The Effects of Unplugged Early Childhood Software Activity on Problem Solving and Science Investigation Skills

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Abstract

This research aims to examine the effects of unplugged early childhood software activity on the problem solving and scientific investigation skills of young children. The research subjects were 38 five-year-old children from two classes at the E child-care center in G city. Class A with 18 children was randomly selected as the experimental group and Class B with 20 children was selected as the comparison group. The unplugged software activity was carried out for 4 weeks from April 2nd 2018 to 4th May 2018. It was demonstrated that the children who used the unplugged early childhood software activity had significantly higher problem solving and science investigation skills. The result suggests that unplugged software activity can be a meaningful teaching method in classrooms.

Keywords: Unplugged, early childhood software activity, problem solving skill, scientific investigation skills

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Introduction

In the future, society will most likely require talents who can creatively empathize and solve problems through interdisciplinary integration and consolidation, instead of just acquiring or understanding fragmentary knowledge. As such, in 2014, the Department of Education pronounced the importance of 'happiness education' which supports student's dreams and aptitudes and also the significance of software education, as a source of national competency (Ministry of Education, Science and Technology, 2014). Following this government initiative some schools were selected for pilot or pioneering projects. Since this announcement, software education has become a requirement in elementary and middle school curriculum. Early childhood education takes place before children reach school age, which makes it important to consider it as a foundation for elementary school education. Consequently, early childhood education should also encompass software education.

It is safe to say that interest in software education is global. Advanced countries such as the US and the UK are testing various strategies that allow elementary school students to learn computing science concepts without using computers but instead through engaging in games and play, which is easier and more fun for the students Software training encompasses using the processes and logic of computer operation, from problem recognition to understanding, disassembling, and resolution. Among those strategies is the unplugged computing program proposed by New Zealand professor Tim Bell, which promotes the understanding of the principles and concepts of computing science without the use of computers (Bell et al., 2009). Unplugged computing is learning the principles and concepts of computer science through various activities and games. Through this process, regardless of age, people can learn the principles and concepts of computer science easily. Unplugged computing is thus suitable for infants, especially as it can be designed to be fun and interesting. The unplugged approach helps children to learn the fundamental principles of computing through play and to develop the skills to use these principles for problem solving (Kim et al., 2016).

In this fast changing information age, problem solving skills not only in a specific discipline but also in real life are becoming more important for early childhood. Indeed, problem solving is one of the basic skills that is required for learners of future generations and can be developed through the processes of solving everyday life problems with reasonable solutions by applying what they learned in information technology education (Choi, 2016). Further, science investigation skills, which foster reasoning abilities exercised when learning science, encourage children to acquire new knowledge through specific experiences. This ability provides necessary reasoning skills for everyday life as well as for learning science, making it essential for children dealing with daily routines (Althouse, 1998; Martin, 1997). Children employ this investigative skill to verify outcomes from the scientific processes of observation, questioning, hypothesis, experiment, analysis, and forming conclusions and begin new in-depth investigations based on this outcome (Martin, 1997). In other words, science investigation skills can be developed by the activities of children's spontaneous participation and direct experiences with curiosity.

In that regard, this research is aimed at developing and verifying activities by integrating software education with play-based unplugged computing to increase children's problem solving skills and science investigation skills.

Until now, unplugged computing in early childhood education has remained an unfamiliar concept and in fact, there has been limited research undertaken on this topic (Kim et al., 2016; Jung et al., 2018). Since early childhood development is largely based on learning through play, it would be worthwhile to study software education with unplugged computing for our future generations and to review the possibility of its implementation in the early childhood classrooms.

