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THE EFFECT OF DIGITAL MEDIA ON DESIGN COMMUNICATION AND CREATIVITY IN A DESIGN GROUP: A STUDIO AS A CASE STUDY

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ABSTRACT
Design is a group behavior and creativity is the result of social interaction. Digital media are regarded both as the environment in which designers accomplish creative ideas and as a platform of design communication for designers in a social group. This study aims to investigate the phenomenon of design communication in the group design process using digital media. The study was conducted by observing a design group in a case study. A practical design "studio" was selected to serve as the observation environment. The observed results were used to promote understanding of how digital media inspire design thinking and facilitate the communication of design ideas.

Keywords: case study/studies, communication, creativity, social design, digital media

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1 INTRODUCTION

Lawson (2006) stated that design is a group behavior. Designers should be aware of the ways their thinking might be affected by group behavior and the ways in which they can influence the thinking of other members of groups to which they belong (Lawson, 2001). The interaction of the members in a design group depends on the ability to share concepts (Peng, 1994; Lawson, 2004, 2006) and access collective knowledge and experience to complete a design (Laxton, 1969; Hertzberger, 1991). Design activities always occur in groups. A platform for dialogue is required by group members in order to achieve creative results, and design media can provide this platform for information exchange.

The use and sharing of design media has two major impacts on designers in a social group. Design media are regarded both as the environment in which designers accomplish creative ideas (Bilda and Demirkan, 2003) and as a bridge for designers (Kvan, 2006). Previous studies showed that digital media change design processes and design thinking. It can help to stimulate creativity (Boden, 1998; Gero, 2000; Gero and Maher, 1993; Mitchell, 1993). Branki et al. (1993) noted that the assistance of technology was necessary during the design process. Technology not only helps in the completion of design tasks but also promotes the relationships among designers (Bannon and Schmidt, 1991; Kraut et al., 1988).

Previous literature on the influence of digital media on design can be categorized based on two major issues. One issue regards the application of digital media in the design process. Many researchers, proposing to reduce costs by producing more design plans in a short time, emphasized the possibilities for innovation using computer systems. They attempted to develop new platforms for drawing in order to reach a new relationship between computers and sketches (Elsas and Vergeest, 1998). The second issue concerns the impact of digital media on the creative thinking of an individual designer. These studies focused on the application of nontraditional digital media to inspire individual design thinking (Boden, 1998; Gero, 1996, 2000; Gero and Maher, 1993).

2 PROBLEM AND OBJECTIVE

A thorough examination of the previous literature reveals that few studies have discussed the influence of digital media on design communication from the perspective of group design. Nevertheless, design media play a crucial role in this area because they communicate designers' ideas clearly to other designers and facilitate the spread of key messages. These processes, in turn, help designers to gain approval from evaluators, to affect more designers, and to achieve social creativity.

This study asked whether today's digital media, already proven to be a crucial tool in the design process, serve effectively as a platform of design communication. If the answer is yes, what facilitates design creativity? If not, is a new communication system needed for the presentation and dissemination of digital creations? Because digital media are already in wide use in the design field, the researcher conducted field research to investigate the phenomenon of design communication in the group design process using digital media.

3 METHODS: A QUALITATIVE OBSERVATION AND CASE STUDY

Previous studies showed that design behavior is a group activity suitable for field observation (Lawson, 2006). Therefore, in this study, the author aimed to collect research data from a group design process in as natural a setting as possible. Considering that the research must involve a design group in which appropriate observation and data collection are possible, a practical design "studio" was selected to serve as the observation environment for this study as it is the most common course style in design disciplines. The instruction in a studio is similar to that of a seminar, in which the instructor and students discuss the designs face-to-face in a shared educational environment. The schedule of the selected studio dictated that the students first reported their design progress, after which the instructor gave a public or individual lecture according to the presentation result of the chosen design media.

The objective of this study is to understand how digital media inspire design thinking and facilitate the communication of design ideas. Therefore, all designers in the case study were required to use CAD/CAM technology in their design processes while the author observed the application and communication of digital media in the design group.

