Design Artificial Intelligence Convergence Teaching and Learning Model CP3 and Evaluations

Kil Hong Joo[1] & Nam Hun Park[2,*]

[1]Dept. of Computer Education, Gyeongin National University of Education, Anyang, South Korea

[2]Dept. of AI Convergence, Anyang University, Anyang, South Korea

*Correspondence: Dept. of AI Convergence, Anyang University, Anyang, Korea. Tel: 82-32-930-6021. E-mail: nmhnpark@anyang.ac.kr

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Abstract

In this paper, CP3 model (Converged model of Problem recognition, Plan and Play) is developed to perform the artificial intelligence convergence education as a teaching and learning model for elementary school students. The convergence education was applied to actual classes with five subjects: data collection and analysis, understanding sorting algorithms, understanding sequential structures, understanding repetitive structures, and procedural thinking. When the class was conducted using the CP3 model, the overall score is improved by 41.6% compared to the general classes. There were improvements of 53% of male students and 33% of female students, and male students in the lower grades participates more actively in Artificial Intelligence convergence classes. When the satisfaction of the class with CP3 model is analyzed, the interest level is improved by 83%, the problem-solving ability is improved by 70%, the satisfaction level is improved by 68.5%, the understanding level is improved by 64%, and the expectation level is improved by 68%. The overall satisfaction to the class is very high when the subjects and objects closely familiar in daily life are used due to the characteristics of the lower grade students, and the result is more effective when playable elements are applied. However, for low-grade students, they are still experiencing a little difficulties in classes with complex classes like CP3. Considering the characteristics of low-grade students, simple algorithms with a topic closely related to daily life would make a better result.

Keywords: CP3 model, AI convergence teaching and learning, teaching and learning model

1. Introduction

Recently, the computer technology is rapidly developed, and in particular, new computer technologies based on artificial intelligence are emerging in various fields. Therefore, accelerated digitization and data accumulation become important. The society comes to facing various changes. In particular, the education field is an area directly connected to the people who lead social changes, and the consensus that artificial intelligence education should be properly implemented even in elementary education continues to grow.

In the United States, AI4K(Four Public Artificial Intelligence for Kids), an artificial intelligence curriculum guideline, is developed and communities to support and collaborate on AI(Artificial Intelligence) education for elementary, middle, and high schools are active (Association of related Ministries Report, 2019). In China, systematic efforts are being made at the national level, such as issuing AI textbooks, introducing AI education from infancy, operating pilot schools, and nurturing AI teachers (Association of related Ministries Report, 2020a). In addition, in Finland and the UK, programming, which is the basis of artificial intelligence technology, is taught from the first grade of elementary school as an essential part of the national curriculum (Association of related Ministries Report, 2020b).

In the case of Korea, 'artificial intelligence education' will be officially introduced into the new curriculum for elementary, middle, and high schools that will be applied from 2025 through the April 2021 and 2022 revised curriculum promotion plan. Kindergartens focus on AI education through play, and elementary, middle and high schools will include AI education from 2025, when the revised curriculum will be applied in 2022. However, in the case of elementary school students in the lower grades, it is difficult to apply them as they are because their developmental characteristics are different. Therefore, there is a need for research on AI teaching and learning methods suitable for lower grade students. Considering the characteristics of elementary school students in the lower grades, development should focus on the following areas.

First, AI education should be implemented using a subject convergence education method that considers the characteristics of elementary school students. For students in the lower grades of elementary school, the achievement standards should be integrated around a sub-theme in accordance with the characteristics of the developmental stage and learning method to form a unit, and textbooks for each subject should be developed and operated. Because in this period, students learn new, inexperienced, and unfamiliar things starting from what they know, what they know, and what they have experienced. In addition, it is because the world of knowledge is formed from subjective to objective, from psychological to logical, and from personal to social. Therefore, to introduce students from the world of experience to the world of subject, it is appropriate to learn in an integrated way using what students are accustomed to in their lives rather than a subject-division approach. Second, it is necessary to develop a game-based edutainment teaching/learning model and program considering the characteristics of elementary school students. Since the lower grades of elementary school have a temporary and often confusing character, it is better to organize them around a play or activity that the students can easily find interests. Therefore, it is appropriate to use edutainment to alleviate the boredom or difficulty that education may have, and to increase familiarity with learning. Third, considering the developmental characteristics of lower grade students, student activity-centered classes should be developed. Since it is a period of vigorous physical development along with physical development, teacher-centered teaching methods are relatively ineffective. It should be structured as a student activity-centered class in which the learner can actively participate and the student can move and learn through specific experiences.

