

Design Fiction as a Convergence and Divergence Tool in the Design Thinking Process: Developing Smart Communication Service for Childcare

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Abstract

Background This study aims to provide a framework of design fiction as a participatory tool in the design thinking process and to investigate the possibilities of a service design methodology that actively engages multiple stakeholders. We adopted a new approach for developing a Smart Communication Service for Childcare (SCSC) that is rapidly gaining traction in South Korea's childcare facilities.

Methods A multidisciplinary team of researchers with diverse backgrounds in visual design, product design, and child and family studies collaborated to identify issues and propose solutions. To address social, technological, and future issues, design fiction was incorporated into the double diamond model process as a generative practice. This served as a tool for converging fiction on problem definition and a divergent tool to comprehensively imagine a future with multiple possibilities.

Results Developing a design for SCSC confirmed that design fiction elicits divergent and convergent functions at each stage. At the problem-defining stage, it is conceivable to foresee a preferred future that takes into account a broader range of diverse and particular possibilities than a process leading to a single solution. Finally, the proposed design fiction and prototype of service application were effective in imagining a desired communal future and elicited a holistic discourse among specialists in child and family studies, service developers, and designers.

Conclusions The study successfully suggested design fiction as a convergent and divergence tool in the design thinking process for the development of SCSC. The design fiction approach contributed to creating a preferred collaborative future and shifted from focusing on “present solutions” to “future problems” by expanding the framework within the “discourse” stage.

Keywords Design Thinking, Participatory Design, Design Fiction, Smart Childcare, Design Discourse

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1. Introduction

In today's world, services are developed through collaborative processes with various disciplines using new technologies. Businesses are increasingly incorporating design thinking methodologies into their development processes. The double diamond model is a design thinking methodology that incorporates both divergent and convergent thinking when identifying problems and discussing solutions with diverse stakeholders. Further, participatory techniques that are used to deal with conflicting interests from multiple perspectives help to deepen the understanding of people's emotions, dreams, and imaginations (Sanders, 2002). The double diamond model is a design approach that considers users as partners in a process that makes a shift beyond "designing for" and toward "designing with" (Forlano & Mathew, 2014; Sanders & Stappers, 2008).

This study believes that a project to supplement the functions of the Smart Communication Service for Childcare (SCSC), which has been widely implemented in Korean childcare facilities in recent years, necessitates a variety of discussions at the social, technical, and educational levels. We intentionally combined aspects of design fiction into the double diamond framework in order to propose design fiction as a divergent and convergent tool that can be applied as a generative practice in the design thinking process. Further, we suggest a framework that allows more active engagement with stakeholders in the multidisciplinary design project. By developing a design for SCSC, it was confirmed that design fiction elicits divergent and convergent functions at each stage. The main contribution of this work is that it shows how the grafting of design fiction as a new framework to service design, which requires such participatory design thinking, can propose a preferred future. In addition, by analyzing the results that discuss the social, technological, and future issues related to SCSC, we show the need for the development of such a new framework for future service design development.

2. Background

2. 1. Smart Communication Service for Childcare(SCSC)

According to Korea Media Panel Survey Statistics, as of 2020, Korea has had a fairly high smartphone retention rate of 91% and has been active since the outbreak of COVID-19 with the introduction of a smartphone-based notification function. Smart Communication Service for Childcare (SCSC) refers to an application that provides services such as back and forth management, notices, and photo albums based on interactions between parents and teachers who send their children to daycare centers (Lim, 2016). According to domestic and international studies, both teachers and parents felt the need for SCSC in order to provide a smooth interaction between teachers and parents. As such, parents suggested using smartphone applications in parent/teacher communities (Seo & Seo, 2018; Thompson et al. 2015). Previous studies on SCSC have mainly dealt with differences in perception between teachers and parents about SCSC and differences in perception between infants and infant classes (Can, 2016; Kang & Kim, 2017; Kim & Hang, 2019; Seo & Seo, 2018). Additionally,

studies on mobile notification sites have mainly focused on the convenience of notifications, teacher stress or workload, and technical issues encountered by parents. In these studies, teachers and parents were interviewed about their views on the benefits and drawbacks of mobile notification sites. Currently, no research has been found to indicate whether teachers' and parents' views on smart notification services have been actively incorporated into these platforms.