3.1 Participants and design task

The case materials were derived from the observation of a real second-year undergraduate design studio in the Department of Art and Design at Yuan-Ze University. The course objective was to simulate a design studio in practice and to familiarize students with the digital design process, including digital design concepts and operation training. There were 17 students in the course, who all received basic design training when they were freshmen. Most of them graduated from fine arts programs in high schools around the country and therefore had experience in creating art. The instructor specialized in digital fabrication and strongly encouraged the students to employ digital media in their designs. The nature of the design group and its frequent application of digital media made it a suitable subject for our investigation.

There were two design programs in the course. The first program lasted for 11 weeks and was based on product design, focusing on the solving function-related problems. The second program lasted for 6 weeks and was based on space design, focusing on the exploration of ergonomics. This research gathered warm-up data from the first program, in which the researcher may get familiar with the characteristics of the group and understand the individual difference and the relationship among the group members. The formal research data were taken from Program Two. The following is the basic information of Program Two:

- **Design theme:** Reading space design: figure and Chinese stroke
- **Class member:** 17 students (3 males and 14 females), 1 instructor, and 2 Teaching Assistants (including the researcher of this study)
- **Course time:** 7 sessions total, 1 session per week
- **Design description:** Design a comfortable reading space that can encompass a human body.
- **Design topic:** Read an essay on space and develop a 3D spatial form to interpret the article individually. Develop 3D reading space design based on body postures and the Chinese stroke. Learn to use and integrate traditional 2D and 3D media (sketch, handcrafted Styrofoam model) and digital CAD/CAM media (AutoCAD 2D drawing, AutoCAD 3D model, Styrofoam cutter).

The studio class was arranged such that after a student reported his or her own progress and ideas to the instructor and the peers, he or she would receive comments from the instructor mainly and the student and instructor would then discuss future steps. All students were required to participate in the entire design presentation process. The only exception was during the sixth class, which occurred during a later stage of the design process when it was more appropriate for students to receive individual feedback based on their progress; this sixth class was structured to focus on one-on-one discussion.

3.2 Data collection

To collect data and observe the class, the researcher blended into the research field as a teaching assistant. As the task of the teaching assistant was to help the instructor organize the course materials, the teaching assistant had to participate in weekly meetings and collect students' assignments after class. All sessions were recorded with a video camera focused on the students' presentation and the discussion between the instructor and the students. The researcher also took notes on the progress of the design process and the observation of digital media use in class.

There were two types of data in this case study. One was descriptive data, including the transcripts from the video record on the presentation and discussion, the observation notes from the researcher, and the concept writing from students. The other was image data, including the pictures took by the researcher and the posters submitted by students, which included sketches, 2D/3D CAD drawings, renderings, and pictures of physical models, etc.

There were 17 students in the studio, who were coded as Student A, Student B, Student C, …, Student Q. Student J was absent from the design presentations several times and didn't complete the final mock-up, so the data from Student J were not included in this case study. The subjects of this case study were 16 students in total. The studio lasted for six weeks and included five public presentations in the design process. Public presentations took place in the second, the third, the forth, the fifth, and the seventh session. But, Student B and C did not finish their design in the final presentation; they continued to work on the design for two more weeks to finish the final model. Figure 1 of the 16 final creations showed the relationship between the use of digital media and design form.

Figure 1. Final creations correspond with the Chinese stroke

4 ANALYSIS AND DISCUSSION OF DIGITAL MEDIA

This study aimed to investigate how digital media influence design creativity in group design interactions. Digital media play two roles in the design process: they are a platform to inspire designers' creativity and the media by which a group of designers express their design thinking. Therefore, the data collected during this case study were analyzed from these two perspectives. Every section of the analysis was composed of weekly progress reports, which were integrated into a final analysis to observe the overall digital design process and results.

4.1 Structure of the analysis

The case study was conducted for 6 weeks and a total of 7 class sessions. In the first session, the instructor assigned the design topic and introduced previous cases. The next five class sessions involved face-to-face discussion. The last session was used for final presentations, for which three guest judges were invited. Data were analyzed from two perspectives: the use of digital tools as design media and as a platform for design communication. In terms of design media, the researcher mainly observed the variety of design media adopted in the design process; in terms of design communication, the researcher observed presentations and communicative efforts using digital media in every session. The analysis structure of this case study was summarized in Table 1. The observation data of collection was specifically classified according the structure and then the observed results were received based on the research objective as well.

