The Theoretical Framework of Design Thinking Behavior Model

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ABSTRACT

Presently, established research and development (R and D) based companies employ various expertise from different knowledge domains mainly to study and develop new products. These multidisciplinary organizations were formed with an integrated structure of various domains that include engineering, conceptual design, manufacturing, marketing, human factors, information technology and human resources. However, each domain comprises different characters of design thinking behavior, which results in dissimilar understanding of fundamental issues, user problems, product functions, aesthetic value and problem solution. Therefore, these differences, will affect the achievement of task objectives and timeframes. In relation to this, our paper approached a multidisciplinary organization to present a theoretical framework for studying the character of the design thinking behavior model from different knowledge domains involving a new product development process (NPD). The research utilized the Design Protocol Analysis (DPA) methodology, through observation on design experiments. Thirty participants were selected from different groups of knowledge domain and were tested on their behavior as part of the data collection. The data analysis clarified the specific character of design thinking behavior from a different domain groups, thus elucidating some queries on how the they defined task brief, focused factors, understanding the fundamental issues, extracting and composing information for problem-solving. Based on the research findings, the role and capability of each domain in the organization will be optimized, thus it proposes an appropriate position within a multidiscipline organization.

Keywords: Design Thinking Behavior, Multidiscipline Organization, New Product Design Process (NPD).

1. INTRODUCTION

Undoubtedly, the critical role of design into new product development (NPD) will determine the future of the company business. Design in all its form was born within a business environment to meet the need and serve business purposes [1]. The recent practice of NPD process in the research and development-based business (R&D) required a multidiscipline organization which consists of various fields of expertise from different knowledge and experience backgrounds, including the product system programmer, engineer, conceptual designer, marketing, manufacturer etcetera. These differences will influence the selection of factors on design strategy to user need, market trend and technology innovation, marketing plan and manufacturing process [1]. As a result, the differences of knowledge domain in multi-discipline contribute to a complex scenario,

increasing other aspects of policies, institutions and behavior, where sometimes the consequences is based on prediction, which is worse than the actual issue [2]. The different context of thinking behavior basically relates to the level of understanding the task brief, identifying the fundamental issue, focus on which concern factor that will influence the behavior approach of problem-solving. Design thinking is the way designers think, applied mostly in the field of design research and design education [3] and [25]. However, recently it is often used by other domains with different approaches [4] especially those involved in new product development activities such as engineering, marketing, and product planning divisions. Therefore, this research focuses particularly on the interrelated issue of design thinking factors approached in the design process within the multidiscipline organization (Figure 1).
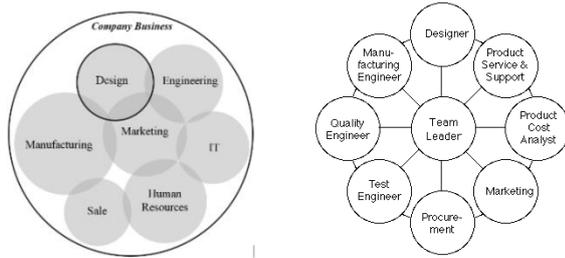
Figure 1: The concept of business function network in multidiscipline organization by Cuffaro (2013)

2. DESIGN THINKING PROCESS

A wide and complex range of design thinking comprises the whole cycle of human-centered innovation, including extracting the designer's knowledge for integrating user needs, identifying the appropriate technology to use and to adapt the essential business achievements [5]. Design thinking is an approach for new product development concerning business strategy. Broad contexts, subjective and personal-based, depending on individual interpretation, understandings and perception of a particular issue, as 'the language of design' [2]. It's such a reciprocal process between user and designer, to the users understanding, propose assumptions and refine issues towards organizing solution strategies that may not directly be accessible through a concise understanding. Plattner [6] underlined six phases of the divergent and convergent process of design thinking (Figure 2), through the theoretical model of 'problem space' which is the cause factor of 'what and why' and the 'solution space' which is the solution and implementation, systematic study methods through observation, questioning, brainstorming and other moderation techniques with a wide-range of ideas, imagination, user-oriented, direction based of corporate strategy vision. All these are within a certain time limit and cost for new designs through the concept of 'Stay Focused', with the principle of 'fail early and often'.