Therefore, in this study, a teaching system design model for artificial intelligence-based subject convergence education was developed for elementary school students, and based on this, an AI-based subject convergence education program was designed and developed, and its effectiveness was analyzed.

2. Related Works

AI-related technologies such as smart appliances, Google, Siri, and AI computer games have become common in our daily life. Most people know about the existence of these services and products, but only a few understand the technology and principles behind them. Therefore, scholars have stated that the education of AI knowledge and technology should be emphasized. Research shows that the development of technology in recent years has promoted the upgrading of computer software and hardware, allowing many teachers to conduct courses of AI knowledge and applications via computers. However, due to its complexity, the teaching subjects were mostly students in higher education and those with programming skills (Williams, Park, Oh & Breazeal, 2019). Besides, its various content also troubles many teachers when they design introductory courses, as introductory courses include many topics which are seemingly unrelated to specific AI technology teaching (Markov, Russell, Neller & Coleman, 2005).

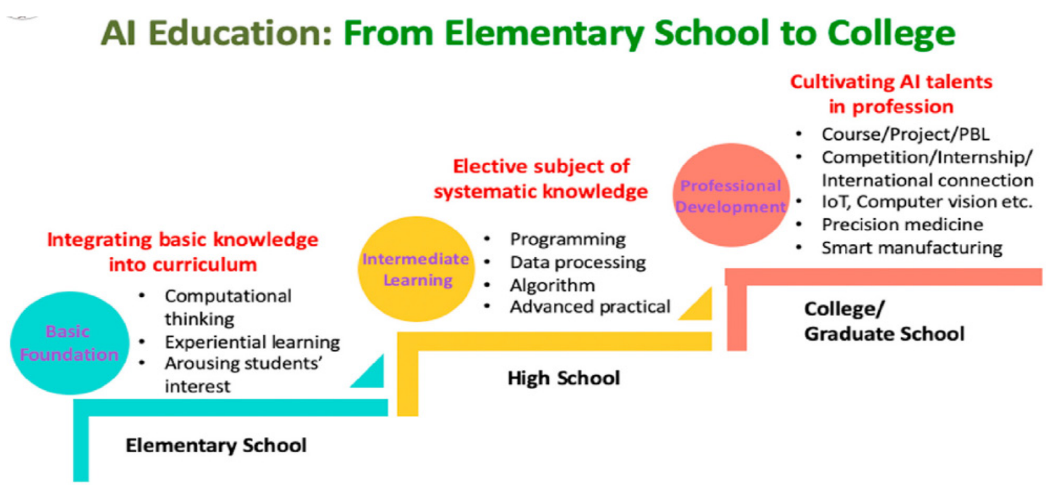

Figure 1. Key Strategies of AI Education at Different Stages

With the increase in children's contact with emerging technology products and even learning through AI systems, children's AI education has gradually been emphasized. For example, the research by (Williams, Park, Oh &

Breazeal, 2019) designed related robot teaching materials, hoping to cultivate children aged from 4 to 7 to have the correct concept of AI technology and to build an appropriate relationship. Some scholars also stated that, in addition to focusing on the convenience and applications of AI technology, safety and privacy were also an important issue. In addition, the research by (Druga, Williams, Park & Breazeal, 2018) pointed out that children seemed to trust smart robots too much. Due to the increasing demand for children's AI education, many online platforms overseas have created development environments integrated with programming blocks, such as Machine Learning for Kids, eCraft2Learn, Cognimates, providing many AI experiences and learning activities for children, so that users could try to make a personalized AI project to understand its applications. As for the teaching strategy (Fig. 1) for emerging technology proposed by Taiwan's Ministry of Education in recent years, the importance and future of AI education from elementary schools to colleges were also mentioned. For the stage of primary and secondary schools, it is hoped to combine the technology course syllabus of 12-year compulsory education with the overall development project of technology education.

