Chinese families. In the kitchen, it is placed with other cleaning tools and detergents; in the bathroom, it is hung with towels or among toiletries.
SETIG Influences	This artefact is designed according to the physical characteristics of the material.People found that the delicate reticulate veins of the inside of dry loofah sponges can be used to easily clean the oily surfaces of tableware when wetted.(1, 2, 3) Then, people designed loofahs into different shapes for multiple uses, and use was translated into hygiene and beauty care products as a non-toxic, natural option.(2,3)
	Function Realization
User Behaviours Concerning the Artefact	The process of washing dishes and pots with a loofah sponge brush is simple and natural:1) soak the brush in water to soften it; 2) scrub stains with the wet loofah sponge brush, changing the contact area and scrubbing motion as needed; 3) use clean water to rinse the object being cleaned; 4) rinse the brush and shake off the remaining water; 5) store the brush in a well-ventilated and dry place to avoid the growth of mildew. The loofah sponge will become softer after several uses.(1, 2, 3)
Product Performance	The use of loofah sponge has continually evolved through a history of discovery.(4) It can be used to wash objects that need to be carefully cleaned,

	and thus has direct relations with human hygiene and food safety. People discovered the physical characteristics of the material and fit the material to their daily needs.(4)
Ergonomics Performance	It can be made into many shapes and sizes. During use, it is soft as cloth; after, it is easy to dry and store.(1)
Function and Economics Efficiencies	It's quite easy to clean dishes and oily kitchenware, especially with the addition of warm water. Usually, one loofah sponge can be used for a couple of months of continuous use. It is used frequently during everyday life and costs very little to buy or make at home.(1)
Product Lifespan and Disposals	Usually can be used for 3–6 months and disposed of without pollution.
	Design and Making the Artefact
Material Selection and Processing	It is made of a single material—100% natural, dried loofah sponge.(1,2,3,4) In Anhui and Hubei rural families, dry loofahs are stored year-round in the home. This drying processing is also the loofah's natural process.(2,3) The process of making a loofah sponge brush is as follows: 1) crack the outside of a dry loofah sponge; 2) shake the loofah sponge to remove the seeds; 3) section the loofah sponge using scissors or a knife.
Structure/ Components	One dry loofah sponge can usually be cut to 2–4 brushes. These are commonly 15–20cm in length for washing dishes, and longer than 20cm for bathing. The processing keeps the natural texture and colour of the loofah sponge in the product.(4)
Form, Style, Decorations	One dry loofah sponge can usually be cut to 2–4 brushes. These are commonly 15–20cm in length for washing dishes, and longer than 20cm for bathing. The processing keeps the natural texture and colour of the loofah sponge in the product.
Cultural and Symbolic Meanings	The artefact itself represents a natural lifestyle with a focus on simple solutions, by its use of original, natural material.(4)

Table 2: Highlight Keynotes of Artefact Deconstruction

3. Organize Keynotes to the SPD Attributes

CRITERIA	*3.5 Select material for functional and economic efficiency.*
SPD ATTRIBUTE	1. The material of the loofah sponge makes it an economic solution for cleaning kitchenware.
DESIGN REASONING	1) People found that the delicate reticulate veins of the inside of dry loofah can be used to easily clean the oily surfaces of tableware when wetted. 2) The process of washing dishes and pots using a loofah sponge brush is simple and natural: 1) soak the brush in water to soften; 2) scrubs stains with

the wet loofah sponge brush, changing the contact area and scrubbing motion as necessary; 3) use clean water to rinse the object being cleaned; 4) rinse the brush and shake off the remaining water; 5) store the brush in a well-ventilated and dry place to avoid formation of mildew. The loofah sponge will become softer after several uses.

3) The loofah sponge makes it quite easy to clean dishes and oily kitchenware, especially with the addition of warm water. Usually, one sponge can be used for a couple of months of continuous use. It is used frequently during everyday life and costs very little to buy or make at home.

4) It can be made into many shapes and sizes. During use, the loofah is soft as cloth; afterward, it is easy to dry and store.

5) It is made of a single material—100% natural, dry loofah sponge.

