Augmented Reality Based Information Systems: An Exploratory Study of Understanding Children's Perception

AR 기반 정보 시스템에 대한 아동 인식 연구

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ABSTRACT

Augmented Reality (AR) is a mix of the real world that is enhanced by virtual objects from computer-generated information. AR is currently used in a variety of information systems and library services. AR technologies are also being developed for today's children, who are digital natives and are exposed to various technologies even earlier. To assist librarians who need to accurately understand users' information needs and perceptions of the technology being used in their libraries, we conducted a study of AR perceptions among children. We conducted two online co-design sessions using "Would you rather?", a co-design technique that facilitates research into children's opinions. Through the co-design sessions, we found that children were psychologically wary about AR technology due to a lack of trust in the technology, and realism had a significant impact on these judgments. We also identified that children considered AR technology environments as an extension of the real world. Their real-world values directly influenced their perceptions of AR. This research provides insights into the wariness that libraries need to be aware of when developing AR content for children in the future, and how libraries can use AR as an educational tool.

초 록

도서관은 어린이들이 신기술을 활용할 수 있는 기회를 적극적으로 제공하는 공공기관으로, 미래 세대를 위한 다양한 기술 기반 정보 시스템의 영향력에 대한 이해가 필요하다. 증강 현실(Augmented Reality)은 최근 어린이들의 교육, 치료, 여가 등 다양한 분야에 활발히 적용되고 있는 기술이다. 그러나 이러한 발전에도 불구하고 어린이들의 AR에 대한 인식과 요구에 대한 연구는 제한적인 실정이다. 따라서 본 연구에서는 공동 디자인 세션을 통해 AR 기술에 대한 어린이들의 인식과 요구를 직접적으로 조사하고자 하였다. 'Would You Rather?' 기법을 통해 어린아이들은 AR 기술에 대한 경계와 기대를 동시에 가지고 있으며, AR 기술 환경을 현실 세계의 확장으로 간주한다는 것을 확인할 수 있었다. 본 연구는 향후 도서관에서 어린이를 위한 AR 콘텐츠를 개발할 때에 고려해야 하는 요소를 제안한다는 점에서 의의를 지닌다.

Keywords: children, user perception, augmented reality, virtual reality, user study
어린이, 이용자 인식, 증강현실, 가상현실, 이용자 연구

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1. Introduction

In modern society, various technologies are emerging and being utilized at an accelerating pace, with advancements in devices and media that support these technologies. Recently, technologies that extend beyond the boundaries of the physical world, such as the metaverse, VR, and AR, have garnered attention. Children, often referred to as "digital natives," exhibit a high level of adaptability to various technologies, starting from the ages of 6 to 12 under the guidance of tech-savvy parents (Sung, Byun, & Nahm, 2015). Novel technologies that engage multiple senses and stimulate interest have the potential to enhance children's enthusiasm and sustain their learning experiences (Shim & Oh, 2007). These features have recently led libraries to utilize technologies such as the metaverse to provide more diverse experiences for children (Kim & Kwon, 2022). Children can explore a variety of new learning activities in the library, such as playing games and investigating careers, by using metaverses, which is an unfamiliar technology (Kim & Kwon, 2022). This intersection of libraries and the virtual world is being studied more actively since the COVID-19 pandemic has brought contactless distance learning into the spotlight (Noh, Kang, & Kim, 2020). However, this challenge for libraries has not always been positive. Concerns have been raised about the potential adverse effects of technology use on children's physical and mental well-being. Studies have shown that excessive media use by children under the age of four may have negative impacts on their concentration and learning abilities (Oh & Park, 2019). Recognizing these concerns, the Ministry of Education in South Korea issued guidelines in 2019, urging children to refrain from using headset-type VR and AR technologies (Oh, 2019).

