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Introducing and Clarifying the Ideas Makes Team Work Successful

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Abstract
To examine the development of design teams' ideation using the IDEATOR design supporting tool, five design teams were invited to conduct a design task. The verbal communication data and idea sketches of the five design teams were explored and analyzed by researcher and three coders. The research results revealed that the frequent verbal communication of team members expounding their ideas and spontaneously proposing concepts contributed to the lateral-thinking development reflected in the sketches. However, their frequent verbal communication inviting other members to propose ideas or decisions had a negative effect on said thinking development.

Index Terms—design ideation, lateral thinking, idea sketch, verbal communication

I. INTRODUCTION

In the field of design cognition, much research has focused on visual resources. For example, Petre et al. [1] observed designers' knitwear design process and provided diverse stimulating resources to explore whether these stimuli changed the designers' knitwear design behavior. Cheng et al.[2] examined the differences in product design originality among 40 students with a design background, where some of the students referred to partial product photographs and the rest referred to complete product photographs. Chan et al. [3] studied whether the examples referred to by designers were proximate to the design problems confronted, thereby assessing the originality of their designs. Chaiet al.[4] analyzed the analogical reasoning and design behavior of 52 design students and 12 designers, discussing the differences between the professionals and students in terms of what reference images they chose, and the consequent divergence in their approaches to solving design problems. Casakin[5] verified that collecting abundant pictures can assist students and professional architects in solving problems. Furthermore, Gonçalves et al. [6] surveyed 52 professional designers and 103 industrial design students using questionnaires, and determined that images were an essential design stimulus for both groups. Clearly, referring to abundant images can stimulate designers' design-thinking activities and assist them in reasoning and solving design problems [5][6]. Thus, the IDEATOR ideation tool, which is an achievementof previousresearch, assesses designers' behavior of actively searching visual resources and provides them a function of imageboard, allowing them to gradually converge their creative ideas through referencing, reflection, and sketching processes.

The development of auxiliary teamwork supporting tools and undertaking of related studies have multiplied. For example, Cruz and Gaudron proposed "open-ended objects" for use in brainstorming workshops in 2010 [7], which allowed the participants to reflect on their emotions and expectations, thus creating an atmosphere of participation and forging connections among a group of strangers. Similarly, Siangliulue et al. [8] created the IdeaHound online auxiliary system, supporting design team members in developing ideas and, in the process, identifying semantically related and distinctly

different ideation groups using an idea map, thereby further generating higher quality and more diverse design ideas. Settles and Dow [9] collected the records of individual and collaborative creative productions created by all songwriters on the February Album Writing Month server from 2009 to 2012 and conducted a qualitative and quantitative survey as well as cross-reference analysis; the results revealed distinct modes of music collaboration, indicating that nuanced complementary interest and sharing among collaborators contributed to the success of the collaboration process. Thus, mechanisms driven by internetworking and based on creative idea support tools for team collaboration are crucial in relevant research and development.

To examine the contribution of the IDEATOR ideation tool for teamwork and understand how team-based designers jointly structure and solve design problems using ideation supporting tools, design teams with practical experience were invited to take a design task in this study; IDEATORwas employed as theideation supporting tool (The functions and features of IDEATOR refers to [10] p.16 and Fig.1). The focus was on evaluating the design teams' verbal communication and idea development in ideation. In addition, through the ability of IDEATOR to record and save the content of a design team's mind mapping during idea development, the characteristics of idea development and association modes of the design teams were also examined to serve as a reference for related research on design awareness. The functions and features of IDEATOR are presented as follows:

Fig.1Three main functions of "IDEATOR"

A. Mind-mapping function

Cheng [11] reported that, in early conception, some designers had a mind-mapping ideation, which embodies the flow of their verbal thinking. This behavior explains the pivotal role of text in the early stages of design, as documented by Segers[12]. At this point, text is used to record and externalize the designer's thinking, representing the semantic cues of their idea development. Stimulation by and association through text are indispensable in the design process, reflecting the capacity of verbal and textual thinking for encouraging the designer's conceptualization of a space in which to reflect on design problems. Momentary ideas are thus recorded and become a further source of inspiration for other design directions. Jonson [13] argued that, compared with sketching by hand, verbal statements are a primary ideation tool in the early stages of design. Yuan and Hsieh [14] similarly asserted that mind mapping allows designers to organize thoughts logically and unfold their thinking. Accordingly, IDEATOR begins with generate textual concepts through mind mapping (Figure 1a), whereby design team members can communicate and develop textual concepts simultaneously. This enables team members to
unfold design concepts using the textual mode, structure design problems and a solution space, and reason possible design strategies.