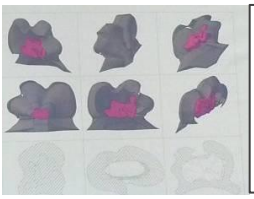
Table 1 Analysis structure

Type	Class	Description
Digital media as **design media**	traditional media	Including sketches, handcrafted models, concept texts, and photography.
	digital media	Including digital sketches, digital 2D drawings, digital 3D models, renderings, 3D CAM physical models, 2D plans and elevation drawings.
Digital media as **design communication**	presentation	About communication tools for design presentation, including oral expression, texts, drawings, and models.
	communication	About design expression and influence on others in the group by using of digital media.

4.2 Case study

4.2.1 Digital media as design media

In the first class, owing to no use of digital media, no analysis was conducted regarding the lecture.
In session two was in the design concept stage. Because handcrafted models and digital 3D study models were both allowable methods to realize 3D forms, most students chose to use only one of the two methods. Those who employed handcrafted models engaged in more discussion about the manipulation of the physical object, and those who employed digital 3D models engaged in more discussion about the skills required for 3D modeling, as shown in Figure 2.



Student H: *Should I build the model first and then drill the hole, or should I leave a space for the hole frist and construct the space on the top… that way there'll be an opening on the top…*
Instructor: *You should leave the space for the hole.*
Student H: *So I just leave the space for the whole and construct the model around it ?*

Figure 2. 3D study model and discussion of Student H and Instructor

In session three, students modified their concepts from the previous class and began to think about the spatial relationships, functions, and materials of their final models. Handcrafted models were the main traditional media used in the design development stage, and some students supplemented these models with sketches and photography. The digital media used were mostly developed from handcrafted models and included CAD drawings and digital 3D models. Some students drew 2D drawings and then made handcrafted models based on the components and units of the drawings, as shown in Figure 3a. However, this process had a tendency to produce 2.5D forms that were actually 2D outlines that gained thickness. The instructor rejected this approach because it lacked 3D thinking. Another type of process used by the students involved producing the handcrafted model first, as shown in Figure 3b, and then creating a 3D digital model according to the physical one. CAD drawings could then be drawn for use with the cutter.

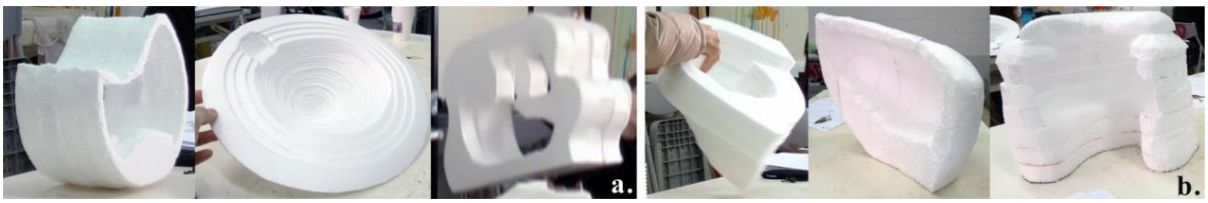


Figure 3. a. Left to right: handcrafted models by Student C, N, and Q;
b. Left to right: handcrafted models by Student E, F, and K

Detailing the model became the main task *in session four*, including the construction of the physical model. This week the emphasis was on the construction of the physical model. The use of traditional media was primarily focused on 1:4 scale handcrafted models. The use of the digital media this week saw the first inclusion of CAD/CAM techniques in the design process. Some students converted their prototype handcrafted models from the previous week into 3D digital models and 2D CAD drawings. They used the Styrofoam cutter and exported the 2D CAD drawings into the cutting units. After assembly, the models were modified by hand once again. The CAD/CAM operation procedure was completed by few of the students.

In session five, students reported the progress they had made during the last four weeks. This class required a progress report: a summary and documentation of the concept texts, photography, sketches, and model manufacture. More students had begun modifying the details of their digital CAD models and attempted to export physical CAM study models, and studied the transition between the two types of models.

The sixth session focused on solving problems arising from the physical model manufacturing process. The class was held in two different settings. The first component was held in the computer classroom, where the instructor and students worked on computers to solve problems with the digital 3D models and 2D CAD drawings. The discussion was supplemented by printed drawings and physical models. The second component was held in the design studio, where the instructor discussed the physical models with individual students.