The characteristics of AI convergence education compared to existing education are realization, connection, intelligence, and convergence. Realization refers to realistic education that stimulates students' senses, connection refers to education that interacts anytime, anywhere, intelligence refers to an AI teacher and convergence refers to education that reinforces the fusion of educational content. Among them, intelligence is the trend of advancement of customized education for learners, and practical individualization and harvest instruction are possible (Nam & Cho, 2020) (Kim, Kapsu & Park, 2017). The research by (Shin & Shin, 2020) suggested the teaching and learning strategies of AI-based science education through automation, individualization, diversification, and cooperation. Automation means that AI continuously analyzes and manages individual students' information in real time, individualization means that AI enables individual learning guidance that considers students' level, and diversification means that individual customized curriculum and textbooks are provided. In addition, cooperation means promoting a multi-faceted system of cooperation between schools and communities. The research by (Wu, Kuo & Wang, 2017) provided the contents of the lesson after examining whether it had a precedent concept for the learning concept.

The computer science teachers association and the international society for technology in education announced the domain and definition for computational thinking as an example activity for the lower grades of elementary school as shown in Table 1.

Table 1. Definitions and Domains of CT

Domain	Definition	Kindergarden-2nd grade
Data Collection	The process of gathering appropriate information	Conduct an experiment, find a fast toy car on a slope and record it on a chart.
Data Analysis	Understand data, find patterns, draw conclusions	Find and generalize the order of fast toy cars according to the weight of the car. Test the conclusion of adding car weight.
Data Visualization	Depict and organize data with appropriate graphs, charts, words or images	Create a graph or line plot that shows how the speed of the toy car changes as its weight changes.
Problem Decomposition	Break the task into smaller, more manageable parts	Create directions for school locations by breaking the directions into smaller areas. Combines the wayfinding area as a whole.
Extraction	Reduce complexity to define key ideas	All triangular abstractions of many sizes and colors are 'triangles'.
Algorithm and Procedure	A series of steps taken to solve a problem or achieve a goal	Create directions to key attractions around the school.

Given that CT will become a fundamental technology for the 21st century, it is important to introduce these concepts into the content domain in primary and secondary education. Specifically, computational thinking should begin at the beginning of elementary school (Qualls & Sherrell, 2010), and a multi-dimensional approach is needed to integrate it into the curriculum (Barr, Stephenson & Bringing, 2011) (Popenici, Stefan & Kerr, 2017).

3. Development of Artificial Intelligence Convergence Education Model

3.1 Artificial Intelligence Convergence Education Teaching/Learning Model

The AI-based convergence education teaching/learning model developed in this paper has the following characteristics so that effective AI-based convergence education can be achieved in subject classes centered on the lower grades of elementary school. First, an artificial intelligence convergence education teaching/learning model was developed based on the framework of computational thinking in the problem-solving process presented in (Kalelioglu, Gulbahar & Kukul, 2016) (Kim, 2021). Using this, the problem-solving process was reorganized to suit the level of the lower grades, and a teaching/learning model was developed by applying step-by-step computational thinking skills. Second, the edutainment factor, which is expected to have a high learning effect for lower grade students, was used. Third, considering the developmental characteristics of lower grade students, a student activity-centered class was developed. This is a student activity-centered class in which learners can actively participate, and students can move and learn directly through specific experiences. Finally, to achieve the goal of AI education, we explored ways to educate by fusion of AI education elements with other subjects. In this study, it was developed by fusion with the mathematics subject. Based on these characteristics, in this paper, a problem-solving framework was developed as shown in Table 2, and the components of computational thinking skills were arranged step-by-step.

Table 2. Computational Thinking Framework in Problem-Solving Process

Problem recognition	Data collection, Presentation and analysis	Generalization, solution selection and planning	Implement the solution	Evaluate and improve solutions
Abstract(3) Decomposition(3)	Collecting data(2) Data analysis(3) Pattern Recognition(1) Conceptualize(1) Data Visualization(2)	Mathematical Reasoning(1) Algorithm and Procedure establishment(3) Parallelization(2)	Automation(3) Modeling and simulation(3)	Testing(1) Debugging(1) Generalization(1)

Table 3. CP3 Model-Specific Problem-Solving Process and Computational Thinking Skills

Steps		Problem-solving process	Computational think skills
Problem recognition	Explore problems Understanding prior learning	Problem recognition step	Abstract, decomposition
Plan	Data collection/analysis	Data collection/visualization/analysis	Data collection, analysis, visualization, pattern recognition, conceptualization
	Practice game	Generalization/choose a solution/planning	Mathematical reasoning Algorithm and procedure establishment Parallelization
Play	Join the game	Implement solutions	Automation Modelling and simulation
	Share results	Evaluate and improve solutions	Testing Debugging Generalization