In this study, SCSC is treated as an important mesosystem. Bronfenbrenner's Ecological System Theory presented the effects of various social systems surrounding children directly or indirectly on their growth as an ecological model (Bronfenbrenner, 1979). Among them, the importance of micro-system interactions such as parents and teachers directly involved in childcare, that is, smooth exchanges and interactions in the intermediate system, can contribute to promoting a child's growth and development. SCSC is a project with various stakeholders including parents, teachers, children, developers, educational experts, and designers. It needs a careful approach as it recognizes the preferred future as a key social task among many feasible futures that apply new technologies. This serves as the main reason for incorporating participatory design and future-oriented design fiction into the design process.

2. 2. Design Fiction as Participatory Method

The term design fiction was introduced by science fiction author Bruce Sterling. Following this, Bleecker defined it as a "prototyping technique tailored to facilitating conversations about the near future (3-5 years)" that is about "creative provocation, raising questions, innovation, and exploration" (Bleecker, 2009). Design fiction has been applied as a communication tool that provides inspiration and motivation for design (Tanenbaum, 2014). The participatory design community has long recognized design fictions as ideal for participatory activities (Knutz & Markussen, 2014), elevating participatory design toward being playful and forward-thinking. It also acts as a discussion tool in workshops with users and stakeholders (Lyckvi et al., 2018) to enable participants to share their ideas, become exposed to others' ideas, and generate new ones (Forlano & Mathew, 2014). Despite the effort to increase the understanding of design fiction as a research method and approach (Lindley, 2015; Knutz & Markussen, 2014), there has been a lack of a framework about how and when to incorporate design fiction into the participatory design process.

Moreover, in practice, participatory design is not an easy or seamless process for collaboration because it generates tension and friction between diverse stakeholders (Forlano & Mathew, 2014). One reason for this is because everyone envisions the future differently; thus, friction over such scenes is bound to arise. In that respect, design fiction can be a suitable means to comprehensively imagine a future with multiple possibilities such as probable, plausible, and possible futures, rather than a scenario as a concrete solution. This study believes that design fiction could serve as a divergent tool for imagining these various futures from a broad perspective through participatory activities. In addition, it is suggested that friction on problem definition could be converged by empathizing with the problematic situations found by different stakeholders in the initial design stage by implementing them as design fiction.

3. Research Framework

Interdisciplinary researchers approached the research from various backgrounds ranging from child and family studies to design studies. From ideation to prototype evaluation and paper writing, the whole research process took 12 weeks (2021.9.15 ~ 2021.12.8). The research was constructed in four major phases consisting of the Discover, Define, Develop, and Deliver phases. Each phase consists of various different participatory tools such as observation, interview, five whys, HMW (How Might We), design fiction, role-playing, and in-depth interviews (See Table 1). The Discover phase was conducted within a real-life setting to better understand and identify actual problems, while the other three phases were conducted online.

Table 1 Design thinking process for SCSC

Discover	Participatory tool	Context	Participants
Discover	Observation, Interview	Home, Playground	Children, Parents, Instructors
Define	5 whys, HMW	Online	Design, Child & Family Studies researchers
Develop	Design Fiction, Role Play	Online	Parents, Instructors
Deliver	In-depth Interview	Online	Service Development Researcher, Preschool Education Experts

4. Double Diamond for SCSC development

4. 1. Discover

During the first stage of design thinking, it was discovered that teachers, parents, and children all had different viewpoints on childcare issues. We conducted a semi-structured interview with two children (age 5) and their parents, followed by a conversation with two teachers at a childcare center. Teachers have an overwhelming number of children to care for in comparison to their actual employment, which adds to their burden and produces a great deal of stress. Furthermore, the lack of information on children's activities in childcare facilities and the lack of communication with teachers lowers parents' satisfaction with educational institutions. Additionally, these concerns indicate that children are more likely to have sporadic interactions with teachers and are much more likely to be exposed to the danger of safety hazards.

