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Validation of A Brainstorming Tool "IDEATOR"

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Abstract

The study carried out the validation on the designers' working efficiency during ideation by using IDEATOR as a support tool, what is an achievement of previous research and project. Observations were applied to investigate the differences on the behavior linkages and the idea sketches between the designers' ideation with IDEATOR and without IDEATOR. The results show that: 1) a coding scheme with 10 design behavior codes is made by reviewing the behaviors of designers' ideation with IDEATOR; 2) the designers with IDEATOR presented gathering information (GA) and generating ideas (GI) behaviors more frequently than the designers without IDEATOR in the ideation; 3) designers with IDEATOR in the ideation can be inspired both by words and images but the designers without IDEATOR in the ideation mostly inspired by images; 4) IDEATOR do support designers' lateral thinking in the early design based on the analysis of designers' idea sketches.

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Keywords: Design tool; ideation; lateral thinking

1. Introduction

In a previous study on design support systems, Ozkaya and Akin [1] explored the integration of the architecture and design fields, investigating methods of formulating questions and forms. Ozkaya and Akin proposed requirement–design coupling, creating a continuous interactive design system that aids architecture designers in their design thinking processes, spanning from the design of the initial idea to actual construction and the final maintenance phases. Ahmed [2] developed a knowledge-indexing method to promote design knowledge reuse. His observation of engineering designers revealed that approximately 24% of them spent most of their time collecting information. Therefore, he claimed that information searches are an essential part of the design process that would be aided by indexing design-related knowledge. Segers et al. [3] constructed an idea space system that aided architects in performing design thinking. The word–image connections in the system served as stimuli for designers to produce diverse aspects of creative thinking, thereby enhancing their work efficacy.

Compared with the aforementioned foreign studies on design-support systems, IDEATOR places greater emphasis on recording the word-triggered thinking processes and paths of designers. An keyword in the record of idea thinking can not only serve as a source of inspiration in the follow-up process of ideation, but also as a tool for idea communication and sharing in group brain-storming sessions. Therefore, this app supports idea development among individual designers and creates more satisfactory communication effects in both the self-reflection of a single designer and group design tasks. By comparison, the idea space system developed by Segers et al. [3] used the words written by designers to trigger image feedback from the system, which could build up the image references to form the image-initiated thinking ability of designers. Most previous studies have maintained that the mental imagery of designers is triggered by substantial information or visual clues [4-10]. This mental imagery further enables designers to conceive ideas at that specific moment [11]. Therefore, in the previous stage of the present study, IDEATOR was developed to enable designers add their idea sketches and short explanations to each keyword of the idea record, presenting the idea development process as a self-report. Any keywords, explanations, idea sketches, and representative images designers add to the process can serve as part of the stimuli or contents in the seeing part of the

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seeing–moving–seeing model proposed by Schön and Wiggins [10]. In addition to allowing designers to develop ideas from infinite image stimuli, this function enables enriching the database of IDEATOR, where references related to design tasks could be stored for future references.

Besides, protocol analysis cannot retrieve and analyze the nonverbal thinking behaviors in the design process; it has limited capacity in the research of design activities [12]. The study adopted IDEATOR as an ideation support tool, which may support designers' creative thinking, whereas the keywords and referenced items will be recorded in the process by IDEATOR while designers are taking design tasks, which may serve as a key research tools for the researchers. In other words, IDEATOR simultaneously served as a facilitator of creative ideation and a data-recording tool, as an effective data-collecting method for cognitive studies on design, specifically for design thinking. Therefore, the study aims to verify and determine whether the designers using IDEATOR in the ideation can assist them in forming and developing creative ideas.

2. Research method

The present study employed IDEATOR, the result of a previous stage of this study, as a support tool for ideation among designers to verify their efficacy in this process. This study investigated whether differences existed between the behavioral connections and sketched ideas of designers who used or did not use IDEATOR. The research method and details of its execution are presented in the following section.

2.1. 1.1. Three core functions of IDEATOR

In IDEATOR, the "mind map idea development function" supports the design thinking needs; the "search engine image search function" supports the needs related to image stimuli and references, and the "sketch pad sketching function" supports the design action needs. Furthermore, users can freely switch among several functional interfaces of IDEATOR to form mutual associations.