Understanding the impact of technology on users is important for organizations like libraries that need to understand and serve the rapidly evolving needs of their users (Lee & Lee, 2011). In particular, there is a need for more knowledge about the technology used by children, who may be more sensitive to technology. However, while various studies have been conducted on children's use of technology and its impact, there is still a dearth of research on the psychological aspects of children when they encounter new technologies. This study aims to investigate children's perceptions of a relatively unfamiliar technology, with a focus on Augmented Reality (AR) based information systems. AR enables learners to navigate between the real and virtual worlds through natural interfaces and facilitates experiential learning (Kaufmann & Schmalstieg, 2002). AR experiences provide users with realistic sound, 3D visuals, and other sensory elements, enhancing the user's perception of social situations (Noh, 2014). AR is predicted to be a key medium for implementing the metaverse, an anticipated next-generation communication platform (Guo et al., 2023). Academic librarians for instance have utilized AR technology in disseminating information in new ways by attaching the digital information to real-world objects which allows the patrons to interact with information (Santos & Esposo-Betan, 2018).

As such, AR, which delivers information to users

in a new and sensory way, has been actively researched in the information system field. Harborth (2017) pointed out that insights from the information system field are needed for the development of AR. In his literature review of information systems related to AR, he found that the most AR studies were in the education and learning domain. Also, Aslan, Çetin & Özbilgin (2019) surveyed the current landscape of information systems that have started to integrate such new technologies as AR. Findings showed how AR has been gaining traction in fields such as aerospace defense, medical, and the industry. These prior studies show that AR is being actively utilized in professional education and various digital information system fields. On the other hand, they also found that there is a lack of research in the information systems research area related to user perception of AR. Harborth argues that we need to properly analyze and understand the users' behavior towards the system, not just the technical aspects of AR, and emphasizes the importance of the user perception of AR research within the information system context. This study sought to investigate the children's perceptions of AR as they utilize it in libraries and other places to obtain information or manipulate the system. By observing how children understand and accept AR technology and its content, we pursue the advancement of AR and its use.

In this study, we aim to understand how children perceive and utilize AR through a co-design methodology. Utilizing the "Would You Rather?" technique, we ask children about their perceptions of AR as end-users of the technology and conduct content analysis (Krippendorff, 2018) of their perceptions. Additionally, we aim to suggest directions for assessing future AR content that children prefer that can be utilized in library activities. Our research questions are the following:

- RQ1. How do children perceive AR technology, and what factors influence their perception?
- RQ2. How do children perceive AR content and what elements do they prefer?

2. Related Work

2.1 Children perception on children's technology

The majority of technologies encountered by children are predominantly used in educational contexts, leading to most research on children's technology perception focusing on learning-related aspects. Park (2011) found that utilizing various technological media in learning can easily arouse children's interest and motivation, resulting in higher learning outcomes than traditional learning methods (Park, 2011). On the contrary, Kim (2020) found that children's dependence on smart media has a direct negative impact on the development of their language and behavioral skills (Kim, 2020).

Extensive research has been conducted on children's reactions to technology, yet studies on the psychological states and emotions of children during technology use have often been limited to specific

media or situations. In the library setting, one of the most common technologies that children may encounter is e-books. E-books are digital books that can be read as images through electronic devices such as computers or smartphones. (Korea Internet Security Agency, 2010) Studies have shown that children felt it was inconvenient and unfamiliar to use a separate device when using e-books. However, their preference for the device also extended to their preference for the content, and they responded positively to the fact that they could experience the content of the book more realistically than a regular book (Chung & Choi, 2012). Furthermore, children were more psychologically affected when experiencing content through extensive media than e-books. In the case of TV programs, research indicates that younger children face difficulties distinguishing between reality and virtual content, experiencing heightened fear when exposed to content that blurs this boundary (Bonus & Mares, 2019). Subsequent advancements in technology and media have led to increased interactive capabilities and utility during technology use. Consequently, children tend to perceive technology more realistically, displaying a trend toward enhanced immersion and acquisition within technological environments (Shim, 2009). Moreover, with the development of technologies like Augmented Reality (AR) and Virtual Reality (VR), where direct experiences of virtual reality are possible, there is a tendency for children to find it challenging to differentiate elements presented in these technologies from reality. The clear distinction between virtual and real experiences has been shown to impact the psychological stability of children during technology use (Deák, 2006).