In this context, the design thinking process approach requires communication, integration and tolerance within the team and section in a design organization. Such user issues with various levels of complexity, through a different person and the issues, requires a specific method for each problem. Different knowledge backgrounds produce different concern factors, influenced ideas, and experiences towards tackling certain design issues. Thorough review on various contexts of the Design Thinking theory models in Table 1, there are no studies focusing on design thinking from a different domain, even though design activity involves multidiscipline organizations.

Table 1: Review on various contexts of Design Thinking theory models

The Design Thinking Behavior	Contexts & approached
'As language of design- sometimes the design solution of issue is towards prediction of consequences, might be worse than the actual issue' (Schön, 1983).	*Design solution by prediction-Intuitive.*
'The design approach toward different principles of designing visual elements & the combination of different form structure' (Akner-Kohler, 2002).	*Visual elements & form structure.*
'The thinking aloud' of designer's inner speech (thought) & external speech (verbal conversation), both is connected (Cross, 1996).	*Inner thought (Intuitive) & external speech (verbal).*
Design thinking is a reciprocal process, involves user understanding, propose assumptions & refine issues to organize solution strategies, might indirectly be accessible by comprehensive understanding (Georgiev, 2012).	*User perception, assumptions on proposes (Intuitive), analyze issue*
The argument from the data analysis correlates with the cognitive process (Ericson & Simon, 1993).	*Data analysis & cognitive process (Intuitive)*
Problem-based design, 'an Engineering Design (ED) suggests the cooperative work concept: Concurrent Engineering and Multidisciplinary Optimal Design concept' (Xu et al., 2007 & Tovar et al., 2007).	*Problem-based design*
Summary: The contexts & approach of design thinking -Prediction of consequences. -Inner speech (thought). -Data analysis correlates with cognitive process. -Assumptions on propose.	**# Issue:** **No study** focusing on design thinking from different domain, even though design activity involves various disciplines.

2.1 The Research Method for Design Thinking Behavior

The research methodology approach is mainly to understand the way of thinking and rationale of the design solution process. Bakeman and Deckner [7] emphasize some challenges in collecting research data ~~in~~ during the analysis process. The appropriate study method for problem-solving through behavior study from the design experiment will provide an option for the evaluation procedure. Newel and Simon [8] insisted that the data findings from the video recording in the thinking aloud protocol process contributes to the logic in design solutions supported by nonverbal and verbal data. The verbal report is meant to achieve the research aim of investigating the participants thinking at the experiment stage [9]. It fact, the Design Protocol study offers a key role in empirical research [10]. Lakof and Johnson [11] initiated a specific 'meaning' on the study of people's intuition, imagination, and feeling, in order to understand their experiences and body language. However, the 'meaning' is unstructured and holistic, where the data analysis of structure behavior requires description

through the process framework. Therefore, through those theories, the behavioral issue of verbal or non-verbal needs to be defined, for the development of think-aloud protocol or Design Protocol study (DPA) from Anwar [10]. This provides a great impact on the development process and the method selection for the design thinking study.

2.2 Multidiscipline Design Thinking Approach

Based on Figure 1, there are three major domains which are closely involved in the new product development activity namely the creative domain (art-based), technical (engineering), and product user system (interface).

a) Art-Based Design thinking: The art-based design approach mainly focuses on the product appearance with a rather deep concern on the actual fundamental issue. 'The design approach focuses on the combination of system rules' [12] and 'the different principles of designing visual elements and the combination of different form structure' [13]. The criteria of product appearance includes the aesthetic elements, form styling, color, texture, and surface finishing. This specific approach is slightly inappropriate to the direction of a multidiscipline design management concept that needs optimum collaboration, exchange information, compromise between two issues, or contexts. *'Design in all its form was born within a business environment to meet the needs and serve the business purposes'* [1]. Even though the business needs and purposes are varied and changeable according to business target and strategy, it must also follow the user desires and issues, product function, and trends.

