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USING THE DIGITAL CONTEXT TO OVERCOME DESIGN FIXATION: A STRATEGY TO EXPAND STUDENTS' DESIGN THINKING

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Keywords

design fixation; design thinking; digital context; design education; design strategy.

Abstract

Design fixation has been described as a lack of flexibility in relation to a limited set of design ideas. This study empirically sought to use different strategies to overcome various forms of design fixation. As strategic approaches to negating design fixation, a digital world that has no physical limitations was selected as a thinking expansion motif and an abstract task was given as a design problem. It was anticipated that combining limitlessness of the digital world with an abstract design task would break design fixation, leading to a creative design process. The results supported the usefulness of the adopted strategies. The combination of the digital context and the design task overcame participants' design fixation and encouraged the creative design process by generating thinking expansion. Further, combining 'Team Based Learning' and an 'abstract design task in a digital context' led to natural brainstorming and problem solving that exhibited co-evolution. In conclusion, the digital context is one of promising strategies that could be used as a thinking motif to expand students' design thinking and promote 'creativity' in education.

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INTRODUCTION

Know-how and flexibility accumulated from extensive experience are indigenous competences in humans. Recently, artificial intelligence (AI) systems have begun to use large data to absorb humans' know-how and flexibility and, consequently, begun to replace humans in many domains. Although the world transforms to a digital world emphasising AI everywhere, 'creativity' continues to have great significance in design as the ultimate indigenous thinking realm of human beings. Before this research, several design experiments were conducted in which abstract tasks were used as a strategy to enhance the creativity of student participants. It was found that while abstract tasks encouraged participants to engage in inferential thinking (e.g., using metaphors and analogies) several forms of design fixation (e.g., memory and conceptual fixation, and knowledge and functional fixation) still occurred. Design fixation occurred from the problem analysis phase to the ideation phase of the design process, and was found to hinder thinking expansion and have negative effect on participants' creative output. This study was designed to provide students with strategic approaches to overcome design fixation. Students have acquired know-how through their education and experiences. The usefulness of the established strategies would be analysed by observing changes in students over a long period of time. Specifically, a design studio (programmed as a design experiment) was taught for one term (i.e., over a period of 16 weeks) at a university.

Numerous limitations (i.e., construction, material, spatial scale, human scale and reliance on known information or knowledge) exist when a physical space is designed. However, a digital world has no such physical limitations and thus was selected as a thinking expansion motif to surmount design fixation and encourage participants to be imaginative. It was anticipated that combining limitlessness (e.g., zero gravity, nought objects, no time and nil scale) with an abstract design task would eliminate design fixation, leading to the creative design process. Further, it was anticipated that understanding the digital context from a cognitive perspective and using a digital world in the design of a space would provide participants with an opportunity to engage in unlimited thinking expansion.

The entire process was built on Team Based Learning (TBL). 'Solving an abstract design task in a digital context' was a new attempt to students who had not experienced it before. It was anticipated that forcibly combining TBL and an 'abstract design task in the digital context' would lead to natural brainstorming, the most substantial strategy in any problem-solving process. Further, 'creative' is often taken as a qualification of a final outcome, but cognitive psychology associates it with certain processes that have the potential to produce 'creative' outputs in designing (Gero, 1992; Visser, 2004). It was anticipated that during this process, co-evolution (a significant feature of any creative design process) would be naturally induced. It was hypothesised that:

Hypothesis 1. The combination of a 'digital world' and an 'abstract design task' would expand student participants' thinking and thus overcome design fixation.
Hypothesis 2. The combination of TBL and an 'abstract design task in the digital context' would lead to natural brainstorming and problem solving would exhibit co-evolution.