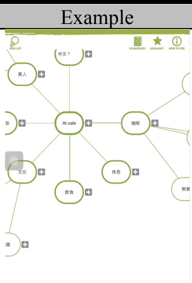
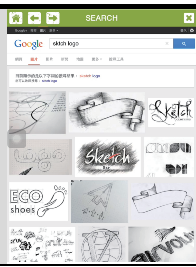
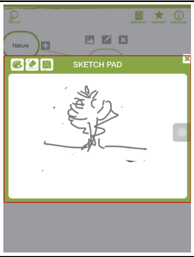
Function	Example
Idea development function	
Image search function	
Sketching function	

Fig. 1. Functions of IDEATOR.

2.2. Observation records of the progression of design tasks

To provide relatively objective analysis results, the present study involved developing different methods to record the behaviors of participating designers. For participants who used IDEATOR, their design process was videotaped; in addition, a screen-recording program for mobile devices (Shou.TV mobile game streaming 0.7.13) was employed to record the ideation processes of designers when using IDEATOR. For participants who did not use IDEATOR to facilitate their creative idea development, their design process was videotaped and a computer screen-recording program (Camtasia Studio 7.0.1) was adopted to record the searching process the participants performed on a personal computer.

2.3. Participants

This study adopted judgmental sampling to recruit 30 designers who possessed more than 2 years of work experience in graphic design-related fields (e.g., media, marketing, and advertising; all participants were required to be current design practitioners). The participants comprised 12 men and 18 women; the average work experience of the participants was 5.96 years. 22 of them are working for a design firm, include advertising company and media company, 8 are working for an individual visual studio.

The participants were categorized into two groups because of the between-subjects design of this study; each group consisted of 15 designers. One group received an iPad mini with Internet access and had IDEATOR installed as the ideation support tool, and the other group was asked to collect data, search references, and perform ideation using a personal computer with Internet access.

2.4. Design task and test environment

To ensure a relatively objective analysis of the results, the same design task, developing a logo for a coffee house named

At Café, was assigned to all participants as the test task. Therefore, relatively consistent discussion standards could be applied in subsequent data analysis. Considering the limited time allocated to the participants, a relatively quick task was selected. Before the participants began their work, they received a task explanation sheet and several A4-sized papers for taking notes and sketching during idea development. In addition to explaining the task process, the researchers instructed participants who were assigned to complete their task using IDEATOR on how to operate the app. The participants were allotted time to familiarize themselves with the interface and raise questions related to its use. They proceeded to their design task only after confirming that they could operate this app on their own. Upon the completion of the design task, the researchers collected all task explanation sheets and notes to conduct research analysis.

All participating designers performed their design task in a quiet office. Designers who used IDEATOR during ideation were provided with a set of office desks and chairs and an iPad mini with the IDEATOR installed as well as Internet access. By comparison, designers who did not use IDEATOR in ideation were provided with a set of office desks and chairs and a personal computer that was connected to the Internet. In addition, designers in both groups could freely search for and refer to any online resources they required.

2.5. Data analysis

The researcher and two coders performed data analysis, and the internal consistency of video segments coding and verbal data classification by the researcher and two coders were also examined.

To code the video data, the researcher first used behavior-observing software, Observer XT, to mark all points of change in the videotaped behaviors of the participants, applying the coding principles of design behaviors developed in the previous phase of this study (Figure 2). Subsequently, according to these coding principles and definitions of behaviors, the two coders corrected inappropriately paired results and listed clips that could not be categorized into any behavioral code. Subsequently, the researcher and two coders discussed the additions and eliminations of behavioral codes as well as the additions or revisions of the definitions of behavioral codes.

