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Co-designing the Library Makerspace with Children: A Case Study of Seoul Children's Library with a Focus on 3D Printing

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ABSTRACT

This study aimed to discuss the utilization of a makerspace regarding 3D printers in a children's library by conducting co-design sessions targeting the end-users, children. To achieve this, a program utilizing a 3D printer was conducted for seven children at the Seoul Children's Library, followed by interviews with both the children and their parents. The results revealed several key findings: First, during the design sessions, participating children showed interest in the physical realization of ideas through the use of a 3D printer. Researchers adjusted their level of intervention based on each child's tendency, playing a supportive role. Second, children became aware of various limitations associated with 3D printers and public library makerspace. Third, the rapport between children and researchers positively influenced the design sessions, driven by the active communication of children. This study suggests a reevaluation of the value and necessity of library makerspace from the perspective of user autonomy and creativity and emphasizes the need to closely understand the end user's requirements in establishing operational strategies for library makerspace.

Keywords: Makerspace, Co-design, Public Library, Children's Library, User Study

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논문접수일자: 2024년 1월 22일 최초심사일자: 2024년 1월 31일 게재확정일자: 2024년 2월 14일
한국문헌정보학회지, 58(1): 151-179, 2024. http://dx.doi.org/10.4275/KSLIS.2024.58.1.151

1. Introduction

The growing demand for library makerspace and their associated programs reflects a cultural and educational shift toward interactive and community-driven learning environments. Research on the necessity of makerspace in the library field and strategies for their activation has consistently continued in the academic community. Chang (2019) highlighted the role of public library makerspace in serving all community members, emphasizing the need for programs that cater to local needs and foster digital literacy. Abbas & Koh (2016) contributed to this dialogue by identifying key competencies needed by makerspace professionals, particularly in engaging with children.

Especially about the program of library makerspace, the foundational work of Ahn (2014), which critiqued the traditional focus of domestic library programs and advocated for a strategic adoption of makerspace concepts, has paved the way for a broader vision of library makerspace in South Korea. Also, the Ministry of Culture, Sports and Tourism of South Korea established guidelines in 2018 for the operation of public library makerspace, emphasizing creativity, spontaneity, convergence, and sustainability. These guidelines have further shaped the operational models of makerspace, ensuring they align with the overarching objectives of cultural and educational policies.

The existing research in library and information science has established the importance of library makerspace and guided program planning (Kang & Jung, 2018; 2019). However, there is scarce research on methods for planning library makerspace programs from the actual perspective of users. Considering the nature of the makerspace that embodies the user's imagination, it is necessary to explore methodologies aligning the services offered by library makerspace more closely with users' expectations. In this study, we specifically chose to design with children and their potential use of the 3D printer in the library makerspace area as a case study.

To deepen the understanding of this engagement, the study is structured around three guiding research questions:

1) How did the children participate in the co-design sessions, and what were the roles of the adult partners in this participatory content?
2) What were the adult partner's perceptions of children's engagement and interaction with 3D printers in the library makerspace area and what implications do these have for enhancing learning experiences?
3) What reflections emerged from Library and Information Science (LIS) students regarding their experiences co-designing with children in the library's makerspace area?

This study aimed to reassess the value and necessity of library makerspace from the perspective of user autonomy and creativity. Additionally, it sought to investigate how such spaces could be utilized from the viewpoint of the end-users. To achieve this, we planned a 3D printer utilization design session targeting children by applying the co-design methodology.

The significance of this study lies in directly addressing the disparity between the intentions of program developers and user expectations, thereby creating a space for a user-centered makerspace experience. By understanding user demands more deeply, this study aims to promote the development and improvement of makerspace programs. By doing so, it endeavors to provide valuable insights and resources for librarians, professional instructors, and libraries at large in shaping the future trajectory of makerspace initiatives. In redefining the operational strategies of library makerspace, the study not only draws upon the work of Ahn (2014), Abbas & Koh (2016), and Chang (2019), but also contributes to a broader understanding of how these spaces can evolve into even more fertile grounds for creativity, learning, and community engagement.

2. Related Works

For the related works section, we first introduce the concept of the makerspace and its current research. Afterward, as the study focus is specifically on 3D printers, we give definitions and research regarding such technologies. In our final section, we discuss the co-design method, A method used for designing with end-users.

2.1 Makerspace

As the educational landscape navigates through the fourth industrial revolution, the maker movement has risen to prominence, advocating for an educational system that fosters creativity and innovation (Park, 2017). The embodiment of this movement within the educational sphere is evidenced by the establishment of makerspace introduced in schools since 2017 as tangible platforms for maker education (Son & Lee, 2021). These spaces are strategically equipped with a variety of tools, equipment, and materials to support the endeavors of young makers, which have garnered significant interest among students (Byun & Cho, 2016; Chang, 2017).

Makerspace serves a dual purpose: to nurture future talent by fostering students' ability to produce creative ideas and to offer a versatile environment that facilitates a wide range of educational activities and the realization of creative thought (Korea Foundation for the Advancement of Science & Creativity, 2022). These objectives resonate with the goals of technology education, highlighting a synergistic relationship between the makerspace's founding principles and educational aims.

In South Korea, makerspace is diversified across various institutions, including science centers, libraries, museums, universities and community centers, each tailored to the unique features of its host institution. They are classified into four distinct types: workshop-experiment type, research and development (R&D) linked type, storytelling club type, and children's idea club type, with each type aligning with the specific educational and communal goals of the setting.

Further emphasizing the strategic importance of these spaces, the Institute of Museum and Library Services (IMLS) in the United States identifies three core factors for successful makerspace operations: purpose, people, and materials/equipment/spaces. The IMLS underscores the need for each library to craft its makerspace to reflect its unique characteristics and environmental context. It stresses the importance of initial planning stages that ask fundamental questions about the necessity and operational vision of the makerspace, rather than focusing solely on the equipment to be provided.

In the field of library and information science, research related to makerspace often necessitates consideration of the operational aspects when integrating creative spaces within libraries. It involves deliberation on what programs to offer, how to run them, and what personnel are needed. Through various case studies, a comprehensive proposal for potential programs, projects, and target groups can be made when operating creative spaces in libraries (Moorefield-Lang, 2015; Colegrove, 2017; Molnár & Vas, 2022). Fourie and Meyer (2015) pointed out that while much of the research in library and information science has focused on the spatial aspects of makerspace, including the use of equipment in DIY and creative spaces, there is a need to shift towards a more foundational approach that incorporates libraries' information resources and maker learning into intellectual and informational spaces. They argue for expanded objectives and operational methods that encompass information literacy education, research, and community support, emphasizing the importance of broader goals beyond the physical space.