In general, surveys and parental inquiries have been pivotal in conducting research on children's technological awareness (Bae & Kim, 2013). However, for younger children, who often face challenges in reading or understanding vocabulary, relying solely on surveys makes it difficult to discern the child's perspective. Additionally, parents may have limitations in fully describing the psychological state of their children (Zill, 2001). Recently, there has been a shift towards employing methods such as co-design and participation observation in research on children's technological awareness, where children directly play or engage in the creation process of content (Muñoz Cardona et al., 2021). These methodologies offer the advantage of directly understanding children's values and perceptions through their active participation in technology-related activities. Early co-design was used to allow people who had not used technology or were unfamiliar with it to try out prototypes and generate ideas about them. It was especially popular to include the voices of workers who were at risk of being marginalized by the introduction of computer-based systems. Researchers created a wooden mouse prototype to study the perceptions of working-class people who had never had direct experience with computers before so that they could understand how the new machines would affect them (Ehn, 2017). In this way, co-design allows us to understand not only individual perceptions, but also current perceptions shaped by the environment around them. This allows us to pre-

dict how they will use these technologies in the future (Kensing & Blomberg, 1998). Therefore, in this study, we aim to utilize the co-design methodology to interact directly with children, seeking insights into their perceptions of technology.

2.2 A child as an AR user

Augmented Reality (AR) is a technology that enhances users' real-world experiences through digital media (Radu & Schneider, 2019). Due to its minimal spatial-temporal constraints and active user interaction, AR has been extensively applied across various fields. However, research on roles beyond education in AR for children is limited, as most children currently use AR for educational purposes. Studies on AR for children predominantly focus on preschoolers, emphasizing language learning, social development, and empathy enhancement (Isa, 2023). There have also been AR studies for therapeutic purposes in children with autism or trauma experiences (Herrera et al., 2018). However, both cases avoid prolonged AR use, posing challenges in actively investigating children's experiences.

Research in this field has explored the benefits children can derive as AR users. In educational contexts, AR plays a role in stimulating children's interest and motivation, enhancing their understanding of complex spatial and visually concealed structures (Radu & Schneider, 2019). It seamlessly connects real-world problems to virtual scenarios, ensuring the authenticity of learning, and encouraging natural interactions tailored to the situation (Kim & Kim, 2019). Additionally, as a medium amplifying non-verbal and visual stimulus, AR aids in the comprehension and immersion of language stimuli (Bloom & Lahey, 1978), potentially contributing to the recovery of autism and language disorders.

These benefits make AR-based activities more interactive and engaging for children when implemented in a library setting. Children can get more sensory satisfaction from AR by manipulating situations in books and interacting directly with characters (Bang & Hong, 2021). At this point, realism has a significant impact on children's multisensory AR experience. Realism is the perceived correspondence between an experience through technology and a similar experience not through technology (Lombard et al., 2015). It has been observed that the more realistic AR elements are, with minimal disparity from the real-world background, the higher the level of engagement among children (Alakärppä et al., 2017). This leads to a reduced sense of unfamiliarity when using the technology. However, in such cases, there is a risk of treating real-world elements as virtual, which can lead to difficulties in the application or even hinder the learning effects (Deák, 2006; Radu & Schneider, 2019). This implies that providing the appropriate level of realism when children are using AR is an important factor in usability.

2.3 Children's AR content

Currently, the majority of AR-based content for children is produced with a specific purpose. This extends beyond traditional academic subjects to en-

compass areas such as lifestyle habit correction, extracurricular skills development, and virtual reality experiential learning (Radu, 2012). A typical AR content for traditional learning is an AR book. Unlike regular books, AR books offer formats such as games and movies through augmented technology. This allows children to experience richer interactions and contents than traditional books (Wang, Huang, & Lee, 2017). These educational contents range from basic subjects like reading, English, and math to interactive edutainment (Education + Entertainment) which is an AR content that combines entertainment with learning. Such content allows students to directly experience cultural heritage, historical events, and more (Jeong & Cha, 2015). In contrast to traditional educational materials, AR experiences typically require screens or media devices, incurring additional costs for users. However, with basic conditions met, such as a webcam or AR simulation app, it is possible to use AR content in various settings with ease. Smartphone-based AR content is particularly accessible, offering various services through a single application, which is a strong point in the realm of educational content (Noh & Ro, 2021).

To facilitate access to AR for more children, public libraries are often equipped with the devices so they can try out AR. Libraries provide not only the devices and space, but also the AR content that children need for learning, so children can select and try the content themselves. These efforts by libraries have made AR content more accessible, allowing the educational benefits of AR to be highlighted. For instance, the National Library for Children and Young Adults in South Korea has been widely providing space and content for AR. They provide free AR book cards and character card files on their web pages, making it easy for children to access AR content without visiting the library.