The framework implies the use of computational thinking components in the problem-solving process. In the first problem recognition stage in the problem-solving process, there are abstraction and decomposition elements. In the second data collection/expression/analysis stage, there are elements of data collection, data analysis, pattern recognition, conceptualization, and data expression. The third generalization/solution selection/planning stage includes mathematical reasoning, algorithm and procedure establishment, and parallelization elements. The fourth solution implementation phase includes automation, modeling and simulation elements. The final solution evaluation and improvement phase includes testing, debugging, and generalization elements. Using this, the problem-solving process was reorganized to suit the level of the lower grades, and a teaching/learning model was developed by applying step-by-step computational thinking skills. An artificial intelligence-based convergence education teaching/learning model was developed in the direction set as above, and in this paper, it was called the CP3 (Convergence P3) model as shown in Table 3. The CP3 model is largely composed of a problem recognition stage, a plan stage, and a play stage. This is a three-step process, but it consists of six detailed steps.

3.1.1 Problem Recognition Step

Problem recognition is the step in which learners recognize, understand, and explore problem situations to be solved. Therefore, this stage is subdivided into a problem search stage and a pre-learning understanding stage to present a problem situation that can be found in real life, and to think about how to solve it. At this time, since the lower grades have a specific stage of thinking, that is, the recognition of objects is limited to the visible range, the teacher should suggest an appropriate direction (Cho, 2022) (Park & Yoon, 2022). In addition, since it is subject fusion education, there is subject knowledge required for each problem situation. Check whether pre-learning is understood and provide guidance on related subject matter. If it is difficult to proceed with the activity because the relevant subject knowledge is not understood in the next stage, the effect of artificial intelligence-based convergence education is difficult to show. If it is observed that students do not understand the relevant subject in the practice game stage, the teacher returns to the problem recognition stage and proceeds with sufficient guidance.

3.1.2 Planning Step

The planning step integrates the data collection and analysis stage of the problem-solving process and the generalization/solution selection/planning stage through practice problems. In this stage, students learn the process of collecting data necessary for problem-solving, analyzing it, and making a plan. To experience the problem-solving process to the end, it is important to prepare materials suitable for the level of the lower grade students. The teacher must determine whether the prepared material is familiar because it is closely related to real life and does not deviate from the course progress. By using concrete manipulations, lower grade students can be more immersed in the class. At this time, it is more effective to learn how to play through practice games before moving on to the play stage. By playing the practice game, students can discover unexpected variables and explore how to solve them. These questions and answers help students fully understand the rules of play. As such, the planning stage is a process that prepares students to perform well in the play stage, where they experience the actual problem-solving process.

3.1.3 Playing Step

The play stage is a stage that implements a solution to a problem, and a stage that integrates evaluation and improvement stages. The process of participating in play should be a problem-solving process. At this time, the teacher guides them to keep the order and rules of play well, and the students actively participate in the play and experience the process of setting up strategies on their own. After the play is over, it provides an opportunity to self-evaluate and think about areas for improvement through time to share what they have learned and felt through participation, reminding them of intrinsic motivation such as appropriate sense of achievement and enjoyment of play, so that students can continue to the next activity. to actively participate.

3.2 Playing Step

3.2.1 Achievement Standards for Lower Grades by AI elements

AI4K in the United States, established to systematically teach artificial intelligence to elementary, middle and high school students, presents artificial intelligence in five major categories: recognition, expression and reasoning, learning, natural interaction, and social impact. Based on this, the achievement standards of lower grade students for each of the five big ideas are summarized as follows.

Table 4. CP3 Model-Specific Problem-Solving Process and Computational Thinking Skills

AI categories	Achievement standards
Recognition	Distinguish between sensors used in computers, robots, and intelligent devices.
	Interact with intelligent agents like Alexa and Siri.
Expression and reasoning	Construct a model of something and compare it with the modeled one.
	Decision trees can be used to make decisions.
Learning	Unplugged activities can learn patterns in data.
	Use an image classification tool that recognizes pictures. ('Google Autodraw' or 'Conginmates Train'
	Investigate how the training set behaves to recognize images using tools like 'Doodle'. Then discuss how the program can figure out what the students' drawings are.)
Natural interaction	Check the words in the story with the implications.
	Recognize facial expressions and display them as appropriate emotions (happiness, sadness, anger). Explain why it is marked in that way.
	Experiment with software that detects emotions from facial expressions.
Social impact	Find AI applications in daily life.
	Can discuss whether using AI technology is good or bad.

