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Craftsmen Versus Designers:
The Difference of In-Depth Cognitive Levels at the Early Stage of Idea Generation

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Abstract : *This paper investigates the in-depth cognitive levels at the early stage of idea generation for craftsmen and designers. Examining this early stage may explain the fundamental thoughts in observing and defining design problems. We conducted an experiment using think-aloud protocol, where verbalized thoughts were analyzed using a concept network method based on Associative Concept Network Analysis (ACNA). Furthermore, we identified semantic relationships based on Factor Analysis. The findings showed that craftsmen tended to activate low-weighted associative concepts at in-depth cognitive level with a smaller number of polysemous features, thus explaining their concerns about tangible-related issues, such as proportion and shape. Designers, however, activated highly weighted associative concepts with more polysemous features, and they were typically concerned with intangible issues, such as surroundings context (i.e., eating culture) and users' affective preferences (i.e., companion, appeal).*

Keywords: In-depth cognitive level, Early stage of idea generation, Designers, Craftsmen

1. Introduction

This study focuses on the early stage of idea generation to capture the associative concepts at the in-depth cognitive levels of craftsmen and designers. Examining the early stage of idea generation may explain the fundamental thoughts in observing and reframing design problems. Many attempts have been made to capture users' affective preferences based on users as subjects. However, we examined the in-depth cognitive levels of the creators (craftsmen and designers), who attempt to grasp users' feelings when producing successful impressions of products (Cross, 2006; Nagai, et al., 2011). We conducted an experiment using think-aloud protocol, where verbalized thoughts were analyzed using a conceptual network based on associative concepts and semantic relation analysis.

1.1 Early Stage of Idea Generation

Idea generation, which consists of observation and ideation, is the essential step in the design thinking process. It is the interplay of cognitive and affective skills that lead to the resolution of a recognized difficulty (Houtz & Patricola, 1999). Following are general steps of design thinking; the early stage of idea generation is the step mainly discussed:

1. Early stage of idea generation: the stage to observe and reframe the design problem.
2. Later stage of idea generation: the stage employing sketches, graphs, or paper models to generate ideas visually.

The early stage of idea generation is one of observation by craftsmen and designers through first-hand experiences. This stage is associated with greater diversity of ideas (Leijnen & Gabora, 2010); therefore, it is reasonable to assume that one's fundamental thoughts are captured fairly at this point.

1.2 In-depth Cognitive Level

It is generally known that designers cannot express their thoughts explicitly; their latent sensitivity is widely researched in cognitive psychology. It is known as implicit cognition, which is understood to be that which is not explicitly recognized or verbalized (Reingold & Colleen, 2003). Explicit expression, which is presumably a shallow analysis, is referred to as surface-level cognition, and underlying cognition that is difficult to express is referred to as in-depth cognitive level (e.g., feeling, taste, impression) (Nagai et al., 2011; Georgiev & Nagai, 2011, Taura, et al., 2010) (see, Figure 1).

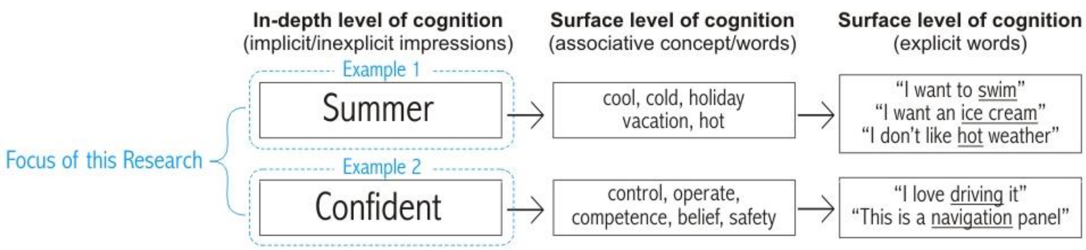


Figure 1. Focus of this research: capturing the in-depth cognitive level

Taura et al. (2010) explain that implicit impressions could exist in the feelings and are implied underneath explicit impressions that are related to deep impressions. Humans establish extremely rich metaphorical concepts (within in-depth impression) as key features of cognition in creative design; thus, a designer is able to capture a profound understanding of an object (Nagai et al., 2011). Previous studies have focused on capturing in-depth cognitive levels (impressions) of users based on created artifacts, but our study focuses on the creators of the artifacts (craftsmen and designers).