4. 2. Define

A group of researchers - three are based in design and four are based in child and family studies - applied the "5 Whys" technique to the identified issues and were able to identify the root cause by continuously asking and answering questions about the reasons. Through the "How Might We" (HMW) technique, the derived root cause was transformed into a productive inquiry. The problem to be considered by various stakeholders is outlined in Table 2.

Table 2 5 Whys and How Might We for Discover and Define

1 Why	Why is it difficult for parents to understand the child's life at the center?	There is a barrier in the communication between teachers and parents in SCSC.
2 Why	Why are current SCSC features, such as notifications, a problem?	There is no way to check the teacher-child interactions.
3 Why	Why is there no way to check the teacher-child interaction?	Due to the child-teacher ratio, it is impossible to take pictures and record them individually.
4 Why	Why is the child-teacher ratio a problem?	As the number of children exceeds the number of teachers, the workload of teachers increases.
5 Why	Why is teachers' high workloads a problem?	Leads to a lack of qualitative interactions between children and teachers.
HMW	How Might We design a smart communication service that can ultimately help the child-teacher-parent interaction by assisting teachers with repetitive tasks?	

4. 3. Develop: Design Fiction Survey

HMW envisioned a near future that would ultimately bring positive results to parents, children, and teachers by solving current problems. In order to deliver the current problem as a vivid scene, a 5-cut visual scenario was composed from the perspective of parents and teachers, respectively, with a combination of rough images (Figure 1). Design fiction, which embodies this “present” situation, was used in the online survey as a tool for wider audiences to emphasize the current issues of SCSC experienced by parents and teachers using previous interviews. The process of materializing each scene requires a careful value judgment to be drawn after sufficient consideration beyond questions like “Is this possible?” and “What would happen if this technology/services/system was to exist?” (Lyckvi et al., 2018). It was necessary to find out what value the future SCSC would create through the participation of broader stakeholders and dissemination of diverse opinions. We provided selections of probable, plausible, and possible scenes from the near future through a series of questions combined with images and text—the online survey also asked narrative reasons for choosing specific scenes. The selections we provided demonstrate a wide range of possibilities that are not constrained by technological, social, and ethical issues. Our main intention was to understand the diverse childcare environments in the near future that parents and teachers dream of by asking respondents to choose their Preferred Future. The questionnaire was conducted for five days (11. 15. 2021-11.19.2021) with a total of 36 parents and teachers who had experience. The questions started by guiding people to imagine a situation in which smart services were introduced in public daycare centers in 2025 and then asking what role parents and teachers would play in answering the questionnaire. They were asked to imagine and respond to what kind of scene the smart device would take and send to the parents and how the functions for safety accident prevention (fever, fall accident, medication) would work.



Figure 1 Present problem and “present” design fiction

4. 4. Deliver

4. 1. 1. The analysis of results from the survey

A total of 36 people participated in the survey (17 teachers and 19 parents). Differences in opinions on the necessity of introducing smart devices in childcare facilities between parent and teacher groups were confirmed through chi-square verification, but were not statistically significant $\chi^2(22(2, N = 36) = 2.08, p > .05)$. In other words, both teachers and parent groups responded positively to the introduction of smart devices in childcare facilities. In order to improve the function of the application, a cross-analysis table was prepared by dividing it into a teacher group and a parent group to confirm the difference between parents and teacher response values. First, both teachers and parents had the highest preference for teachers to take pictures of the children when they wanted using machines that automatically recognize their child and take pictures. Second, the most common times to photograph activities in childcare facilities were outdoor and indoor play, followed by lunch and nap. Third, both teachers and parents preferred real-time notifications using a machine that detects their children's body heat. Fourth, teachers and parents had opposing views on the system for detecting children's falls. Parents preferred real-time notification (to teachers) using motion-detecting machines, while teachers preferred real-time notification (to teachers and parents) using motion-detecting machines. Finally, both parents and teachers agreed that the teacher's smart device should automatically set an alarm for when the child needs to take medicine. Instructors responded that additional functions were needed to notify teachers when to administer children's medicine, and for parents to verify that the child took it. In this study, the daily routine of daycare centers in the future where smart devices are introduced was organized into scenarios by selecting parents and teachers' responses that had a high preference. The tendency to show differences in position on one problem could be found in descriptive questions and answers. The components, "Thoughts on the use of smart devices in childcare installations" and "Thoughts on using machines to take pictures of children," were divided into three optional types: "positive, negative, and don't know." Subject 3 "What do you want to say about smart notification?" classified "expectations, problems, and limitations" by type according to the nature of the response. Then, sentences were divided and classified to select one main word for each type. After classifying by a main word, an objective and general sentence was prepared to deliver the core content comprehensively. The analysis results are shown in the Table 3.