In addition, the library has set aside a space for children to experience AR musicals and other AR elements with their own bodies, providing a unique learning experience and allowing them to experience new ways of communicating (Kang & Cha, 2020). As such, the prevailing theme of AR content for children is focused on improving their experiences and enhancing their learning abilities. However, the variety and breadth of AR content means that it would be impractical for a library to adopt all of the content. Therefore, librarians need to know what content children will need and prefer, rather than just buying and adopting AR content for their library. This is even more important when using AR in libraries, as they need to create a safe environment for children to try out the technology. Despite these concerns, there is a lack of research that examines how children perceive AR technology and what aspects of AR make them more engaged. This study aims to provide insights that librarians can use to understand children's perceptions of AR and to support content development and adoption.

3. Methods

Co-design is a methodology in which end-users participate in the development process of products

or services, taking on the role of co-designers. When children participate in co-design sessions, they collaborate with adults contributing their worldviews to the design process and offering diverse perspectives and insights (Walsh et al., 2012). Trying out prototypes or concepts of technologies in co-design can give children an understanding of technologies they have not experienced in depth before and can help them generate ideas for future uses. To ensure that children are equally involved in the session as the adult designers, they need support and respect for their opinions. In co-design, there has been an ongoing conversation on how much freedom and structure the designers and researchers need to provide to the end-users. Makhaeva, Frauenberger, & Spiel (2016) argue about finding a balance to meaningfully include the children in the process of design. In our study, we decided to provide some structure to narrow down the range of concepts the children would be considering for a meaningful design process. For this purpose, the study used the "Would you rather?" (WYR) technique, which is an activity that helps children keep their own goals in mind and facilitates the mixing of ideas. The researchers provided scaffolding for the children through this setting but allowed them to answer beyond the set and discuss variables that were not part of the prepared assumptions. Through this method, we aimed to find a balance between structure and freedom in a session with the children.

WYR, contributed by Simko et al. is a co-design technique based on the interactive game of the same name. Based on a thought-provoking scenario, two options are presented and participants are asked to choose one of them. It is used to encourage discussion and rationalization of participants' choices by presenting opposing values or difficult choices and situations. The process typically proceeds as follows: scenario creation, voting and discussion, and analysis. During voting and discussion, participants decide on their choices in the scenario, and the moderator asks them questions about their reasons. Depending on the setting, participants can choose a third option not assumed in the scenario, or none at all. These choices can lead to insights that go beyond the scenario, and in the process of explaining them, other participants can recognize the value provided by the scenario in a broader context (Simko et al., 2021).

By providing scaffolding through scenarios, WYR can be used in a variety of ways, not only for co-design activities but also for any discussion activity that requires children's input, even if the participants have no prior design experience or are too young to clearly state their opinions (Warren, 2022). In addition, it helps children formulate their own arguments by presenting options with contrasting values, allowing them to explore different ideas and values when explaining their choices (Lee et al., 2021). Furthermore, the hypothetical scenarios provided by WYR allow children to imagine different situations and assumptions and consider their arguments for things they have not experienced or thought about in-depth yet. These discussions can naturally reveal participants' values, interests, and personal contexts. Thus, we found the WYR technique to be appropriate for our study, which sought to investigate perceptions of AR, future use of it, and preferences.

3.1 Participants

The participants in this study consisted of one adult researcher and ten children aged 8 to 12. The children were selected from those who regularly participated in physical education and learning activities at a church in Gunpo, South Korea. When conducting co-design sessions, the relationship between the researcher and participants significantly affects motivation, equality, and other variables (Druin, 2002). Since our study was not a long session, we chose a church where the researcher had already built a relationship with many children in order to gather a variety of opinions and insights in a short session. The researcher posted an announcement in the learning activities program asking for participants interested in AR, and the children volunteered to participate. Although recruited from the same church program, the children came from different backgrounds: four different schools, three different regions, and all had different interests. Participants of the same age were already familiar with each other before the session, and all participants had a sufficient relationship with the researcher.