Method

Research subjects

The research participants were 38 five-year-old children from the E child-care center in G city. Candidate child-care centers for participation were randomly sampled before the E child-care center was selected. Class A composed of 18 children (10 boys, 8 girls) was selected as the experimental group and Class B composed of 20 children (11 boys, 9 girls) was selected as the comparison group. The teachers of both groups have three-year undergraduate degrees majoring in early childhood education. One teacher has 7 years of career experience and the other has 5 years of career experience. The subject's gender and average age are shown below in Table 1

Table 1. The subject's age and gender

Group	*n*	Gender		Avg. Month of Age (SD)	*t*
		Male	Female		
Experimental	18	10	8	69.38(3.12)	.413
Comparison	20	11	9	68.95(3.39)	

Research tools

Problem solving skills

This research employed the early childhood problem solving skill assessment developed by Tegano, Sawyers & Moran (1989) which was modified and supplemented by Eun Ja Moon (2000). To evaluate problem solving ability, the process of problem solving was divided into three steps and each step was then divided into 8 sub-categories. Each step was rated by four criteria from 0 to 18 points. The reliability, Cronbach α of the assessment tool was .88.

Science investigation skills

Martin(1997)'s science investigation skill assessment was used. This tool is composed of five elements, namely prediction, observation, classification, measurement, and

discussion. The assessment of prediction, observation, classification, and measurement was performed individually, and the assessment of discussion was carried out in groups of 4 children. The order in which the testing was done was prediction, observation, classification, and measurement. Discussion was tested with scientific aptitude assessment. The Likert 5 point scale with the lowest point of 1 and the highest of 5 was used and the sum total of points in each element indicates the investigation skills. The Cronbach's alpha, reliability of the whole test, was .80.

Research procedure

Preliminary test

A preliminary test was performed with 5 five-year-old children (3 boys, 2 girls) for 3 days from Mar 21st 2018 to Mar 23rd 2018 to evaluate the suitability of the test tools and process, children's level of understanding of teacher's questions, the relevance of teacher's postscript, score criteria and test method, and the suitability of the duration of the test.

Ex-ante test

From March 26th 2018 to March 30th 2018, the ex-ante test was carried out during free play times and morning routines to examine the homogeneity of the experimental group and the comparison group. Problem solving skills and science investigation skills were tested on different days in consideration of the children's attention spans. Further, the test was administered individually by research assistants during morning free play times in a suitable playroom relatively free from distractions.

The organization of the unplugged software activities

To ensure that the activities selected were suitable, the unplugged computing activity developed by Professor Tim Bell was reviewed by an early childhood education expert, a computer education expert, and two people who had majored in early childhood education and had extensive teaching experience. Resultantly, the domains of 'Abstruseness' and 'Encryption' were suggested as not appropriate for five-year-old children and were ruled out. The selected learning topics and activities are shown below in Table 2.

Table2. Activity selection process

Domains of Unplugged Activity	Activities of Unplugged Learning	Selected Unplugged Learning	Selected Activities
Data	Binary Number	Image Representation	Making Butterfly Patterns
	Image Representation		
	Text Compression		Making Flower Hills
	Error Detection		
	Information Theory		
Algorithm	Searching Algorithms	Sorting Algorithms	Queen of Flowers
	Sorting Algorithms		
	Sorting Networks		
	Minimal Spanning Trees		
	Routing and Deadlock	Sorting Networks	Finding the Number One Bee
	Network Communication Protocols		
Expressing the Process	Finite State Automata	Programming Languages	Ways to Run an Errand
	Programming Languages		Invitation to Our Home
Abstruseness	Graph Coloring	Graph Coloring	-
	Dominating Sets		
	Steiner Trees		
Encryption	Information Hiding	Information Hiding	-
	Cryptographic Protocols		
	Public Key Encryption		
Interacting with Computer	Human Interface Design	Human Interface	A Door That Opens Better
	The Turing Test		Creating Emotions for Errands

Experimental treatment

The experimental treatment was administered for four weeks from April 2nd 2018 to May 4th 2018 in 8 sessions during free play times in the morning and the afternoon. The unplugged software activities were carried out twice a week for the experimental group, while general activities from the Nuri curriculum were carried out for the comparison group. The unplugged activities and their descriptions for each session are shown below in Table 3.