RELATED WORKS

Many design researchers and educators have tried to establish effective design curricula and education strategies in architecture education (Gaber, 2014; Salama, 2009; Salingaros & II, 2007). Gaber (2014) described the specific contexts for the design-build curriculum, the processes of the implementation and the agency of making both for the students and instructors. Salama and El-Attar (2010) paid attention to the educational value of the jury system which lies in enabling students to acquire effective knowledge of solving architectural problems while offering them sufficient framework of guidance. Masdeu and Fuses (2017) reconceptualised the design studio in architectural education because the design studio has played a key role in the training of architects and needs to be adapted to the current situation. Above all, this research is mainly interested in the design fixation occurred in design studios because students are exposed to cases of designs in similar settings for studio courses, leading them to produce often routine designs.

Herzberger (1991) stated that everything that is registered in our mind adds to the collection of ideas stored in the memory, where we can consult whenever a problem arises. According to his argument, the more we experience, the more points of reference we will have, consequently these processes are quite useful and adaptive. The unconscious cognitive system rapidly responds to situations in relation to highly practiced activities such as reading and driving, and provides the means for cognitive offloading of highly repetitive responses. However, the use of examples can also negatively impact the design process, and potentially cause limiting fixations in relation to existing examples (Jansson & Smith, 1991). The information that designers hold in their minds could potentially cause designers to fixate on precedents during the design process (Toh, Miller, & Kremer, 2012).

Design fixation has been described as the inability to solve design problems or a lack of flexibility in relation to a limited set of ideas in a design process (Toh et al., 2012). Individuals with design fixation often use familiar methods and self-imposing constraints (Youmans, 2007). Moreno et al. (2015) argued that a number of factors can contribute to fixation, including a designer’s expertise or unfamiliarity with the principles of a discipline, personality type and conformity due to the proficiency of the methods and supporting technologies of an existing solution (Cross, 2004; Linsey et al., 2010; Purcell & S.Gero, 1991)

Jansson and Smith (1991) were the first to empirically study design fixation effects in design. They found that showing designers a picture of a potential design solution at the idea generation phase of the design process resulted in design fixation, as the picture created a cognitive block, reducing access to other solutions. Further, they found that both novice and expert designers who were shown pictorial examples reused more features from those examples than those not shown such examples. A number of follow-up studies reported similar results in relation to the fixation effects that occurred when participants were shown examples during the design process (Chrysikou & Weisberg, 2005; Linsey et al., 2010; Smith & Linsey, 2011).

Purcell and Gero (1991) reviewed the results of recent experiments addressing the fixation issues in design problem solving with a focus on what implications they have for design education. They suggested that a designer’s susceptibility to fixation depends on the discipline of the designer and contended that design fixation is more likely if the example problem contains principles in line with the designer’s knowledge base of that discipline. They found that traditional teaching approaches that largely use precedent designs raise important questions about the effects of traditional design education on students’ innovative capabilities. Thus, methods need to be developed that reduce fixation effects.

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Researchers have sought to break or negate the fixating effects of precedents in designing (Christensen & Schunn, 2007; Jansson & Smith, 1991; Linsey et al., 2010). Encouraging designers to find new ways to frame problems may lead to mitigating design fixation (Linsey et al., 2010). Problem framing is the most important process for understanding the nature of any design problem. The initial definitions of problems may be associated with typical work contexts that are similar to those in which previous problems have been defined. To avoid any fixation effect in relation to existing solutions, design problems need to be redefined by considering fixation effects outside a designer's typical work situation (Smith & Linsey, 2011). When working on design tasks, designers must articulate problems, generate design solutions and employ appropriate strategies in relation to the design activities.

According to Smith and Linsey (2011) incubation effects in problem-solving are essential cases for creative design in which insightful solutions are frequently realised if an individual temporarily stops working on a difficult problem. Incubation effects provide unexpected insights into memory, creative problem solving and brainstorming (Choi & Smith, 2005; Kohn & Smith, 2009; Vul & Pashler, 2007). In the absence of fixation, problem solutions can be directly realised. Thus, fixation is a precondition for the observance of incubation effects. By temporarily putting aside a fixation problem, an individual can consider the problem without the counterproductive influences of inappropriately applied knowledge. Thus, temporarily putting aside a fixation problem may be helpful.