In this paper, we developed a convergence play that can perform an AI-based convergence education program for lower grades considering the achievement standards for mathematics subjects and AI achievement standards. The convergence teaching and learning materials were developed as follows so that they can be used in the mathematics departments where possible.

3.2.2 Data Collection and Analysis

The learning to collect and analyze data proceeded to collect and analyze information through a self-developed four-digit guess game. Based on studies about the composition of four-digit numbers and place values, collect and analyze the data to guess the four-digit number. Based on this, develop data collections and analysis skills while exploring strategies to win the game. Table 5 below shows the main activities of data collection and analysis.

3.2.3 Understanding Sorting Network Algorithm

Understanding the Sorting Network Algorithm enabled the activity to understand the algorithm through the activity of comparing the sizes of various numbers through procedural thinking. Using the sorting network algorithm, we learn about sorting while comparing six four-digit numbers, and explore the advantages and usage methods of using the algorithm. Table 6 below shows the main activities to understand the sorting network algorithm, and Figure 2 is the sorting network algorithm activity sheet.

Table 5. Key Activities for Collecting and Analyzing Data

Topic	Collecting and analyzing data
Objectives	Collect and analyze information through guessing the four digits.
Materials	Activity sheet
Sequences	1) Summarize the four-digit number structure and place value learned in the last lesson 2) Learn how to play Guess the Four Digits 3) Play Guess the Four Digits with partners 4) Summarize the characteristics of a four-digit number discovered through play

Table 6. Key Activities for Understanding Sorting Network Algorithms

Topic	Understanding sorting network algorithms
Objectives	Procedural thinking to compare the sizes of different numbers.
Materials	Connection cube, activity sheet
Sequences	1) Think about how to arrange connecting cubes of different lengths. 2) Understanding the sorting network algorithm 3) Sort the connection cubes using the sorting text worksheet 4) Sort several four-digit numbers in order 5) Think about the advantages of using an algorithm

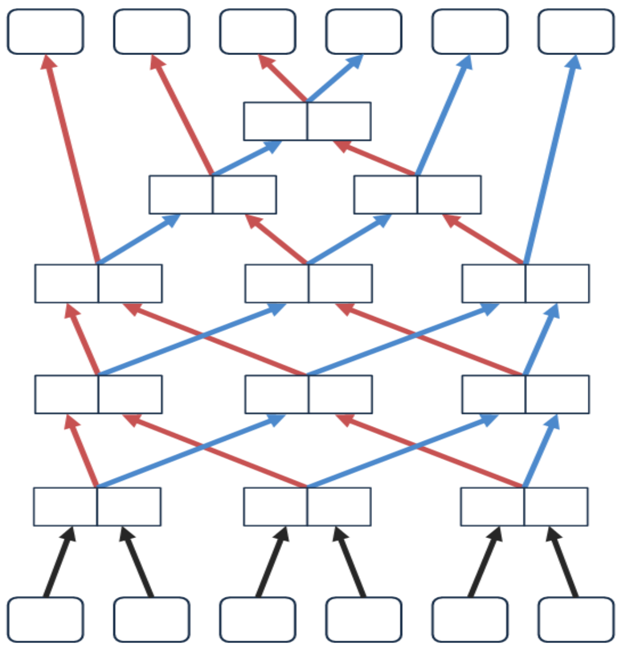

Figure 2. Sorting Network Activity

3.2.4 Understanding Sequential Structures

Understanding sequential structure was developed as an activity to experience and understand sequential structure through sequential dice. Unlike conventional dice, sequential dice have several directions drawn. After acquiring the desired number to make a four-digit number through dice, use the directions shown on the sequential dice to understand the sequential structure. Table 7 below shows the main activities of Understanding Sequential Structure.