The University of Nevada's library has exemplified this shift by transforming the content of traditionally offered information/digital literacy instruction to include makerspace-related content such as 3D modeling, scanning, design, and intellectual property. By utilizing online education to facilitate this transition, the library experienced a significant increase in both the use of library instruction and the utilization of the makerspace, effectively linking makerspace operations with digital literacy education (Radniecki & Klenke, 2017).

2.2 3D Printers

Within the makerspace area, 3D printers have been a common technology implemented in the makerspace area. 3D printers are devices that create three-dimensional objects from digital blueprints. It has rapidly expanded into fields such as medicine, construction, retail, food, and fashion (National Science Museum, 2017). 3D printing technology has revolutionized manufacturing by reducing the time and cost to produce mock-ups (Oh, 2016). The advent has enabled the creation of unique products with creative designs from the affordability of equipment and raw materials.

3D printing has garnered attention in the era of the fourth industrial revolution for enabling the physical creation of designs from digital data, transitioning from mass production to catering to small-scale, individualized demands. This shift has facilitated the emergence of products reflecting the requirements of a multitude of small-scale consumers and entrepreneurs in various sectors. Although students using makerspace show high interest and frequency in using 3D printers, there are challenges in advancing beyond simple 3D modeling to developing design skills due to the rooms' current focus on printing from existing models (Byun & Cho, 2016). Research into educational applications of 3D printers is underway across various disciplines, with proven effectiveness in programs like invention education and art education within the broader scope of STEAM education (Jeon et al., 2019).

Studies show that STEAM programs based on scientific principles can enhance elementary students' creative problem-solving abilities, and 3D printer-based invention education can improve creativity, especially fluency and positive learning attitudes (Kim & Choi, 2012; Lee & Kim, 2015; Moon & Kim, 2011). A specialized gardening program using 3D printers in elementary agricultural education has been proposed, which can increase identity and effectiveness by utilizing the latest agricultural information (Kwak & Kim, 2014). The educational use of 3D printing provides opportunities to physically manifest abstract knowledge, enhancing understanding and offering design experiences based on algorithms and adjustable parameters. It signifies the potential for learners to utilize the hardware they've created themselves (Choi & Yu, 2015).

Students who participated in classes positively evaluated the opportunity to learn new content and enjoyed the experience of designing with their own ideas. The use of 3D printers in education, which allows for sophisticated production in a relatively small space, is considered a suitable method for elementary creative education (Lee & Kim, 2015). Tinkercad, one of the software options, is highlighted for its ease of learning and use, making it suitable for beginners to 3D modeling. Roh (2018) also states its popularity in 3D printing education due to its website.

The Ministry of Culture, Sports, and Tourism (2018) has emphasized that libraries should guarantee users' access to information by providing services with high-tech devices and that makerspace can be utilized as places where local residents can freely create, share, and exchange. In response, in the field of library and information science, previous research on library makerspace has primarily focused on discussing the infinite possibilities of these spaces and addressing supplementary measures for their physical and human resource limitations.

For instance, Chakraborty (2021) viewed the library's characteristics that promote human interaction and knowledge sharing as the reason why a library can establish itself as a makerspace. Chang, Kim, and Jeon (2019) conducted interviews to study the perceptions of librarians and users regarding public library makerspace, revealing positive perceptions of the necessity of public library makerspace. However, issues related to difficulties in securing professional staff and budget, as well as problems with equipment and space improvement, were pointed out concerning actual operation (Jung & Kang, 2018). In this study, we go more in depth about how to improve such service by conducting co-design sessions with the end-users.

2.3 Co-designing in the children's library

Co-design is a collaborative design thinking process that aims to include end-users in the design process for improvement. In libraries, design thinking has been integral in finding solutions to problems (Bell, 2008). In this study, we explored the makerspace specifically located in the children's libraries. Children's libraries serve as a means to enhance children's sensibility and imagination, aiming to foster them into individuals by providing quality materials and cultural programs (Jung & Kim, 2016). Furthermore, children's libraries have a long-term impact on shaping the thoughts and values of children who frequently use them, influencing the creation of the future and truly manifesting significant values. Therefore, ongoing evaluation and analysis of children's libraries are essential (Cho, 2011). The makerspace installed in children's libraries is an optimal space for children to actively explore their interests and engage in learning the process of independently conducting desired projects. In makerspace, children can experience the element of "interaction with others," a key aspect of the maker spirit. They also can learn how to adjust issues that may arise in collaborative work and develop collaboration skills (Kim, 2022). Therefore, as end-users we design with children. Co-designing with children has been particularly utilized in public spaces to tailor technology programming to meet their specific needs by involving them as design partners.

Our research builds upon this by examining four consecutive co-design sessions. This work provides insights into considerations for 3D printer use in the makerspace area for children's programming.

3. Methods

3.1 Case Study

This study adopts the case study methodology as its research approach. The primary objective is to observe the behavior of children and their interaction with adults through design sessions, aiming to elicit children's opinions on the makerspace and 3D printer. Therefore, direct observation of children and its subsequent analysis holds significant importance. Yin (2018) has asserted that case studies are appropriate for understanding how a program has been implemented. Additionally, according to Yazan (2015), from Yin's perspective, a case study is a comprehensive research strategy that investigates a case by addressing "how" or "why" questions concerning the phenomenon of interest. In this study, the case study methodology is employed to analyze how design sessions effectively elicited the opinions of children who are the end users, and how well researchers understood it. The case we examined was a 4-week co-design session that occurred in the children's library makerspace area. The 4-week program was designed based on previous research of conducing design thinking sessions in the library (Lee, 2023). The 4 weeks were split so that the children had the opportunity to explore, evaluate, apply, and share out in the end.

3.2 Context

This research was conducted in collaboration with the Seoul Children's Library. The cultural center of the library operates a makerspace equipped with a 3D printer and various production tools, offering creative learning programs for children. This study adopted the 'KidsTeam' as a specific protocol for design sessions. KidsTeam, initially conceived in 1998 at the University of Maryland's Human-Computer Interaction Lab, aims to facilitate ongoing collaboration between adults and children as design partners to create new technologies for children. KidsTeam is a form of action research where individuals with similar interests collaborate to progress research through observation, questioning, and experimental design (Druin, 2002; Yip et al., 2017). By offering children with everyday materials that they are used to using, such as pencils, colored paper and toys, etc., children are provided to express their thoughts and opinions through low-prototyping to various scenarios that are relatable to them. Such relatable scenarios for instance is rather in asking directly how children want to use 3D printers in the library makerspace area, adults come up with scenarios of an instance of how a librarian bought a 3D printer and the children can print anything for their friends what they would print and how they would print. Scholars conducting co-design sessions with children have continually explored new techniques in better communicating with children who have limited verbal language compared to adults (Walsh et al., 2013). In exploring the utilization of 3D printers and makerspace for children, this study deemed it appropriate to adopt the session format of KidsTeam to effectively engage children and adults as a team in design activities.