RESEARCH METHODS

Subjects

Eighteen third-year university students majoring in a four-year interior design course participated in a studio class for one term. Prior to their third year, these student participants had completed basic design practice classes, including classes on computer tools, drawing and expression techniques, residential space design and special space design.

Class Composition and Procedure

The classes were conducted over 16 weeks and included an introduction designed to enable participants to understand the digital world. To promote creative and open thinking in participants, the introductory three-week period included courses on idea stimulation (i.e., watching movies and appreciating design cases on the digital world) and lectures on design theories. Participants were assigned to teams during this period (Table 1).

Table 1: Class Composition and Procedure (Source: Authors).

Introduction	
Week 1	Class introduction, team formation and screening movies on the digital world for stimulation
Week 2	Viewing space design cases in which digital technology had been applied Lectures on design theories
Week 3	Lectures on the design theories, presentations and discussions on the movies viewed by participants
Task 1 Public Space/ Private Space	
Week 4–9	Participants worked in teams of four for six weeks
Task 2 Intermediate Space	
Week 10–16	Viewing digital related art exhibitions Participants worked in teams of six for seven weeks

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① Introduction: Idea Stimulation and Lectures

- Watching movies: This activity was designed to create a sense of teamwork and expand participants' ideas in relation to future society and human relations in the digital context. To avoid fixation effects, we tried to put participants outside a typical world situation and encouraged them to be imaginative in an unfamiliar context of the digital. Participants were shown movies such as 'Her', 'Inception', 'Minority Report', 'Oblivion', 'Avatar' and 'Elysium'.
- Viewing examples of digital design and art: This activity was designed to expand participants' understanding of current digital technologies and stimulate participants' broad ideas of contemporary people. Participants were shown space design cases that used digital and design prototype cases that include digital art works prior to the first task. They were also required to view digital related art exhibitions and sketch gallery scenes to stimulate imagination prior to the second task.
- Lectures on Design Theories: Our previous design research has shown that to encourage students to think divergently, students need to learn about the concept of design thinking, the thinking process, inferential thinking methods, etc. Thus, lectures on design theories were given to students during the class, and students were consecutively taught a number of design theories by a lecturer even when they worked on design tasks.

② Design Task 1: Public Space and Private Space

- Intention: Participants' first task was to learn how to grasp their adaptability in relation to a given problem. Students were given a design task that had an open theme (i.e., public space and private space) and did not reveal a specific character (i.e., the task was not a residential or commercial design). It was six-week task.
- Team Formation: To minimise the deviation level among teams, the 18 student participants were divided into four teams based on their grades in design studio classes and their professors' evaluations of their work: two teams of four and two teams of five. The first two teams were directed to design a public space and the other two teams were directed to design a private space in the digital context. There were fortnightly presentations of the progress and final presentations.

③ Design Task 2: Intermediate Space

- Intention: The second design task was to design intermediate space design in the digital context and conducted over a period of seven weeks. Participants' second task was to learn how to consider the digital context from a cognitive perspective by compensating for defects identified in the first task. The teaching plan for the second design task was amended based on the outcomes of the first task.
- Team Formation: Participants were also to form teams to minimise the burden of performing a challenging task. Six teams were formed: two teams of four, two teams of three and two teams of two. Students used every possible method (i.e., sketching, writing, searching the web, using digital planning tools, collaging images and modelling). There were also fortnightly presentations of the progress and final presentations.

