Construction of Intermediate Knowledge in Design: A Case Study of Cultural and Creative Product Design

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Abstract. Intermediate-level knowledge is conceptual knowledge that resides between design instances and theories. It supports designers in lateral thinking and facilitates the sharing and communication of specific domain design knowledge. This paper proposes a method for constructing intermediate knowledge to support team knowledge co-creation. We introduce the knowledge construction process through a case study in the context of creative cultural design. In this case study, eleven design patterns were extracted from a collection of 121 design instances. These patterns, serving as typical intermediate knowledge, were transformed into a card-based tool to support designers' creative ideation. Finally, we evaluated its efficiency and effectiveness in two student projects.

Keywords. Intermediate Knowledge, cultural and creative design, creative Ideation, card-based Tools

1. Introduction

The goal of design research is to systematically explore knowledge (Archer, 1981; 1995). Creative procedures, design methodologies, guidelines, principles, patterns, and heuristics are all design knowledge. This paper focuses on the intermediate-level knowledge in design, which resides between concrete instances and abstract theories. Starting from the standpoint that intermediate knowledge plays a pivotal role in the design of creative thinking, we put forth a method to construct intermediate knowledge. Through a case study, we will illustrate the constructing process of intermediate knowledge for cultural and creative products and assess its impact on novice designers during the ideation stage.

A critical skill possessed by the expert is to develop abstract conceptual knowledge through the accumulation of extensive design practice (Cross, 2004). Experts can identify underlying patterns, principles, and techniques, and apply them to new design contexts. Darke (1979) observed that professional architects often employ generative conceptual principles known as "Primary Generators" to aid in framing design problems and developing design solutions. However, novices, tend to focus more on the structure of the problem and lack domain-specific generative principles, which hinders their ability to co-evolve between problems and solutions (Dorst & Cross, 2001). Lawson (2004) suggested that the development of designers, progressing from novices to experts, relies

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on continually acquiring patterns (schemas) and strategies (gambits) from accumulated design precedents. In other words, the development of a designer's professional knowledge largely depends on their ability to accumulate experiential knowledge such as strategies, principles, patterns, and techniques.

Hoök and Löwgren (2012) referred to this experiential knowledge as intermediate knowledge, which resides between design instances and theories. It is more abstract than specific instances but not as general as theories. The history of intermediate knowledge can be traced back to the pattern language in the field of architecture (Alexander et al., 1977). Later, "design patterns" in the field of software design (Gamma et al., 1995), "design heuristics" in product design (Yilmaz et al., 2011), and "strong concepts" in interaction design (Hoök & Löwgren, 2012) were successively proposed.

We argue that Intermediate knowledge can help designers engage in creative thinking, support their lateral thinking (de Bono, 1970), assist them in framing design problems (Schön, 1983), and generate more promising solutions. Numerous prior relevant studies indicated that intermediate knowledge can be constructed into design tools, especially card-based tools, to support design innovation. Lockton et al. (2013) developed the Design with Intent toolkit, and employed design patterns to help designers solve sustainable behavior problems. Zhuang and Leung (2015) employed the Interaction Tarot card-based tool to construct intermediary knowledge, assisting designers in creative ideas for interactive design. Hu et al. (2020) introduced a design heuristic tool named SDHC into classroom teaching to promote the dissemination of professional knowledge in service design. Chen and Ma (2022) employed grounded theory to extract GUI micro-interaction design techniques, providing references for designers' divergent thinking.

2. An Approach to Constructing Intermediate Knowledge

In this paper, we start from the position that "design knowledge resides in products themselves" (Cross, 1999). Design instances not only embody the knowledge of form and structure but also reflect the thinking, professional skills, and values of their designers. In other words, designers' knowledge is "embedded" within the works they create. Cross (1999) referred to this research as "Design Phenomenology".

Previous research on design instances has mainly focused on perspectives such as Design Precedents, Case Studies, Design by Analysis, and Everyday Design. Stolterman (2008) described it as "ultimate particulars," emphasizing the uniqueness of instances in the design space and the conceptual knowledge they contain; Eckert and Stacey (2000) argued that instances provide a language for designers to describe the context and possible new designs; Kim and Lee (2014) emphasized the interactive context reflected by instances in users' daily use, naming them "daily design", which can serve as a design resource to support designers' creative thinking. Whether as potential concepts, communication languages, or sources of inspiration, instances are a shared form of knowledge in the field of design. This paper will follow Lawson's suggestion to explore the schemas and gambits within design instances, which is the intermediate knowledge we refer to in this context. Then, how do we construct intermediate knowledge?