3.3 Participants

The research team consisted of six members, including five undergraduate students and one graduate student, all from the Department of Library and Information Science. One librarian took charge of recruiting and promoting the involvement of participating children. There were a total of seven participating children. <Table 1> summarizes the information on the children involved in this study. The age range of the participating children was from 9 to 10 years old, and recruitment was carried out by posting a poster promoting the program at the library. The poster included information about the lead researcher, the activities, and the time and location of participation. Participants were recruited on a first-come, first-served basis starting from July 20th, 2023 till the opening of the co-design session. Before participating in the program, all participating children and their guardians expressed their consent to participate in the research. All names shared below are pseudonyms that will be used in the findings section.

〈Table 1〉 Participants of the Design Session

Participant No.	Name (pseudonym)	Team	Gender	Age
1	Yeon	1	Female	10
2	Seo	1	Female	10
3	June	2	Male	9
4	Yunseul	2	Female	9
5	Eunsae	3	Female	9
6	Seah	3	Female	9
7	Jeong	3	Female	10

3.4 Co-Design Sessions

A total of seven participating children, including the lead researcher and five other team members, took part in the design sessions. The lead researcher, took the role as the facilitator, introduced topics and questions, guided sessions where around two children paired with two researchers as a team. The sessions, totaling 4 hours, were conducted in the makerspace within the Seoul Children's Library. The objective of the design sessions was to collaboratively design a 3D printer program in the makerspace with adults and children working together. The themes for each session were designed to organically evoke this objective from the children. Each session started with a "Question of the Day" related to daily life and concluded by sharing the activities and ideas. <Table 2> summarizes the questions and specific activities for each session.

〈Table 2〉 The question of the day and the activity

Session No.	Date	Question of the day	Activity
1	23.08.01	How do you want to learn something new?	Exploring 'Tinkercad'
2	23.08.03	How do you get good ideas?	Creating prototypes using 'Thingiverse'
3	23.08.08	How do you solve problems when they arise?	Understanding space and time
4	23.08.10	How do you share what you have created?	Presenting and Sharing

The theme of the first session was 'How do you want to learn something new?' During this session, participants discussed topics related to what makerspace and 3D printers are and what they can do with them. Following this, they experienced the 'Tinkercad' program, designed a 3D model, and shared their design ideas. Tinkercad, developed by AUTODESK in 2011, is an online free software collection that allows activities such as 3D modeling, electronic device design, and coding within the website without the need for separate hardware installation.

The second session focused on 'How do you get good ideas?'. Participants explored the 'Thingiverse' program, freely browsing designs created by users worldwide. They also selected themes they liked or disliked among the various design themes offered by 'Thingiverse' and shared the reasons for their choices. 'Thingiverse' is a 3D printing community where users can freely share and download 3D printing designs via the website.

The third session addressed 'How do you solve problems when they arise?' Based on opinions shared in the second session, participants explored and printed 3D designs as a team using 3D printers. Afterward, they utilized various props and objects prepared by researchers to imagine and visually represent the ‘Future Library using 3D Printers’ on a designated board.

The theme of the fourth session was ‘How do you share what you’ve created?’. Participants shared their reflections on the activities from the previous sessions. They read and discussed the 3D printer usage manual written by adult researchers for child users. Additionally, they shared any difficulties understanding the material and suggested modifications. The session concluded with team presentations on the imagined libraries and the utilization of 3D printers.

3.5 Data Collection

In this study we have recorded approximately 240 minutes of video data of the four co-design sessions and one librarian and a researcher took photos of children and adults working together and captured the artifacts that were created in the design sessions. The facilitator of the study summarized the presentations that each group presented in the whiteboard and the process of the presentation and the whiteboard and the post-it notes that the children and adults both used to record questions were all collected in analyzing the data. Additionally, researchers wrote diaries documenting details such as the activities conducted during each session, how they progressed, what stood out, and insights gained about the curriculum of the department of library and information science. A total of 21 diary entries were recorded.

After concluding all design sessions, semi-structured interviews were conducted via the video conferencing platform (ZOOM) with participating children and their guardians. The interviews were broadly structured into four parts: ‘Relationship and perception on their local library,’ ‘Relationship and perception on Makerspace,’ ‘Individual Preferences on creating and designing’ and ‘Design Sessions.’ For children, the focus was on their participation experiences and emotions felt at the time, while for parents, the emphasis was on the child’s preferences and shared experiences. In the ‘Relationship and perception on their local Library’ section, questions were asked about the frequency and occasions of using the library, as well as perceptions of the library. The ‘Relationship and perception on Makerspace’ section focused on experiences and perceptions of using makerspace. In the ‘Individual Preferences on creating and designing’ section, questions for children pertained to preferences for team and individual activities, while questions for parents revolved around the child’s usual behaviors and preferences regarding communication and creative activities. In the ‘Design Session’ section, participants were asked about their thoughts and evaluations of the KidsTeam activity experience and suggestions for improvement. All interviews were recorded with the participant’s consent and transcribed for analysis.

3.6 Data Analysis

For data analysis, we used a grounded theory approach with constant comparative analysis (Strauss & Corbin, 2007). We observed emergent patterns in understanding how the children participated in the co-design sessions and in sharing their thoughts about the 3D printer used in the library makerspace. The three authors completed a codebook by labeling and categorizing the content of all collected data, including diaries of researchers, interviews, sticky notes, etc. The codebook was created through open coding, labeling the data in a format that grouped similar sets of data. For example, diary data was broadly categorized into participants and facilitators, activities, and evaluations and improvements. In the 'Participants and Facilitators' section, the data analyzed how participants and facilitators behaved during the design sessions and why they exhibited such behaviors. The 'Activities' section contained data on the activities that took place during the design sessions and how participants specifically reacted to the 3D printer. Finally, the 'Evaluations and Improvements' section analyzed how participants evaluated the design sessions in terms of time, space, and active aspects and how improvements could be made. For validity, we presented each design session to the librarian who was not part of the data analysis but who helped recruit the children to ensure our understanding of the results.

4. Findings

The findings section is organized by answering each of the research questions.

- **Research Question 1:** How did the children participate in the co-design sessions, and what were the roles of the adult partners in this participatory content?

The first research finding shows how the children reacted to the presented situations and the actions the adult partner took based on those reactions.