A FRAMEWORK FOR ANALYSIS

The design process was divided into four phases: Problem Analysis, Inspiration, Ideation and Implementation (Table 2). The four phrases were derived from Howard et al (2008). Our intention was to measure how much time students spent in each phase with a focus on co-evolution while they worked on design tasks, and further to observe their design behaviours

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occurring in each phase. Creative design can be modelled in terms of the co-evolution of problem and solution spaces (Cross & Dorst, 1999). Further, we paid more attention to the ideation in addition to the problem analysis in the design phases. There was weekly recording of the process of each team's project (each team member used a smartphone). In addition, weekly observation notes were made on each team (a lecturer noted down students' behaviours). Customised improvement plans for classes were provided to students for any problem identified at each class.

Table 2: Design Phase and Observation Focus (Source: Authors).

Phase	Observation Focus
Problem Analysis (PA)	Problem reframing, problem re-representation, autonomy of subjective expression, team cooperation, originality of viewpoints and active brainstorming
Inspiration (IN)	Active inferential thinking to solve the abstract task, divergent ideas, fluent development by using plentiful ideas and brainstorming
Ideation (ID)	Active expressions, including sketching and writing, idea leaps using brainstorming, reflection, evaluation and feedback on ideas
Implementation (IM)	Brainstorming, evaluation, elaboration and presentation

An analysis framework was developed to analyse participants' design processes and validate the usability of the digital context and the abstract task in overcoming design fixation (Table 3). The analysis framework was adopted and extended from the research of Moreno et al. (2015). Our intention was to identify how students overcome their design fixation during the design process.

Table 3: A Framework to Analyse Participants' overcoming Design Fixation (Source: Authors).

Classification	Key Analysis Point	
Intrinsic Level	Problem reframing	Reconstituting the problem from various perspectives
	Enabling incubation	Reflecting on ideas
	Using analogies in relation to the abstract problem	Inferential thinking to solve the abstract task
	Brainstorming	Collaboration, mutual evaluation and free communication to enable understanding
Extrinsic Level	Graphical representations	Graphical expressions such as sketching
	Using word graphs	Language expressions such as memorandums
	Developing functional models	Raising the degree of completion by using modelling that considers functional elements
In-Ex Level	Brainstorming	Collaboration, mutual evaluation and free communication to enable understanding

RESULTS

Task 1: Public Space and Private Space in the Digital Context

Students who encountered 'spatial design in the digital context' for the first time found the entire process (from understanding concepts and task analysis to deduction of an output) difficult (Table 4). Students took almost four of the six weeks to complete the problem analysis. Due to pressure to finish the task, it seems that they could not perform sufficient idea deduction and concept actualisation at the inspiration and ideation phases. Further, when the final output was actualised, students' involvement at the implementation phase was

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insufficient and, consequently, the degree of completion was low. There was also very little co-evolution throughout the task.

Table 4: Each Team's Process of Progress—Task 1 (Source: Authors).

Classification	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Characteristics
Team A	PA			ID			• Weak IN Phase • Difficulties of concept actualisation occurred at the ID Phase
				IN		IM	
Team B	PA		PA			ID	• A long time spent at the PA Phase • Weak IN, ID, IM Phases
		IN			IN	IM	
Team C	PA					IM	• No IN Phase • Completed after deducting one idea
					ID		
Team D	PA				ID		• A long time spend during the PA Phas • Weak IN and ID Phases
				IN	IM		

Note: PA: Problem Analysis, IN: Inspiration, ID: Ideation, IM: Implementation

An analysis of design fixation was undertaken using a five-level Likert scale of 'poor, poor–average, average, excellent–average, and excellent' (Table 5). Each factor was analysed and the level of design fixation was assigned by researchers according to the frequency of typical design activities. It was found that overcoming design fixation limitations occurred more at the intrinsic level than the extrinsic level. Students' comprehension of the digital world remained based in a technological perspective (i.e., a smart device or the limitlessness of the digital context in the cognitive aspect) and thus was not used as a thinking motif. Further, participants were unable to overcome design fixation effects in the current digital technologies and design implementation conditions of real, physical spaces and experienced 'blocks' in their thoughts.