Session seven was for final presentations. A final design presentation usually includes the display of the final physical creations, supplemented by large drawings on a poster. Similarly, the final presentation in this course included a mock-up and a poster, where texts, drawings, and photography related to the design process were presented.

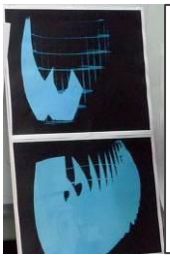
4.2.2 Digital media as design communication

In the first class, the instructor introduced the class project. This class aimed to inform students of the purpose of the design project, so no assignments were due. No analysis was conducted in the lecture.

In session two, the students reported their overall design concepts. In terms of traditional media, the presentation of the concept texts, photography, and sketches were printed in a 2D layout, and the presentation of the handcrafted model was shown physically. The digital media, which included digital sketches, digital 2D drawing, and digital 3D modeling, were all exported in the form of 2D prints. The sketches played a major role in concept presentation. The sketches demonstrated the development of the design form and also left more room for discussion and more flexibility for future modifications. Because most digital sketches included more geometric lines than freehand sketches and the class requirement was to create free-forms, many students were asked to redraw the forms in their digital sketches with free lines. The students' use of 3D digital models showed that they were still unfamiliar with the software and therefore failed to successfully convey their concepts.

In session three, a physical 1:4 scale model was due. The presentation of the designs consisted mainly of physical models and was supplemented by 2D and 3D CAD drawings. Therefore, the discussion on media centered on the conversions between physical models and digital data. Most students handed in physical models in this class session to communicate designs. Therefore, the design discussion was centered on physical models, including the assembly of model units, the modification of the forms, and the forms' expression and function. As in the previous session, the students' unfamiliarity with the digital media resulted in difficulties in conveying design ideas with 2D and 3D CAD drawings.

In session four, the students made a second model and gradually modified the outside form, inside space, and its proportions. Some of the models already had the quality of a prototype. More students decided to make handcrafted models to visualize their design concepts first before they began manipulating digital media. They then exported the 3D digital models into CAD drawings to be made into CAM physical models. In terms of communication, more students used physical models for design discussion this week, whether they were handcrafted or CAD/CAM models. However, it was difficult to imagine the final forms of the projects from the CAD drawings because the presentation of the drawings did not aid intuitive understanding. For example, Student O presented the concepts in drawings of the digital CAD/CAM model, and others had to imagine the final form from various plans. The presentation method posed difficulties for novices, and only experts who were familiar with the CAD/CAM method were able to achieve a better idea of the final model's appearance. The effectiveness of communication with the CAD/CAM models was limited, as shown in Figure 4.



Instructor: *Your final model would look like this, right? (See Fig 4-9.) That's how it will look like…this part is solid…I would recommend that you make it solid, and gradually it goes from very dense to sparse. Or else there is no transition…You should make a smooth, gradual transition…the upper part will be most sparse. Now you have regular distances between them…you can make them irregular…*
Student O: *So it goes from dense to sparse both longitudinally and laterally…*
Instructor: *……That way you will have more variety.*

Figure 4. CAD drawings and discussion of Student O and Instructor

In session five, the task was to continue developing the previous week's model. More students have completed their digital CAD models. Therefore, the design form expressed concretely how the final creation would roughly look like, and it also enabled a better understanding of space configuration. The instructor requested a more detailed presentation of the digital models.
Session six was divided into two components. In the first component, problems regarding computer cartography were resolved in order to correctly export drawings to create 1:1 physical units. In the second component, the physical units were assembled, and students scraped and colored their final creations. Students chose to work in the computer classroom or in the studio according to their work schedule and needs. Therefore, more equipment was used in design communication, and there was a greater diversity of media in the presentations. Student F also presented her renderings, which demonstrated clearly her plans for the design installation (See Figure 5).

Figure 5. The renderings of Student F

In session five, after the students introduced their projects in the shared space, the guest judges commented on each creation. The guest judges commented only on the concepts presented in the poster and the final mockup. Therefore, the students' design process was not taken into consideration. The final result determined the quality and creativity of the design. For the guest judges, the final creation was the most important communication medium by which the design could be understood.

4.3 Results and discussions

The use of media in the design process indicated that the practices of the pioneers in the group had a significant influence on the followers. Innovative methods of using design media were often imitated by other students in the following week, as shown in Figure 6. The process began when a few students tried a new way to manipulate the design, went through a discussion process, and were encouraged by the instructor in their methods. These students, in turn, inspired their peers to adopt a similar method in presenting their own designs during the next week.