1) Different supporting roles taken by the adult partner based on the participant's ability

Participants had the opportunity to freely respond to initial inquiries, partake in 3D modeling, hands-on activities, and subsequently present their opinions. The diverse style of sharing one's opinion and concentration levels exhibited by participants during these activities occasionally resulted in technical challenges during presentations and the design phase of 3D printing. In response to such challenges, the adults took on a supportive role, acknowledging and addressing participants' needs in overcoming difficulties. This is demonstrated through the following example:

> "During the first presentation, considering the tendency of Eunsae, a student who was shy about coming forward during the activity, the adult partner helped Eunsae participate by listening to other friends' stories and saying things like 'Do you want to try that next time?'" (Source: Researcher Jae's diary on August 1, 1st session)

This quote underlines the researcher's proactive involvement in assisting children who had difficulties sharing their opinions in a public space. The adult partner facilitated active participation by posing questions that complemented the technical aspects of the presentation. Furthermore, in many instances, the adult partners facilitated the conversation to enhance the thought process regarding the technology by asking follow-up questions for the children to expand one's thoughts. Below, two examples are shared of different examples of adult partners trying to assist children such as through different actions to expand one's thoughts.

> "During the 4th session of making a future library, I considered Yunseul's tendency to be immersed in only one thing and thought about a guide to lead creative thinking." (Source: Researcher Kyo's diary on August 10, 4th session)

> "In the 2nd session of writing down likes and dislikes, considering the tendency of Jung, a student who had difficulty choosing what she liked and disliked, I helped the child by asking preference questions." (Source: Researcher Min's diary on August 3, 2nd session)

This supportive stance of the adult partner extended into the 3D printing design phase.

> "In the 1st session of designing with TinkerCAD, when June had difficulty moving objects on the screen, I directly intervened by bringing the mouse to help." (Source: Researcher Yoon's diary on August 1, 1st session)

This example shows how the adult partner's supportive role in the intervention was tailored to an individual's tendencies toward solving a problem. The level and method of how to interact with the child changed based on children's proactiveness and concentration levels during collaborative activities. The adult partner carefully considered these variations, determining when and how to intervene for each child, thereby customizing the level of assistance to enhance child engagement. Instances of this approach include the following when to intervene or not.

> "In the 1st session of Tinkercad design time, I considered the three children's self-concentrating tendencies and helped the children by observing them in distance as opposed to directly intervening." (Source: Researcher Jung's diary on August 1, 1st session)

> "In the 3rd session of designing with different arts and craft materials, considering June's tendency to focus only on his own work and not listen to teammates during the activity, I threw related questions to guide him back to concentrate." (Source: Researcher Yoon's diary on August 3, 2nd session)

> "In the 4th session of making a future library, considering Yeon's tendency of autonomy to lead the design, I showed a posture of adjusting to the child's thoughts rather than leading the activity." (Source: Researcher Jung's diary on August 10, 4th session)

These instances underscore that the adult partner's intervention strategy, whether through respect or guidance, played a crucial role in optimizing the children's concentration by acknowledging and navigating their autonomy during participatory activities. After all the sessions ended and in asking about the children's experience with their adult partners who were students in the Library and Information Science program, the majority of the children stated that they felt that the adults were helpful in helping them understand what to do. One child stated that they would prefer someone younger like in the age of a teenager suggesting less of an age gap.

2) Children's positive responses to participatory activities

The researchers' diaries showed how the children showed interest and actively participated in activities such as 3D printing and making. The empirical evidence highlights how the children actively engaged and expressed enthusiasm, particularly in activities such as 3D printing and crafting, when they had the opportunity to directly be involved in the creative process. This is evident in the following instances:

> "In the 2nd session of 3D printing, Yeon was interested just by looking at the monitor of the printer. Yeon wanted to see if her work was being printed even after class ended. She constantly checked if the printer was 'heating up.' She left only after the adult partner stated that it was now being heated" (Source: Researcher Jung's diary on August 3, 2nd session)

> "In the 3rd session of making a future library, students felt interested because they could make a library with various materials." (Source: Researcher Yoon's diary on August 8, 3rd session)

Through the examples above, it shows that children's intrinsic interest and active involvement in activities was facilitated by their ability to operate machinery autonomously and actualize their creative ideas. Although children showed enthusiasm for participatory activities, children also demonstrated positive and proactive engagement during presentation sessions and design periods. From the parent's interview data, we were able to learn that not all children were active talkers at home. Within the parent's interview of asking how talkative or communicative their child is at home around half parents stated that they were overall talked a lot at home whereas the half stated that they did not talk as much or express their thoughts at home.

> "In the 2nd session of modeling, June initially found it difficult to operate the method, but after completing the modeling, he showed reactions like 'It was more fun than I thought.'" (Source: Researcher Yoon's diary on August 1, 1st session)

> "In the 1st session of sharing opinions, Seo actively participated by raising her hand first during the time to speak his thoughts." (Source: Researcher Jae's diary on August 3, 2nd session)

These instances collectively show the children's active engagement not only in participatory activities but also in presentation classes and design periods. Such findings underscore the multifaceted nature of children's positive responses within the framework, wherein the choice to engage in diverse modalities contributes to a comprehensive and enriching learning experience. This differs from the interview data when asked about their prior experience and perception of the library. In asking about their prior perception of the library, half the children stated as having many books, one child stated that it is a place to focus, and two children stated as a quiet place. Another child stated a comfortable area. One child stated she had no thoughts about it.

- **Research Question 2:** What were the adult partner's perceptions of children's engagement and interaction with 3D printers in the library makerspace area and what implications do these have for enhancing learning experiences?

The second research question is a question that explores improvement points that the children pointed out regarding 3D printers and the observed behavioral patterns and the reactions of children in those sessions from the researchers. From the interviews, we were able to learn that among the seven children, for five children it was their very first time using the 3D printer. Two children stated that they have experience using the 3D pen but not the 3D printing machine. Therefore, for all children they first had to explore the technology before giving their opinions on it.

1) Children seek to use 3D printers for personal designs and aiding others

During the time for creating designs using platforms like Tinkercad and Thingiverse, children often showed a preference for making things that were either personal acquisitions or thoughtful gifts for individuals who shared similar interests. This inclination was evident in such specific examples.

> "In the 1st session of Tinkercad exploration, June wanted to create a Mazinger Jet because he likes robots." (Source: Researcher Yoon's diary on August 1, 1st session)

> "In the 2nd session of Thingiverse exploration, Seo wanted to create jewelry accessories because she likes jewelry." (Source: Researcher Jung's diary on August 3, 2nd session)

The following examples are instances where children wanted to print a design that would help others.

> "Yunseul wanted to make a bag as a gift for her younger sibling that had things that her sibling liked." (Source: Researcher Kyo's diary on August 1, 1st session)

> "In the 3rd session of making a future library, Yeon expressed a desire to create an elevator for her baby brother as she discussed that the library did not have an elevator and her mom had to carry him up. In addition, she stated about designing and creating different toys her siblings can enjoy."

