AN INSTRUMENT FOR ASSESSING LEVELS OF ABSTRACTION IN EDUCATIONAL DESIGN BRIEF FORMULATIONS

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ABSTRACT
This paper proposes means for examining the relationship between language use in design briefs and design outcomes in order to support design educators in the formulation of purposeful design guidance.

Keywords: Design brief formulation, design education, assessment, abstraction

1 INTRODUCTION

Problem formulations are believed to be an important factor affecting mental representation and performance [5, 7]. Varying design brief formulation has previously been examined in the form of a heuristics method to promote creativity in design outcome, often leading to the comparison of two extreme cases being described as "open-ended vs. closed-ended" or "imprecise vs. precise" formulations. In general, design outcomes are more creative and original when based on open-ended and imprecise formulations, which seems to encourage designers to seek additional information and further define the design task. Goldschmidt [7] reports that using an open-ended formulation, which aims to avoid the forming of preconceptions, leads to more original design proposals. Fricke [6] also describes that designers who are given a precise formulation tend to perceive the information in the design brief as complete and proceed to develop their responses without seeking further information. However, these formulations still rely mainly on an individual design educator's experience while no formal framework has been proposed to study the effects of different types of educational design briefs on design students. In order to study the relations between problem formulation and design performance while limiting the influence of design expertise level to design students, this paper proposes and presents a validation of an instrument for assessing types and levels of abstraction used in educational design briefs. The purpose of this work is to examine the relationship between language use in design briefs and design outcomes in order to support educators in the formulation of purposeful design guidance.

2 BACKGROUND

Many researchers in different domains have suggested that experts tend to form abstract representations of problems while novices focus more on the surface features of the problems [2, 4]. Utilising these findings, the notion of abstraction is chosen as the tentative framework for a brief formulation instrument reflecting this tendency and corresponding to different mental representations naturally formed by designers with

different levels of expertise. The proposed instrument shown in Table 1 incorporates three types of abstraction, based on Rasmussen's *abstraction hierarchy* (AH) [10], Rosch's *linguistic taxonomy* (LT) [11] and *scenario-based design* (SB) as described by Carroll [1], Guindon [8], et al. These three concepts are closely related to problem-solving, preconceptions of everyday objects as well as design expertise. Abstraction hierarchy is developed to systematically analyse and solve complex problems by examining the problems from both the designer's and end-user's point of view (functions vs. physical structures). Linguistic taxonomy suggests that a natural abstraction of physical objects (e.g. table) exists in mental representation. Any words above this level of abstraction are called superordinate (e.g. furniture) while the ones below are called subordinate (e.g. kitchen table). For expert designers, scenario-based design is applied to effectively uncover hidden design requirements and to identify potential constraints when solving design problems [1]. These three concepts of abstraction are modelled as diagrammatic dimensions to describe, to analyse and potentially to guide design brief formulation.

3 METHOD AND PROCEDURES

Semi-structured interviews were conducted with 7 design educators (teaching experience ranging from 5 years to 25 years) from three design disciplines (environmental design, product design and visual communications) to solicit background information on how design briefs are formulated according to different learning objectives. A seemingly common position articulated in all interviews is that a design brief needs to provide an anchor point for the design students to explore the problems and generate initial concepts for solutions. Educators also consider the students' experience level, skills-based ability, project schedule and, where applicable, desirable types of outcomes when choosing this anchor point. Each of the educators was asked to share some of their design briefs used in actual design courses. A total of 13 design briefs were collected and examined based on their content and formats. The collected briefs are in written format ranging from 2 to 5 pages. The content of the brief varies depending on disciplines but generally consists of five main sections, which are background, aims and objectives, design task, deliverables, schedule and assessment criteria. These findings were later integrated to supplement the abstraction instrument to formulate different design tasks used in the survey questionnaire.