There was a total of three pairs of participants who attended with their families. Siblings participated in the same session with their siblings. The family participants were separated into different rooms so they could not communicate with each other on-site. All participants had previous experience with a variety of activities that directly involved AR at school and home. They reported that they had used AR content in their daily lives, such as AR books and Pokémon Go. The researcher additionally provided basic information about AR, such as how the technology works and the different types of content available in AR. This process aimed to help the children gain a basic understanding of AR.

All participant names in the data were replaced by pseudonyms.

3.2 Design Sessions and Data Collection

From August to September 2023, a total of two

〈Table 1〉 Child Pseudonym

Sessions	Child pseudonym	Gender	Age	Note
1	Tina	Girl	11	
	Jane	Girl	11	Siblings (Twins)
	Haley	Girl	11	
	Lian	Girl	11	
	Hyun	Boy	8	
2	Jason	Boy	12	Siblings
	Jake	Boy	10	
	Yune	Boy	12	Siblings
	Ella	Girl	10	
	Theo	Boy	8	

online design sessions were conducted. The online sessions were approximately 1 hour long, considering the children's ability to concentrate. The session consisted of an introduction and technique practice (10 minutes), the "Would you rather?" activity (45 minutes), and a reflection on the session (5 minutes). The sessions were held remotely via the online streaming platform Zoom to be inclusive of both children who lived far from the church and whose school commitments made it difficult to participate in person. Data collection during these sessions involved video capture by the researcher, note-taking, and using Zoom's audio and screen recording functions. Each group used the same questionnaire prepared by the researcher, and discussions were conducted using 12 prepared questions. Before conducting the sessions with children using the codesign methodology, two-choice "Would you rather?" questions were created to facilitate smooth progression and choices. According to Simko's research (Simko et al., 2021), 7 to 10 scenarios are suitable for a 1-hour session with children. The questions were divided into one practice question and 11 regular questions. The question creation process was guided by the execution instructions provided in the aforementioned study. Each question was designed to align with three main themes: exploring children's values, assessing their awareness of AR technology, and investigating their preferences for content. The questions are as follows, as shown in the Table 2.

〈Table 2〉 WYR Questionnaires

No.	Topic	Methodological variations	Scenario
1	Exploring Children's Values	Practice Options	WYR choose midsummer or midwinter?
2		Preferences for group activities	WYR always study alone or study with someone else?
3		Perception of competition	WYR be first on the last place team or last on the first-place team?
4		Writing and speaking preferences	WYR just call or just text?
5		Recognizing and responding to negative situations	WYR be in a situation where no one listens to you, or be in an embarrassing situation where you have to introduce yourself in front of a group of strangers?
6	Perceptions of AR technology	Researching VR and AR preferences	WYR be in a fairy tale or have a fairy tale character come out into your world?
7		Preferences between AR and digital content without AR	WYR play Pokémon Go or Nintendo Pokémon?
8		Researching preferences between premade objects and self-made objects	WYR have the pictures in the book come to life or the character you drew come to life?
9	Preferred Content	Preferences for linguistic scaffolding assistants in content	WYR have a friend who says everything you want to say, or a friend who always listens to you when you talk?
10		Preference for passive and active content	WYR imitate a character or the character imitate you?
11		Preference to solving problems	(If you're working on a problem and don't know the answer) WYR work through it with a friend or ask your teacher for the answer right away?
12		Preference for presented vs. authorized content	WYR explain your favorite things to your friends or have them explain them to you?

〈Figure 1〉 Session Material (PPT)

These questions were pre-created with explanations and related visuals in a PowerPoint presentation (PPT) to make it easier for participating children to understand. During the Zoom online sessions, the PPT was shared on the screen to enhance immersion and focus when addressing the questions.

During the session, children were asked to make choices between the provided options by raising their fingers. Under the guidance of the researcher, they explained their choices and engaged in discussions. They expressed their thoughts on specific technological scenarios and offered valuable insights through the process of making and explaining their choices. This information was used as analytical data.

3.3 Data Analysis

We recorded the online sessions using Zoom client to analyze participants' facial expressions and audio. We used a grounded theory approach with an inductive and qualitative method (Creswell & Poth, 2016). First, we watched and transcribed a total of 180 minutes of video data. To examine children's perceptions concretely, we transcribed the entire conversations and group discussions. After the transcription, the primary author created an initial set of analytic memos of the observation. With the analytic memos, we first open coded the interactions that occurred in each co-design session. However, referring to prior literature, we performed deductive coding with the following codes based on a previous study (Simko et al., 2021): 1) how children participated in the co-design session; 2) how children reacted to the technology; 3) children's thoughts about AR technology; 4) how children integrated their value with the presented scenarios; and 5) the children's preference in AR elements.