Table 3 Present problem and “present” design fiction

Teacher	Parents
1. Thoughts on the use of smart devices in childcare institutions.	
[Positive] Reduces the burden of additional tasks and increases efficiency so that teachers can focus on interacting with children.	[Positive] They can help teachers focus on the children while receiving objective, practical, and diverse information from them. This can improve childcare services and help teachers, parents, and children. With the advancement of technology, new methods appear necessary.
[Negative]	[Negative] Exposure to smart devices is likely to have a negative effect on close contact with teachers.
[Don't know] It depends on the range of use.	[Don't know] The necessity of introduction varies according to the type of smart device, the degree of use, and the purpose.
2. Thoughts on using machines to take pictures of children	
[Positive] Teachers can use machines to reduce work, focus on student activities, and reassure parents that their child was not photographed for personal reasons.	[Positive] It's good to be familiar with smart devices as it helps focus more on childcare, overcome the constraints of children's information, and make high quality childcare services possible.
[Negative] If the teacher is not aware of the children's' playtime activity, it is still doubtful whether the photos can be taken well.	[Negative] They think that interaction with people is more important than machines.
[Don't know] The results vary depending on the level of use of the machine.	[Don't know] It varies according to the use, function, and management of the smart machine before/after the photo is taken.
3. What do you want to say about SCSC?	
[Expectation] Smart notification functions are automated, reducing teachers' work and allowing them to focus more on childcare.	[Expectation] By reporting objective data through SCSC, you can better observe and examine children's lives more efficiently and usefully.
[Problem] There is still something to consider in terms of managing and using smart notifications.	[Problem] It is not easy to manage the acquired information in SCSC, and the necessity varies according to the purpose of use.
[Limitation] The information provided to parents by smart alerts must be machine-based or teacher-inspected. Overall functional effect can only be confirmed by genuine user experience and feedback.	[Limitation] Use smart devices to take photos of children in safe places. In order to use smart notification photographs, parents must first analyze the data. Teachers' and students' rights must be safeguarded while ensuring educational stability.

4. 1. 2. Scenario and App Visualization

In order to imagine the survey results more vividly as a preferable future, researchers with teacher experience reconstructed it according to the daily routine of daycare centers. The following is a visual narration (Figure 2) showing the year 2025 and a future application (Figure 3).



10:30 AM Indoor free playtime. *The machine moves around and takes pictures.*
 11:30 AM. Outdoor playtime. *Taking pictures as machines follow teachers/children around.*
 1 PM. Time to take medicine. *The teacher gives medicine and notifies parents*
 1:30 PM Large group activities. *A machine detects fever.*
 2:30 PM Free playtime. *Recognize the child's movement and alert the teacher's smartwatch.*