Knowledge construction involves discovering common patterns through the expression of designers' thoughts, skills, and values and subsequently forming explicit and communicable domain-specific knowledge. Just as Dieter Rams proposed "Ten Principles of Good Design" and Jakob Nielsen introduced "Usability Heuristics"

(Nielsen & Molich, 1990), accomplished designers can externalize their professional experience into various principles. This necessitates those producers of intermediate knowledge, including professional designers, design researchers, or design educators, to possess a certain level of expertise. They have the capability to abstract and generalize generative strategies, principles, patterns, and techniques from design instances. Moreover, they also need to employ specific methods to help them extract and express these pieces of knowledge.

In this context, the method of "Annotated Portfolios" (Gaver & Bowers, 2012) has been adapted to support collaborative knowledge production. This method was described as a means of explicating design thinking and communicating design outcomes (Gaver & Bowers, 2012). Designers annotate the instances in the portfolio to create textual descriptions. The text serves as a substitute for theory, establishing a relationship between the abstract and the concrete, as well as between indexing and being indexed. A single annotation holds specific significance for an individual instance and, when shared across the portfolio, attains generalized meaning. The shared annotations within the portfolio represent the "family resemblance" in design quality, which is also referred to as intermediary knowledge.

Gaver & Bowers' method involves initially annotating the first instance, then introducing a second instance to the collection and comparing their annotations. This process is repeated in subsequent instances. However, this method is more suitable for a smaller number of instances. When dealing with a larger set of instances, adaptations to the method are necessary.

The adapted method consists of three main stages: Building a Portfolio, Annotating Instances, and Comparing Annotations. Building a Portfolio involves collecting relevant instances. Annotating Instances involves understanding and expressing the creative strategies (Cross, 2006) inherent in the instances. Through the comparison of annotations, which essentially involves comparing and summarizing creative strategies, conceptual intermediate knowledge is obtained.
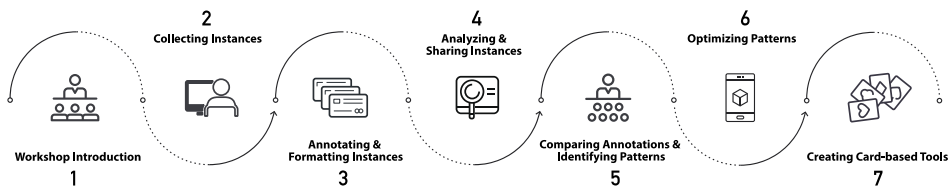

Figure 1. The process of intermediate knowledge construction.

3. A Case Study of Intermediate Knowledge Construction

In this case, we extracted creative strategies from typical cultural and creative design instances and then generalized them into design patterns. These design patterns, as a typical form of intermediate knowledge (Löwgren, 2013) were compiled into card-based tools to support the cultural and creative design practices of novice designers.

We employed a workshop for knowledge co-creation, by breaking down the process into 7 steps. The process is illustrated in Figure 1. The workshop engaged 23 second-year industrial design master's students (12 males and 11 females), with an average age

of 23. These participants had systematic knowledge of design theory and practical experience in cultural and creative design. The workshop spanned three weeks and was led by two experienced teachers.

3.1. Workshop Introduction

Due to the diverse aesthetics, functionalities, and contexts inherent in design instances, combined with participants' varied motivations, experiences, and values, their attitudes towards instances reflect a wide range of multifaceted and heterogeneous characteristics (Gaver & Bowers, 2012). To ensure alignment of perspectives among all participants, the facilitator provided a comprehensive introduction to the workshop's objectives and the methodology for constructing it.

3.2. Collecting Instances

After obtaining a preliminary understanding of the subject, participants were asked to select 5 to 10 cultural and creative design instances based on their interests and preferences, thus forming a collection of instances. Granting designers freedom in collection ensured instances presented varying creative strategies or design heuristics. Given the workshop's time and efficiency constraints, the total number of instances was limited to around 150 to alleviate cognitive pressure during the annotation and comparison process.

3.3. Annotating & Formatting Instances

Participants were encouraged to adopt concise and prescriptive textual annotations to highlight the creative strategies within the instances. It should be noted that annotations involve a deep understanding of instances rather than superficial descriptions of phenomena. They can consist of open-ended and heuristic sentences rather than theoretical terms. The textual annotations should preferably be in the form of imperatives (Fu et al., 2016), rather than descriptive forms, which can aid novice designers in acting during ideation.