1.3 Verbalized Thoughts and Associative Concept Analysis

To examine the structure of thoughts from subjective experiences, a think-aloud, as a part of protocol analysis was employed to produce verbal reports of the thinking process (Ericsson & Simon, 2010). Subjects were instructed to describe their thoughts and observations and reframe design problems through verbal expression. Verbalized thoughts reflect some aspects of the regular cognitive process; for this study, they were reconstructed using a computational model to reproduce observable aspects of the in-depth cognitive level (Junaidy, et al., 2015).

Associative concept analysis captures concepts of an expression associated with the individual's mental state. The associative concept is comprised of six sub-types: connotative, collocative, social, affective, reflected, and thematic (Mwihaki, 2004). It is latent within implicit cognition. Therefore, a conceptual network is suitable as an associative analysis tool for exploring the latent links among concepts. In the field of psychology, the conceptual networks depict human memory as an associative system, where a single idea can contain multiple meanings (polysemous). The concept dictionary utilized in conceptual network is from the

University of South Florida free association, rhyme, and word fragment norms database (USF norms database) (Nelson, et al., 2003; Maki & Buchanan, 2008).

2. Aim

The aim of this research is to capture the differences in associative concepts at in-depth cognitive levels of craftsmen and designers at the early stage of idea generation in design thinking. Thus, we conducted an experimental study using think-aloud protocol, where designers and craftsmen freely expressed their ideas verbally.

3. Method

In this study, we used a concept network method based on the associative concept dictionary to extract verbalized thoughts. The framework of this research was comprised of the following steps (see, Figure 2):

1. Four craftsmen and four product designers conducted a think-aloud protocol. They were instructed to imagine designing a fruit basket/container and freely express their ideas verbally without necessarily drawing or observing the object. Verbal data were recorded, and the sorted verbal expressions were then transcribed into English.
2. The verbal data, which consisted of explicit words, were transferred onto vector graphs (conceptual network on the basis of the USF norms database) to obtain extraction of highly weighted associative words indicated by the out-degree centrality score (ODC).
3. Differences in the concept network structures were identified by analyzing the following:
   a. Density of connection, which exhibits the property of idea within the associative concept network.
   b. Semantic relation, which finds the characteristics of the associative concepts at the in-depth cognitive levels using an orthogonal semantic map based on factor analysis.

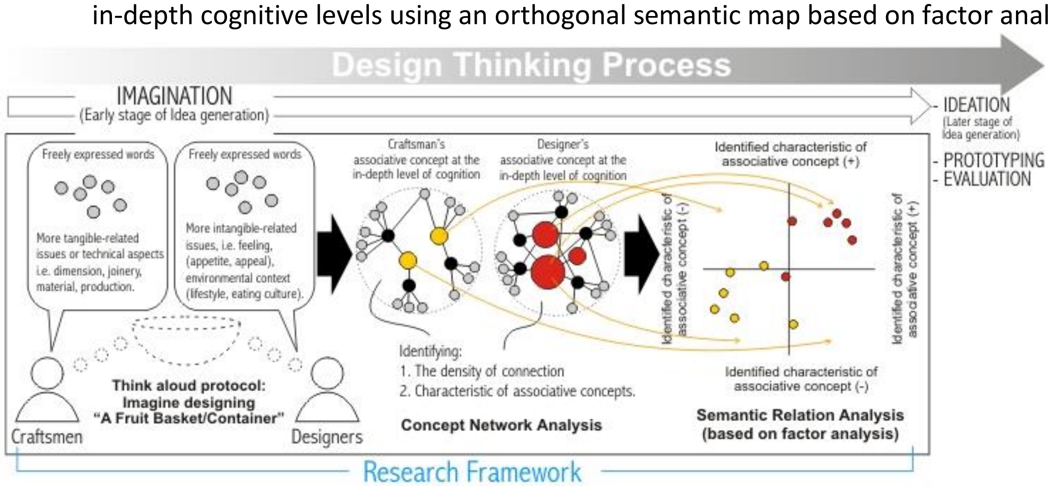


Figure 2. Research framework: capturing craftsmen's and designers' associative concept at in-depth cognitive levels at the early stage of idea generation

4. Experiment

4.1 Subjects

Eight subjects (four Indonesian craftsmen and four Indonesian designers in the age range of 27–51 years) participated in this experiment. The four designers were university graduates with experience in craft design and concern for natural material utilization. Each of the four craftsmen, known as master craftsmen, who has acquired special skills in artistry and apprehends design as an artistic or decorative creation. They gained their special expertise, passed down from one generation to another in the local village's traditional bamboo crafts.