Figure 2 Design Fiction for 2025, Daily routine at a daycare center

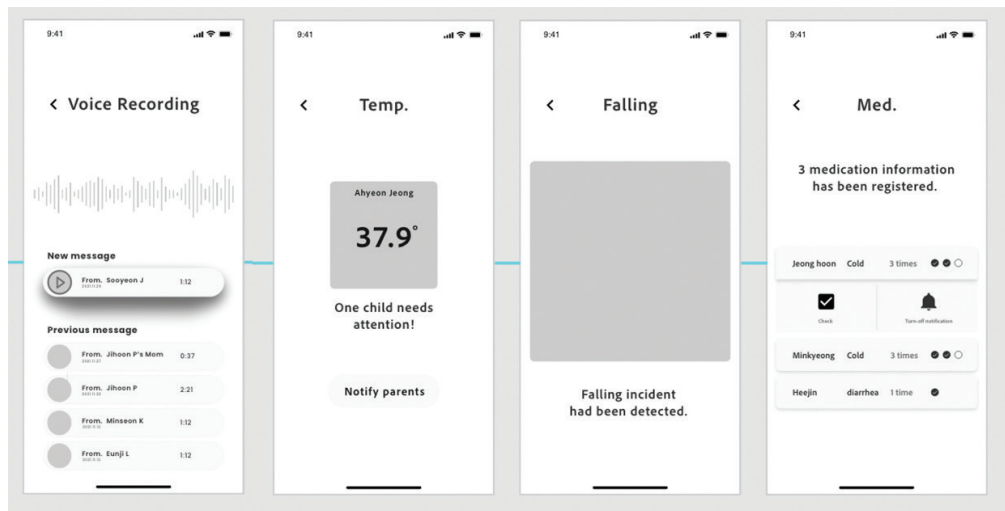


Figure 3 Design Fiction for 2025, The application

Table 4 Design Fiction for 2025, A manual for application

- a. Recording: This can help tutors communicate with parents. In addition, it reduces the tutor's workload, which improves tutor-child interactions.
- b. Temperature Detection: A camera-based robot detects temperature and motion. An excellent tutoring tool. The service can check the child's temperature and match it to their face using a sensor. This feature helps tutors and students. The "alert parents" button simplifies notifying parents.
- c. Motion Detection: Using motion detection technology, the service can detect a fall. However, the child may be playing, or the accident may not have been serious. Only the tutors will be notified.

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4. 5. Discourse

The proposed design fiction of “preferred futures” was reviewed by the research team from their respective fields of expertise. From the perspective of child family researchers, designers, and developers, experts in each field were able to have a theoretically supported discussion about SCSC in the near future and could evaluate whether these future services are ultimately beneficial for the qualitative interaction between children and teachers, or if they could lead to other problems. These additional discourses on “future” design scenarios act as a divergent tool for evoking critical and holistic issues of the future.

5. Discussion

In this paper, the discourse process was added to the design thinking process as a divergent tool, prompting the initiation of the second iteration of the double diamond. The discourse should be understood as a different concept from user evaluation of prototypes used in the traditional design process where the scenario is focused on presenting a prototype as a complete solution and technically evaluating whether it is probable (Figure 4).

The preferred future derived from design fiction is meaningful as it empathizes with the dreams of future users without being restricted by feasibility. It creates a discussion about future-oriented problems by enabling a more flexible ideation, not limited to possible technologies and resources, away from the away from a profit-oriented approach (see Figure 5).

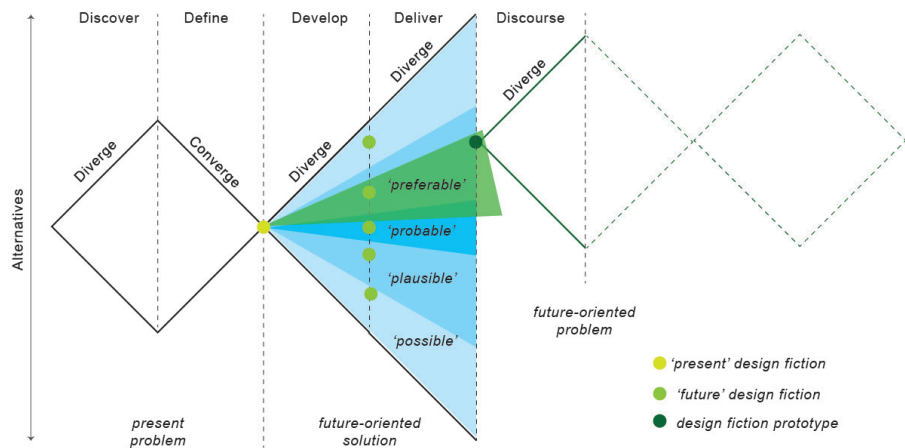


Figure 5 Design thinking process for a “preferable future”

5. 1. Discourse as the second cycle in the design thinking process

Does the proposed future scenario solve the root cause? What should be considered if these services are introduced in 2025? What should be approached more carefully? The discourses from child studies researchers, service developers, and designers were as follows.