The coding of design behaviors conducted in the previous stage of this study mainly referred to the models developed by previous studies, comprising the modes of gathering information, sketching, and reflecting proposed by Cross et al. (1994), drawing, examining, and thinking proposed by Akin and Lin (1996), and gathering information, generating ideas, and modeling (Atman, 1999). Subsequently, according to the analysis of the participants' recorded data, their design behavior modes were classified into gathering information (GA), consisted of retrieving information (RI), referring to relevant information (RRI), and referencing saved data (RSD); generating ideas (GI), comprised writing down ideas (WI) and creating new sketches (CNS); and thinking modes (TH), composed of looking at own sketches (LOS) and continuing to sketch (CS).

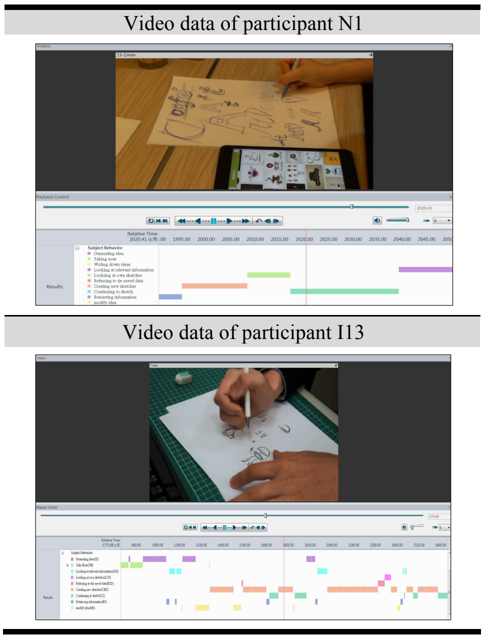


Fig. 2. Screenshots of behavior coding using Observer XT.

3. Results and discussion

To investigate whether IDEATOR assisted designers in ideation, this study conducted several investigations, namely observations of the ideation behaviors and retrospective interviews with the designers in the IDEATOR group (hereafter referred to as Group I) and non-IDEATOR group (hereafter referred to as Group N), and the satisfaction questionnaire returned by the designers in Group I. Related research results were subsequently obtained. In addition, during the design task-based test, for two designers in Group I, the adopted screen-recording program for mobile devices stopped unpredictably when videotaping the ideation process, rendering the records incomplete and unsuitable for analysis. Consequently, the task-based test data that were assessed in the final phase comprised 28 entries of complete data, namely those of 13 designers in Group I (hereafter referred to as I.1–I.13) and 15 designers in Group N (hereafter referred to as N.1–N.15).

The following section provides detailed explanations on four aspects, namely the analysis of and comparison between the behavioral segment (BS) coding of Groups I and N, connections among designer behaviors during ideation, horizontal development of the idea sketches drawn by designers in Groups I and N, and satisfaction levels and suggestions for further improvement regarding the main functions of IDEATOR.

3.1. Analysis of and comparison between the behavioral segment coding of Groups I and N

On the basis of the results of the analysis conducted by the researcher and two coders through Observer XT, the videotaped observation of the 13 designers in Group I was cut into a total of 572 BSs; the mean time used was approximately 24 min (M = 1453 s). By comparison, for the 15 designers in Group N, the videotaped observation was cut into a total of 250 BSs; the mean time used was approximately 27 min (M = 1647 s). Because IDEATOR was first employed in ideation only in the current stage of this study, several behaviors had not been previously coded. Therefore, the tables of the behavior codes were expanded from seven to 10 in the present stage (Table 1). The 10 behavior codes belonged to the three aforementioned modes: RI, RRI, RSD, and taking notes (TN) in the GA mode; WI, CNS, and adding a new branch idea (ANI) in the GI mode; and LOS, CS, and revising a branch idea (RBI) in the TH.

The three newly incorporated behavior codes were ANI, RBI, and TN (marked in a darker shade in Table 1). ANI meant that the designer added a new branch of ideas to the main screen of the mind map in IDEATOR; RBI indicated that the designer revised existing idea branches on the mind map screen, such as changing idea-related words or adjusting the levels of the branches; TN denoted that the designer left a record on the functional interface of a note in IDEATOR after referring to related information in their own sketches.

Table 1. Revised table of behavior codes and their definitions after the addition of the three new behavior codes (expanded from a table in previous study, [13]).