4.2 Procedure

The experiment was set up simply; the subjects (craftsmen and designers) were not required to engage in specific activities, such as drawing or observing stimuli. They were deliberately conditioned with minimum instruction to be able to capture fundamental associative concepts. Rigid instructions about determining design theme, market segmentation, or design function were avoided since they might provide excessive information that would be unfair and misleading. Minimum instruction maintains a fair stage for noting craftsmen's and designers' first-hand experiences in observing and reframing design problems. There were no constraints on the subjects for expressing their ideas verbally and engaging in spontaneous thinking. All procedures were recorded as verbal data and transcribed word by word. Grammatical rules were followed for connecting words, such as prepositions, a few general verbs, articles, and pronouns; also, other less relevant explanations were omitted (Georgiev & Nagai, 2011). Finally, the sorted verbal data consisting only of nouns, adjectives, adverbs, and verbs were translated into English and further analyzed according to the concept network method on the basis of the USF norms database (also visualized as graphs using Pajek 2.05 with the algorithm of Fruchterman Reingold (Batagelj, 2003).

4.3 Concept Network Analysis

At the first stage of analysis, 107 sorted verbal expressions (nouns, adjectives, adverbs, and verbs) were obtained from craftsmen; 102 were sorted from designers. Expressions of craftsmen tended to focus on tangible aspects, such as technique, material, and production (bold text). Designers, however, paid more attention to intangible-related issues, such as users' affective preferences and the environment (bold text) (see, Table 1).

Table 1. Sorted verbal expressions

Category	List of sorted verbal expressions (partly shown)
Craftsmen	**capacity**, **dimension, measure**, **standard**, **super**, **big**, **count**, **size**, **leg**, **height**, **thin**, **shape**, **square**, **position**, **part**, **head**, **stack, body**, **solid**, **base**, **width, top, long**, **oval**, **three-dimensional**, **thick**, **centimeter, box,** design, container, fruit, duck, salt, egg, adjust, buyer, function, capable, form, set, color, supply, bamboo, scar, spot, glue, mark, sandpaper, etc.
Designers	**place**, **kitchen**, **pluck**, **tree**, **shop**, **sensation**, **reap**, **pick**, **preservation**, **tropical**, **rotten, fresh**, **delicious**, **interaction**, **inform**, **remind**, **children**, **invite**, **accommodate**, **people**, **way, salad**, **commercial**, **habit**, **crowd**, **appeal**, **appreciate**, **attractive, dignity**, **snack**, put, table, hang, fruit, wood, appear, stand, durian, banana, apple, orange, watermelon, grape, etc.

The sorted verbal data were further visualized as graphs of conceptual network analysis (see, Figure 3). Craftsmen's conceptual networks generated 1941 vertices (nodes), and designers' networks generated 1662 vertices (nodes). The networks were too dense and complex for analysis; therefore, it was necessary to simplify the created networks by a reduction method. Systematic reduction was based on considerations that not all the words from verbalized protocols contribute to an in-depth cognitive level, and surface-level cognition is overemphasized. The following indicate low scores associated with explicit words/surface-level cognition (bold).

- Craftsmen (total: 1941 words): 0.000–0.010 = 1462 words; 0.020 = 352 words; 0.030 = 94 words; 0.040 = 27 words; 0.051 = 6 words
- Designers (1662 words): 0.000–0.010 = 1259 words; 0.021 = 293 words; 0.032 = 77 words; 0.043 = 23 words; 0.054 = 8 words; 0.065 = 1 word; 0.076 = 1 word