B. Image searching function

Research has revealed that when designers engage in a design task, they first input keywords into a search engine to retrieve relevant information, displaying the results in the "image search" mode, before browsing abundant visual resources online as a source of design inspiration. Through this

Internet searching behavior, designers obtain abundant visual stimulation based on textual thinking through operation of a search engine interface. Designers may save specific images as references for subsequent idea development. Thus, at this point, designers engage in verbal and visual thinking methods. This is supported by Ozkaya and Akin's[15] claim that design problem solutions require a design space where textual and visual information is jointly presented. Thus, the image search function of the Google search engine is embedded in the IDEATOR program (Figure 1b), supporting design team members in directly linking the text of mind-mapping ideation to the keyword field of the search engine and enabling the retrieval and browsing of relevant images; designers can also save reference images in the IDEATOR database.

C. Imageboard function

Studies have reported that, in the sketching process, designers not only retrieve related images using a search engine, but also open and browse the downloaded images as a source of inspiration for composing design sketches. During this stage, designers mostly exercise visual thinking, as reflected in the seeing-moving-seeing model proposed by Schön and Wiggins [16], which explains designers' repeated behavior of reception and response toward visual stimulation in the design process. IDEATOR addresses the aforementioned requirements of designers and includes an additional imageboard function (Figure 1c) to present the images saved in the ideation space. These images are categorized using each input keyword generated during mind-mapping process, thereby facilitating the convergence of design ideas to assist with related idea association, communication, and developing concepts or sketches for design.

II. RESEARCH DESIGN

This study used the IDEATOR as an ideation supporting tool and communication tool for design team members performing design tasks. This study examined whether IDEATOR contributed to the design teams' communication and assesses the ideation development characteristics and association modes of team members undertaking design tasks with this tool. Accordingly, an observational method was employed for recording the external behavior and verbal communication content of the design teams throughout the design task. Screen recording was also conducted to document the teams' operation of the ideation tool, retrieval of reference content online, associations of key ideas, and development of sketches, which are further explained as follows.

A. Design task and procedures

This study invited five design teams (each comprising two people) to participate in a team design task; each of the designers had more than 2 years of design work experience and currently were a design practitioner in total, three male and seven female, with an average 5 years of design experience (mean = 4.55), participated in this study. Detailed information about the design teams is presented in Table 1.

For more consistent analysis and examination standards of the data of the participating design teams in the research and analysis process, a "logo design of Happy Preschool" was adopted as the theme for the team design task. Prior to the design task, the researcher provided a task instruction sheet to each design team member. A4-sized paper and pencils for sketching, and an Internet-enabled iPad Pro with preloaded IDEATOR was also issued to each team. The researcher then instructed the team members in operating IDEATOR, providing them sufficient time to become familiar with the tool interface and operation and pose questions till all the team members confirmed that they understood the design task and tool operation. The researcher informed the participants that all of the

sketches, research data, recorded material, and research tools from the design task process would be collected for subsequent analyses after the design task was completed.

Table 1. Information of the design team members

Grou	Participa	Gender	Age	Experie	Position
G1	G1-1	Female	28	4	VI
	G1-2	Male	26	3	VI
G2	G2-1	Female	25	3	Designer
	G2-2	Female	25	3	Designer
G3	G3-1	Female	25	2	Designer
	G3-2	Male	25	2	Designer
G4	G4-1	Male	27	2.5	VI
	G4-2	Female	32	8	VI
G5	G5-1	Female	39	14	VI
	G5-2	Female	38	4	VI

From the beginning of the team design task, all of the external behavior, IDEATOR operating behavior, and verbal communication content of each of the participants were recorded using a video recorder; QuickTime Player for the Mac operating system was used for screen recording on the iPad Pro to record their ideation and conception development as well as the content of their image retrieval and communication on consensus image during the design task. The researcher then stopped the recording and observation once the design teams informed that they had completed ideation sketches for the design task and reached a team consensus.

B. Data analysis

Regarding data collection and analysis, research data of the teams included video records of verbal communication during the design task, iPad-recorded screen data, ideation sketches on paper. The researcher and two coders conducted the data analysis as well as a test of the internal consistency of the categorization of codes for the verbal data.This study focused on analyzing the content of communication and discussion in team design.The verbal data from the team design task were transcribed into text, the main points of which were summarized and jointly analyzed by the researcher and coders. The verbal table in Gabriel and Maher's (2002, p.205) study of communication in architectural collaborative design was adopted to analyze the verbal data of the five teams' ideation. The verbal table comprises 16 verbal codes, which were categorized into four types of communication, namely communication control, communication technology, social communication, and design communication (refer to Table 2). Communication control consists of three verbal codes, namely "interruption (INT)," "floor-holding (FLO)," and "hand-over (HAN)"; communication technology and social communication are coded as CTE and SOC, respectively; design communication, that most immediately related to the conceptualization process, comprises 11 verbal codes, namely "introduction of idea (IDE)," "acceptance of idea (ACC)," "rejection of idea (REJ)," "clarification of idea (CLA)," "refinement of idea (REF)," "evaluation of idea (EVA)," "low-level design (LLD)," "high-level design (HLD)," "brief (BRI)," "schedule (SCH)," and "task instruction (TAS)." The 16 verbal codes, their corresponding communication types, and example sentences drawn from the collected verbal data and listed under their code definitions are presented in Table 2.