b) Engineering-Based Design: The design thinking theories from Engineering Design (ED) featured with various intentions in multidiscipline organization contexts. [14] Tovar is concerned with the problem-based design, demand for cooperative works, through the 'Concurrent Engineering and Multi-disciplinary Optimal Design' approach from the concept of 'Function-Based Design' insisting on technical specifications to direct the design. The process required communication, integration, and tolerance within the team and division in a design organization. Meanwhile, the 'Domain Position' theory from Pahl and Beitz [15], emphasizing different concern factors and positioning specific issues, relies on individual knowledge and experiences of senior or high-level positions. *'The good idea solution comes from those having long experiences and knowledge experts, who forced the design issue into consensus'* [15]. However, the reality is where multidiscipline team members might be unfamiliar with specific specifications or requirements of each phase in the process. In the interim, the theory of design thinking from Tjalve [16] asserting a *'quantified structure concept'* which connects the product function and design elements, focuses on product appearance and features, but fewer concerns on user issues. For example,

how to design a handle or to decorate the product control panel. Therefore, generally, the theories from the Engineering Design (ED) group highly focuses on sub-component problems of technical factors and sometimes concern for user issues. As the multidiscipline organization concept requires a collaboration among the development team, therefore the approach of design thinking from a specific category of technical knowledge is also a demand for collaboration between different domains, which is a huge challenge to some theory model from the Engineering domain.

c) Interface Design: The design thinking of Interface Design is specifically related to human-computer interaction (HCI), while connecting physical data input (button key-in) and visual perception (eye contact), involves a cognitive process. *'It's about using software or computerized devices, concerning style or outlooks of screen-based of Interface Design"* [30]. The focus on a certain area only, which is related to cognitive interaction activity for digital on-screen problems, including contents, commands, and operating systems. Theory from Dillon [17] stated, *'the HCI process involves psychomotor, problem-solving, navigation, representation, perceptual and sub-cognitive elements',* related to *'the functionality'* of design, transfer information from product to user, less concern ~~of~~ for aesthetics, user desire on product physical form, operating mechanism, technical specification, and market trend. Therefore, design thinking from the Interface Design group moves toward a specific approach, however it is imbalanced at the full cycle of the new product design. Meanwhile, it has contradicted the principle of multidiscipline organizations for expanding problems and the use of different knowledge and sources of the invention [18]. The diverse approach requires equal division of various concern factors and not just focusing heavily on certain factors. Through the various approaches, design thinking is different based on different (three) knowledge domains. The context of design thinking involves cognitive thinking.

2.3 Cognitive in Design Thinking for Problem Solving

The internal thinking of problem-solving involved both cognitive psychology and functional psychology [19]. The cognitive psychology is about the information of sensory processing, a non-physical element, and a sort of transformation context, description, storing, usage, images, illusions, plus a different part of mental science. Moreover, the functional psychology involved conceptual behavior, non-informative, language and thinking, connecting environment, and behavior through prediction [20]. Besides, the C-K theory model of Hatchuel and Weil [26], insisted the transformation of knowledge (K) and design concept (C) is described through the new concept transformed into new knowledge to become a proposed problem solution. However, through the multidiscipline organization, each domain individually thought of a proposal with different

contexts of solutions, through the different approaches of cognitive thinking. For example, the art-based designer insists on the aesthetic, form, color, and visual design, while engineering design is concerned with product functions, user issues, and usability, thus resulting in different solution approaches [12] and [21]. Specifically, Hubka and Eder [22] classified cognitive knowledge into five categories including.1) Declarative knowledge: the fact of information, to get knowledge about something. 2) Procedural knowledge: the way knowledge is stated, to know the approach process. 3) Situation knowledge: understanding about where and when to acquire declarative and procedural knowledge. 4) Strategic knowledge: the processes for planning and approach to ease the knowledge purpose. 5) Tacit knowledge: previous knowledge from experiences. Therefore, the cognitive thinking from various knowledge domains plays an important role to determine problem-solving. In these contexts, to understand the internal thinking (cognitive) of problem-solving from different domain requires d a design experiment to observe the behavior of participants during the design activity, which carry meaning and criteria through the Design Protocol Analysis (DPA) methods.