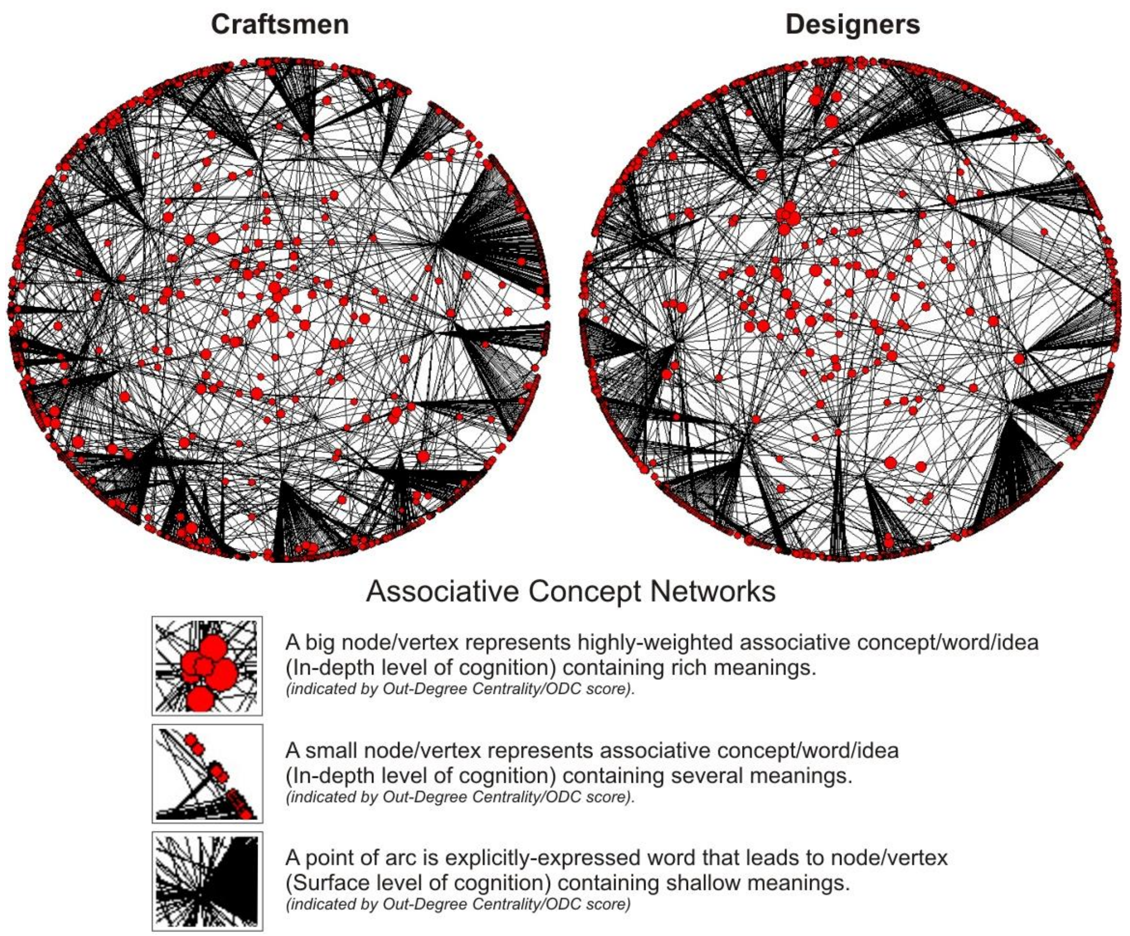


Figure 3. Associative concept networks of craftsmen's and designers' before reduction (words and scores not shown due to complexity)

5. Analysis and Results

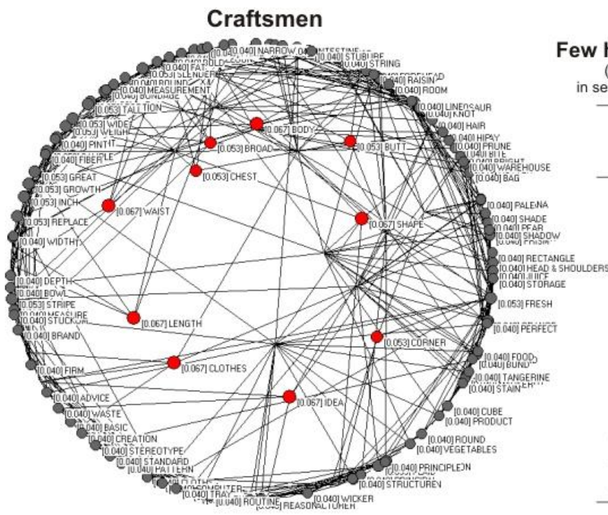
5.1 Conceptual Network Analysis (After Reduction)

Application of the simplified concept reduced the words that were less important to the networks so that the extraction of the associative concept within the in-depth cognitive level was apprehensible (Figures 4a & 4b). The reduction omitted <50% words with lower ODC scores to get an observable network diameter (Leskovec, 2008), (i.e., craftsmen: 50% × 0.051 ODC = >0.025ODC score ; designers: 50% × 0.076 ODC = >0.038 ODC score).