Next, we refined the codebook through researcher group meetings and data comparisons between researchers. In group meetings, we discussed integrating some codes to analyze themes. To clarify the theme, we decided to focus on the children's answers to the questions and the cognitive processes they revealed during the sessions, rather than their co-design engagement behaviors. Once we narrowed down the topic, we found that two particular emotions, fear and anticipation, significantly impacted on children's perceptions of technology. Based on

this, we revised our coding scheme and laid out a variety of data, including video, audio, and notes, to support each other. Finally, through the data analysis and the codebook, we were able to determine two main themes: 1) children's attitude toward AR technology; 2) perception of AR content.

4. Findings

4.1 Children's attitude toward AR technology

The sessions provided a means to ascertain children's awareness of AR technology. In questions probing opinions on examples or applications of technology, such as 'WYR be in a fairy tale or have a fairy tale character come out into the world?' and 'WYR imitate a character or the character imitate you?', the children exhibited a considerable level of consensus in their responses. Furthermore, during the discussions, they introduced third alternatives or provided diverse insights beyond the presented scenarios. Throughout this process, the children displayed two prominent features of perception: 1) Psychological wariness of unfamiliar environments and technologies; 2) Perception of AR content

4.1.1 Psychological wariness of unfamiliar environments and technologies

During the sessions, we noticed that the children were generally wary of the situations or problems presented in the questions. In particular, they tended to express negative opinions when presented with options that were completely different from what they were used to: unfamiliar environments and technologies. When asked to choose between AR and VR, children made assumptions that went beyond the situation presented by the researchers and gave negative opinions:

"If you fall into a fairy tale, you might be in a dangerous situation because you don't know anyone and you don't know the way." - Lian

In making these comments, the children discussed the "trustworthiness" of the technological environment, and while there was no consensus, a common argument was that fairy tales are dangerous because they are "an environment without prior information". Even though they limited the scope to fairy tales that they knew, we could see that they perceived the environment provided by technology as an unfamiliar "real space". In addition, we found that they often considered the negative effects and responsibilities of new technologies before they considered their expectations:

"I'm curious to see the characters come to life, but I'm afraid that the bad characters will come to life." - Haley

"What if the wrong character you drew comes to life and destroys the world?" - Jane

Even when we provided plenty of examples of

positive activities and characters in the scenarios, children seemed to first consider the possibility of it functioning negatively. Children who viewed the technology positively also did not deny that it could be abused. The children who expressed positive opinions consistently maintained their positive opinions throughout the discussion, and the two separate groups tended to be similar in ways of answering their responses, which indicated that this was not a case of herd mentality or a single child leading the discussion.

4.1.2 Extension of real-world values

When asked about the use and application of technology, children responded by extending their real-world values. They accepted the situations presented in the fictional scenarios in a realistic context and judged the characters presented in the same way as their real-life counterparts:

"I can't play (with fairy tale characters) because my mom scolds me if I don't study" - Jane

"I don't need a helper (supporting character) because I can speak well by myself" - Jason

"My friends don't like it when I explain things to them, so I want her (supporting character) to explain it to them" - Hyun

Especially in situations such as studying or playing, they naturally applied the rules of their home as a basis for judgment. In this case, we could see various family rules and values, such as 'play after finishing homework' or 'don't bring friends home when you don't ask'. This suggests that the home environment has a strong influence on children's judgment of technology.

Outside of the home, children were more likely to accept situations and aftermaths caused by technology without separating them from reality, or to match technology needs with real-world desires. It can be assumed that realism is an important factor in children's perceptions of technology, and that they extend their real-world values to the context of technology use in order to satisfy realism.

4.2 Perception of AR content

During the session, the children were shown videos utilizing AR or given examples of their own experiences using AR content. At this time, the children directly and indirectly expressed their perceptions and preferences for AR content, which allowed us to identify the elements of AR content that they preferred.