The questionnaire was distributed to 52 (Yr1: 9; Yr2: 38; Yr3: 5, 24M: 28F) BA(Hons) in Product and Industrial design students (of a three-year programme). Each student was asked to take up to 1 hour to finish the questionnaire independently. In the first part of the questionnaire, the subjects were asked to rate the perceived levels of abstraction and complexity of 13 pairs of design tasks based on a 5-point scale (i.e. from very abstract(5) to very concrete(1) and from very complex(5) to very simple(1)). 4 pairs out of the 13 pairs were selected for the second part as actual design tasks, which required the subjects to answer in their own words what the brief ask them to design, how they plan their design activities, and make conceptual sketches describing initial solutions. The questionnaires were quantitatively analysed. The short essay-type answers were examined by means of a basic content analysis for student's ability to outline different design activities with the given tasks. The sketches were later evaluated quantitatively on a 5-point scale by two expert reviewers for six different criteria including originality, interest, innovativeness, usability, functionality and usefulness.

4 RESULTS

4.1 Questionnaires survey

Mean values were calculated for the abstraction and complexity score and paired-samples T-tests were performed on the 13 pairs of design tasks. The results shown in Table 1 indicate that there is a significant difference in abstraction perception for task pairs formulated by the LT dimension, which is in agreement with the studies of psychological categories of concrete objects [11]. Upon closer examination, the abstraction score comparisons of furniture set (3.5) > table (3.1) > kitchen table (2.7) seem to support Rosch et al.'s findings of a basic level of abstraction. Since the basic level of abstraction is the most available representation when recognizing an object [11], design tasks formulated under this abstraction may promptly be recognized by the subjects and this explains the lowest complexity score reported among the three design tasks, furniture set (3.2) > table (2.6) < kitchen table (2.8). For the SB dimension, the abstraction scores conform to the expectation of concrete scenarios.

Table 1 Abstraction Dimensions and formulated design tasks

Abstraction Dimensions	**Design brief questionnaire items abstract (a) vs. concrete (c)**	**Abs. Mean**	**Comp. Mean**
(*linguistic taxonomy, LT*) Superordinate vs. Subordinate	1a) Design a table	**3.1***	2.6
	2a) Design a piece of clothing	**3.8***	2.9
	3a) Design a furniture set	**3.5***	3.2
	4a) Design a vehicle	**3.5***	4.3
	1c) Design a kitchen table	**2.7***	2.8
	2c) Design a dress shirt	**3.0***	3.0
	3c) Design a children sitting sofa set	**2.6***	3.0
	4c) Design a sport coupe	**2.9***	4.1
Whole vs. Parts - - - - - - - - - - **(*abstraction hierarchy, AH)*** Functions vs. Structures	5a) Design a ventilation system for a kitchen	2.7	3.6
	5c) Design an exhaust fan outlet for a kitchen	2.5	3.4
	6a) Design a device to remind important day and time for the visually impaired	**2.2^**	**3.7***
	7a) Design a wearable time-telling device	3.0	3.2
	8a) Design a new board game that friends and family can enjoy playing together	3.3	3.4
	9a) Design a lighting device that enables books reading at night	2.6	2.8
	10a) Design a kids' toy for learning the English alphabet	2.7	**3.3***
	6c) Design a talking alarm clock	**2.7^**	**3.0***
	7c) Design a diamond watch	2.8	3.2
	8c) Design a new game board for the game *Monopoly*	2.4	3.4
	9c) Design a desktop lamp	2.8	2.8
	10c) Design an English alphabet playing set	3.0	**3.0***
(*scenario-based design, SB*) Formal specifications vs. Narrative scenarios	11a) Design a flash memory-based portable music player	2.7	3.1
	12a) Design an automatic door	**3.2***	**3.4***
	13a) Design a desktop lamp	**2.8***	2.8
	11c) Design a music player that will let a jogger enjoy listening to music when jogging	3.0	3.3
	12c) Design the front door for a busy department store	**2.8***	**3.1***
	13c) Design a bedside lamp for people who like to read at night before going to bed	**2.4***	2.8

*denote a significant pair at $p < 0.05$ level, ^denote a significant reverse pair at $p < 0.05$ level

The results for the AH dimension remain inconclusive, especially with the reverse scoring pair for task 6. Therefore, a factor analysis, specifically a data reduction method aiming to uncover hidden structures of statistical data, was performed for the perceived notions of abstraction. The first two factors fit predominately with the LT and AH dimensions while the last factor contains items from both the AH and SB dimensions. Tasks 12a and 13a from the SB dimension are incorporated into the first factor which suggests those two formulations can possibly be grouped under the LT dimension. This finding indicates that readers should exercise caution the abstraction instrument should be treated as a tentative tool for aiding design task formulations but not solely as a theoretical device. For the notions of concreteness, no clear structure was observed from the factor analysis. A possible explanation is that all the concrete dimensions are associated with physicality and cannot be separated into distinct sub-dimensions.