   The collected instances were transformed into physical cards to standardize their format. The cards measured 57mm wide and 88mm long, roughly the size of poker cards, printed on both sides (Side A and Side B). Side A displayed the instance image and card number, while Side B included annotated text and essential information about the instance, such as design year, design description and the information about the designer or institution. (Figure 2)

3.4. Analyzing & Sharing Instances

Every designer shared the instances collected during the session and provided detailed explanations about their annotations. This can familiarize participants with all instances, understand how others annotate instances from different perspectives. The facilitator should guide participants to provide in-depth explanations about the instances, rather than evaluating the strengths and weaknesses of the instances and annotations. These cards would be revised based on the discussions during the session and multiple copies would be produced for use in the next stage.
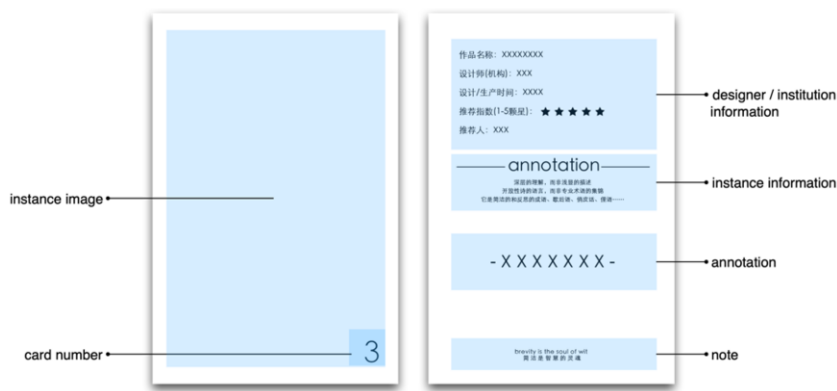
Figure 2. Instance card sample.

3.5. Comparing Annotations & Identifying Patterns

To identify patterns in creative strategies, all annotations were compared and categorized. The facilitators provided an A3-sized paper as the "Pattern Board" (Figure 3). The Pattern Board included sections for "Pattern Name," "Instance Placement Area," and "Pattern Board Guidelines." The tool used a concentric circles diagram to define affinities between annotated instances. The most representative instance, designated as the "Chief," was placed at the center to signify its typicality in terms of creative strategies. Other instances with related or similar strategies were positioned on different concentric circles based on their affinity relationships.
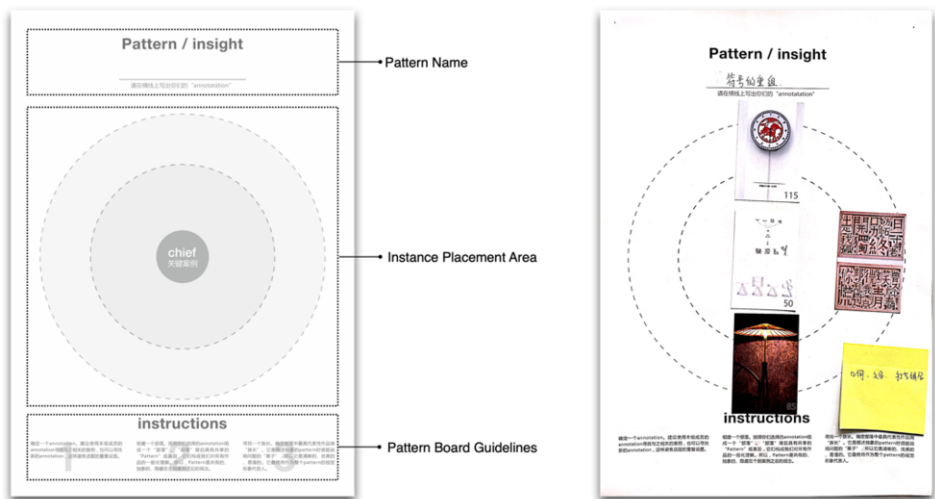

Figure 3. Pattern Board.

This step was conducted in small groups of 2 to 3 designers each. Small-group annotation comparison offered several advantages. It promoted more active and energetic discussions, reduced the chance of deflection due to excessive group size; facilitated consensus within groups for quicker decision-making; and more, limited participants more likely to discover diverse patterns.