4.2.1 Expectations for augmentation

In the technology-related choice, a significant number of children showed a preference for AR-related choices over other technologies. They often chose AR technology over other options, such as VR, 2D gaming devices, and analog picture books, citing the "augmented" aspect as the most influential factor in their choice:

"Rather than me going into the fairy tale (VR), I think it would be better if the fairy tale characters came out and played with me (AR)" - Jake

Most of the children said that they preferred AR, which allows them to encounter new elements in the real world through augmentation, rather than analog content that they can experience every day or VR content that requires too much immersion. Among the AR elements, there were some answers that can be interpreted as preferring perceptual AR content that they can draw or move themselves rather than marker-type AR that moves the already presented picture:

"I just look at pictures every day, so I think it would be more interesting if my own drawings popped up." - Yune

4.2.2 Access through familiar devices

In the WYR 7 scenario comparing preferences between Pokémon GO and Nintendo Pokémon, a number of responses indicated a preference for familiar devices such as cell phones over unfamiliar devices such as Nintendo. In particular, many respondents felt that it would be easier to use new technologies such as AR through familiar devices:

"Nintendo is uncomfortable to carry around, and it's hard to move (the character)." - Jason

"It's all new to me, so I think it would be better to just use my phone" - Haley

Overall, the responses showed more psychological wariness when the device was unfamiliar than when the content was unfamiliar. AR elements were also more acceptable when explained through familiar devices such as phones and tablets than when elements such as dedicated devices or markers were mentioned.

4.2.3 Preference for self-directed content

When presented with passive and active options, children tended to choose the active option. If they perceived that they could do something on their own, they didn't feel the need for help, or in some cases, they felt that getting help would hurt their pride. Overall, passive and active options were associated with learning, and passive options were often perceived as less fun:

"Why should they (the characters) do it for me? I can do it myself!" - Yune

"It's not fun to listen to someone else explain things" - Ella

"It hurts my pride to ask the teacher for answers" - Jake

However, the responses to this option varied by age. Children aged 10 to 12 years old mostly did not find the active option difficult. If they chose the passive voice, it wasn't because they lacked the ability or couldn't do it themselves, but because they found it easier and more comfortable. However, the

8-year-olds chose the passive option because they were unable to do it themselves or needed help. In this case, the most influential factor in choosing the passive option was the idea that doing it on their own would be too slow and would cause disturbance to their friends. This highlights the need for age-specific considerations when organizing learning content.

5. Discussion

We aimed to investigate children's perceptions and preferences for AR. Existing research on AR tends to focus on the use of AR and its content (Kim et al., 2017). However, it is also important to understand how children feel while using AR and how they perceive it from their perspective. We provide empirical findings for understanding children's perceptions of technology through co-design sessions utilizing the 'Would You Rather' technique used in HCI research (Lee et al., 2021; Simko et al., 2021). By looking at the whole process from the child's perspective, we were able to identify their attitudes towards AR and their preferences for AR elements.

Children's attitudes toward AR technology emphasize realism. In the provided scenario examples, the children showed a lack of "trust" in the technological environment. To them, the technology-enabled environments were fairy tale-like and fantastical, but also unfamiliar and dangerous. This is consistent with previous research showing that the more distant from reality, the more anxious children are in virtual environments (Radu & Schneider, 2019). But beyond mere anxiety and wariness, within the space of technology, they were acting within a realistic context and set of values. Reality and values became the basis for their judgment when using the technology. This suggests that children have psychological boundaries around AR technology that stem from their real-world context and that children's values strongly influence their psychological pressure and attitudes toward the technology.

Children also showed clear preferences for AR content: they were wary of AR, but excited about the "augmentation" and the new stimulation it would provide. Due to their psychological wariness of AR, these expectations were amplified when using a device that they were already familiar with. In addition, children wanted to be able to be active and self-directed in the situation. We found that children's preferred AR content needs to evolve in a way that breaks down their psychological boundaries. To meet children's wariness and expectations at the same time, a "familiar virtual environment" should be implemented. In this case, content that includes familiar devices and voluntary interactions using gamification will be effective (Reed & Miller, 2020).