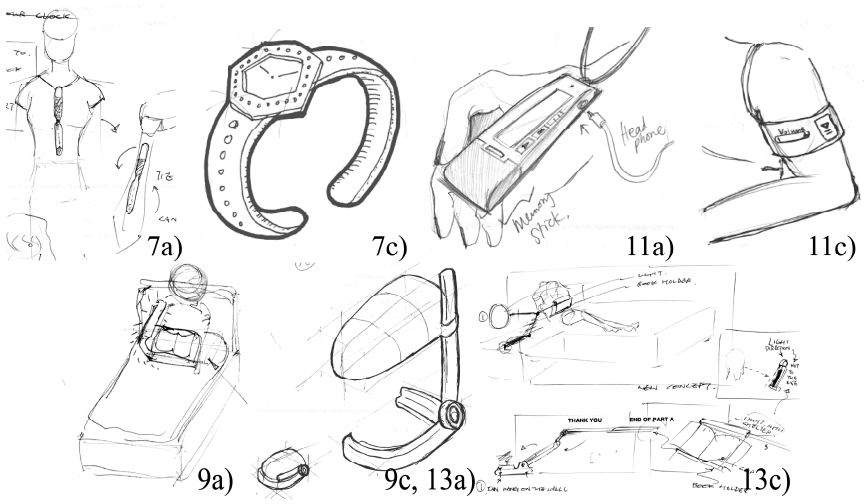

Figure 1 Samples of preliminary sketches

4.2 Preliminary sketches

For the qualitative design exercises, subjects' preliminary sketches (Figure 1) were evaluated by two expert reviewers (a design educator with 7 years of teaching experience and a PhD design student) based on a five-point scale ratings of originality, interest, usability, functionality, usefulness and innovativeness. The sketches were also analysed for the subjects' attentions to different task formulations (Table 2). Design task 7a is a somewhat typical example that accords with the previous notion and results of an open-ended design brief [7] which is free of preconception. The ANOVA results (not shown) are significant in all the creativity ratings (originality, interest, innovativeness) when compared to those from the concrete version 7c. For the next pair of task (11), the findings suggest that the subjects' representation is primed by the image of similar existing players even though "a portable music player" was not considered a preconception when it was used to formulate as a design task 11a. Subsequently, attention was drawn to the design of the control buttons layout instead of the actual player. This reaction was unexpected and it explains to some extent the insignificant difference in all the ratings between the tasks. Task pairs 9 and 13 are overlapping because all the formulations are based on desktop-type lamps. No significant difference was found between the two pairs in any of the ratings. Sketches from Task 13c which is

formulated based on a scenario achieved higher scores in the usability rating compared to the rest of the sketches. Interestingly, when the design task was only about the physical object, the subjects were much more engaged to improve and added values to existing designs.

Table 2 Preliminary sketches analysis for students' attentions to different formulations

Design task 7 (AH)	7a) Design a wearable time-telling device	7c) Design a diamond watch
Common features (# of sketches showing the feature)	-display time using conventional methods (3/12) -use a speaker to tell time (3/12) -wear on the wrist (5/12)	-wear on the wrist (18/19) -display time using conventional methods (19/19) -contain diamonds (19/19)
Design task 11 (SB)	11a) Design a flash memory-based portable music player	11c) Design a music player that will let a jogger enjoy listening to music when jogging
Common features (# of sketches showing the feature)	-with a USB-connection (3/12) -showing control buttons (8/12) -small size, portable (9/12)	-showing control buttons (3/12) -small size, portable (4/12) -showing an end-user (8/12)
Design task 9 (AH)	9a) Design a lighting device that enables books reading at night	9c,13a) Design a desktop lamp
Common features (# of sketches showing the feature)	-showing an end-user laying on a bed (4/12) -showing an end-user (6/12) -showing a book (8/12)	-varying light intensity (4/13) -adjustable lamp height (6/13) -typical lamp structures (light bulb / lamp shade / power switch/support mechanism) (7/13)
	13c) Design a bedside lamp for people who like to read at night before going to bed	
	-emphasize on a typical lamp structure/construction (3/12) -scenario showing a book (7/12) -scenario constructed with an end-user laying on a bed (7/12)	