(Source: Researcher Soo's diary on August 8, 3rd session)

2) Identifying the temporal constraints of 3D printing

Throughout the conducted sessions, children had the opportunity to engage in the design and subsequent 3D printing processes facilitated by various 3D modeling applications. In <Figure 1> we share a moment where the adult partner is finding an image for the child using the 'Thingiverse platform'. In contrast to prior research methodologies wherein experts assumed the role of introducing and elucidating the functionalities of these applications, the design sessions adopted an approach that allowed children dedicated time and space to undertake a critical assessment and share insights concerning the technological constraints inherent in their direct utilization of the aforementioned technology.

In addition, during the interviews, when asked to the child and parent about their prior experience with makerspace, there was little interaction with the area overall. Among the seven children, four had never used the makerspace area. Only one child started using the area to learn about editing. Another child replied that they were not sure if they had ever used the makerspace area in the library. However, during the parent interview, all parents stated that their child had never used the makerspace area in the library and expressed uncertainty about its availability for their use.

〈Figure 1〉 A researcher finding images on the Thingiverse platform

The children demonstrated a heightened awareness of the technical limitations associated with the 3D printing mechanics surrounding the utilization of design applications, and constraints linked to the institutional framework of the public entity, the ‘library’. Preceding the actual 3D printing phase, children engaged in modeling activities utilizing Tinkercad and Thingiverse. This preparatory phase revealed children’s perceptible encounters with entry barriers, as exemplified by the ensuing instances:

> “In the 1st Tinkercad session, Seah felt limitations to what she was able to design due to the lack of shapes.” (Source: Researcher Jung’s diary on August 1, 1st session)

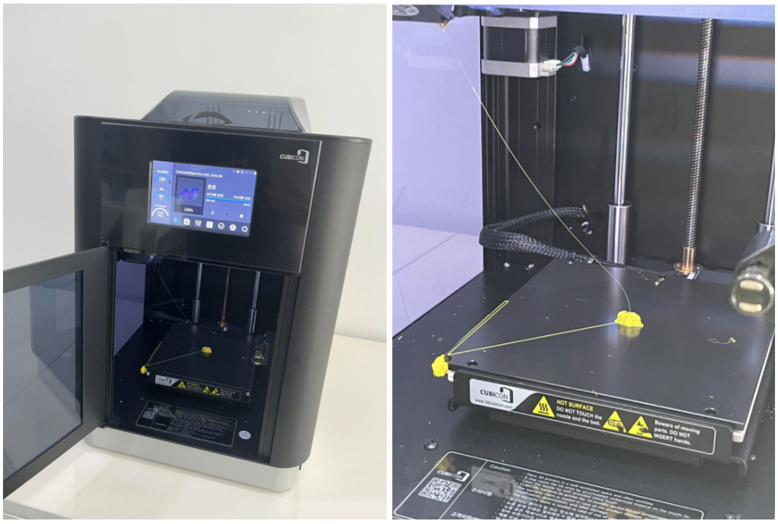
> “In the 2nd 3D printing session, Yunseul stated not being satisfied as the search results for the Thingiverse were not diverse.” (Source: Researcher Kyo’s diary on August 3, 2nd session)

> “In the 1st Tinkercad design session, Eunsae was not happy because the design she envisioned couldn’t be implemented due to difficulty in placement and size adjustment.” (Source: Researcher Jung’s diary on August 1, 1st session)

As evidenced by the above examples, children perceived constraints stemming from a shortage of design diversity and the impediment related with the manipulation of design applications. For instance, in <Figure 2> we share the result of the printing process with strings still attached. This limitation precipitates a cascading effect, wherein the scarcity of design diversity serves as an impediment, hindering children from engaging in direct design activities. Extending beyond the realms of design and printing, children encountered limitations during the actual printing process, as delineated in the subsequent examples:

> “In the 2nd 3D printing process, Yunseul noticed how the printing process was not clear-cut but had many strings attached that made it not clean.” (Source: Researcher Yoon’s diary on August 3, 2nd session)

> “In the 3rd time of checking the 3D printing process, June was surprised by how small the size of Lizamon* (a Pokémon character) came out due to time restrictions of taking turns.” (Source: Researcher Yoon’s diary on August 8, 3rd session)



〈Figure 2〉 The result of the printing process with strings still attached

Via the preceding instances, children confronted tangible limitations intrinsic to the 3D printing machine, including the inadequacy of its dimensions for printing desired models and the emergence of ‘ghosting’ issues attributable to operational characteristics. Beyond the realms of design and printing, additional constraints manifested in limitations pertaining to the sharing of resources and temporal constraints imposed by the operational parameters and temporal restrictions by the public library.

> “In the 3rd 3D printing session, the group of Eunsae, Jeong, and Seah felt worried on how to reduce the size into great portions to be on time before the makerspace area was closed for the session. They did not like the fact that they had time limitations and could not use the room afterwards as it was closed. The librarian had previously explained about sharing the space with other patrons of the library” (Source: Researcher Jae’s diary on August 8, 3rd session)

The makerspace within the library imposed temporal constraints, as its utilization necessitated advance reservation within predetermined time allocations. Consequently, children were precluded from exceeding the reserved temporal confines, thereby influencing their decision-making processes. This temporal restriction compelled children to make choices reflective of the available time, including the reduction of design dimensions and the necessity to select only a singular item for printing within the stipulated temporal parameters. Furthermore, the constrained availability of printing machines introduced limitations on resource allocation, thereby necessitating moments of negotiation and compromise among children.

- **Research Question 3:** What reflections emerged from Library and Information Science (LIS) students regarding their experiences co-designing with children in the library's makerspace area?

The third finding question is a question that examines the insights obtained through co-design, exploring factors necessary for a better session progress and unexpected limitations.

1) Relationship building necessity for participation

In the beginning of the sessions the children showed initial hesitancy towards active participation such as sharing their opinions through presentation activities primarily attributed to manifestations of shyness. Nevertheless, as temporal progression ensued and children developed a heightened sense of familiarity with both the sessions and their co-participants, a noticeable transformation transpired. In <Figure 3>, we share an image of children working on their design projects and afterward a group sharing their ideas. Consequently, there emerged an aptitude towards uninhibited exchange of opinions, presentation of ideas, and active engagement in the participatory discourse.

> "Eunsae, who lacked confidence, actively explained to June, who arrived late, showed an active attitude, being the first to present during presentation time. In addition, as the children's familiaritygrew, I noticed no resistance to sharing diverse ideas." (Source: Researcher Jae's diary on August 8, 3rd session)

> "During the 3rd session of making a future library, the children actively generated ideas, and even Jeong, who was the most passive, actively participated." (Source: Researcher Min's diary on August 8, 3rd session)

> "In the 4th session of making, June and Yunseul showed a familiar attitude, asking each other for opinions and communicating." (Source: Researcher Kyo's diary on August 10, 4th session)

<Figure 3> Children working on their design projects and afterward a group sharing their ideas.

