

A Study on the Effects of Technology Utilization Workshops to Improve Pre-service Early Childhood Teachers' Technology, Pedagogy, and Content Knowledge (TPACK)

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Abstract

This study examined the effectiveness of a technology utilization program implemented to cultivate TPACK in prospective early childhood teachers. To this end, the TPACK scores of prospective early childhood teachers were measured using the TPACK test tool before and after participating in the program to verify the difference, and qualitative interviews were conducted about their participation and impressions. As a result, significant differences were found in the overall TPACK score and the TK and TPCK scores. Through the program, prospective early childhood teachers were able to resolve their existing misunderstandings about technology and gain confidence in using technology. Interest in technology-based education increased, as did the willingness and motivation to practice it in the future. The desire to continue learning about the use of technology in the educational field was also heightened. The results confirmed that the technology-utilizing workshop was effective in enhancing TPACK, addressing a critical educational demand, although not uniformly across all domains. These findings are significant as they provide direction for the development of educational programs aimed at improving the technological content teaching knowledge of pre-service early childhood teachers.

Keywords : *TPACK, technology education, edu-tech, prospective early childhood teacher*

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Introduction

In contemporary society, technology functions not just as a tool for using devices, but also as a cultural artifact that conveys information and values, reflecting the culture of its society (Spawls & Wilson, 2017). Born into and living within the digital revolution, young children naturally encounter technology through frequently used devices, adopting them as significant means of cultural learning and information assimilation. Early childhood educators can facilitate developmentally appropriate teaching and learning by utilizing technology-interaction devices, thereby effectively promoting children's learning (NAEYC & Fred Rogers Center, 2012). In early childhood education settings, technologies such as flash and PowerPoint are utilized to deliver stories and poems, and virtual or augmented reality is used to invite extinct dinosaurs into the classroom. Digital picture books on electronic pads, where children can interact by touching the pictures to move or disappear them, are also common. The use of relatively simple technologies like electronic microscopes or webcams connected to computers to enhance children's interest and creative expression can be easily found in early childhood education environments. Research by Sakr, Connelly, & Wild (2016) observed that children aged 4-5 participating in the creation of digital art using technology formed new concepts of expression and acquired skills in using devices, showing increased engagement in activities.

Early childhood teachers must support children in using digital devices appropriately according to their developmental characteristics and levels, helping them to enrich their lives and develop the competencies necessary to adapt to future society. However, teachers often face difficulties in integrating technology into their lessons due to a lack of training and expertise in technology. Mishra and Koehler (2006) argued that for teachers to effectively utilize technology in educational contexts, their Technological Pedagogical Content Knowledge (TPACK) needs to be developed. They proposed TPACK as an integrated concept combining Pedagogical Content Knowledge (PCK)¹ and Technological Knowledge (TK)² to enhance the use of technology in lessons. TPACK represents the capacity to select

¹ Pedagogical content knowledge (PCK) is concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge, and theories of epistemology.

² Technology knowledge (TK) is knowledge about standard technologies, such as books, chalk and

and effectively use technological tools in teaching and learning contexts. It underscores the importance of the interaction between TK, Content Knowledge (CK)³, and Pedagogical Knowledge (PK)⁴, facilitating the development of comprehensive Technological Pedagogical Content Knowledge. To equip prospective teachers with the capability to use technology appropriately and effectively, it is crucial to incorporate TPACK education in teacher training programs (Mishra & Koehler, 2006).