Table 3. Unplugged early childhood software activities

Daily Themes	Activities	Description of Activities	Unplugged Activity Element	Nuri Curriculum Element
Spring, Animals and Plants	Making Butterfly Patterns	This demonstrates how computers represent pictures and photographs with numbers. Children color a graph paper on which a butterfly is drawn according to a number board presented by teachers. 0 indicates black and 1 indicates white.	Data	Nature Exploration
	Making Flower Hills	Children have a graph paper with different spring flowers, and mark numbers on a number board. Partners see the number board of their peers and color the graph papers. 0 indicates the color they want and 1 means white.		Artistic Experience
	Queen of Flowers	This demonstrates how computers use sorting networks to sort certain numbers. 6 children with flower crowns form a group and stand on a network board in a random fashion. Moving in a circle following a line, children compare the number cards with others coming from different directions. Students with a smaller number move to the left and those with larger numbers move to the right.	Algorithms	Nature Exploration Physical Exercise
	Finding the Top Bee	This is an activity to find the best way to sort things by order of weight. Four opaque bottles of different weight with honey are to be arranged from the lightest to the heaviest. The team that is successful with the least number of attempts wins.		

Me and My Family	Ways to Run an Errand	This is an activity to show how children can use computers to find solutions for everyday life. They try to find the best course to visit every shop on their errand list.	Representation of Process	Nature Exploration Communication Social Relation
	Invitation to Our Home	Split the children into pairs (teams), blindfold one child and have the other guide him/her. Set a place in the classroom as home and then try to get them to find this home only from verbal instructions. The instructions will be adjusted until they finally get home.		
	A Door that Opens Better	Understand the actual properties or identification of properties of things. Split into small groups to examine the design of a door and discuss how to open it. Discuss how they can make some changes for a better door.	Interaction with Computers	Nature Exploration Communication
	Create Emoticons for Errands	Icons or shapes used in computers look similar to the real things. By representing errands with icons, children experience human-computer interactions.		

The activity plan for the experimental group using unplugged software activity is shown below in Table 4.

Table 4. Activity plan for experimental group

Date		May 10th 2018	Participant	18 five-year-old children (10 boys, 8 girls)
Daily Theme		Me and My Family	Activity Title	A Door that Opens Better
Unplugged Element		Interaction with computers	Materials	Pictures of various doors
Nuri Curriculum Element		• Nature Exploration> Develop Investigative Aptitude> Use Investigative Skills • Communication> Listen> Listen to a Story and Understand • Communication> Speak> Speak about Feelings, Thoughts, and Experience		
Activity Objective		• Be able to predict how a door might open from examining its design. • Be able to propose how to open a door.		
Phase		Activity Description		Note
Contents of Activity and	Introduction (5)	▶ Talk about the use of things from examining their design 🕮 Discuss the use of things in pictures 🕮 Discuss the reasons why they think so.		Pictures of household items

Method	Development (30)	▶Explain the activity 🗀 Recall the doors we opened as we came to the classroom. 🗀 Discuss what made us to decide how to open those doors. ▶Apply 🗀 Look at various doors on the activity paper and discuss how to open them. 🗀 Discuss what kinds of doors would be more convenient if they could change them. 🗀 Decide what kind of door to have for our classroom and write the reasons for the decision.	-Pictures of various doors, hinges, doorknobs, etc. -Help them to examine various doors at the facility if necessary.
	Conclusion (5)	▶Share 🗀 Each team introduces the doors they chose for classroom. 🗀 Vote for the most suitable doors.	

Ex-post test

After 12 sessions of experimental treatment, the ex-post test was carried out from May 8th 018 to May 11th 2018 by a research assistant during morning free play times through personal interviews with the same method as the ex-ante test was carried out.

Data analysis

The collected data were analyzed with SPSS 23.0 software. To examine the reliability of the assessment tool, Cronbach'α was calculated for the inter-rater reliability. The average scores and standard deviation were calculated for children's problem solving skills and science investigation skills of the experimental group and the comparison group. An independent sample t-test was performed to verify the homogeneity. As the homogeneity of ex-ante test scores between groups was verified, the t-test was performed on average scores of the ex-post test to analyze the difference between groups.