Table 7. Key Activities for Understanding Sequential Structures

Topic	Understanding sequential structures
Objectives	Complete four digit numbers using sequential dice
Materials	Sequential dice, game board, worksheet
Sequences	1) Understanding sequential backgammon 2) Try making a four-digit number by playing backgammon 3) Compare the four-digit numbers with friends

Table 8. Key Activities for Understanding Sequential and Repetitive Structures

Topic	Understanding sequential and repetitive structures
Objectives	Procedural thinking can explain rules related to rotation or position.
Materials	Textbook, worksheet
Sequences	1) Look at the traditional muntin patterns, find the rules, and complete them
	2) Explain the rules found
	3) Find out the types and meanings of command symbols
	4) Look at regular patterns and write commands
	5) Design regular patterns and write commands
	6) Completing regular patterns by looking only at the pair's commands

3.2.5 Understanding Sequential and Repeating Structures

Understanding sequential and repeating structures is an activity to make rules and express them using command symbols. While making a rule that repeats the same shape, we will see how it can be expressed using a set command symbol. Furthermore, think about the command symbols to add, and use them to create and introduce various patterns. Table 8 shows the contents of the main activities to understand the sequential structure and repetition structure, and Figure 3 shows the command set and activity contents used in this process.

↑	Push up	←	Swipe left
↓	Push down	→	Swipe right
COLOR ( )	Redraw with the color in parentheses	( ) X	Repeat the commands in parentheses times

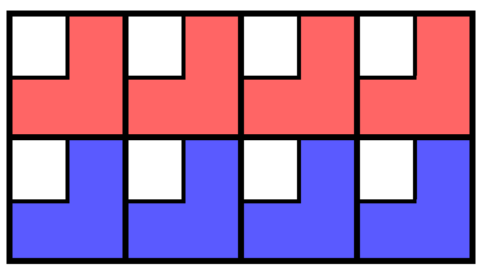

Figure 3. The Command Set and Activity Contents

3.2.6 Understanding Procedural Thinking

Table 9. Key Activities for Understanding Procedural Thinking

Topic	Understanding procedural thinking
Objectives	Find rules and solve problems with procedural thinking.
Materials	Textbook, worksheet
Sequences	1) Find various rules in life
	2) Explain the rules in school life
	3) Discuss the rules found at the traffic lights
	4) Write the traffic light rule as a command sentence for each group
	5) Check the result of the statement using the traffic light model

Understanding procedural thinking is an activity to find rules in life and find out how to explain them. Learn about the various rules in students' daily life, and use familiar topics among them. Think about how to explain morning routines after school to introduce it to students. Do it based on the explanatory text, check whether there are any missing or missing parts in the process, and develop procedural thinking. Make a crosswalk traffic light rule with group members, share it with friends, and think about what a good command is.

4. Experimental Results

In this paper, the beaver challenge test conducted by the Korea Beaver Challenge was performed to measure the computational thinking ability of the research subjects. The reason is that there is currently no suitable evaluation factor for analyzing the effect of artificial intelligence education, so an authorized evaluation tool was selected to analyze the effectiveness of the program based on the factor of computational thinking ability. Since AI education is based on computer science and computational thinking, it is judged that it can be analyzed by replacing it with computational thinking. In addition, the CP3 model proposed in this paper can also be evaluated based on computational thinking ability. Therefore, the AI-based convergence education program is designed to develop computational thinking skills as shown in Table 10 below.

Table 10. Evaluation Factors for Each AI-based Convergence Education Program

	Program contents	Computational Thinking Elements
1	Collecting and analyzing data	Data collection and analysis
2	Understanding sorting network	Algorithm and procudere establishment, parallelization
3	Understanding sequential structures	Pattern recognition, algorithm and procudere establishment
4	Understanding sequential and repetitive structures	Abstraction and data visualization
5	Understanding procedural thinking	Modeling and Simulation

To evaluate the degree of improvement after applying the artificial intelligence-based convergence education program to which the CP3 model is applied, the difficulty weight of the beaver challenge problem was used as it is, and 1 point (lower), 1.5 points (medium), and 2 points (upper) were scored. Afterwards, the pre- and post-test results were analyzed. As a result of the pre-test of 47 students (22 males, 25 females) who participated in the program, the average score was 7.2. After participating in all AI-based convergence education programs to which the CP3 model was applied, the average of the post-test results was 10.2, an improvement of 41.6%. As shown in Table 11, when the test results were divided into male and female students, the average pre-score for male students improved by 53%, from 7.0 to the average post-score of 10.7, and for females, the average post-score from 7.4 to 9.8 for female students improved by 33%. Although female students had higher prior scores, it was confirmed that male students improved their scores more after participating in the program.