The intervention and guidance capabilities of teachers directly influence children's participation in activities. Therefore, training institutions must equip future teachers with the necessary skills from the outset. A study investigating the pedagogical content knowledge and educational needs of pre-service early childhood teachers before training on technology use found significant differences between the competencies they possessed and those they deemed necessary, with all factors and items showing a greater need than possession. This indicates that pre-service early childhood teachers recognize their current capabilities as insufficient compared to the technological competencies they consider necessary (Kim, Kim, & Choi, 2021). Despite the academic research on ICT utilization for pre-service early childhood teachers being less active in colleges, and about 50% of current early childhood teachers reported not having received education or support for technology use (Park & Han, 2007; Pila, Blackwell, Lauricella, & Wartella, 2019). Kara and Cagiltay (2017) also reported that early childhood teachers wish for programs in their teacher training courses that could strengthen their skills in using technology. Conversely, studies have shown that pre-service early childhood teachers' knowledge of technology pedagogy increased after taking computer education or technology-based courses (Lee & Yoon, 2020; Song & Hwang, 2019), suggesting that appropriately conducted education can enhance pre-service early childhood teachers' capabilities in utilizing technology. Hence, the need for teacher education to cultivate technology competencies is highlighted.

Niess (2005) criticized that while many teachers are interested in acquiring technological knowledge, they lack understanding of its practical application in effective teaching. If

blackboard, and more advanced technologies, such as the internet and digital video.

³ Content knowledge (CK) is knowledge about the actual subject matter that is to be learned or taught.

⁴ Pedagogical knowledge (PK) is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims.

technology education focuses solely on the technology itself, separate from the class children or the content, it becomes difficult to integrate into teaching practice. For technology to be effectively utilized in educational settings, teachers must learn how to incorporate technology into their teaching actions (Donohue, 2014; Hughes, 2005; Niess, 2005; Snoeyink & Ertmer, 2002). Technology education for teachers should be conducted with a focus on specific, experiential strategies that can develop the capacity to utilize technology. This study aims to investigate the effects of an education form that allows direct experience and manipulation, rather than mere knowledge transmission, to cultivate the technological utilization competencies of pre-service early childhood teachers.

Method

Research Participants

The This study targeted 34 pre-service early childhood teachers enrolled in the Department of Early Childhood Education at J University in Gyeonggi-do, South Korea. All participants were third-year students who had completed the same curriculum. Regarding technology utilization, they had previously studied Edutech application methods over approximately three sessions in the “Early Childhood Education Materials Research and Teaching Methods” course during the first semester of their third year.

Research Tools

Program for Enhancing TPACK Competencies

To cultivate the TPACK competencies of pre-service early childhood teachers, a non-curricular program was developed and implemented. The program was devised based on literature review and field research by four experts in the field of early childhood education and one developer from two Edutech companies in the community. The program consisted of 10 sessions, including two sessions on digital technology theory, four sessions on coding and robotics education for early childhood, and four sessions on utilizing VR/AR in education.

Table 1. *Program for Cultivating TPACK among Pre-service Early Childhood Teachers*

Theme	Content	Method	Lesson Number
Early Childhood Education and Technology Utilization	• The Necessity and Significance of Utilizing Digital Technology in Education • Characteristics and Necessity of Utilizing Digital Technology in Early Childhood Education • Types and Applications of Various Educational Digital Technologies • Examples of Digital Technology Utilization in the Field of Early Childhood Education	On-Campus Lecture	1 ~ 2
Coding Education and Robot Utilization in Early Childhood	• The Meaning and Educational Significance of Coding Education • Characteristics and Necessity of Coding Education in Early Childhood • Examples of Coding Education in Early Childhood • Simulated Experience with Coding Education Programs for Young Children • Exploration and Operation of Educational Robots as a Medium for Early Childhood Coding Education • Practice with Robot-Assisted Coding Education Programs	On-Campus Lecture and Practicum	3 ~ 4
	• The Meaning and Educational Significance of Drones • Exploration and Operation of Drones • Examples of Drone Utilization in Education and Play for Young Children • Practice with Drone-Based Coding Education Programs	On-Campus Practicum	5 ~ 6
VR/AR and Drone Utilization Education in Early Childhood	• The Meaning and Educational Significance of VR/AR • Characteristics of VR/AR Utilization in Education for Young Children • Examples of VR Utilization in Education for Young Children • Exploration and Operation of Media for VR Education • Experience with VR Educational Content for Young Children • Composition and Practice of VR Utilization Education Programs for Young Children	Field (Industrial) Lecture and Practicum	7 ~ 8
	• Examples of AR Utilization in Education for Young Children • Exploration and Operation of Media for AR Education • Experience with AR Educational Content for Young Children	Field (Industrial) Practicum	9 ~ 10