CRITERIA *2.1 Safe and non-toxic solutions.*

SPD ATTRIBUTE 2. It is a safe, non-toxic, and natural solution.

DESIGN REASONING

1) People found that the delicate reticulate veins of the inside of dry loofah can be used to easily clean the oily surfaces of tableware when wetted.

2) The process of washing dishes and pots using a loofah sponge brush is simple and natural: 1) soak the brush in water to soften; 2) scrubs stains with the wet loofah sponge brush, changing the contact area and scrubbing motion as necessary; 3) use clean water to rinse the object being cleaned; 4) rinse the brush and shake off the remaining water; 5) store the brush in a well-ventilated and dry place to avoid formation of mildew. The loofah sponge will become softer after several uses.

3) The loofah sponge makes it quite easy to clean dishes and oily kitchenware, especially with the addition of warm water. Usually, one sponge can be used for a couple of months of continuous use. It is used frequently during everyday life and costs very little to buy or make at home.

4) It can be made into many shapes and sizes. During use, the loofah is soft as cloth; afterward, it is easy to dry and store.

5) It is made of a single material—100% natural, dry loofah sponge.

CRITERIA *3.1 Minimize environmental impact along the product lifecycle*

SPD ATTRIBUTE 3. It's non-polluting and has no harmful effects on the environment.

DESIGN REASONING

1) People found that the delicate reticulate veins of the inside of dry loofah can be used to easily clean the oily surfaces of tableware when wetted.

2) The process of washing dishes and pots using a loofah sponge brush is simple and natural: 1) soak the brush in water to soften; 2) scrubs stains with the wet loofah sponge brush, changing the contact area and scrubbing motion as necessary; 3) use clean water to rinse the object being cleaned; 4) rinse the brush and shake off the remaining water; 5) store the brush in a well-ventilated and dry place to avoid formation of mildew. The loofah sponge will become softer after several uses.

3) The loofah sponge makes it quite easy to clean dishes and oily kitchenware, especially with the addition of warm water. Usually, one sponge can be used for a couple of months of continuous use. It is used frequently during everyday life and costs very little to buy or make at home.

4) It can be made into many shapes and sizes. During use, the loofah is soft as cloth; afterward, it is easy to dry and store.

5) It is made of a single material—100% natural, dry loofah sponge.

CRITERIA *4.3 Cultivate modest desire and taste*

SPD ATTRIBUTE 4. It is an appreciable natural form that fosters a healthy lifestyle.

DESIGN REASONING

1) The use of the loofah sponge is continuously evolving.

2) People discovered the physical characteristics of the material and then fit the material to their daily needs.

3) It is made of a single material—100% natural, dry loofah sponge.

4) The processed product keeps the natural textural and colour of the original material.

5) The artefact represents a natural lifestyle that is characterized by finding simple solutions, by its use of original, natural material.

Appendix I:

Examples of Three Levels of Insight Abstraction

LEVEL ONE: *Artefact Level Insight Abstraction*

CTEAs	Satisfied SPD Criteria	Design Reasoning Brief	Abstracted Insight: (Type A: Artefacts Level)
Loofah Sponge Brush 	3.5 Select material for functional and economic efficiency.	The function of cleaning is decided by the physical characteristic of material. Selecting useful material acts as the key design solution.	Directly use the physical material structure of loofah sponge as an easy way to clean in certain contexts.
Flour Lamp 	1.1 Design multifunctional product.	There are three functions that the artefact involves: decoration, lighting, and food. These are connected by integrating the natural process of burning the (peanut) oil for lighting and heat.	Cook the flour cake using a lampwick that also provides gentle lighting.
Flour Stick 	1.3 Involve user as a part of the design to simplify the product.	The artefact is simply designed and made. The design combines a set of operational skills that rely on human intelligence and practice.	Manipulate repeated moves of stick-shaped object to evenly flatten plastic material.
Bamboo Steamer 	3.2 Design for energy efficiency.	The artefact structure is designed of overlapping multi-hole drawers that facilitate use of steam's physical attribute of floating upward.	Overlap same shaped multi-hole container as a cooking structure to utilize leftover energy from heating or cooking.