After annotation comparison, each group named the pattern boards to obtain more generalized design patterns. Pattern identification can establish a hierarchical relationship between individual annotations and design patterns. Each group then shared and presented the design patterns they had discovered (Figure 4).

Figure 4. Design patterns sharing.

3.6. Optimizing Patterns

Through pattern identification, a total of 35 design patterns were identified from 121 annotated cards. Due to some degree of similarity among these patterns, they were condensed to 11 patterns through consensus discussions. Each pattern includes a pattern name and a description of the pattern (Table 1). Taking the **Creating Blessings** pattern as an example, we found that 11 instances employed this strategy for creativity.

The number of instances per pattern ranged from 2 to 34, indicating the varying prevalence of different patterns. **Reconstructing and Recombining Symbols** was the pattern with the most instances (34), while the **Providing Proof of Travel** pattern was observed in only 2 instances. The study also revealed some instances that employed multiple creative strategies. For instance, "Diaolou Cast Iron Teapot" (Wen, 2017) demonstrated both **Arranging Miniature Landscapes** and **Reconstructing Traditional Crafts** patterns.

3.7. Creating Card-based Tools

The history of card-based tools in design dates to Charles and Ray Eames, renowned American designers who created it in 1952. They intended to provide images of items they appreciated to inspire designers' creativity (Roy et al., 2019). Card-based tools were initially a way to support designers in storing design knowledge and fostering

brainstorming. Lockton et al. (2013) found that designers, after using card tools, could spark concepts that hadn't emerged in traditional brainstorming sessions.

The 11 design patterns were presented in card format, as shown in Figure 5. The front side of each card includes the pattern name, pattern explanation, and a QR code for accessing more instances. The back side contains a representative instance and its information.

Table 1. Eleven design patterns were identified from 121 annotated cards.

Patterns	Descriptions	instances
Recreating Past Experiences	Enabling products to recreate past behaviors and experiences during usage, such as adapting cultural artifacts for new contexts using modification.	6
Enhancing User Engagement	Creating dynamic interactive effects for users during product usage, such as allowing the product to be in an incomplete state that users can complete through interaction.	14
Providing Proof of Travel	Enabling products to record visited locations and serve as a memento for sharing travel experiences.	2
Reconstructing & Recombining Symbols	Transforming cultural symbols or combining them to create a new product.	34
Arranging Miniature Landscape	Creating a sense of unfamiliarity by miniaturizing typical cultural heritage elements such as landscapes and sculptures.	11
Making symbols wearable	Viewing the body as a "display platform" and cultural symbols as "wearable exhibits."	16
Crafting Punning Allusions	Creating products using well-known " Punning Allusions" "idioms," or "catchphrases" can generate unexpected feelings.	5
Creating Blessings	Enabling users to experience the culture of blessings provided by the product.	11
Turning waste into treasure	Transforming seemingly useless local materials into commemorative items.	3
Reconstructing Traditional Crafts	Exploring the potential of incorporating traditional craftsmanship into new products' CMF.	6
Stimulating Sensory Experience	Initiating sensory exploration by engaging various sensory attributes such as visual, auditory, taste, smell, and touch to stimulate people's sensory experiences.	25

4. Empirical Evaluation of Intermediate Knowledge Cards

Through participatory observation, this study conducted two distinct cultural and creative practice projects to test the efficiency and effectiveness of intermediate knowledge cards in specific contexts.

4.1. Participant Observation

The experimental task is a virtual project for two senior students, namely the cultural and creative design of Shang and Zhou bronze culture and Beijing's central axis culture.

Before the experiments, the two designers conducted thorough investigations into Shang and Zhou Dynasty bronze culture and Beijing's central axis culture, respectively, and developed preliminary proposals. The proposals indicated that the first designer was constrained by the form and texture of bronze artifacts, while the second designer was fixated on the idea of a cultural map. This reflected that the two designers possessed varying degrees of design fixations (Jansson & Smith, 1991)

During the experiments, researchers presented the cards to designers one by one and allowed designers to browse the cards independently. Inspired by the cards, designers verbally reported the ideas they envisioned. If necessary, researchers could provide explanations for the cards but tried not to interrupt the designers' thought process. The experiment was recorded in audio format, transcribed into written notes, and used for analyzing the design activities. After the experiment, brief interviews were conducted regarding the opportunities and challenges presented by the intermediate knowledge cards. Designers were also asked to develop the solutions discussed during the session.

Figure 5. Intermediate knowledge card sample.