TPACK Assessment Tool

The self-report questionnaire by Chai, Ng, Li, Hong, and Koh (2013), focusing on the technology utilization competencies of TK, TPK, TCK, and TPCK, was utilized to measure

the technological application competencies of pre-service early childhood teachers. The questionnaire, adapted by Jo (2016), comprised 17 items: four items for TK (Technology Knowledge), four for TPK (Technological Pedagogical Knowledge), four for TCK (Technological Content Knowledge), and five for TPCK (Technology Pedagogy and Content Knowledge).

Table 2. *Reliability of the research tool*

	Number of Items	Content	Reliability (Cronbach's α)
TK	4	Competency in Computer Usage and Technology Learning Abilities	.825
TPK	4	The Capacity to Introduce Technology to Learners and Facilitate Their Utilization	.907
TCK	4	Knowledge of Software and Technological Tools Applicable in Teaching	.882
TPCK	5	The Ability to Appropriately Integrate Teaching Content, Technological Skills, and Pedagogical Methods	.934
Total	17		.960

Research Procedure

The study proceeded through stages of program development, pre-testing, program implementation, and post-testing. Program development was carried out in September 2022, following consultation with four early childhood education experts and two developers from educational technology companies, resulting in a 10-session program. Pre-tests were conducted in October 2022 among all 34 third-year students at J University. The program, consisting of two sessions per week, was conducted in October and November 2022. Given the hands-on nature of the program, it was delivered in two groups to ensure educational efficiency, with the same educators, content, and methods used for both groups. The first six sessions were held in classrooms and laboratories at the university where the pre-service teachers were enrolled, while the remaining sessions took place at the premises of a company that co-developed the program to facilitate effective use of the equipment. Post-tests were conducted in December 2022 for all participants who completed the 10-session program, using the same questionnaire as the pre-test. Surveys were conducted online using Google

Forms.

Data Analysis

Pre- and post-test data collected to examine the effect of the technology utilization capacity enhancement program for pre-service early childhood teachers were statistically processed using SPSS 28.0. Reliability of the research tool was measured by calculating Cronbach's alpha coefficients for each sub-domain and the overall questionnaire. The program's effectiveness was assessed by comparing mean scores and standard deviations from the pre- and post-tests and analyzing differences using paired-sample t-tests.

Results

Effectiveness of the Program for Cultivating TPACK among Pre-service Early Childhood Teachers

The effectiveness of the program aimed at cultivating TPACK among pre-service early childhood teachers was examined using paired-sample t-tests.

Table 3. *Result of t-test*

	M	SD	df	t-value	p
TK	0.37	0.79	34	2.785**	0.009
TPK	0.29	1.02	34	1.678	0.103
TCK	0.40	0.93	34	1.983	0.061
TPCK	0.40	0.93	34	2.557*	0.015
Total	0.40	0.80		2.974**	0.005

* $p < .05$, ** $p < .01$, *** $p < .001$

The results showed significant differences between pre-test and post-test scores across the overall scores ($t=2.974$, $p<.01$). Looking at the scores by domain, significant differences were observed in TK ($t=2.785$, $p<.01$) and TPCK ($t=2.557$, $p<.05$), while TPK and TCK did not

show significant differences. Considering the changes in the total score, the program for cultivating TPACK among pre-service early childhood teachers was evaluated as effective.