Results

The effects of the early childhood software activities with unplugged computing on problem solving skills

As shown in Table 5, the average ex-post test scores of the experimental group were higher than the average ex-ante test scores in all sub-categories and the sum total in children's problem solving skills. The sub-categories of problem solving skills, 'Identification and Expression of the Problem' ($t=2.439$ $p<.01$), 'Proposal and Application of a Solution' ($t=6.918$, $p<.001$), 'Conclusion of the Problem Solving

Process' (t=3.768, p<.001), and the sum total (t=7.316, p<.001) all showed a statistically significant increase. Therefore, the early childhood software activities with unplugged computing were demonstrated to have a positive effect on children's problem solving skills.

Table 5. Ex-ante and ex-post test scores for problem solving skills

Sub-Category	Group		N	M	SD	*t*
Identification and Expression of the Problem	Ex-ante	Experimental	18	5.77	2.28	.344
		Comparison	20	5.50	2.64	
	Ex-post	Experimental	18	9.22	2.10	2.439**
		Comparison	20	7.65	1.87	
Proposal and Application of a Solution	Ex-ante	Experimental	18	3.55	1.29	-.794
		Comparison	20	3.90	1.37	
	Ex-post	Experimental	18	9.22	2.34	6.918***
		Comparison	20	7.65	1.39	
Conclusion of the Problem Solving Process	Ex-ante	Experimental	18	2.05	.80	.022
		Comparison	20	2.05	.75	
	Ex-post	Experimental	18	3.38	.69	3.768***
		Comparison	20	2.30	1.03	
Total Score	Ex-ante	Experimental	18	11.38	3.23	-.062
		Comparison	20	11.34	2.85	
	Ex-post	Experimental	18	20.83	3.31	7.316***
		Comparison	20	13.90	2.51	

**p<.01, ***p<.001

The effects of the early childhood software activities with unplugged computing on science investigation skills

As shown in Table 6, the average ex-post test scores of the experimental group were higher than the average ex-ante test scores in all sub-categories and the sum total in children's science investigation skills. The sub-categories of science investigation skills, 'Prediction' (t=3.302, p<.001), 'Observation' (t=3.748, p<.001), 'Classification' (t=2.00, p<.01), 'Measurement' (t=2.541, p<.01), 'Discussion' (t=2.408, p<.01), and sum total (t=4.374, p<.001) all showed a statistically significant increase. Therefore, the early childhood software activities with unplugged computing were demonstrated to have a positive effect on children's problem solving skills.

Table 6. Ex-ante and ex-post test scores for science investigation skills

Sub-Category	Group		N	M	SD	*t*
Prediction	Ex-ante	Experimental	18	5.22	1.69	-.296
		Comparison	20	5.35	1.26	
	Ex-post	Experimental	18	10.33	1.57	3.302***
		Comparison	20	8.45	1.90	
Observation	Ex-ante	Experimental	18	5.55	1.50	1.004
		Comparison	20	5.10	1.29	
	Ex-post	Experimental	18	10.27	1.60	3.748***
		Comparison	20	8.20	1.79	
Classification	Ex-ante	Experimental	18	5.33	1.32	.082
		Comparison	20	4024	1.26	
	Ex-post	Experimental	18	10.00	1.32	2.00*
		Comparison	20	8.85	1.17	
Measurement	Ex-ante	Experimental	18	5.66	1.332	.884
		Comparison	20	5.25	1.55	
	Ex-post	Experimental	18	10.11	1.45	2.541**
		Comparison	20	8.60	2.11	
Discussion	Ex-ante	Experimental	18	5.27	1.27	-.511
		Comparison	20	5.50	1.39	
	Ex-post	Experimental	18	9.72	1.87	2.403**
		Comparison	20	8.20	2.01	
Total Score	Ex-ante	Experimental	18	27.05	4.00	.425
		Comparison	20	26.55	3.31	
	Ex-post	Experimental	18	50.33	3.42	4.374***
		Comparison	20	42.65	6.69	