3. THE DEVELOPMENT OF THEORETICAL RESEARCH FRAMEWORK

The diagram in Figure 3 presents all contexts of research to study, which consist of all major components in the theoretical framework, including the concern factors, established or variables, and the presumed-correlation for each of them [23]. The concept structure and process flow are adapted from the Design Research Methodology (DRM) framework [24]. The grounded theory of this concept is to understand the design management and design strategy in a multidiscipline organization for (NPD) activity. The detail contexts is clarifying the definition, criteria, scope, process, and methodology approach, which are reviewed from several credible theory models. Additionally, it clears up the design thinking behavior, design management, and design process problem-solving in NPD from a different domain. The central highlight of the design thinking approach are the concern factors, problem-solving process, and product usability concern. The fundamental problems in multidiscipline management relates to the complexity in communication, the decision making among the group members, and lack of leadership skills in the design organization [28], contributes a loophole to the NPD process and the project outcome, where it involves anticipating and solving some of the conflict [27], plus the inability to convince their idea solution, whether internally or externally.
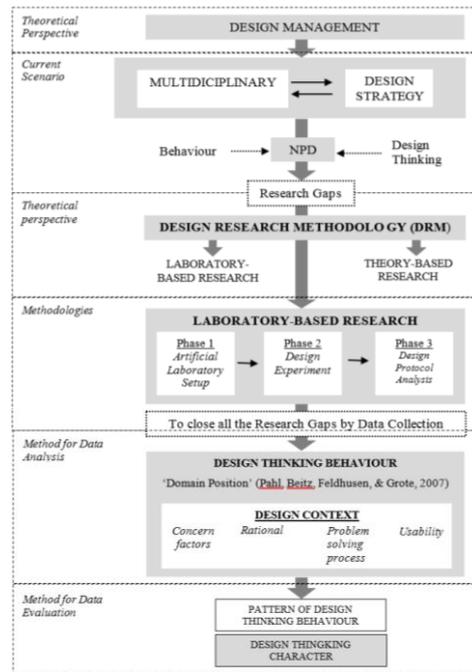
Figure 3: The mitigation of core issues of literature reviews, (arrows: influenced by others and the connection between variables)

Based on all the differences and weaknesses, the design experiment of Design Protocol Analysis (DPA) method from Anwar [10] and Cross [4] is approached within a controlled environment. The design task requires them to draw a new design of Astro TV remote control unit for the elderly or special needs users. The controlled area laboratory was equipped with various reference materials and devices. The study involves critical inquiry, extracting research phenomena of the participants from different domains. The research direction focused on the cognitive connection of the design process and product, which is observing the design activity and reference materials. In addition, the cognition collaboration factor was approached at the design improvement stage. Moreover, the theoretical research framework focuses on the participant's behavior during the information searching process within the context of the cognitive system from different domains. Figure 3 shows how the allocated cognition gives the framework for presenting the processed information and which theory and design process acts significantly.

The framework presents an active involvement of the cognition element. In design, the solution justifies the major design context of concern factors, the problem-solution process, and the usability approach. The participant's decision-making is relevant as a reference model for design thinking behaviors through the pattern of problem-solving in the design process. Simon [29] stated the decision making and design are related to each other, influencing the design thinking perspectives. Furthermore, the research framework starts of in being goal-oriented and stating the plan on how certain

activities are connected with different ranks of design achievement. Diagram in Figure 4 shows how the process of identifying a valid practice activity in this research to study the different knowledge background participants, specifically in the process of design thinking. Moreover, it identifies the relationship of dimensions (character) of the research phenomena or the differences among the different domain s groups which include the Engineering Design group (ENG), Interface Design group (ID) and Industrial Design group (IDE).

The theoretical framework clarifies the specific criteria of design thinking behavior from three domain groups, collected in the design experiment of DPA. The fundamental background of the research is to confirm the context of a multi-disciplinary design strategy to be adapted by the design management team for the NPD process. The design experiments required them to redesign a new Astro TV remote control for the elderly or special needs users with some reference material as a design influence or guideline. Based on the task, the behavior of design thinking will be observed and analyzed, on how they perceive and study information, thus strategizing problem solving through design sketches or drawings.

Figure 4: The theoretical framework of design thinking behavior from multi-discipline design organization

4. CONCLUSION AND FUTURE WORKS

In this paper, we integrated the variables through inductive reasoning, where the design activity (DPA) provides related evidence of design thinking behavior in multidiscipline organizations for the New Product Development (NPD), while moving towards a constructive approach. The argument from inductive logical will support the conclusion stage of this research, which includes the design meaning in the design thinking process. The observation session during the design activity will provide the true answer, which is the pattern

of design thinking behavior from the design idea and their behavior action while designing.

Our future work will include exploring and clarifying the rationale behind the final decision from the collaborative work toward constructive reasoning.

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