Table 5: Observations of Participants overcoming Levels of Design Fixation (Source: Authors).

Classification	Check Point	T_A	T_B	T_C	T_D
Intrinsic Level	Problem reframing	PA	P	P	P
	Enabling incubation	PA	P	PA	PA
	Using analogies in relation to the abstract problem	PA	PA	PA	A
Extrinsic Level	Graphical representations	A	P	PA	A
	Using word graphs	PA	EA	PA	A
	Developing functional models	EA	PA	PA	EA
In-Ex Level	Brainstorming	PA	P	P	PA

Note: P: Poor, PA: Poor–Average, A: Average, EA: Excellent–Average, E: Excellent

Intrinsic Level

Imagination has no limit. Further, in a non-existent digital space, it can be expanded using zero gravity, nought objects and no time. It was assumed that defining the public and private space in the digital context would be possible given the limitlessness of imagination; however, participants who had learnt under convergent education systems experienced significant difficulties reframing problems from their own points of view. Further, when performing the task, participants' agonising process occurred when they were 'stuck' (not when they were incubating ideas) and participants engaged in very little inferential thinking using digital as a thinking motif. Additionally, a number of participants asked: 'Is this possible?'. Thus, it demonstrates that they approached the task with concerns that there could be technical difficulties rather than a view that the digital context was cognitively limitless. Participants were also strongly fixated on 'current digital technology' and

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tended to engage in evaluations of what was 'right' and 'wrong', feared expressing their thoughts and deduced ideas in very passive ways.

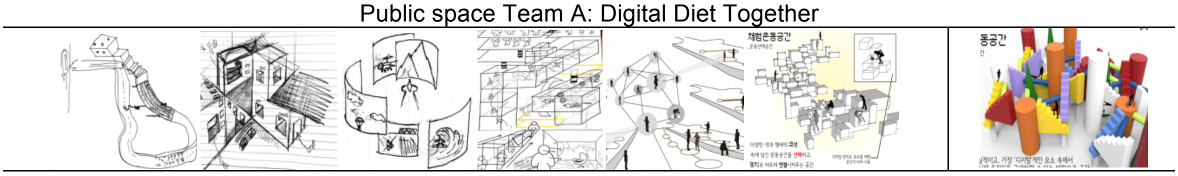
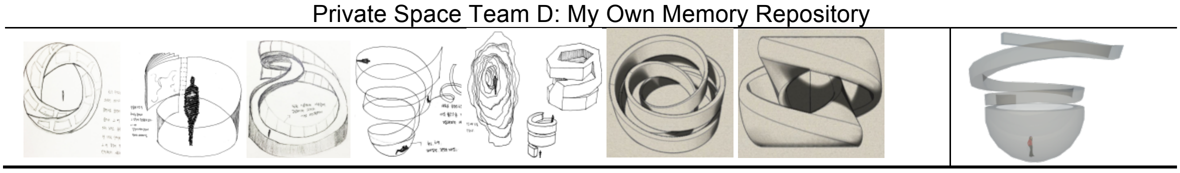
Extrinsic Level

Extrinsic behaviours were induced throughout the design process to overcome design fixation levels and some expressions were congested. Participants used familiar methods such as sketching, note-taking and computer tools to create graphical representations, but had difficulties expanding their thoughts that subsequently became interlocked with expanding expressions. Each team spent four weeks analysing the problems (see Table 4). Consequently, participants were unable to undertake sufficient reviews of the implementation of their designs. However, in spite of time constraints and compared to other elements, the development of functional modelling was conducted smoothly, as participants were familiar with drafting work and the use of computer tools.