The reduction was applied independently to each group where the highly weighted associative words were identified at the in-depth cognitive level with ODC scores as follows (bold text) (see, Table 2a and 2b):

- Craftsmen (total: 202 words): 0.000 = 75 words; 0.040 = 94 words; **0.053 = 27 words; 0.067 = 6 words**
- Designers (total: 81 words): 0.000 = 48 words; **0.083 = 23 words; 0.104 = 8 words; 0.125 = 1 word; 0.146 = 1 word**

Hereafter, we selected the top 10 highly weighted associative words from each group for further analysis.



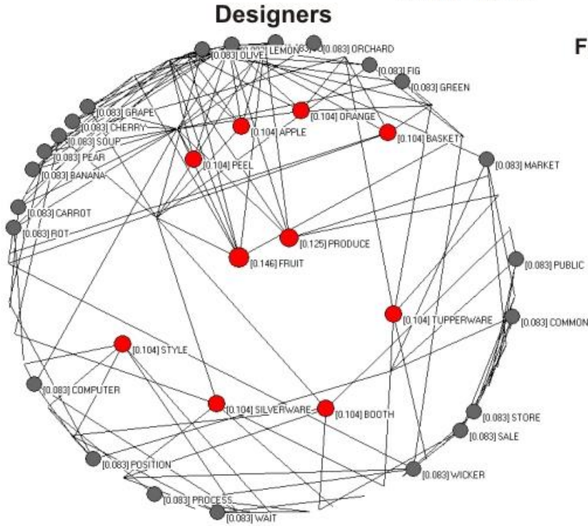
Few highly-weighted associative words
(a number of associative words are employed in semantic relation analysis based on factor analysis)

No.	In-depth Associative	ODC Score
1.	Body	0.067
2.	Clothes	0.067
3.	Idea	0.067
4.	Length	0.067
5.	Shape	0.067
6.	Waist	0.067
7.	Broad	0.053
8.	Butt	0.053
9.	Chest	0.053
10.	Corner	0.053
200.	Usual	0.000
201.	Wicker	0.000
202.	Width	0.000

Figure 4a. Simplified concept networks of craftsmen's in-depth cognitive level

Table 2a. Extracted verbal expressions of in-depth cognitive level (after reduction)

Category	List of 202 extracted verbal expressions (ordered by the highest ODC score)
Craftsmen	**body, clothes, idea, length, shape, waist, broad, butt, chest, corner**, creativity, exercise, fresh, great, grow, grown, growth, ideal, impression, inch, oval, plaid, portion, replace, sample, size, slender, stripe, suggestion, tall, tight, weigh, wide, advice, bag, etc.



Few highly-weighted associative words
(a number of associative words are employed in semantic relation analysis based on factor analysis)

No.	In-depth Associative	ODC Score
1.	Fruit	0.146
2.	Produce	0.125
3.	Apple	0.104
4.	Basket	0.104
5.	Booth	0.104
6.	Orange	0.104
7.	Peel	0.104
8.	Silverware	0.104
9.	Style	0.104
10.	Tupperware	0.104
79.	Way	0.000
80.	Wicker	0.000
81.	Wood	0.000

Figure 4b. Simplified concept networks of designers' in-depth cognitive level

Table 2b . Extracted verbal expressions of in-depth cognitive level (after reduction)

Category	List of 81 extracted verbal expressions (ordered by the highest ODC score)
Designers	**fruit, produce, apple, basket, booth, orange, peel, silverware, style, Tupperware,** banana, carrot, cherry, common, computer, fig, grape, green, juice, lemon, market, olive, orchard, pear, position, process, public, rot, sale, soup, store, wait, etc.

Up to this stage, data extraction according to the associative model suggested that craftsmen tended to activate low-weighted associative concepts, as demonstrated by the surface-level cognitive score of 169/202 (83.6%). Designers, however, activated more highly weighted associative concepts concerning issues linked to the presence of the fruit basket/container, as significantly demonstrated by a high ODC score and lower surface-level cognitive score of 48/81 (59.2%). Following are identified characteristics of craftsmen's and designers' associative concepts after reduction:

Table 3. Identified characteristics of craftsmen's and designers' associative concepts
List of identified characteristics