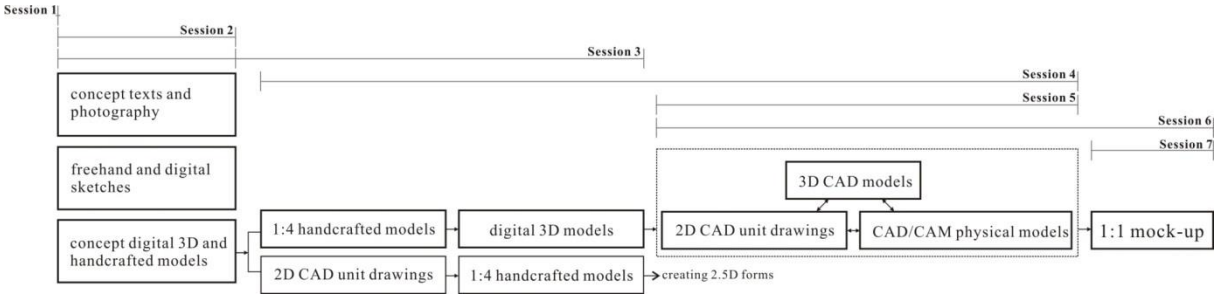


Figure 6. The using procedure of design media in the seven sessions

Despite this phenomenon, the designers produced diverse final creations in the design process. One purpose of design training is to teach students to pursue originality and diversity. In this case, despite the fact that some of their works might have looked similar, students attempted to be different from each other regardless of whether they arrived at better solutions in the end. The desire to create unique works is an important motive to inspire creativity (Amabile, 1983). A group environment encourages designers to embrace the spirit of both competition and cooperation. A designer does not need to be unique in his opinions or design methods throughout the entire design process to prove his creativity. It is enough that he finds new solutions at certain points in the design process and has an influence on the group as a whole with these solutions. It was observed that students who were more comfortable with experimentation had a richer experience manipulating their physical models. They were also better at communicating with digital models and achieved a greater diversity in their design results.

On the subject of digital media in design communication, the environment for reporting or presenting design results is not very different from the traditional environment in which the presentation of design media focuses on a large number of drawings and physical models though we live in a digital era. There are most likely several reasons for this phenomenon. Designers are accustomed to showing their works in this manner, and the environment for showcasing design progress and results greatly resembles a showroom. Therefore, a spacious room is required, and it is essential that designers display every physical object in a fast, simple manner. Due to design conventions, judges and reviewers pay the most attention to final drawings and models of designs. In this case study, the author found that the designers selected traditional media to communicate with their peers despite employing new digital media to execute their designs. They were hard to accurately convey their digital design thinking in the traditional presentation style. This tendency has slowed down the spread of knowledge and could possibly influence the design creativity of a group. CAD/CAM technology was, moreover, a new design medium for many designers in this case study. Though every week designers shared their experiences in using various media, it was difficult to communicate the details and complicated manipulation of the media by looking only at drawings. Therefore, specific media techniques were likely to be adopted by others only after the physical models were made.

The communication media used by the students were sketches and models across the design process. Session six was the only class involving one-on-one discussion, and the instructor and students were able to conduct a design discussion in different environments. This discussion enabled diversity of communication media and gave the instructor an opportunity to solve individual problems. However, one-on-one discussion cannot be employed in a presentation environment, and further research is required to explore whether direct manipulation of design media is appropriate for design communication. In addition, the nature of the conceptual drawings exported from digital media left less room for discussion and idea generation due to the high level of completion and distinct drawing lines. Previous studies have indicated that vague and unstructured sketches in the concept phase are the key to design creativity (Purcell and Gero, 1998; Goldschmidt, 1994; Verstijnen et al., 1998). In the manipulation phase, the CAD drawings were hardly noticed by the group because they were difficult to comprehend. This incomprehensibility created a gap in design communication during the transition from digital to physical models. This example shows that it is crucial to adopt appropriate communication media in various phases of the design process. Drawings generated in the design process may not be an appropriate interface for communication. Students' unfamiliarity with using the digital media was another reason for communication difficulties during the design process.