In-Ex level (Brainstorming)

Overall, participants' brainstorming was extremely passive with a lack of thinking expansion experience. Team C showed a particular lack of active brainstorming, mutual evaluation and feedback. Further, one member of Team C dominated the decision-making process, including idea deduction, concept decision and the expression of the concept. As the teams were formed based on each participant's competence, the level of closeness among team members was very low. Thus, participants experienced difficulties 'freely communicating their own thoughts' on unfamiliar topics. Viewing movies together for three weeks during the introductory period to 'break the ice' did not make participants feel any closer. Further, it took time for participants educated in individual-centred convergent learning environments to adapt before they felt comfortable cooperating with their other four or five team members. They were observed to experience a number of difficulties in cognitive understandings of digital space (e.g., participants used limitless digital worlds in limited manners). They also seemed to have difficulties in making unique interpretations of public and private spaces, including a lack of conceptual understanding about spaces with unexposed characteristics. The table 6 shows examples of public space by Team A and private space by Team D.

Table 6: Task 1 Design Themes and the Process of Progress (Source: Authors).

Public space Team A: Digital Diet Together

Private Space Team D: My Own Memory Repository


Task 2: Intermediate Space Design in the Digital Context

Participants' progress improved significantly in the second task compared to the first task; however, there were differences between the teams (Table 7). Overall, participants understood the digital context in the cognitive perspective and analysed the problem from diverse viewpoints as they contemplated the problem and the solution.

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Table 7. Each Team's Process of Progress—Task 2 (Source: Authors).

Classification	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Characteristics
A	PA		PA	IN	IM	IN		IM			IM		• Active co-evolution • Adapting to the cognitive use of the digital
		IN		ID		ID			ID				
B	PA			IN	PA			IN		IM			• Co-evolution was observed, PA was relatively congested • Difficulties were encountered, as team members held different opinions
				ID			ID		ID				
C	PA		PA	IN	PA		PA		ID				• Active co-evolution/focused ideation • Elaboration was obstructed due to continuous idea suggestions
		IN		ID		IN		IN			IM		
D	PA		PA		PA		ID		ID		ID		• Active co-evolution and focused ideation was observed •Insufficient output despite the process due to late decisions being made about concepts
		IN		IN		IN		IN		IM		IM	
E	PA					ID				ID			• Co-evolution was observed/insufficient IN Phase • Completed after the selection of one idea
					IN			IM			IM		
F	PA		ID				IN			IM			• Insufficient co-evolution/rushed IM attempts • Re-induction to In Phase was needed by a professor
		IN				IM			ID				

Note: PA: Problem Analysis, IN: Inspiration, ID: Ideation, IM: Implementation

Members of Teams C and D spent insufficient time refining ideas and actualising concepts, but did discuss their thoughts without hesitation. Despite variations among teams, participants oscillated between the problem analysis phase and the inspiration and ideation phases until weeks two or three. They actualised their ideas by repeating the inspiration and ideation phases at weeks four and five, but engaged in insufficient implementation at weeks five and six. Teams A, C and D displayed clear co-evolution during the process. An analysis of design fixation was also undertaken using a five-level Likert scale of 'poor, poor–average, average, excellent–average, and excellent' as shown in Table 8. Design fixation was similarly overcome at the intrinsic, extrinsic and in-ex levels. Participants experienced difficulties when completing the first task, but gained a base to cognitively understand the digital context and showed design fixation improvement in the second task.

Table 8. Observations of Participants overcoming Levels of Design Fixation (Source: Authors).

Classification	Check points	T_A	T_B	T_C	T_D	T_E	T_F
Intrinsic Level	Problem reframing	EA	A	EA	EA	PA	PA
	Enabling Incubation	EA	A	PA	PA	A	PA
	Using analogies in relation to the abstract problem	A	EA	EA	EA	A	PA
Extrinsic Level	Graphical representations	A	A	EA	EA	PA	PA
	Using word graphs	A	A	PA	A	A	A
	Developing functional models	EA	EA	A	A	A	A
In-Ex Level	Brainstorming	A	A	E	EA	A	PA