List of identified characteristics
(Proportion) length, inch, oval, portion, size, tall, tight, wide, centimeter, width, thin, thick, form, rectangle, measurement, narrow, weight, etc.
(Shape) body, shape, waist, butt, chest, corner, round, leg, hip, giant, cube, prism, etc.
(Operation) exercise, grow, replace, advice, bold, blend, bond, decision, firm, fit, perfect, stain, form, combine, cover, tie, trace, use, etc.
(Companion) fruit, apple, orange, peel, banana, carrot, cherry, fig, grape, green, lemon, olive, orchard, pear, etc.
(Appeal) salad, peel, juice, soup, process, produce, display, method, rotten, put, save, buy, shop, stand, fresh, etc.
(Scene) booth, silverware, tupperware, market, public, store, crowd, leaf, tree, wood, etc.

5.2 Analysis of Semantic Relation Based on Factor Analysis

We distributed 120 associative words corresponding to identified characteristics of associative conceptual structures; ODC scores ranged from highest to lowest (Table 3). Identified characteristics were proportion, shape, operation, companion, appeal, and scene—six variables used in factor analysis. Furthermore, the correlation among variables was extracted into two factors; the KMO score of 0,571 was significant. The factor matrix and corresponding names are as follows:

Table 4. Rotated factor matrix

Adjectives (+)	Adjectives (-)	F1	F2
Scene	Less Scene	,942	,009
Appeal	Less Appeal	,932	,193
Companion	Less Companion	,891	-,199
Proportion	Less Proportion	-,757	,613
Shape	Less Shape	-,722	,636
Operation	Less Operation	,140	,912
Eigenvalue (After rot):		**3,66**	**1,6**
KMO:		**0,571**	

Table 5. Corresponding name

Factor	Adjectives	Eigenvalue	Factor Name
F1	Scene, Appeal, Companion, Less Proportion, Less Shape,	3,66	**SURROUNDINGS**
F2	Operation	1,6	**OBJECT-ORIENTED**

For Factor 1, *Scene, Appeal*, and *Companion*, *Less Proportion*, *Less Shape*, hereafter referred to as *Surroundings*, were associated with the presence of the fruit basket/container. For Factor 2, *Operation*, hereafter referred to as *Object-Oriented*, concerned technical aspects of the fruit basket/container. Furthermore, factors were displayed on an orthogonal map to investigate the semantic relationships of the identified characteristics of craftsmen's and designers' associative concepts (see, Figure 5).