Changes Experienced by Pre-service Early Childhood Teachers through the TPACK Cultivation Program

Pre-service early childhood teachers experienced various changes through participation in the TPACK cultivation program. They moved away from their misconceptions about technology education, gained confidence in using technology skills, and developed motivation for implementing technology utilization in education as future teachers. Meanwhile, some pre-service teachers felt the program experience was somewhat insufficient and showed an increased desire for continuous learning about technology utilization in education.

Resolving Misconceptions about Technology Education

Pre-service early childhood teachers changed their perspectives on technology education through participation in the TPACK cultivation program. Initially indifferent or considering it irrelevant to early childhood education, they discovered through hands-on experience in the program that this was not the case.

“When I first heard the word ‘coding’, I thought it had nothing to do with me. I doubted its application in early childhood education. However, after trying it out for myself, I found it wasn't difficult to operate, and I was amazed that just a few button presses could initiate activities” (participant 5)

“I used to think coding was necessarily complicated and difficult, but after directly experiencing activities where I manipulated robots with simple commands, I realized it wasn't so.” (participant 26)

“Previously, I thought VR education seemed complex and distant, but after attending

lectures and experiencing it firsthand, I found it more enjoyable than expected and could see how it could be used to educate children.” (participant 17)

Through direct engagement with technology, pre-service teachers overcame their initial reservations and uncertainties, moving towards a positive and confident approach to incorporating technology in early childhood education.

Enhancement of Confidence in Technology Skills

Nearly half of the study participants, 13 pre-service early childhood teachers felt anxious about their lack of technology skills. However, through participating in this program and acquiring these skills, they gained confidence in using technology and integrating it into their teaching.

“I considered myself a technophobe, but this training allowed me to learn how to incorporate AR into education in line with the Fourth Industrial Revolution, broadening my educational scope and giving me the confidence to be a creative teacher who can unlock children's imagination.” (participant 5)

“With the advancement of technology and the changing times, various teaching methods are being applied in educational settings. Having this experience made me less worried about encountering and utilizing new technologies when I become a teacher.” (participant 19)

“To be honest, I felt like a technophobe and lacked the skills to handle technology, worrying about what I'd do if I couldn't do anything when I got into the field. This opportunity has been great, making me feel like I can plan various lessons.” (participant 8)

Pre-service early childhood teachers, who considered themselves technophobes or were unfamiliar with cutting-edge technology like VR and AR, felt anxious and uncertain.

However, direct experience with various educational technology tools helped them overcome these fears. They were satisfied with the knowledge and skills they acquired, hopeful and confident that they could become creative teachers capable of designing lessons utilizing a range of technologies.

Enhanced Interest and Motivation for Technology Utilization in Education

Pre-service early childhood teachers experienced an increase in interest and motivation for utilizing various technology tools in future educational settings through their participation in the program.

“Even as an adult, I found it so engaging that I thought young children would find it even more fun. I especially want to try activities like coding where a toy turtle navigates a path with the children.” (participant 23)

“Having the opportunity to visit a company and experience classes using smart devices for young children was great. It made me think that not only would we enjoy these lessons, but the children would too. I now think it's something I should definitely utilize when I become a teacher.” (participant 11)

“Participating in these activities was so interesting even for me; I can only imagine how fun it would be for young children. I particularly want to try the coding robot activity as a mathematics education activity.” (participant 5)

Many pre-service teachers enjoyed participating in the program, thinking not only of their own enjoyment but also how the experiences would feel for young children. They believed that children would find these activities even more enjoyable and engaging than adults do, and they became motivated to implement these technologies in their future teaching.

Increased Desire for Continuous Learning about Technology Utilization in Education

Some pre-service early childhood teachers felt the program was too short and expressed a desire for continued and deeper learning in technology utilization.

“I wish we had more time to learn thoroughly.” (participant 12)

“I was disappointed that we didn't get to experience more. Just as I was getting used to it, the program was over.” (participant 22)

“I wish we could have learned more about how to implement this in real classrooms.” (participant 26)

“While VR was fun to experience, I thought it might be difficult for young children to operate. I wish we had learned more about how to apply it in actual teaching contexts.” (participant 3)

The participants expressed a desire for more comprehensive learning experiences, not just about the technology itself but also about how to apply these technologies effectively in educational settings. This sentiment reflects a strong desire for ongoing learning and professional development in educational technology.