Note: P: Poor, PA: Poor–Average, A: Average, EA: Excellent–Average, E: Excellent

Intrinsic Level

Teams A, C and D distinctively improved their processes at the intrinsic level, surmounting the substantive view that spaces should have walls, floors and ceilings. Participants fully understood the cognitive use of digital motifs, freely generated ideas and engaged in positive inferential thinking. Notably, Team D had a lower level of completion given their capabilities compared to the other teams, as they spent too much time in the inspiration and ideation

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phases. Teams B and E performed better in the second task than the first; however, Team E still experienced difficulties reframing the problem and was often 'stuck'. Team F showed the least progress. Team members of Team F struggled to overcome the difficulties that they had experienced at the intrinsic level, made an impetuous decision on concept and attempted to produce the final output. The professor also had to constantly encourage members of Team F to re-analyse the problem.

Extrinsic Level

Teams A, C and D showed significant improvement at the extrinsic level and also displayed advanced behaviours. Teams C and D produced the final outputs that focused only on aesthetic points; however, team members did not spend substantial time thinking about developing functional models despite engaging in large amounts of free sketching and being interested in inspiration. Unlike the other three teams, the progress of Team B was tedious. Inferential thinking was observed; however, members of Team B were passive in expressing and developing their thoughts. Members of Teams E and F were reluctant to express their thoughts, as they had no self-confidence in their sketching abilities and hesitated even when producing simple drawings. Team F attempted to complete the final model by using computing tools at week three; however, members of Team F did not make any sketches or write any memorandums despite these being common practices in design processes.

In-Ex Level (Brainstorming)

Visiting the museum and allowing participants to freely form teams appeared to effectively overcome the factors that made brainstorming difficult during the first task (e.g., a lack of closeness among team members, fear of a new theme and a lack of experience working in teams). Participants unravelled their thoughts by discussing the exhibitions that they had viewed while performing the task. Variations existed among teams; however, in relation to the digital theme, mutual evaluation feedback occurred and was experienced at least once by each participant. Team B experienced difficulties mediating opinions at the problem analysis phase. Team B comprised three participants; however, one team member continuously opposed the ideas of the other two team members. This led to cooperation and mediation difficulties within the team and the work undertaken was predominantly based on the concept of the dominant team member. Excluding Team F, every team that experienced issues during the design process engaged in active brainstorming that significantly helped overcome design fixation. Table 9 shows design themes and design processes by each team in task 2.

CONCLUSION AND DISCUSSION

This empirical study sought to use different strategies to overcome various forms of design fixation that act as obstacles in creative thinking and design. The results supported the usefulness of the adopted strategies. The study was conducted over a 16-week period to enable changes in participants to be observed. The analysis tool used to measure the extent to which participants overcame design fixation was adopted from the research of Moreno and Yang et al. (2015).

Hypothesis 1. The results of the study supported Hypothesis 1; that is, the combination of the digital context and the design task overcame participants' design fixation and encouraged the creative design process by generating thinking expansion. In relation to the first task, participants encountered difficulties until they cognitively understood the digital concept; however, the design process of participants did improve in the second task. Setting the