Table 2. Verbal data in Collaborative Design (codes adopted from Gabriel and Maher [2002] with example verbal data from this study)

Type	Sub-category	Code	Description	Examples in the study
Communication Control	Interruption	**INT**	Interruptions are associated with simultaneous speech.	G1-1: No, no...rather, it should be about knowledge...
	Floor Holding	**FLO**	Occurs when one speaker tries to take the floor while the other attempts to hold the floor while producing utterances that do not contain any information.	G1-1: Wait a minute, didn't we see one before; G1-2: Is that important? Is this matter important?
	Hand-over	**HAN**	3 indications of relinquishing floor: a) Use of questions; b) using stereotyped questions such as "isn't it?" "Aren't they?" or statements as "you know'; c) naming the next speaker.	G1-1: Hmm...what else, kids, a preschool… what else do we associate with a happy preschool? G1-2: Do you remember what they said about creating the feeling of a happy preschool?
Communication Technology	Tools & Environment	**CTE**	Communication in regards to use of tools and collaborating environment.	G1-2:Because you will exit the interface soon after, I will simply take a screenshot; why do you exit now to go back in to take a screenshot later?
Social Communication		**SOC**	Communication content dealing with interpersonal relationships.	G1-2: We don't have that, because the resources are rather outdated; G1-1: Oh, I know; isn't that my nephew?
Design Communication	Introduction of idea	**IDE**	When participants directly or indirectly (in the form of a question) introduce a new idea.	G1-2: Otherwise, it can also be arranged as a…face of the robot...; G1-2: Knowledge, exclamation point, or this is a light bulb, light!
	Acceptance of Idea	**ACC**	When a participant makes it clear to the other participant that he/she accepts a particular idea.	G1-1: Light bulb, not bad, not bad. Why not! Knowledge, where are you? Where are you? Books...light bulbs...
	Rejection of idea	**REJ**	When a participant makes it clear to the other participant that he/she does not accept a particular idea.	G1-1: Why? No, not for now. Why change it to a uniform?
	Clarification of idea	**CLA**	When a participant clarifies his/her idea to the other participant in either question or answer forms.	G1-1: I want to combine these two, not necessarily to say it's football! I just want this logo to look like... um...Didn't we just said it should have some meaning besides being colorful and happy.
	Refinement of idea	**REF**	When participants spend time refining and further developing an idea.	G1-2: The light bulb, the filament inside, this thing is simplified to make a fun symbol.
	Evaluation	**EV**	When participants spend time	G1-2: Let's check again... Actually, I

of idea	**A**	evaluating an idea.	think it's pretty good to do it this way; it's very simple.
Low-Level Design	**LLD**	When designers place individual elements, discussing coloursetc …	G1-2: In fact, the color of the childlike thing we're looking for...this color fits the requirements, or just use blue or powder blue...
High Level Design	**HLD**	When designers make broad decisions which affect significant aspects of their later decisions.	G1-2: Because the main axis of our whole thing is actually to be knowledgeable...knowledgeable and fun.
Brief	**BRI**	When participants referred back to brief.	G2-1:I think one thing is the service being provided, and since we're designing a logo today, perhaps it…perhaps one more detail here.
Schedule	**SCH**	When participants worked or referred back to a schedule or program.	G1-2: Okay, so now everyone draws individually, and we will pick one later.
Task/Instruction	**TAS**	When participants handed over specific tasks to the other participant or Instructions on how or what to draw by one participant to the other.	G1-1: I think we need some examples, examples of logos.

III. RESULTS AND DISCUSSION

The study explored whether IDEATOR positively contributed to the ideation of the design team members and further investigated the characteristics of the idea development, association mode, and usage requirements of team members using this tool to conduct a design task. Relevant findings were obtained through analysis of the video data recording the external behavior of the five design teams operating IDEATOR, screen-recorded data, and all the sketches manually drawn by these members. This stage of analysis focused on the data records of the five teams' verbal communication while they used IDEATOR for ideation; these records were subsequently named G1, G2, G3, G4, and G5, representing the five design teams (refer to Table 3).

The findings of the analysis of the verbal communication and idea sketches during team design are presented as follows.