5 CONCLUSIONS

Design media provide a way to inspire creativity in designers. However, when digital media are placed in the context of a group, design communication and message delivery become crucial, and design media become a platform for effective communication with others. This study emphasizes the exploration of the latter issue, aiming to understand the influence of digital media on design communication. The study was conducted by observing a design group in a case study, and the observed phenomena were used to promote understanding of how to inspire design creativity.

5.1 Observation One

- *All members of the group should have the same level of professional knowledge and familiarity with a digital tool in order to lower discrepancies in communication and promote a better understanding of the design content.*

If a designer doesn't understand the manipulation method of the other designers in the design process, misunderstanding in design thinking is likely to arise. However, digital media requires a higher level of technique and is used less intuitively compared to traditional media. As a consequence, the use of digital media in the group focused on the learning of manipulation methods, and the role of communicating design concepts was neglected. It lacked a more diverse thinking or application by using and appreciating digital media form other perspectives.

If a designer does not understand the manipulation methods of his or her peers in the design process, misunderstandings in design thinking are likely to arise. However, digital media require a higher level of technique and are used less intuitively compared to traditional media. As a consequence, the use of digital media in the group focused on acquiring skill in various manipulation methods, and the role of communicating design concepts was neglected. Therefore, more emphasis was placed on the design process when digital media were used in communication, while the design thinking and expression arising from the use of digital media failed to be appreciated by the group.

Besides, knowledge of design media should contribute to the group's collective knowledge through presentations, but due to the lack of digital media knowledge in the group, many designers were unable to internalize new knowledge for their own use. In other words, thoughts on digital media were presented to the group but not fully exchanged among members. Designers could not put new ideas to use freely, which had an influence on creativity.

5.2 Observation Two

- *A new presentation system, mainly the changes of the partial current/traditional presentation space and procedure, was necessary to accommodate to new forms of design works that were created with digital media.*

When we look at when design media as a tool for communication in a group, it should facilitate judges' and reviewers' comprehension of the designs and aid in paradigm shifts among the designers. Most people in the case study had a better understanding of physical models, which meant that physical models were more widely discussed and evaluated by the group. Content presented with digital media, such as CAD drawings and 3D digital models, was more difficult to understand to just show in the traditional showcase space or hard copy and therefore less discussed by the group.

Conveying information to the group in a precise manner can facilitate creativity. In the current presentation environment, the content of 3D digital design must be converted into 2D drawings or made into physical models for presentation, which either limits the presentation's effects or requires great effort and expense. Therefore, to accommodate large amounts of digital design content, the development of new presentation tools is necessary to clearly and correctly express 3D digital design thinking. This development includes improving hardware equipment, such as providing new human-computer interfaces that can clearly display 3D digital information, and enabling designers to manipulate the 3D digital model during the discussion or presentation to fully express their design ideas. The correct application of virtual reality may provide a direction for solving the issue (Kvan, 2000; Shen, 2008).

However, conventional media cannot be wholly replaced by new media in the presentation process. Sketches and physical models are both still important tools in the design and discussion process and should not be neglected in design communication. It is important to think about how two different presentation interfaces, using digital and conventional media, can put together and complement each other in the design communication process.

While previous studies adopted only one perspective, this study employs multi-views on today's frequent use of digital media in the design communication process and suggests that improvement of the design presentation mode should be approached using a "presentation system." The presentation system should be composed of the presentation space and the presentation procedure. Apart from updating hardware facilities, the improvement of the presentation procedure should also be researched and designed to solve the problems encountered in the present digital design presentation environment.

5.3 Limitations and Future Studies

Previous studies began with how computers facilitate group discussion and focused on communication tools and skills but did not investigate whether the presentation of design results conveyed clearly the design message. This study proposed a new perspective on design communication. The observations in the study were made in a sophomore design studio. These students were design novices and had just

started learning how to use digital media. Their knowledge of design and digital media was often limited. The findings in this study represented a preliminary stage of analysis, and further analysis and validation of the results should be made by case studies on a group of design experts in practice.
The analysis component of this study was based on one selected case; therefore, the findings might not be inferred to other groups. More varied research methodology should be employed in the future for further research and for developing a new communication system that can be supported by research findings. The construction of an effective communication platform for the content arising from digital media can help convey clearer design information to groups and will enhance design creativity.

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