4.2. Results

Both designers were able to generate responses and reflections based on the intermediate knowledge cards. They generated many feasible creative ideas with specific patterns. The designers attempted to "bridge" the cultural information they had investigated with the intermediate knowledge, structuring their artifact knowledge into meaningful ideas. This "bridging" often triggered more potential ideas.

For instance, the pattern of **Reconstructing and Recombining Symbols** made designers realize that the evolution process of bronze artifacts could serve as the starting point. Another designer, in the report for the Central Axis buildings with pattern **Enhancing User Engagement**, presented various alternative ideas for users to "fill buildings with colored objects," "color it," and "use them as game pieces".

Beyond the inspiration effects of a single pattern, designers also engaged in conceptual bridging between two or more patterns. In the first experiment, the idea of "utilizing casting and welding rebuilt artifacts" was initially presented in the pattern **Enhancing User Engagement**. Inspired by **Reconstructing and Recombining Symbols***,* an interesting combination emerged that went beyond rebuilding a specific bronze artifact, but also highlighted the different forms and craftsmanship across various eras. In the second experiment, the designer initially proposed the idea of "filling buildings with colored objects" in pattern **Enhancing User Engagement**. Later, Under the influence of **Stimulating Sensory Experience**, an interesting addition has been made to the idea, giving the filling a certain sense of smell. It indicates that the inspirational effect of the intermediate knowledge cards not only occurs within individual cards but also occurs between different cards. The combination of intermediate knowledge cards yields various alternative solutions in specific contexts.

Furthermore, Designers exhibited different levels of attention to the 11 cards, reflecting their varying interests. This study also indicates that not all patterns have equally strong inspirational effects across different projects. This could be attributed to two reasons. On one hand, it is indeed challenging for designers to bridge their existing knowledge of artifacts with certain intermediate knowledge. On the other hand, once designers find a satisfactory solution, their motivation to continue exploring other patterns diminishes. This could be explained by the principle of cognitive economy in the creative process.

4.3. Interviews

In the post-experiment interviews, both designers affirmed the significance of intermediate knowledge cards in their creative processes. The designer from the first experiment admitted, "I initially focused on collecting information about historical artifacts and existing cultural products…, but I only referred to their forms.… The **Reconstructing and Recombining Symbols** card inspired me significantly. I changed my perspective, and the different casting techniques in the Shang and Zhou cultures may be the idea I most want to develop.…." This creative idea was realized in her final solution (Figure 6). She reported her work as follows: "By using a set of combined molds to cast soap, users experienced the casting process of bronze artifacts."

Although the design solution from another designer did not appear directly in the report, the pattern **Enhancing User Engagement** had an indirect impact on designers, and we have given an analysis of this in the results section. The designer's final design, the "Seed Ticket" for Beijing's central axis buildings (Figure 7), incorporated user engagement, and the hidden seeds inside the ticket allow users to plant it.

Figure 6. The proposal for Shang Dynasty bronze culture: Handmade Soap Series

Figure 7. The proposal for Beijing Central Axis culture: 'Seed Ticket' Series

5. Conclusions

The study of intermediate knowledge can be traced back to Alexander's pattern language and the tradition of design thinking by Cross and Lawson. It is the general characteristic of solutions, the design elements of potential design solutions, having a generative role that can be applied by designers to new problem contexts.

This study extracted 11 design patterns from 121 creative cultural instances through a process of knowledge co-creation. These patterns, serving as typical intermediate knowledge, transformed into a card-based tool to support creative ideation. The extracted design patterns do not exhaust all possible intermediary knowledge but reflect the shared interests of participants in the process of knowledge co-creation.

Through two experiments, this study indicates that intermediate knowledge does indeed have a potential inspirational effect during the ideation phase for novice designers. The findings suggest that designers consciously bridge their existing knowledge with intermediate knowledge. This deliberate bridging effectively enhances design solutions and alleviates design fixations. Additionally, it was found that designers tend to further develop their ideas from the previous pattern and create conceptual bridges between two or more patterns, which effectively promotes the deepening and iteration of the solution.

In conclusion, we believe that intermediate knowledge holds some potential academic contributions. First, it can integrate and structure design knowledge from specific domains. Second, it externalizes the implicit knowledge of expert designers, facilitating the transfer of design knowledge between experts and novices. Third, it can enhance the efficiency and effectiveness of designers in design practice, particularly for novice designers. Furthermore, it can also assist innovative teams, companies, and organizations in knowledge innovation, fostering a spiral of knowledge evolution within the organization.

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