Table 11. Comparison of Computational Thinking Ability Pre- and Post-Test Results

Gender	Pre-test reult	Post-test result	Improved ratio
Male	7.0	10.7	53%
Female	7.4	9.8	33%
Total	7.2	10.2	42%

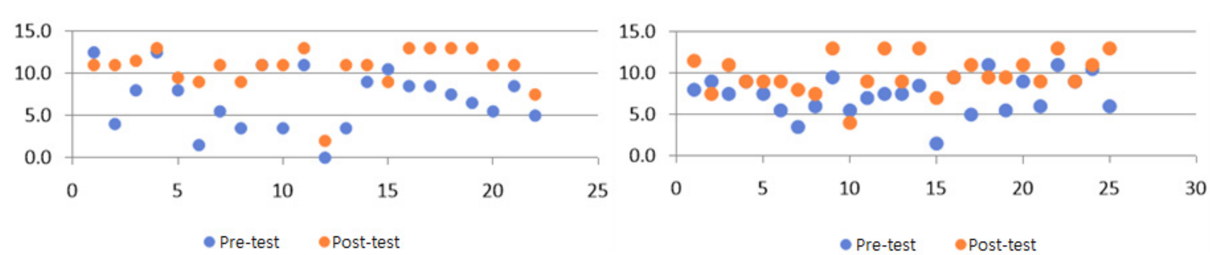

Figure 4. Distribution of Scores

When examining the results of each evaluation area, it was divided into items evaluating ALP (algorithm and programming), ALP and DSR, and DSR (data expression and data structure), and the change was confirmed by comparing the percentage correct in the pre-test and the percentage in the post-test. As for the pre-test results, the ALP and DSR questions had the highest average of 66%, and the ALP questions had the lowest average of 55%. On the other hand, in the post-test questionnaire, the ALP question rose the most with an average of 81%, and the percentage of correct answers was the highest. On the posttest questionnaire, the percentage of correct answers increased to an average of 78% for ALP and DSR questions and an average of 77% for DSR questions. This indicates that lower grade students have difficulty with complex items. Therefore, it can be seen that education in a form in which a single domain is fused rather than a complex form of convergence education should be provided for lower grade students.

Table 12. Correct Answer Rates by Evaluation Areas

Evaluation areas	Ratios		Improvement ratio
	Pre-test	Post-test	
ALP	52%	81%	29%
ALP, DSR	66%	78%	12%
DSR	55%	77%	22%

5. Discusstion

A survey was conducted on satisfaction with the lower grades of elementary school students who participated in the program. Interest in class, class satisfaction, and class expectation were investigated, and how the students felt compared to the existing subject class was measured. The number of respondents who answered 'very much' or 'yes' to all questions was 83% of interest, 70% of problem-solving ability, 68.5% of satisfaction, 64% of understanding, and 68% of expectation, respectively. It can be seen that the overall satisfaction of the participating children with the educational program is very high. We tried to figure out which content the students preferred about the five major subjects of data collection and analysis, understanding sorting network algorithm, understanding sequential structure, understanding repetitive structure, and understanding procedural thinking. As the most interesting activity, 40% of students selected ‘Sort Network Algorithm’ the most. This is because many students felt that the activity to understand the sorting network algorithm was relatively easy, and they approached it with interest because they could use the sorting network algorithm in various ways in real life. As a result of the analysis divided into male and female students, male students answered that 'Understanding the sorting network algorithm' and 'Understanding procedural thinking' were the most fun activities at 31% each, and 44% of female students answered 'Sorting Network Algorithm', and 33% selected the activity 'Understanding procedural thinking'. This shows that the lower grade students feel familiar with the things that are used frequently in real life and can be easily applied. On the other hand, in the case of the repetition structure, it was found that the lower grades felt difficult because complex concepts were applied.