There are things to consider in the preference future. In Scene 1 and 2, there is a possibility that children who should be concentrating on play will focus on and pay attention to the machine because it travels around photographing the children during the indoor free play activity. Nonetheless, the SCSC of the preferred future requires a time constraint function. In the case of SCSC, where interaction and use between teachers and parents is not restricted by time or place, the request for parental interaction can add a new burden to teachers. By instituting a time limit function, teachers' human rights and working hours should be protected. Thus, SCSC should be carefully considered as an intermediate system (Bronfenbrenner, 1979). As such, the interaction between teachers and parents belonging to a micro-system has a positive effect on the development of children. What can be expected

through such a preferable future is that, above all, the workload of teachers is reduced, so that high-quality interactions between teachers and children are increased and smooth interactions between teachers and parents are promoted. From a developer's point of view, the possible implementation this research can apply is the existing machine learning technology. Machine learning (ML) is the study of computer algorithms that can improve automatically through experience and by the use of data. A model called the "Teachable machine" offered by Google was mentioned during the discussion of the technology.

From the designer's point of view, the application must be distinguished differently between parents and teachers. How the camera robot moves, whether it is a drone, and the form of movement are important. Longitudinal research on technologies for detecting heat and fall accidents, and how this technology affects children's emotions is needed. There is the possibility that various technologies can be applied by using camera-based robots. Currently, features using temperature detection, motion detection, and face recovery technology have been introduced, but more technologies can be incorporated into the service, adding to the list of presently used technologies. This may be possible once robots and implementation technology contain more sophisticated service design.

5. 2. Toward a future-oriented problem

Gaver points out that "convergence may not be the only or best model for progress" (Gaver, 2012). In the deliver phase in existing design thinking, among the many good ideas that emerged during the development process, things that cannot be realized with current technology or that cannot be economically successful are rejected, and these are converged as an "only and best" prototype. Although the prototypes are being evaluated, it is still considered as a future-oriented solution within the ambiguous and limited frame of the "present." This is because traditional design thinking is mainly focused on design for the world as it exists today (Johannessen, 2017).

Design fiction draws "a matter of concern" about the changes and social systems that future technology will bring by depicting a fictional world. The process of develop-deliver-deliver in a new design fiction diamond model helps to pivot and build a different future rather than a reformation of the current systems (Gerber, 2018). Further, it helps to depart from the focus in a narrative based on "the matter of fact." The new design fiction diamond model does not limit the output of design thinking to a future-oriented solution but diverges the process to future-oriented problems. The goal of this future orientation was to eliminate the constraints and limitations of our everyday lived experiences in order to stimulate creativity and openness to new ideas that, while not currently viable, may rely on a near-future technology, capability, or scenario (Forlano & Mathew, 2014). In the participatory approach, "what is preferred" depends a great deal on who is doing the preferring (Voros, 2003). Unlike the traditional method in which the development of service design is implemented by experts first, and the prototype is tested by future users, the new design fiction framework suggests a reversed process - where actual users become the core member of the "preferred future" and experts are required to consider what needs to be implemented.

In particular, in services related to childcare, since the role of micro-systems (such as parents and teachers) has an essential influence on the growth and development of children (Bronfenbrenner, 1979), design fiction was confirmed as a participatory activity that recognizes their preferred future as an important factor in the development process. In

this design thinking process, the role of the expert group consisting of designers, service developers, and educators is as a facilitator and co-editor to support smooth exchange and interaction between parents and teachers in the intermediate system. Design fiction in the SCSC process contributes a holistic exercise in envisioning the sociopolitical context of the problem as a whole and then considering how specific technology and function are positioned and operated within that setting to create a preferable future.

6. Conclusion

The study successfully suggests design fiction as a convergent and divergence tool in the design thinking process for the development of SCSC. The design fiction approach contributed to creating a preferred collaborative future and shifted the focus from “present solutions” to “future problems” by expanding the framework within the “discourse” stage.

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