Children, based on familiarity, communicated while generating ideas, and this communication became the foundation for creative thinking. Within the interviews, the children were asked what mode of activities they preferred. With the exception of one child all children stated in preferring group activities as opposed to individual activities. However, the one child stated that it was not that she did not like group activities but preferred her time in interacting with the 3D printer technology itself. In addition, when asked about the ideal number of sessions for this type of program in co-designing, three children stated that 5 sessions, and three children stated 6. One of the children stated 3 sessions being ideal. This shows that while we had a total of 4 sessions, the majority of children (6), felt the need to have more sessions with the exception of one child.

2) Possibility of losing a sense of purpose during the design phase of making and their gains

During the third session of making a future library, children were given design materials to design. However, contrary to the initial purpose of creating a future library that would use the 3D printing technology many of the researchers noted how the majority of the children got distracted in decorating the library and using the materials that was irrelevant to the the initial purpose of using the 3D printing technology.

> "During the 3rd session of making a future library, the children focused more on decorating with various items, and less on choosing items to print from Thingiverse." (Source: Researcher Kyo's diary on August 8, 3rd session)

"In the 4th session of making a future library activity, the children emphasized beautifying rather than imagining the desired future library." (Source: Researcher Min's diary on August 10, 4th session)

Through these examples, it can be seen that the children, while co-designing, concentrated on decoration, neglecting the original purpose of 'printing necessary items' and 'thinking about their desired library and generating ideas.' Therefore, oftentimes the researcher had to make sure to ask follow-up questions such as how it could be related to the 3D printing technology or suggested their own ideas for the children to add on to the ideas.

Regarding what the children gained from the session, we asked about what the children learnt from the experience in participating in the co-design sessions. Six children stated that they learnt about 3D printing while one child stated that she was able to learn about the area of the makerspace and learnt how to share ideas with others. While the majority of the adult partners recorded in the diaries how they were able to witness the children feeling more comfortable sharing their ideas as weeks proceeded, we noticed in the interviews from the children that they were not aware of this skill also being developed. However, in the parent's interview they stated that they appreciated the presentation part most among the program of giving a chance for their child to do public speaking and liked the fact that the adults were interested in what the children had to say which was different from other programs.

3) Possibilities of including the library design session as a form of a library and information science practice class.

While participating in the co-design sessions for research purposes, researchers expressed a desire for the sessions to be involved in a class format that directly introduces new technology to users. This is evident in the following cases.

"It would be nice to learn new technology and programs, such as handling 3D printers during the Library and Information Science class. I hope new courses are created that could be integrated with the makerspace. It would also be good to establish a course linking 3D printing with reading guidance on children's education. I'm also dissatisfied with the quality and quantity of internships, that are currently being provided." (Source: Researcher Jae's diary on August 8, 3rd session)

"I think we need more activities that structure classes based on what partrons like and that is possibly linked with the makerspace." (Source: Researcher Kyo's diary on August 8, 3rd session)

Through these reflections, we can observe how the researchers who were current LIS students hoped for classes or internship times where they can directly connect to the patrons and therefore explore the needs of users effectively through integrating new technology. They stated about establishing an environment where pre-service librarians can learn first to effectively convey new technology to patrons.

5. Discussion

This study aimed to discuss the utilization of a makerspace regarding 3D printers in a children's library by conducting co-design sessions targeting the end-users, children. The purpose was to reflect the requirements from the children for the makerspace area and to understand what the roles of the adult partners were in this participatory content. In addition to understanding children's requirements, we explored the gains from the sessions and the reflections toward the end of the session from interviews and adult's reflection notes. The conclusions drawn from the findings are as follows:

First, the design sessions were structured as participatory activities where children directly explored and shared their opinions using technology. Participating children were curious about the operation process of the 3D printer and showed interest in physically implementing their ideas. Researchers played a supportive role, adjusting their level of intervention based on the children's preferences. Second, participating children became aware of various limitations, such as the physical constraints of 3D printers, difficulties in using 3D printing design programs, and challenges related to the limited time and resources of public institutions. Third, the rapport between participating children and researchers positively influenced the design sessions, driven by the active communication of children. However, some children became engrossed in specific activities, seemingly forgetting the objectives of the sessions. Additionally, some researchers suggested incorporating design sessions into the curriculum of the Department of library and information science.

By applying a co-design methodology and planning design sessions, the study provided a space for children to critically evaluate technology and express their opinions freely. The design sessions took place in a children's library, directly involving children, the main user group of the library's makerspace, in discussing the limitations of the makerspace. This aspect adds significance to the study. In prior literature regarding makerspace, the focus has been on the purpose of having such space (Chang, 2019) and the benefits such as for creativity and educational purposes (Son & Lee, 2021). However, despite the growing importance of having such space for digital literacy, we have identified a gap in literature where there have been difficulties in librarians actually running and successfully operating such space. Therefore, in this study, we have aimed at showing how to include the end-users in the process of creating a program that meets their direct needs.

In addition, during the design sessions and subsequent interviews, researchers unexpectedly discovered results that were not anticipated. In the parent interviews, many guardians responded that their children were not generally proactive. However, the researchers who worked with these children observed their active participation, particularly in evaluating the limitations of the 3D printer and the manual created by the researchers. One child, for instance, evaluated the 3D printer usage manual as too verbose, making it difficult to understand. Observing this, the researchers noted that the children focused more on text than on images, and emphasized that it would be more helpful to highlight key points that need focused reading rather than providing detailed explanations. This was a result contrary to the researchers' expectations, as they had anticipated that including more images and providing detailed explanations would make it easier for children to understand.

Designing technology and technology-related programs for children is challenging because they have distinct needs and preferences compared to adults (Yip, 2013). In prior studies, we rarely asked directly about the needs of the patrons (Byun & Cho, 2016). Before the study, the local librarian and library staff also questioned whether children would be able to actively evaluate or criticize the limitations of 3D printers and makerspace. However, the participating children in this study presented opinions and evaluations that researchers did not anticipate. This indicates that, with appropriate support, children are fully capable of evaluating technology and expressing opinions as end-users.

Yet, it is important to clarify that the seven children who participated in the study may not represent all children of the same age group. The design sessions involved a limited number of children working with adults, and there was a limitation in the diversity of the session participants. First of all, as it was a first-come-first-served base, out of the seven children who participated in the design sessions, there was only one male student. Additionally, many of the participating children had a pre-existing interest in libraries or makerspace, or enthusiasm for the program. If the recruitment methods or composition of participants were different, the research results might have shown variations. Furthermore, in the design sessions, the teams randomly formed by adults and children in the first session continued to work together until the final session. While this fostered positive results in building familiarity between children and adult researchers, it also posed a limitation by restricting the communication targets for children primarily to adults.