6. Conclusion

In this study, the CP3 model, a teaching-learning model that applied a customized AI education teaching/learning method considering the characteristics of low-grade students, and the convergence teaching/learning to improve the computing thinking and artificial intelligence of elementary school students. The materials were developed and applied to the lower grades. It was found that the program applying the CP3 model, which is an artificial intelligence-based convergence education teaching/learning model developed through this, is effective in AI education of lower grade students and very effective in improving computational thinking. The CP3 model was developed based on the computational thinking framework in the problem-solving process, and the applied program was developed based on the AI achievement standards for the lower grades of elementary school. In addition, it was concluded that to increase the effectiveness of the AI-based convergence education program, it is necessary to organize classes using topics and specific objects familiar to the lower grades of elementary school. It was found that the lower grades showed higher satisfaction and interest in class and higher educational effectiveness when classes were conducted using familiar topics and concrete objects closely related to real life. In terms of interest, understanding, and expectation of the class, the students' responses were higher in the AI-based convergence education program than in the general subject classes, and when the problem-solving process was composed as a play by combining the edutainment elements, the students It was found that the response and concentration were very high. Therefore, it was concluded that low-grade students can greatly improve computational thinking ability and artificial intelligence thinking ability by fusion with the subject if learning materials are developed in the form of play closely related to real life through an appropriate teaching-learning model.

References

Association of related Ministries Report. (2019). *National Strategy for Artificial Intelligence.*

Association of related Ministries Report. (2020a). *Plan to Spread AI·SW Education for the Whole Nation.*

Association of related Ministries Report. (2020b). *The Direction of Education Policy and Core Tasks in the Age of Artificial Intelligence.*

Barr, V., & Stephenson, C. Bringing. (2011). Computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads, 2*, 48-54. https://doi.org/10.1145/1929887.1929905

Cho, Y. H. (2022). A Study on the Case and Performance Analysis of the College of Physical Education of Team Team Class. *Asia-pacific Journal of Convergent Research Interchange, FuCoS, 8*, 265-274. http://dx.doi.org/10.47116/apjcri.2022.02.23

Druga, S., Williams, R., Park, H. W., & Breazeal, C. (2018). How smart are the smart toys? Children and parents' agent interaction and intelligence attribution. *Proceedings of the 17th ACM Conference on Interaction Design and Children*, *ACM*, 231-240. https://doi.org/10.1145/3202185.3202741

Kalelioglu, F., Gulbahar, Y., & Kukul. (2016). A Framework for Computational Thinking Based on a Systematic Research Review. *Baltic Journal of Modern Computing, 4*, 583-596.

Kim, Kapsu & Youngki Park. (2017). A development and application of the teaching and learning model of artificial intelligence education for elementary students. *Journal of The Korean Association of Information Education, 21*(1), 139-149. https://doi.org/10.14352/jkaie.2017.21.1.139

Kim, S. C. (2021). A Functional Analysis of Mathematics Learning Support Platform – including Utilization of AI. *Asia-pacific Journal of Convergent Research Interchange, FuCoS, 7*, 315-326. http://dx.doi.org/10.47116/apjcri.2021.11.26

Markov, Z., Russell, I., Neller, T., & Coleman, S. (2005). Enhancing undergraduate AI courses through machine learning projects. *Proceedings Frontiers in Education 35th Annual Conference*, *IEEE*, 3-21. https://doi.org/10.1109/FIE.2005.1611941

Nam, H., & Cho, H. (2020). *Categories of social studies education with artificial intelligence and ideas for teaching practice*. *31*, 119-133. https://doi.org/10.20972/kjee.31.202008.119

Park, C. J., & Ok, H. Y. (2022). Exploration of the STEAM Centered Education System. *Asia-pacific Journal of Convergent Research Interchange, FuCoS, 8*, 145-155. http://dx.doi.org/10.47116/apjcri.2022.03.13

Popenici, Stefan A. D., & Sharon Kerr. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning, 12*(1), 1-13. http://dx.doi.org/10.1186/s41039-017-0062-8

Qualls, J. A., & Sherrell, L. B. (2010). Why computational thinking should be integrated into the curriculum. *Journal of Computing Sciences in Colleges, 25*, 66-71. http://dx.doi.org/10.5555/1747137.1747148

Shin, W., & Shin, D. (2020). A study on the application of artificial intelligence in elementary science education. *Journal of Korean Elementary Science Education, 39*(1), 117-132. https://doi.org/10.15267/keses.2020.39.1.117

Williams, R., Park, H. W., Oh, L., & Breazeal, C. (2019). PopBots: designing an artificial intelligence curriculum for early childhood education. *Proc. AAAI Conf. Artificial Intelligence*, 9729-9736. https://doi.org/10.1609/aaai.v33i01. 33019729

Wu, H. M., Kuo, B. C., & Wang, S. C. (2017). Computerized dynamic adaptive tests with immediately individualized feedback for primary school mathematics learning. *Journal of Educational Technology and Society*, *20*, 61-72.