We went through the process of validating and confirming our research triangulate through our study, but we also got results that did not match with our assumptions. During the recruitment process, we assumed that children would react positively to AR technology because they were already aware of it or had used it before. However, during the sessions, children reacted more negatively to the technology than we thought. Despite the fact that the

scenarios presented were relatively enjoyable, the children's reactions were borderline fearful. It is possible that we have recruited a group of children who were naturally cautious or their parents' upbringing had an impact. Based on research examining children's reactions to creepy technology, it is possible that children have an instinctive level of wariness toward technology (Yip et al., 2019). Future research needs to explore children's fears of technology and their roots in different populations.

We chose the "Would you rather" technique because we thought it would be more interesting than an interview or survey for the children. Traditional interview and survey methodologies made it difficult for children to express their opinions verbally, and it was easy for them to lose interest (Zill, 2001). However, we thought that the "Would you rather" technique would be more engaging because, through co-design, children would be directly involved in the design process and share their opinions. However, at the end of the session, the children reported that the session was not as fun as they thought it would be. They said they did not speak up enough in the sessions, and they were bored to waiting for their turn. They also mentioned that when they were first informed about the sessions, they expected that it would be in the form of a more exciting game or quiz. Yet they felt disappointed because it was actually more like a discussion. This puzzled us because the discussions within the sessions were very engaging overall. We realized that in order for children to enjoy participating in research, we need to encourage other factors besides active participation. In future studies, we would like to do more interactive and fun activities within the sessions, such as using AR on their own or creating design artifacts. In future studies, we would like to do more interactive and fun activities within the sessions, such as using AR on their own or creating design artifacts. Additionally, there were several other limitations to our study. Due to the lack of participants, the diversity of participants was also insufficient. Yet, prior studies that have used co-design methods have suggested that a small number of group members allows a deeper discussion among group members (Druin, 2002). Next, the research methodology is expected to be limited as it was conducted only through online sessions in the same way. This could be improved by conducting future studies with a larger and more diverse group of participants and using an expanded methodology. In addition, the children were not able to actually utilize AR during the study, which limits our ability to explore their perceptions. Our research focused on the general topic of AR. Now that we have identified the general understanding of children's perceptions and preferences for AR, future research can focus on more narrow topics. In particular, this study can provide a good foundation for research on AR content elements.

6. Conclusion

Today, many library programs for children are trying to adopt activities that utilize new technologies like AR, VR, and metaverses. Previous research on

these technologies and their content in libraries has mostly focused on the positive and developmental aspects of their use. Research on user perceptions of the technology has shown similar results. In one study, people lined up to try VR when it was introduced to libraries, feeling curiosity and excitement (Dahya et al., 2021). Even studies that have identified negative perceptions of children's use of new technology in libraries have typically shown children's feelings of unfamiliarity and discomfort with the new technology (Chung & Choi, 2012). However, in this study, we found that the children have fear, rather than curiosity and positive perceptions of the new technology. Their lack of trust in unfamiliar technological environments could be an important factor for libraries that are trying to be inclusive of all children when creating and utilizing AR-related content. We also found that these perceptions were influenced by real-world values, not just discomfort with unfamiliar technology. This allows us to recognize the challenges and wariness that children feel in a digital society. In libraries, where it is essential to accurately identify user needs and technology perceptions, it can also be the role of librarians to understand why children are fearful of these technologies and how they could be used in an educationally meaningful way. To assist this goal, this study sought to understand children's perceptions of AR technology and the factors that influence them through direct collaboration with children. We used the "Would You Rather" technique, which presents children with alternative choices and allows them to efficiently discuss their arguments and rationales. We conducted two online sessions with a total of 10 children. The results of the study showed children's psychological boundaries and fears of over-immersion in unfamiliar technologies, as well as their expectations of AR technology and its scalability. We also found that children's perceptions of technology are strongly influenced by real-world values and that they consider the technological environment as an extension of the real-world environment. In order to break down psychological boundaries in the development of AR content for children, we proposed the formation of a "familiar virtual environment" using familiar IPs and suggested that it would be effective to apply a gamification reward structure to AR content so that children can self-direct the content.

Despite some limitations, this study aims to explore children's perceptions of AR technology. There has been a lack of research on the psychological state of children as AR users, and it is meaningful that this study explored this aspect through direct collaborative design with children. In addition, we summarized the factors that should be considered in developing AR content for children from the perspective of children, and we expect to be able to produce more advanced AR content for children in libraries based on these findings.

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