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

Discussion

This research aims to examine the effects that unplugged software activities have on improving early children's problem solving skills and science investigation skills. The key findings of the research are as follows:

Firstly, it was demonstrated that the unplugged software activities have positive effects on children's problem solving skills. In all sub-categories of identification and expression of the problem, proposal and application of a solution, and conclusion of the problem solving process, results for the experimental group were significantly different than for the comparison group. This is a result of the fact that the unplugged software activities suitable for early children involve algorithmic thinking, which refers to grasping the basic principles of a computer and following its methodology to solve problems (Jung & Park, 2018). This outcome is in line with findings for elementary school students from previous research which reported that unplugged computing

activities have positive effects on improving problem solving skills (Nah & Lee, 2016). In other words, through unplugged activities and discussions, children derived, applied, and analyzed the process of understanding a problem and finding a solution. Further they experienced learning computational thinking to find more reasonable and efficient solutions, as well as using it to solve problems together. Through this problem solving procedure, we believe that children improved their problem solving skills. Thus, it is necessary to make use of developmentally appropriate unplugged activities to enhance young children's computational thinking instead of trying to force difficult programming language upon them.

Secondly, it was established that the unplugged software activities have positive effects on children's science investigation skills. In all sub-categories of prediction, observation, classification, measurement, and discussion, results for the experimental group were significantly different than for the comparison group. Cho and Kim (2015) reported that developing science investigation skills should not be about just making children learn about science that deals with nature, but about having them also understand its contents and seeing it as a tool for solving human problems. Further, the activities were in line with the objective of a nature exploration curriculum which encourages children to logically solve problems in everyday life, enjoy investigating, and use the investigative skills of observation, classification, measurement, prediction, and communication. Therefore, it seems that the unplugged software activities do have positive effects on early children's science investigation skills.

Lastly, based on the findings of this research, it is pertinent to recommend subsequent studies as follows: In this research, the unplugged activity's domains of abstruseness and encryption were ruled out by the experts due to concern about their inappropriateness for classes of five-year-old children. Thus, in the subsequent study, activities in these domains should be added to provide a systematic, quality program. Also, the participants of the experiment were children from a child-care center. Because of differing views on software education between the Ministry of Education and the Ministry of Health and Welfare, students in kindergartens were not available for the research. I suggest consensus on policies of early childhood software education be reached for systematic software activities to take place in classrooms.

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Korean Abstract

언플러그드를 활용한 유아 소프트웨어 활동이 유아의 문제해결력과 과학적 탐구능력에 미치는 영향

정유진 (건양대), 박유영 (건양대)

본 연구는 언플러그드를 활용한 유아 소프트웨어 활동이 유아의 문제해결력과 과학적 탐구능력에 미치는 영향에 대해 알아보고자 하였다. 연구대상은 G광역시 E어린이집 만 5세 두 학급의 유아 38명을 선정하였으며, A학급 유아 18명을 실험집단으로, B학급 유아 20명을 비교집단으로 임의 배정하였다. 언플러그드를 활용한 유아 소프트웨어 활동은 2018년 4월 2일~5월 4일까지 4주에 걸쳐 실시하였다. 연구결과 언플러그드를 활용한 유아 소프트웨어 활동을 실시한 실험집단 유아의 문제해결력과 과학적 탐구능력이 통계적으로 유의미하게 높은 것으로 나타났다. 이러한 본 연구 결과는 언플러그드를 활용한 유아 소프트웨어 활동이 유아의 문제해결력과 과학적 탐구능력에 긍정적 영향을 주므로 유아교육현장에서 의미 있는 교수활동으로 활용될 수 있음을 시사한다.

주요어: 언플러그드, 유아 소프트웨어 활동, 문제해결력, 과학적 탐구능력