6. Conclusion

Overall, this study explored the limitations and utilization of 3D printers in the library makerspace area through utilizing the method of co-design sessions with children as the target audience. Within the findings, we share what children expressed regarding the use of 3D printing. The results showed it having educational significance not only in physically implementing abstract knowledge but also in allowing learners to use the hardware they have personally created, surpassing the use of existing materials, which is similar to prior findings (Fourier & Meyer, 2015). In addition, we have shared the interactions between the end-users who were children and adults from the library and information science program to show how the two groups were designing together. Although this study selected 3D printing as the main theme for the sessions, future research could explore the use of various digital, engineering tools, and media based on their specific targets and purposes. Moreover, while the design sessions in this study were conducted as part of the research, expanding them into the curriculum of library makerspace programs or practical training for undergraduate students could validate their effectiveness with a broader range of participants.

References

강봉숙, 정영미 (2018). 학교도서관 메이커스페이스 조성 및 운영에 대한 인식. 한국문헌정보학회지, 52(3), 171-192. https://doi.org/10.4275/KSLIS.2018.52.3.171

강봉숙, 정영미 (2019). 학교도서관 메이커 교육 프로그램 개발과 운영 사례 분석. 한국문헌정보학회지, 53(2), 117-137.

곽혜란 (2014). 미디어 활용 농업교육 프로그램이 아동의 농업인식 및 진로의식에 미치는 영향. 한국실과교육학회지, 27(1), 67-83.

국립과학박물관 (2017). 사물인터넷.
출처: https://smart.science.go.kr/scienceSubject/iot/view.action?menuCd=DOM_000000101

001012000&subject_sid=1335
김권숙, 최선영 (2012). 과학 기반 STEAM 프로그램이 초등과학 영재 학생들의 창의적 문제해결력과 과학적 태도에 미치는 영향. 초등과학교육, 31(2), 216-226.
김혜영 (2021). 모든 어린이・청소년을 위한 공동 학습 공간: 도서관 메이커스페이스. 국립어린이청소년도서관.
노수황 (2018). 팅커캐드 3D 모델링과 아두이노 & 3D 프린팅 활용 가이드북. 서울: 대광서림.
문성환, 김오범 (2011). 초등학생의 창의성 신장을 위한 슬기로운생활 교과 활용 발명교육 프로그램 개발. 교과교육학연구, 15(2), 333-351. https://doi.org/10.24231/rici.2011.15.2.333
문화체육관광부 (2018). 공공도서관 메이커스페이스 조성 및 운영을 위한 가이드라인.
박형원 (2017). 메이커교육이 가져올 교육적 변화. KEDI 교육개발, 290, 14-17.
변문경, 조문흠 (2016). 무한상상실 이용자의 경험분석과 과학교육을 위한 제언. 한국과학교육학회지, 36(2), 337-346. https://doi.org/10.14697/jkase.2016.36.2.0337
손경옥, 이형철 (2021). 학교내 무한상상실을 활용한 메이커교육 프로그램 적용이 초등학생의 창의적 문제해결력과 자기주도적 학습력에 미치는 영향. 초등과학교육, 40(1), 55-65.
안인자, 최상기, 노영희 (2014). 도서관 무한창조공간의 개념 및 프로그램에 관한 연구. 정보관리학회지, 31(2), 143-171. https://doi.org/10.3743/KOSIM.2014.31.2.143
오원석 (2016). 3D프린팅. 서울: 커뮤니케이션북스.
이경진 (2023). Suggesting structure and direction of a library and information science curriculum applying design thinking methods. 한국문헌정보학회지, 57(1), 339-363.
이영찬, 김희필 (2015). 3D 도면 제작 프로그램 및 3D 프린터를 활용한 발명교육 프로그램이 초등학생의 창의성에 미치는 효과. 실과교육연구, 21(3), 39-54.
장윤금 (2017). 공공도서관 메이커스페이스 구성 및 프로그램 분석 연구. 한국문헌정보학회지, 51(1), 289-306. https://doi.org/10.4275/KSLIS.2017.51.1.289
장윤금, 김세훈, 전경선 (2019). 공공도서관 메이커스페이스 운영 현황 조사 연구. 한국문헌정보학회지, 53(3), 161-183. https://doi.org/10.4275/KSLIS.2019.53.3.161
전재돈, 박종석, 안지훈, 이순천, 이현동, 이효녕 (2019). 3D 소프트웨어를 활용한 메이커 교육이 영재학생들의 공간 시각화 능력에 미치는 영향. 교사교육연구, 58(1), 81-98. https://doi.org/10.15812/ter.58.1.201903.81
정아란, 김동훈 (2016). Maker Space를 적용한 어린이도서관 실내공간에 관한 연구: 무한 상상실 중심으로. 한국실내디자인학회, 170-174.
정영미, 강봉숙 (2018). 메이커스페이스 운영에 대한 학교도서관 전문인력의 인식에 관한 질적 탐구. 한국문헌정보학회지, 52(4), 137-161. https://doi.org/10.4275/KSLIS.2018.52.4.137
조금주 (2011). 어린이도서관의 가치에 대한 연구: S어린이도서관을 중심으로. 한국도서관・정보학회지,

42(1), 51-72. https://doi.org/10.16981/kliss.42.1.201103.51
최형신, 유미리 (2015). 3D 프린팅의 교육적 활용 방안 연구; 창의적 디자인 모델 기반 수업. 정보교육학회논문지, 19(2), 167-174. https://doi.org/10.14352/jkaie.2015.19.2.167
한국과학창의재단 (2022). 2021년 학교내 무한상상실 지원연구단 최종보고서 (D22030001).
Abbas, J. & Koh, K. (2016). Future of library and museum services supporting teen learning: perceptions of professionals in learning labs and makerspaces. Journal of Research on Libraries & Young Adults, 6.
Bell, S. J. (2008). Design thinking. American Libraries, 39(1/2), 44-49. http://doi.org/10.34944/dspace/112
Chakraborty, S. & Chakraborty, SB. (2021). Library makerspace: a new dimension to the future library services. Paper presented at the International Virtual Conference on Library and Information Services (IVCLIS 2021) - Library and Information Services: Past, Present & Future, Barasat, West Bengal, India. https://doi.org/10.2307/40322628
Colegrove, P. T. (2017). Makerspaces in libraries: technology as catalyst for better learning, better teaching. Ingeniería Solidaria, 13(21), 19-26. https://doi.org/10.16925/in.v13i21.1724
Druin, A. (2002). The role of children in the design of new technology. Behaviour and Information Technology, 21(1), 1-25. https://doi.org/10.1080/01449290110108659
Fourie, I. & Meyer, A. (2015). What to make of makerspaces: tools and DIY only or is there an interconnected information resources space?. Library Hi Tech, 33(4), 519-525. https://doi.org/10.1108/lht-09-2015-0092
Institute of Museum and Library Services (2014). Learning Labs in Libraries and Museums: Tranformative Spaces for Teens.
Molnár, T. L. & Vas, G. T. (2022). New community spaces in the library-Makerspace. Journal of Applied Technical and Educational Sciences, 12(1), 270-270. https://doi.org/10.24368/jates270
Moorefield-Lang, H. (2015). Change in the making: Makerspaces and the ever-changing landscape of libraries. TechTrends, 59, 107-112. https://doi.org/10.1007/s11528-015-0860-z
Radniecki, T. & Klenke, C. (2017). Academic library makerspaces: supporting new literacies & skills. Paper presented at the Meeting of the ACRL 18th National conference, "At the Helm", Baltimore, MD.
Strauss, A. L. & Corbin, J. (2007). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory (3rd ed.). Los Angeles: SAGE Publications. https://doi.org/10.4135/9781452230153