Palm Fan 	2.4 Design sustainable, everyday life patterns.	The artefact is a simple and easy solution for lowering environment temperature. It is much more ecological to carry a personal cooling device than to cool down a large space.	Use simple, portable tools to get cool.

LEVEL TWO: ***Design Method Level Insight Abstraction***

The above examples of artefacts level abstractions can be further abstracted into their method level, as shown below:

CTEAs	**Design Reasoning Brief**	**Abstracted Insight:** (Type A: Artefacts Level)	**Abstracted Insight:** (Type B: Method Level)
	The function of cleaning is decided by the physical characteristic of material. Selecting useful material acts as the key design solution.	Directly use the physical material structure of loofah sponge as an easy way to clean in certain contexts.	Use the physical attribute of natural material to support product functions.
	There are three functions the artefact involves: decoration, lighting, and food. They are connected by integrating the natural process of burning the (peanut) oil for lighting and heat.	Cook the flour cake by burning a lampwick, which also provides gentle lighting.	Integrate different functions through the whole process of product performance.
	The artefact is simply designed and made. The design combines a set of operational skills that rely on human intelligence and practice.	Manipulate repeated moves of stick-shaped object to evenly flatten plastic material.	Manipulate simple tools using human skills to accomplish complex tasks.

	The artefact structure is designed of overlapping multi-hole drawers that facilitate use of steam's physical attribute of floating upward.	Overlap same shaped multi-hole container as a cooking structure to utilize leftover energy from heating or cooking.	Design flexible structures for products to elevate their energy efficiency.
	The artefact is a simple and easy solution for lowering environment temperature. It is much more ecological to carry a personal cooling device than to cool down a large space.	Use simple, portable tools that take the user's effort to create coolness.	Design simple tools to make self-sufficient, simple solutions enacted by human efforts.

LEVEL THREE: *level of philosophic abstractions*

CTEAs	**Abstracted Insight:** (Type A: Artefacts Level)	**Abstracted Insight:** (Type B: Method Level)	**Abstracted Insight:** (Type C: Philosophy Level)
	Directly use the physical material structure of loofah sponge as an easy way to clean in certain contexts.	Use the physical attribute of natural material to support product functions.	Seek design solutions from nature for easy and direct products.
	Cook the flour cake by burning a lampwick, which also provides gentle lighting.	Integrate different functions through the whole process of product performance.	Extend the life of a product by discovering its whole life performance.
	Manipulate repeated moves of stick-shaped object to evenly flatten plastic material.	Manipulate simple tools using human skills to accomplish complex tasks.	Involve human intelligence as a part of design.
	Overlap same shaped multi-hole container as a cooking structure to	Design flexible structures for products	Design the product according to the physical attributes of the energy transformation process.

	utilize leftover energy from heating or cooking.	to elevate their energy efficiency.	
	Use simple, portable tools that take the user's effort to create coolness.	Design simple tools to make self-sufficient, simple solutions enacted by human efforts.	Make humans work to satisfy their own needs.

Appendix J:

An Example of Interpreting Insight for Solving a Particular Problem

In one of the five workshops, participants were required to use the ICTEA-SPD method to solve pre-assigned and pre-defined design problems. Their use of the method was based on the everyday sustainability problems defined by them.

Design Problem: *How to fetch foods stored in a nearby refrigerator when people are trapped in ruins following an earthquake?*

The problem was defined by a group of students who used the SPD framework to quickly review their understanding of everyday life. They agreed that when earthquakes happen, people trapped in ruins cannot easily retrieve food. In most homes, people store food in refrigerators. When an earthquake breaks down the construction of a living space, it can become difficult to fetch foods from the refrigerator, for the door may be blocked. If there was a way to make food more easily accessible, people trapped in ruins following an earthquake would have a greater possibility of staying alive long enough to be rescued. After group discussion, the students located their problem solving approach on the product perspective, and decided to redesign the way people store foods at home.