Behavior mode	Behavior (code)	Definition
Generating ideas (GI)	Writing down ideas (WI)	Writing down keywords as the ideas they generated to be used later; listing, adding or adjusting different alternatives; looking at the written ideas.
Gathering information (GA)	Retrieving information (RI)	Retrieving information on-line for capturing ideas, sketching or drawing; saving the retrieved information in the hard disc to be the reference later.
Gathering information (GA)	Referring to relevant information (RRI)	Referring to the information they have retrieved on-line in advance. Retrieving action is not included in the behavior.
Thinking (TH)	Looking at own sketches (LOS)	Looking at the sketches they have drawn in advance.
Gathering information (GA)	Referring to the saved data (RSD)	Referring to some saved data that have been retrieved on-line by them in advance.
Generating ideas (GI)	Creating new sketches (CNS)	Creating the new shapes, labels or arrows.
Thinking (TH)	Continuing to sketch (CS)	Continuing to work on a sketch they have drawn
Generating ideas (GI)	Adding a new branch idea (ANI)	Adding an idea in the mind map area of IDEATOR as the new branch to be used or further thinking later.
Thinking (TH)	Revising a branch idea (RBI)	Revising the idea, fixing the words of an idea, adjusting the level of an idea in the mind map area of IDEATOR.
Gathering information (GA)	Taking notes (TN)	Taking notes after they referred to the information or the saved data they have retrieved on-line, and looked at the sketches they have drawn in advance.

* Items in a darker shade are the behavior codes newly added in the present stage of this study

3.2. Connections among the behaviors of designers during ideation

In accordance with the appearance order of all BSs, the 10 behavior codes relevant to Group I and the seven behavior codes relevant to Group N were compiled into a connection matrix of behavioral connections (Table 2; the upper half comprises the 10 behavior codes relevant to Group I, whereas the lower half consists of the seven behavior codes relevant to Group N). The codes on the vertical axis of the matrix designate behaviors that appear first in behavioral connections, whereas the codes on the horizontal axis of the matrix indicate behaviors that follow the first behavior. Numbers in the columns present the connection frequency of the two corresponding behaviors. For example, number 2 in the second row and first column of Table 2 shows that among the total 572 BSs recorded in Group I, two instances of the RI→ WI connections were identified. Moreover, number 29 in the second row and third column indicates that 29 instances of the RI→RRI connections were recorded. Other fields in the table can be interpreted using the same method.

Table 2 shows that in the behavioral connection matrix, the strongest behavioral connection observed among the 13 designers in Group I was that of RRI→RI (61 times), followed in decreasing order by RI→RRI (29 times), RI→ ANI (25 times), RRI→CNS (24 times), RRI→CS (19 times), CS→CNS (19 times), RI→RBI (18 times), RRI→CNS (18 times), CS→RRI (16 times), CNS→CS (16 times), RBI→RI (13 times), ANI→RBI (11 times), and CNS→RSD (10 times). The results showed that among the behavioral connections of the 13 designers in Group I, the RRI→RI connection was the strongest, followed in decreasing order by those of RI→RRI, RRI→ANI, and CNS→RRI. Of the 10 behaviors relevant to the 13 designers, CNS, RI, CS, and ANI were more likely to be connected with other behaviors, whereas LOS, TN, and WI were less likely to exhibit this.

The strongest behavioral connection identified in the 15 designers in Group N was the connection between RRI→CNS (56 times), followed in decreasing order by those of CNS→ RRI (44times), RI→RRI (40 times), RRI→CS (22 times), RRI→RI (21 times), CS→RRI I (16 times), and CNS→RI (10 times). The findings revealed that among the 15 designers in Group N, the RRI→CNS connection was the strongest, followed in decreasing order by those of CNS→RRI, RI→ RRI, RRI→CS, and RRI→RI. In addition, of the seven behaviors exhibited by the 15 designers, RI, RRI, and CNS tended to be connected with other behaviors, whereas WI and LOS, TN, and WI were less likely to be connected with other behaviors.