Walsh, G., Foss, E., Yip, J., & Druin, A. (2013). FACIT PD: a framework for analysis and creation of intergenerational techniques for participatory design. In proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2893-2902. https://doi.org/10.1145/2470654.2481400

Yazan, B. (2015). Three approaches to case study methods in education: Yin, Merriam, and Stake. Journal of The Qualitative Report, 20(2), 134-152. https://doi.org/10.46743/2160-3715/2015.2102

Yin, R. K. (2018). Case Study Research and Applications: Design and Methods (6th ed.). Los Angeles: SAGE Publication.

Yip, J. C., Sobel, K., Pitt, C., Lee, K. J., Chen, S., Nasu, K., & Pina, L. R. (2017). Examining adult-child interactions in intergenerational participatory design. In Proceedings of the 2017 CHI conference on human factors in computing systems, 5742-5754.

• **국문 참고자료의 영어 표기**
(English translation / romanization of references originally written in Korean)

Ahn, In-Ja, Choi, Sang-Ki, & Noh, Younghee (2014). A study on establishing creative zones and creative zone programming. Journal of the Korean Society for Information Management, 31(2), 143-171. https://doi.org/10.3743/KOSIM.2014.31.2.143

Byun, Moon-Kyoung & Cho, Moon-Heum (2016). Analysis of makerspace users’ experiences and suggestions for science education. Journal of the Korean Association for Science Education, 36(2), 337-346. https://doi.org/10.14697/jkase.2016.36.2.0337

Chang, Yunkeum (2017). A study on the concepts and programs of ‘Makerspaces’ at public libraries. Journal of the Korean Society for Library and Information Science, 51(1), 289-306. https://doi.org/10.4275/KSLIS.2017.51.1.289

Chang, Yunkeum, Kim, Sehun, & Jeon, Kyungsun (2019). A study of public library makerspace operations. Journal of Korean Library and Information Science Society, 53(3), 161-183. https://doi.org/10.4275/KSLIS.2019.53.3.161

Cho, Keum-Ju (2011). A study on the value of S children’s library. Journal of Korean Library and Information Science Society, 42(1), 51-72. https://doi.org/10.16981/kliss.42.1.201103.51

Choi, Hyungshin & Yu, Miri (2015). A study on educational utilization of 3D printing: Creative Design Model-based Class. Journal of The Korean Association of Information Education, 19(2), 167-174. https://doi.org/10.14352/jkaie.2015.19.2.167

Jeon, Jaedon, Park, Jongseok, Ahn, Ji-Hoon, Lee, Soonchun, Lee, Hyundong, & Lee, Hyonyeong (2019). Effects of 3D CAD software-based maker education on spatial visualization skills of gifted students. Research Institute for Science Education, 58(1), 81-98. https://doi.org/10.15812/ter.58.1.201903.81

Jung, A-Ran & Kim, Dong-Hoon (2016). A study on the children's library interior spaces using maker space: focusing on the case of imagine infinite room. Journal of KIID, 170-174.

Jung, Youngmi & Kang, Bong-Suk (2018). A qualitative study on the awareness of makerspaces operation among school library professionals. Journal of the Korean Society for Library and Information Science, 52(4), 137-161. https://doi.org/10.4275/KSLIS.2018.52.4.137

Kang, Bong-Suk & Jung, Youngmi (2018). Awareness on the establishing and operation of the makerspaces in school libraries. Journal of the Korean Society for Library and Information Science, 52(3), 171-192. https://doi.org/10.4275/KSLIS.2018.52.3.171

Kang, Bong-Suk & Jung, Youngmi (2019). Development, implementation, and analysis of a maker education program in school library: a case study of Daegu S high school. Journal of the Korean Society for Library and Information Science, 53(2), 117-137.

Kim, Hye-young (2021). Co-learning space for all children and adolescents: library maker space. National Library for Children and Young Adults.

Kim, Kwon-Sook & Choi, Sun-Young (2012). The effects of the creative problem solving ability and scientific attitude through the science-based STEAM program in the elementary gifted students. Journal of Korean Elementary Science Education, 31(2), 216-226.

Korea Foundation for the Advancement of Science & Creativity (2022). Supporting and research group for school makerspaces in 2021 (D 22030001)

Kwack, Hye-Ran (2014). Effect of analyzing elementary agricultural education media material and developing educational program for children's agricultural career cognition. Journal of Korean Practical Arts Education, 27(1), 67-83.

Lee, Kung Jin (2023). Suggesting structure and direction of a library and information science curriculum applying design thinking methods. Journal of the Korean Society for Library and Information Science, 57(1), 339-363.

Lee, Youngchan & Kim, Heui-Pil (2015). The effects of an invention education program using 3D design and 3D printers on elementary school students' creativity. Journal of Korean Practical Arts Education Research (SKPAE), 21(3), 39-54.

Moon, Seong-Hwan & Kim, Oh-Bum (2011). Development of an invention education program using the wise life textbook for children's creativity. Journal of Research in Curriculum

Instruction, 15(2), 333-351. https://doi.org/10.24231/rici.2011.15.2.333

National Science Museum (2017). Internet of things. Available: https://smart.science.go.kr/scienceSubject/iot/view.action?menuCd=DOM_000000101001012000&subject_sid=1335

Oh, Won-Suk (2016). 3D Printing, Seoul: Communicationbooks.

Park, Hyeongyong (2017). Educational change that maker education will bring. KEDI Journal of Educational Policy, 290, 14-17.

Rho, Soo Hwang (2018). Tinker Cad 3D Modeling and Arduino & 3D Printing Guidebook. Seoul: DaegwangSeorim.

Son, Kyoung-Ok & Lee, Hyeong-Cheol (2021). The effect of maker education program in school maker space on creative problem solving ability and self-directed learning ability of elementary students. Journal of Korean Elementary Science Education, 40(1), 55-65.

South Korea. Ministry of Culture, Sports and Tourism (2018). Establishing guidelines for implementing and operating makerspaces in public libraries.