Discussion

This research examined the effectiveness of a program designed to enhance the TPACK (Technological Pedagogical Content Knowledge) of pre-service early childhood teachers and the transformative changes it induced in them. The program, incorporating an understanding of technology, robotics education, and the utilization of VR/AR, was conducted over ten sessions, with TPACK assessments conducted before and after the program. Significant improvements were noted in overall scores, TK (Technology Knowledge), and TPCK

(Technology Pedagogy and Content Knowledge), indicating the program's effectiveness. Additionally, the study revealed that pre-service teachers moved from a state of indifference or lack of confidence in their technological abilities to a positive perception of technology in education, improved confidence, and a willingness to apply technology in future teaching practices.

The findings underscore the positive impact of systematic and comprehensive technology utilization education on pre-service early childhood teachers, emphasizing the need for such programs in teacher training curricula. Given that future generations of children will be digital natives frequently encountering various modern technologies in their daily lives, it is increasingly important to provide education that can enhance their high levels of digital literacy (South, Por, 2020). Therefore, current pre-service early childhood teachers must be equipped with the capability to integrate digital technology into education. This study suggests that integrating technology education into teacher training programs is not only beneficial but necessary to prepare educators for the challenges of teaching in a rapidly digitalizing world.

A closer examination of the TPACK assessment results revealed that TK showed the most significant improvement. Initially, pre-service teachers had limited knowledge of technology and lacked confidence in integrating it into education (Blundell, Lee, & Nykvist, 2016; Nelson, Voithofer, & Cheng, 2019). However, the program helped them regain confidence and evolve positively, proving direct technology instruction to be highly effective. TPCK, the ability to integrate teaching content with technological and pedagogical knowledge, also showed significant improvement. This indicates that pre-service teachers enhanced their ability to select appropriate content and methods for teaching young children using technology, likely influenced by their prior education emphasizing developmentally appropriate practices and content-method integration.

The program did not show a significant impact on TCK (Technological Content Knowledge) and TPK (Technological Pedagogical Knowledge), suggesting a need for more focused education on how to teach content and methods using technology. Although the program helped pre-service teachers understand technology and develop skills, it was not sufficient for learning how to apply these skills and knowledge in teaching young children. This highlights the necessity for more comprehensive training focusing on applying

technology in educational settings, moving beyond technology skills to include integration with teaching content and methods.

The technology types provided in the program, including coding robots, VR glasses, smartpads, interactive whiteboards, and drones, represent an advancement beyond traditional educational technology, indicating the need for current and future educators to be familiar with a wide range of modern technologies. As the educational landscape continues to evolve with the introduction of digital textbooks, interactive whiteboards, VR, and AR devices, it is essential for teacher training programs to include comprehensive technology education to prepare educators for implementing these technologies effectively (Durak, Cankaya, & Yunkul, 2020; Hunda, Mulyadi, & Anshari, 2021).

However, rapidly producing and integrating various educational technologies into teaching poses challenges. In some cases, the program had to be conducted at community institutions rather than the university due to a lack of infrastructure, highlighting the potential of partnerships between universities and industry to expand educational opportunities and enhance the effectiveness of teacher training programs.

This study's significance lies in its reflection on the need to adapt teacher education to the demands of a digital age, providing evidence for the systematic implementation of diverse technology education for pre-service early childhood teachers. Although the study was limited by its small sample size and short duration, it lays the groundwork for future research to explore the long-term effects of technology utilization training in early childhood education on a larger scale. Furthermore, since a spirit of challenge is essential for educators to apply technological skills in education, further research on fostering an experimental mindset among pre-service teachers is necessary.

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