In both groups, RI and CNS were comparatively more likely to be connected with other behaviors, whereas WI and LOS were less likely to exhibit this characteristic. Furthermore, Table 4 shows that the behavioral connections in Group I were all higher than those in Group N.

These behavioral connections were then categorized according to the four idea association modes developed in the previous phases of this study (Cheng, 2010, pp. 81 and 82; Cheng & Yen, 2008; Table 3). Three sets of connections, namely those between RRI→RI, RRI→CS, and RRI→CNS, were categorized in two association modes because the behavior code RRI referred to images (I) and words (W). If designers referred to word-based data, then the produced behavioral connection between RRI → CNS should be categorized in the WIA mode. In other words, this behavioral connection was an image association triggered by word stimuli. Consequently, all behavioral connections where RRI preceded another behavior were categorized in two different association modes.

The analysis results in Table 3 show that the 13 behavior pairs that exhibited relatively strong connections during ideation among designers in Group I were mainly classified into WWA and IIA modes, followed by the WIA mode, and eventually by the IWA mode. This finding indicates that these designers tended to exhibit behaviors in the WWA or IIA modes during ideation. Among the seven behavior pairs that exhibited relatively strong connections during the ideation of designers in Group N, more pairs were classified into the IWA and IIA modes than into the WWA and WIA modes. This finding indicates that these designers tended to exhibit behaviors in the IWA or IIA modes during ideation. On the basis of these findings, the researcher inferred that designers in Group I were supported by word-and-image-triggered associations during ideation; by comparison, designers in Group N exhibited more image-triggered behaviors in this process.

3.3. Horizontal development of idea sketches drawn by designers in Groups I and N

In this study, the researcher and two coders jointly analyzed the order of all sketches drawn by the designers and the reference contents used during ideation. The sketches were categorized along a horizontal axis of thinking development. The researcher and two coders categorize all idea sketches created during ideation by the 28 participants. The results are presented in Table 4. For example, the number 17 in the field below participant I.1 designates the amount of sketches this designer produced during ideation, and the number 5 in the bottom suggests that these sketches were grouped into five horizontally developed thinking categories. In this vein, Table 4 shows that I.2 drew five sketches that were grouped in two categories, I.3 drew one sketch that was grouped in one category, and I.4 drew eight sketches that were grouped in four categories; the list continues in this manner.

Table 4 presents the results of sketch categorization. Of all Group I designers, participant I.8 drew the maximal amount of idea sketches (n = 19) that covered the widest range of horizontally developed thinking categories (n = 6), followed in decreasing order by participant I.1, who drew 17 idea sketches that covered five horizontally developed thinking categories, and participants I.7, I.9, and I.4, who drew 14, 9, and 8 idea sketches, respectively, that covered four horizontally developed thinking categories. Of all designers in Group N, participant N.11 drew the maximal amount of idea sketches (n = 9), followed in decreasing order by participant N.13, who drew 8 sketches, and by participants N.5 and N.8, both of whom drew 7 idea sketches. Idea sketches drawn by participants N.1, N.4, and N.6 covered three horizontally developed thinking categories; however, those drawn by the remaining designers in Group N only covered one or two horizontally developed thinking categories.

Table 2. Connection matrix of behavioral connections observed in Groups I and N.

The behavior linkage of Designer's ideation with IDEATOR										
	WI	RI	RRI	LOS	RSD	CNS	CS	ANI	RBI	TN
WI			1		1		2	1	2	
RI	2		29		6	7	3	25	18	4
RRI		61		2		18	19	1	1	
LOS			1			5	2			
RSD	2	7	3			8		2	8	2
CNS	2	6	24	4	10		16	4	2	4
CS	1	6	16	3	6	19		2	4	
ANI	1	4	7		3	2	1		11	6
RBI		13	5		5	9	6	4		7
TN		5	9					3	6	

The behavior linkage of Designer's ideation without IDEATOR							
	WI	RI	RRI	LOS	RSD	CNS	CS
WI							
RI	1		40			4	1
RRI		21			3	56	22
LOS							2
RSD			1				3
CNS		10	44	2			3
CS			16		1	4	

Table 3. Association modes of the behavioral connections observed in Groups I and N