5 DISCUSSION AND CONCLUSION

Besides the performance ratings, the different focuses of attention in the preliminary sketches initiated by the abstraction instrument are of great interest to me because of their implications to devise different design briefs according to different objectives especially for projects under a tight schedule. Nonetheless, a few limitations of this study should be noted. Firstly, English is the second language of most participants in the study. Some pilot subjects did express uncertainty regarding English vocabulary in the original questionnaire. In order to alleviate this potential obstacle, Chinese translations [9] at comparable abstraction levels were provided in the final version. Additionally, only 4 pairs out the 13 pairs of design tasks were chosen for the qualitative design exercises with sketches particularly aiming to explore the effects of the AH and the SB dimensions which are considered more complex that the LT dimension. For the LT dimension, the primary difference lies in the semantic representation of categories, releasing and adding concrete features to the design task representation. We speculate that the natural categories of concrete objects tend to convey the perception of a simpler task than their superordinate or subordinate counterparts leading designers to gather less information and solve a simpler problem [3]. Finally, an unexpected result concerning the reverse task pair 6 should be further investigated in future studies.

In this study, a quantitative research approach was used to explore the complex notions of perceived abstraction. Some preliminary results are shown regarding the evaluation of the proposed abstraction assessment instrument to formulate different design briefs. During the validation process, both the samples-t test and factor analysis indicate that the linguistic taxonomy (LT) is the most influential abstraction dimension, which perhaps reflects human's basic ability to differentiate and categorise physical objects. The other two dimensions (AH and SB) appear to be more flexible when formulating design briefs for the intangibles. The results obtained from analysing the preliminary sketches generally echo the educators' notion of an anchor point for design students. We found that students tended to attend to familiar objects that are stated in a design task and these objects will later reappear in their preliminary sketches. Design educators may formulate briefs using the AH concrete dimension to direct students' attentions to improve an existing design. Moreover, AH abstract dimension appears to inspire creative solutions and the SB concrete dimension emphasises usability. It is hoped that design educators with the abstraction instrument are better informed to choose these anchor points when formulating a design brief for different purposes.

REFERENCES

[1] Carroll, J. M. Scenario-based design: envisioning work and technology in system development. John Wiley & Sons, Inc. New York, NY, USA, 1995.

[2] Chi, M.T.H., Glaser, R. and Farr, M.J. The nature of expertise. Hillsdale, NJ: Erlbaum, 434, 1988.

[3] Christiaans, H. and Dorst, K.H. Cognitive models in industrial design engineering: A protocol study. Design Theory and Methodology, 42:131–140, 1992.

[4] Cross, N. Expertise in design: An overview. Design Studies, 25:427–441, 2004.

[5] Dominowski, R.L. Productive problem solving. The creative cognition approach, pages 73–95, 1995.

[6] Fricke, G. Successful individual approaches in engineering design. Research in Engineering Design, 8(3):151–165, 1996.

[7] Goldschmidt, G., Ben Zeev, A. and Levi, S. Design Problem Solving: The Effect of Problem Formulation on the Construction of Solution Spaces. CYBERNETICS AND SYSTEMS RESEARCH, pages 388–393, 1996.

[8] Guindon, R. Knowledge exploited by experts during software system design. International Journal of Man-Machine Studies, 33(3):279–304, 1990.

[9] Hornby, A.S. Oxford advanced learner's English-Chinese dictionary, 4th ed. Oxford University Press, 2002.

[10] Rasmussen, J. Information Processing and Human-Machine Interaction: An Approach to Cognitive Engineering. Elsevier Science Inc. New York, NY, USA, 1986.

[11] Rosch, E., et al. Basic Objects in Natural Categories. Cognitive Psychology, 8(3):382–439, 1976.

Acknowledgements

I gratefully acknowledge the guidance from my advisor, T. Fischer. I also wish to thank the faculty and BA(Hons) in Design students of the School of Design who have contributed to this study. This project is supported by HKPU (SD) PhD studentship (G.73.56.RGCL).

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