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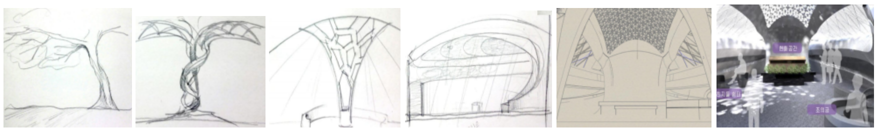
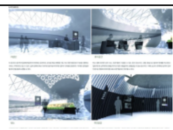
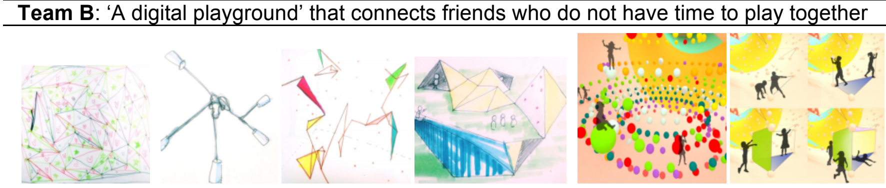
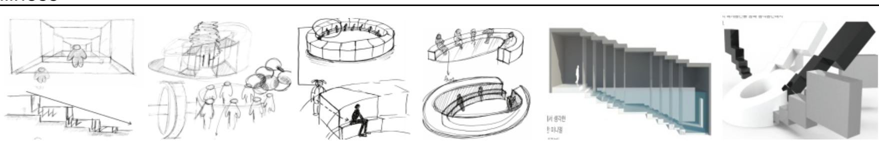
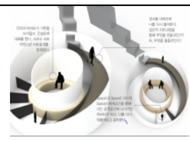
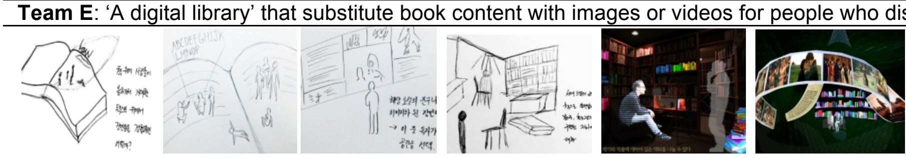
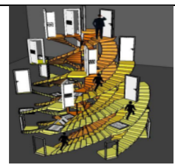
cognitive characteristics of the digital context as a motif of ideas assisted participants' thinking expansion. Participants sometimes evaluated their own ideas as being peculiar, but became more interested in the process and produced a large number of unusual and ambiguous ideas. Combining the digital context and the abstract task proved to be an effective strategy. When participants first encountered tasks with themes of public, private and intermediate spaces, they had significant difficulties in establishing a subjective perspective and had to ask the professor to provide a standard of interpretation. They noted that the previous studio class in which they had been enrolled had a clear character and use of a space (i.e., commercial or residential). However, by week eight (i.e., mid-term), participants appeared to understand how to combine the abstract task to the digital context and were able to reframe the problem from their own viewpoints. Variations among participants existed; however, the most prominent progress occurred in the second task.

Table 9: Task 2 Design Theme and the Process of Progress (Source: Authors).

Team A: 'A digital funeral parlour' where life and death and visible and invisible things coexist	
	
Team B: 'A digital playground' that connects friends who do not have time to play together	
	
Team C: 'A digital mental healing space' for people who refuse to go a hospital due to negative perceptions about mental illness	
	
Team D: 'A digital experience bread advertising space' in which a human and a product are liaised	
	
Team E: 'A digital library' that substitute book content with images or videos for people who dislike reading books	
	
Team F: 'A job experience space' that allows people to do things digitally that they cannot do in real life	
	

Hypothesis 2. The results partially supported Hypothesis 2; that is, that combining TBL and an 'abstract design task in a digital context' led to natural brainstorming and problem solving

that exhibited co-evolution. TBL assisted in the resolution of the difficult design task; however, the fundamental learning environment required improvement. TBL and Project Based Learning (PBL) are notable creative learning methods. However, the current learning environment in Korea's convergent education system has too many restrictions and such innovative learning methods are not commonly used. Participants who had been educated from elementary to high school in individual-centred convergent learning environments could not be naturally induced to engage in brainstorming in either the TBL or PBL environments. Consequently, different learning processes were required. The professor had to lead brainstorming activities, teach this technique and constantly observe each team. Allowing participants to form their own teams with others to whom they felt closer was effective, as it made participants feel less timid and better able to express their thoughts. Thus, it appears that enabling individuals to master the discussion and mutual evaluation process by using an easier theme would be desirable at the beginning of any education programme. By and large, this research showed the usability of research tasks. Based on these results, the digital context is one of promising strategies that could be used as a thinking motif to expand students' design thinking and promote 'creativity' in education.

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