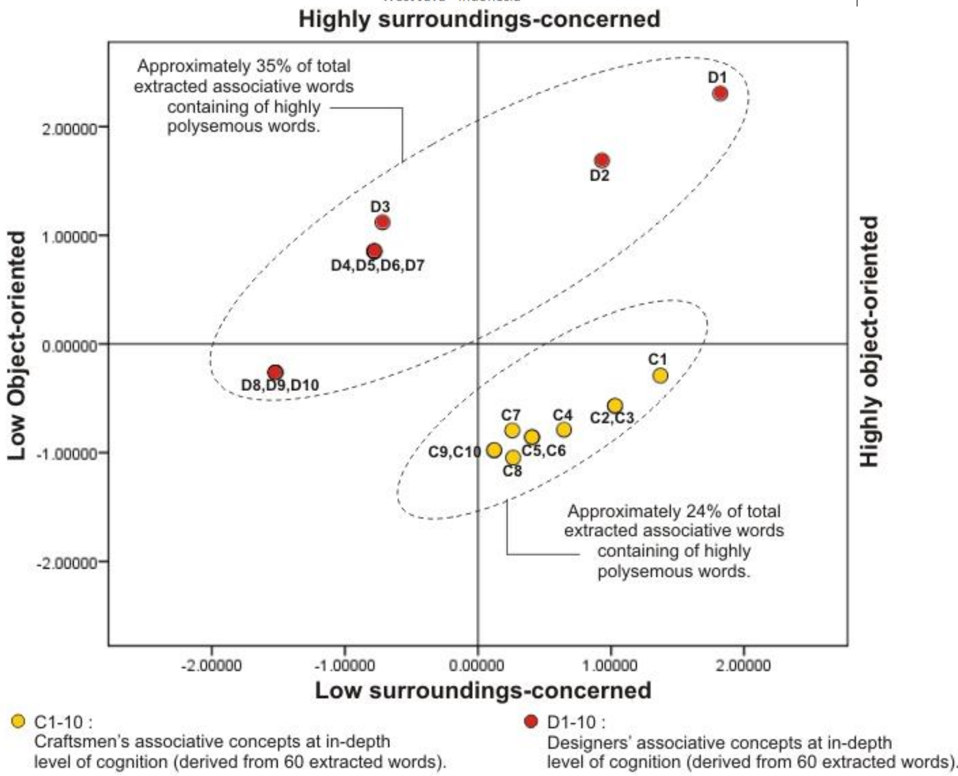


Figure 5. Semantic relation map

6. Discussion

From the initial stage, the sorted verbal expressions showed that craftsmen paid attention to appearance and technical aspects of the fruit basket/container. They described such features as height, length, stack, capacity, standard, coating, and form (e.g., duck, heron). The extracted word obtained from concept network analysis were identified, as well as the characteristic of *operation*. In contrast, designers' sorted verbal expressions concerned issues pertaining to the presence of the fruit basket/container. Descriptive words included *place, kitchen, hang, pluck, tree, wood, inform, remind, children, salad,* and *dignity*. Some interesting comments were, "I don't want to put it on the table; I want to hang it," *"I want it to be inviting so the children will reap its fruits," "How attractive to serve a salad in a fruit container,"* and *"It's like a traditional banana-leaf container with prestige."* The extracted words were identified along with the characteristics of *Scene, Appeal, Companion, Less Proportion* and *Less Shape*.

We identified that craftsmen tended to activate low-weighted associative concepts, as demonstrated by the high surface-level cognitive score of 169/202 (83.6%). Designers activated more highly weighted associative concepts, as demonstrated by the high ODC score and lower surface-level cognitive score of 48/81 (59.2%). We referred to the Associative Gradient Theory, which proposes that the more closely associated or "stereotypical" representations may lead to less creativity. The greater the number of associations, the greater the probability of reaching a creative solution, because remote associations (highly weighted associative concept) are best suited to such solutions (Baer, 1993; Eysenck, 1997; Martindale, 1995). We also found that approximately 24% of 202 extracted words derived from craftsmen and 35% derived from designers were highly polysemous. As Yamamoto et al. (2009) argue, the polysemy of a design idea has significant correlation with its originality. It indicates that designers' in-depth cognitive levels have greater probability of reaching creative solutions.

The findings of this research suggest that the roles of closely and remotely associated concepts at the in-depth cognitive level during the early stage of idea generation are different for craftsmen and designers as they observe and define design problems. Craftsmen's in-depth cognitive levels, with fewer polysemous features, explain their concerns about tangible-related issues, such as proportion and shape. Designers' in-depth cognitive levels, with more polysemous features, concern intangible issues, such as surroundings context (i.e., eating culture) and users' affective preferences (i.e., companion, appeal). The semantic relation map confirms that craftsmen focus on the physical properties of an artifact instead of the surroundings and the user's affective preferences. Designers, on the contrary, are much more concerned about issues pertaining to the presence of the artifact and less attentive to physical properties (see, Figure 6).