The question is located on the SPD framework on the product perspective because the students decided to redesign the structure of the refrigerator to make it more accessible to people trapped in ruined living spaces. The design problem was mapped on the SPD criteria of: design multifunctional products. That means the group wanted a final design solution that satisfies the conditions of normal life as well as the broken environment of a living space following an earthquake. It's a quick process from proposing the problem and defining the problem to determining a specific direction to solve the problem. The scope and boundary were further defined to give the project a specific design purpose.

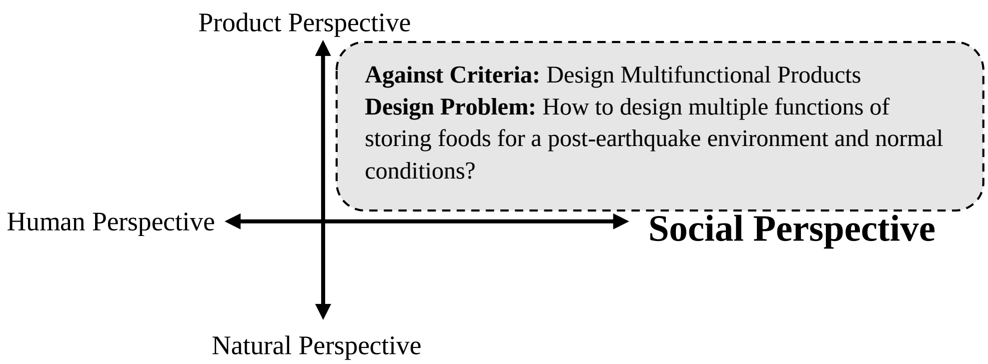


Figure 1: an Example of Identifying the Design Problem

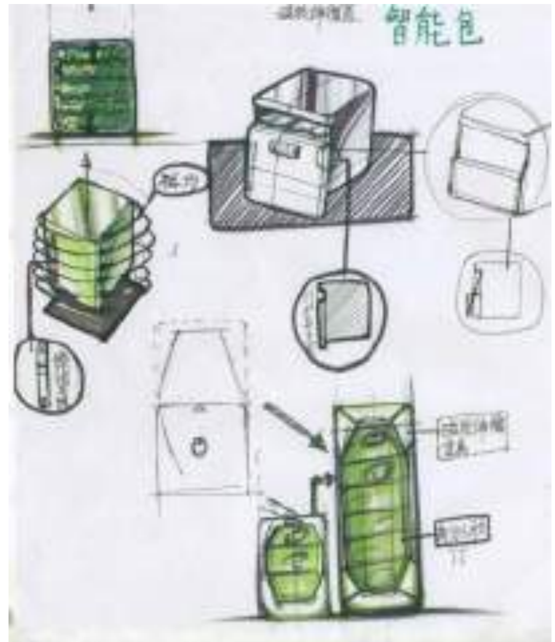
Counting Frame 	**Brief of Design Reasoning:** The artefact supports different ways of using according to the counting tasks needing to be fulfilled. The counting tasks are achieved by moving the beads according to set rules. The single bead serves as a basic structure unit. The operative structure decides its functions.
Satisfied SPD Criteria: 1.1 Design Multifunctional Products	**Abstracted Design Insight:** (on method level) Design assembled structure of flexible units to support multiple functions.

Table 1: An Example of Abstracting SPD Insight to a Particular Design Problem

The group of students chose many CTEAs from their understanding of the supposed dilution direction: to provide a multifunctional product solution for the refrigerator. One of the final selected artefacts for abstracting insight to solve the design problem was the counting frame.

After determining the adaptable design insight, the remaining task is to define the design solution by giving specific elements to the insight. There is a fuzzy process of how designers organize their existing knowledge to fit the requirements of a supposed design solution. Some students prefer to use language interpretation—that is, they prefer to write down all the possible solutions they could figure out in one sitting. Some prefer to use sketching as a way to visualize their thinking toward the design task.

Below is a design concept created by one of the workshop participants, which represents the "successful" interpretation of the insight to the design problem.



Ideals:

The assembled refrigerator. 1) User can change the size and dimension of the product according to their requirements; 2) The structure can be easily disassembled in an emergency situation.

Sketches:

How the components are assembled.

Figure 2: An Example of Interpreting Design Insight for a Particular Problem

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