The idea association modes of Designer's ideation with IDEATOR		
Behavioral connections with relatively high frequency (times)	**Idea association mode**	**Definition**
RRI→RI (61); RI→ANI (25); RI→RBI (18) RBI→RI (13); ANI→RBI (11); CNS→RSD (10)	**WWA**	**Word-shifting-to-word association**
RI→RRI (29); RRI→CS (19); RRI→CNS (18)	**WIA**	**Word-shifting-to-image association**
RRI→RI (61)	**IWA**	**Image-shifting-to-word association**
CNS→RRI (24); RRI→CS (19); CS→CNS (19) RRI→CNS (18) CS→RRI (16); CNS→CS (16)	**IIA**	**Image-shifting-to-image association**

The idea association modes of Designer's ideation without IDEATOR		
Behavioral connections with relatively high frequency (times)	**Idea association mode**	**Definition**
RRI→CNS (56); RRI→RI (21)	**WWA**	**Word-shifting-to-word association**
RI→RRI (40); RRI→CS (22)	**WIA**	**Word-shifting-to-image association**
RRI→CNS (56); RRI→RI (21); CNS→RI (10)	**IWA**	**Image-shifting-to-word association**
CNS→RRI (44); RRI→CS (22); CS→RRI (16)	**IIA**	**Image-shifting-to-image association**

This study analyzed the amounts of idea sketches and horizontally developed thinking categories. The results showed that designers in Group I produced more idea sketches (M = 7.69) and horizontally developed thinking categories (M = 2.92) than did designers in Group N (idea sketches: M = 4.87; horizontally developed thinking categories: M = 1.87). Specifically, although participants I.9 and N.11 both drew nine sketches and participants I.4 and N.13 both drew eight sketches, the sketches of participants I.9 and I.4 covered more horizontally developed thinking categories (n = 4) than did those of participants N.11 and N.13 (n = 2). In addition, of all designers in Group I, only I.3 and I.10 produced a single thinking direction in their idea sketches (n = 1 and 7, respectively). Therefore, this study inferred that the ideation support app IDEATOR enhances the sketching efficacy of designers, and that IDEATOR improves their horizontal idea development in the preliminary design phase.

Table 4. Amount and categories of idea sketches drawn by designers in Groups I and N.

The behavior linkage of Designer's ideation with IDEATOR													
Participant	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
Amount	17	5	1	8	6	5	14	19	9	7	2	2	5
Categories	5	2	1	4	2	3	4	6	4	1	2	2	2

The behavior linkage of Designer's ideation without IDEATOR															
Participant	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15
Amount	6	2	3	5	7	4	4	7	3	5	9	3	8	6	1
Categories	3	1	1	3	2	3	1	2	2	2	2	2	1	2	1

4. Conclusions and future work

This study used the achievement of previous project to develop an online app, IDEATOR, as an ideation support tool for designers and conduct a verification study on the efficacy of their ideation. Specifically, this study investigated whether differences existed between designers use and did not use IDEATOR regarding their behavioral connections and sketched ideas during ideation. The results also can serve as a basis for future revision of the current IDEATOR version. The results are presented as follows: 1) The observation record of the ideation behaviors of designers in IDEATOR using Group should be increased to 10 behavior codes, in comparison with the designers who did not use IDEATOR who have seven kinds of behavior codes; 2) Compared with designers who did not use IDEATOR, designers in using IDEATOR Group exhibited higher frequencies of GA (gathering information) and GI (generating ideas) behaviors and a lower frequency of TH (thinking) behaviors. 3) Designers who used IDEATOR tended to simultaneously produce word-triggered and image-triggered associations during ideation; however, designers who did not use IDEATOR generated more image-triggered associations. 4) The sketch analysis results confirm that the ideation-facilitating app IDEATOR effectively supported the lateral thinking process of idea development in the initial stage of design.

The study explored the difference between the designers use and did not use IDEATOR in their ideation. Besides, the idea generating support app 'IDEATOR' is showed an effective recording tool to researchers in related studies. Furthermore, the study will further investigating whether the app can assist the brain storming process of teamwork members in the future.

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