A. Lateral thinking categories and ratio of idea sketches

the design sketches produced by the five teams were collected (see details in Table 3), G1 drew the most sketches (n = 10), followed by G2 and G4 (five sketches each). G5, however, drew only one ideation sketch, the lowest amount among the five teams. The researcher and coders categorized the lateral-thinking orientation of ideation sketches produced by each design team, with the results detailed in the Idea Sketches section of Table 3; the intercoder reliability was 0.8. G1 drew ten sketches, which were classified into five types of lateral thinking. The ratio of the number of lateral-thinking orientation to the total number of sketches was 0.5. G2 produced five sketches, all of which were classified as the same type of lateral thinking; the said ratio was 0.2. G3 drew three sketches, which were attributed into one type, with a said ratio of 0.33, and G4 created five sketches

attributed to three types, with a said ratio was 0.6. G5 drew only two sketches, which were classified into one type; the said ratio was 0.5. Among the five teams, the ratio of lateral-thinking orientation to the total number of sketches in G4 was the highest, followed by that in G1. Furthermore, the five sketches in G2 all categorized into the same type of lateral thinking, and the lateral-thinking orientation ratio was the lowest among all the teams.

B. Verbal communication of the design teams

The verbal communication among the members of the five teams during ideation were analyzed, as presented in Table 6. The verbal communication data of the five teams were composed of 890 fragments that corresponded to 16 verbal codes; "Clarification of idea (CLA)" was appeared most frequently, to which 132 fragments corresponded, followed by "introduction of an idea (IDE)" (130 corresponding fragments) and "tools and environment (CTE)" (119 corresponding fragments). A total of 111 fragments corresponded to "Hand-over (HAN)"; the least frequently occurring verbal communication code was "brief (BRI)" (9 corresponding fragments), followed by "interruption (INT)" and "schedule (SCH)" (10 corresponding fragments for each code); "floor-holding (FLO)" and "high-level design (HLD)" also occurred less frequently (12 and 14 corresponding fragments, respectively; see details in Table 4).

The analysis results revealed that G1 had the most verbal communication fragments, followed by G2; G3 had the least of these fragments (86). For G1 and G2, CLA was the verbal code that occurred most frequently, whereas IDE occurred frequently in G4 and G5. G3 exhibited the least amount of communication in the ideation, with the HAN code occurring most frequently. Thus, judged through the analysis of verbal communication of the two teams with rather diversified lateral development types corresponding to their sketches, namely G1 and G4 (refer to Table 4), the verbal communications of CLA and IDE contributed to the ideation development results. In terms of the uniformity of lateral-thinking development types corresponding to sketches in G3, which had the least verbal communication fragments, the most frequently occurring fragments in the ideation pertained to HAN; thus, HAN demonstrated a negative effect on the collaborative ideation development of the members. Such as, frequent occurrences of verbal communication of the team members with the purpose of inviting other members to speak did not contribute to diversifying the lateral-thinking development types reflected in the sketches. An example is "What do you think?" and "What ideas do you have?"

Table 3. Amount, lateral thinking categories and ratio of design teams'idea sketches

Group	Sketches	Amount	Categories	Ratio
G1		10	5	0.50
G2		5	1	0.20
G3		3	1	0.33
G4		5	3	0.6
G5		2	1	0.5
Average		5	2.2	0.43

Table 4. Design teams' verbal communication during ideation

Type	Code	G1	G2	**G3**	G4	G5	Total
Communication control	INT	6	--	2	2	--	10
	FLO	8	--	1	1	2	12
	HAN	22	15	21	26	27	111*
Communication technology	CTE	22	32	12	32	21	119*
Social	SOC	21	16	3	11	20	71
Design communication	IDE	24	23	8	39	36	130*
	ACC	15	14	2	12	13	56
	REJ	8	6	3	6	3	26
	CLA	65	39	4	11	13	132*
	REF	17	20	2	3	9	51
	EVA	27	15	6	7	2	57
	LLD	9	6	16	16	12	59
	HLD	2	4	4	1	3	14
	BRI	--	3	1	--	5	9
	SCH	5	2	--	3	--	10
	TAS	11	10	1	1	--	23
Total		262	205	86	171	166	890

The results of a comparison of the teams' verbal communication and number of the types of lateral-thinking development corresponding to their produced sketches revealed that team members' frequent communication, expounding of ideas, and spontaneously proposition of concepts during ideation contributed to the diversity of lateral-thinking development reflected in their sketches. However, frequent occurrences of verbal communication of the team members with the purpose of inviting other members to speak did not contribute to diversifying the lateral-thinking development types reflected in the sketches. An example is "What do you think?" and "What ideas do you have?," the frequent questioning verbal communication of a member of G3. Such verbal communication may have had a negative effect on the collaborative ideation development of the members.

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