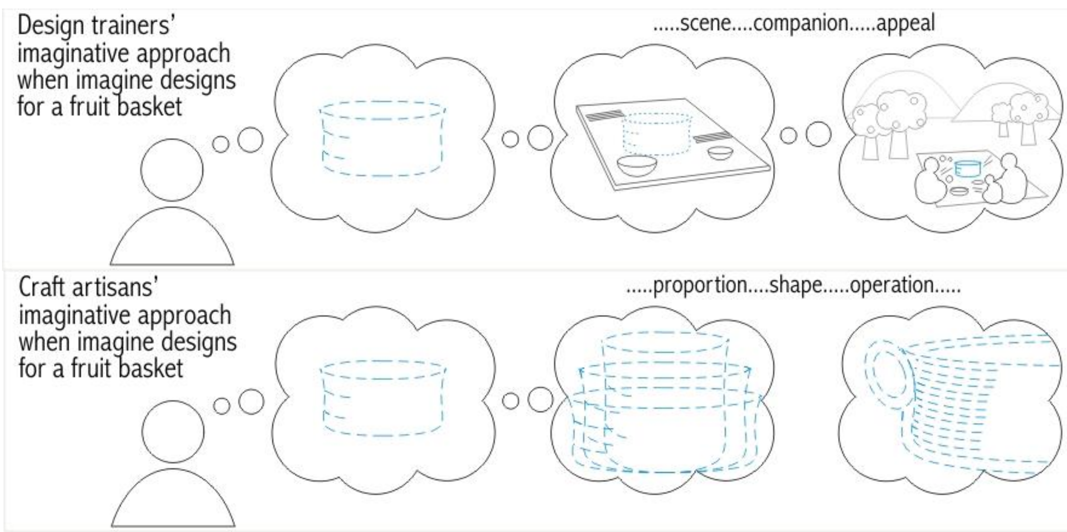


Figure 6. The identified of in-depth cognitive levels of Craftsmen and Designers

7. Conclusion

In general, we can easily differentiate between artifacts created by craftsmen and designers by describing their appearance. However, it is difficult to describe the nature of creative cognition that influences the respective design thinking processes. This study has revealed the differences between in-depth cognitive levels of craftsmen and designers at the early stage of idea generation. Further, these findings can be developed as a reference for a co-created educational program (design training) that suits craftsmen's creative cognition.

References

Baer, J. (1993). Creativity and Divergent Thinking: A Task Specific Approach. Lawrence Erlbaum Associates, Hillsdale NJ, 1993.

Batagelj, V., Mrvar, A., (2003). Pajek – Analysis and Visualization of Large Networks. In: Jünger M, Mutzel P, editors. Graph drawing software. Berlin: Springer, p. 77–103.

Cross, N. (2006). Designerly Ways of Knowing, Birkhauser.

Ericsson, K. A., Simon, H. A., (1993). Protocol Analysis: Verbal Reports as Data, MIT Press, Cambridge.

Eysenck, H. J. (1997). Creativity and Personality. In *Creativity Research Handbook*, edited by Mark A. Runco, Hampton Press. Cresskill NJ, 1, 41-66.

Georgiev, G. V. and Nagai, Y., (2011). A Conceptual Network Analysis of User Impressions and Meanings of Product Materials in Design. *Materials and Design*, Vol. 32, No. 8-9, pp 4230-42.

Houtz, J. C. and Patricola, C. (1999). Imagery, In Mark A. Runco; Steven R. Pritzker (Eds.), *Encyclopedia of Creativity*, Vol.2.

Junaidy, D. W., Kaner, J., Ioras, F., Nagai, Y. (2015). Capturing Characteristics of the Conceptual Ideation Process of Master Craftspersons to Inform Design Education: A Comparative Study of Rural Craft Practitioners in Indonesia and in the UK. *Journal of Design Research*, 13(4), 395–423.

J. Leskovec, J. (2008). Dynamics of Large Networks, PhD thesis, Carnegie Mellon University, September 2008.

Leijnen, S. and Gabora, L. (2010). An Agent-based Simulation of the Effectiveness of Creative Leadership. *Proceedings of the Annual Meeting of the Cognitive Science Society*, Portland, Oregon. Pp. 5.

Maki, W. S., Buchanan, E., (2008). Latent Structure in Measures of Associative, Semantic and Thematic Knowledge, Psychon Bull Rev, 15(3), 598–603.

Martindale, C. (1995). Creativity and Connectionism. In *The Creative Cognition Approach*, Edited by S. M. Steven, T. B. Ward, and R. F. Finke, The MIT Press, Cambridge, MA, 249-268.

Mwihaki, A. (2004). Meaning as use: a functional view of semantics and pragmatics. *Swahili Forum*, Vol. 11, pp.127–139.

Nagai, Y., Georgiev, G.V., Zhou, F. (2011). A Methodology to Analyze In-depth Impressions of Design on the Basis of Concept Networks. *Journal of Design Research*, Vol. 9, No. 1, pp 44-64.

Nelson, D. L., McEvoy, C.L., Schreiber, T.A., (2004). The University of South Florida free association, rhyme, and word fragment norms, Behav Res Methods, 36:402–7.

Reingold, E. and Colleen, R. (2003). Implicit Cognition. in *Encyclopedia of Cognitive Science*, Nature publishing group, 481–485.

Taura, T., Yamamoto, E., Fasiha, M. Y. N., and Nagai, Y. (2010). Virtual Impression Networks for Capturing Deep Impressions. Design Computing and Cognition DCC'10. J.S. Gero (ed), pp. xx-yy. Springer.

Yamamoto, E., Mukai, F., Fasiha, M. Y. N., Taura, T and Nagai, Y. (2009). A Method to Generate and Evaluate Creative Design Idea by Focusing on Associative Process. *Proceedings of the ASME2009*. California, USA, 2009.