

Young Children's Metacognition Expressed during Coding Play

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Abstract

The purpose of this study is to explore young children's metacognition expressed during coding play. The children participating in this study consisted of 13 five-year children(6 males and 7 females) at H Kindergarten in S City. Various data, such as observation records, researcher's own journals, and informal consultation meeting records were collected and analyzed. The results of this study are as follows: First, metacognitive planning can be further activated in coding play while children create their own meaning through judgment and selection. Second, children are engaged in monitoring the degree to which performance is progressing towards a desired goal. Third, metacognitive control actively appeared in coding play while children changed ways of conducting tasks. Fourth, children review task performance and evaluate the quality of performance in coding play. The results of this study are expected to help understand how young children's metacognition appears in coding play, and further reveal the educational value of coding play that helps young children activate their metacognition.

Keywords : young children, metacognition, coding play

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Introduction

Our society is changing at an unpredictably rapid pace. Metacognition is required to adapt to a rapidly changing society for a lifetime. This is because metacognition serves as a cognitive tool for learners with the ability to ‘know’ about one’s cognition and ‘regulate’ the cognitive process(Flavell, 1976). Metacognition means to awareness of one’s cognitive and cognitive activities(Rhodes & Tauber, 2011) and intentional and conscious regulation(Brown, 1980; Matlin, 2009). In other words, metacognition has the characteristic of cognitive ‘monitoring’ and ‘control’(Nelson & Narens, 1994). Monitoring refers to reflecting on one’s own understanding, ability, and emotional state. Control refers to a conscious process of controlling one’s cognitive process based on monitoring.

It was a common belief that metacognition exists in adults or late childhood but not in young children, because metacognition regards one’s own cognition as an object of inspection and requires the ability to control the cognitive processing process. However, many studies(Kim & Park, 2007; Kei, 2013; Rosbon, 2016) have proved that metacognition is also present in young children aged 3 to 5. In addition, studies on mind theory and self-regulation, which are similar concepts to metacognition, have confirmed young children’s cognitive control abilities(Hofmann, Friese, Schmeichel & Baddeley, 2011; Lee, Lee & Shin, 2005; Lee, 2005).

In situations that are developmentally suitable and meaningful for young children, young children’s metacognitive skills can be better emerged. Lomangino(2000) considered that verbal and non-verbal behavior observation was appropriate in measuring young children’s metacognition. Several studies(Rosbon, 2016; Whitebread et al., 2009) have developed tools to observe metacognition in young children’s daily lives, and used observational tools to clarify various evidence that young children expressed metacognition in meaningful situations. Since the most effective learning means for young children is play, it is necessary to look into how metacognition, the main factor of successful learning, is expressed in play.

Coding play is an activity in which young children’s metacognition actively occurs. Coding play contains elements that promote various metacognitive activities in terms of monitoring the process of creating works with a coding program and controlling goals and strategies when problems appear. Specifically, in coding play, young children play freely

according to their interests, and create their own meanings through their own judgments and choices. In this process, young children become the main agents of regulating play situation, planning activities, and using necessary knowledge and procedures.

Even if coding play provides a situation in which young children's metacognition can be well expressed, coding play for young children is possible only if it is suitable for the developmental stage of young children. Recently, studies have been reported that there is no problem in coding education for young children, and that the use of appropriate educational coding program helps young children's development (Grover & Pea, 2013; Kazakoff & Bers, 2012; Portland, Strawhacker & Bers, 2016). So coding play is needed to be taught in the early childhood educational settings.

Sufficient studies have already shown that young children have metacognitive ability, and that there is no problem in coding education for young children, this study attempts to explore young children's metacognitive experiences during coding play. The purpose of this study is to explore the role of coding play in young children's metacognitive process by analyzing young children's metacognition expressed during coding play. The results of this study are expected to help understand how young children's metacognition appears in coding play, and further appear the educational value of coding play that helps young children activate their metacognition.

Literature Review

Components of Metacognition

Metacognition is classified into three components: metacognitive knowledge, metacognitive regulation, and emotional and motivational regulation. Metacognitive knowledge is the individual's knowledge about personal, task and strategy variables affecting their cognitive performance (Annevirta & Vauras, 2001; Pintrich, 2002; Scheider & Lockl, 2002). Metacognitive regulation is the cognitive process taking place during ongoing activities (Nelson & Narens, 1994; Son & Schwartz, 2002). Emotional and motivational regulation is the learner's ongoing monitoring and control of emotional and motivational

states during learning tasks(Boekaertz, 1999; Zimmerman, 2000).

This study tried to explore in depth according to the metacognitive components in order to find out young children's metacognition that appeared in the coding play process. In particular, this study analyzed metacognitive regulation based on the behavioral perspective of metacognition to regulate the cognitive process while performing tasks in coding play. The reason for exploring focusing on metacognitive regulation is as follows. Metacognitive regulation is a more suitable component for this study because it focuses on the cognitive performance process rather than other components. In the process of performing cognitive activities, these three components work in a complex interaction. Even if we focus on metacognitive regulation, the other two sub factors are not excluded, but act as factors affecting metacognitive regulation. Therefore, since this study examines metacognition occurring in the coding play process, it was judged that it is appropriate to focus on metacognition regulation.

Metacognitive regulation contains four skills that are essential, planning, monitoring, control, and evaluation(Brown, 1987; Nelson & Narens, 1994; Pape & Wang, 2003; Son & Schwartz, 2002). Planning means the selection of procedures necessary for performing the task, monitoring refers to the ongoing on-task assessment of the quality of task performance. Control is to change in the way tasks are executed based on the results of cognitive monitoring. Evaluation means reviewing task performance and evaluating the quality of performance.

Definition of Coding Play

With the democratization of technology, the function of play materials that can freely unfold young children's thoughts such as blocks, crayons, and paints is possible in the screen. For growing young children today, tablet PC and mobile phone are no longer high-tech, but everyday tools such as crayons and watercolors. As such, coding is a kind of material that people use to implement what they can make or are thinking about. Based on the material of digital tools, one can realize one's thoughts by creating large and small things that one imagines(Resnick, 2017/2018).

For young children, coding is meaningful as a play material that makes them learn and

think while making and playing. Through the experience of making abstract thoughts by hand, young children can become the subject of learning on their own, setting topics, searching for information, solving problems, and completing results. Therefore, this paper focuses on coding as playground in coding play. Through coding, young children develop the ability to imagine, create, play, think creatively, and work together. At this time, this paper focuses on coding play as developing the ability to think creatively and express it in detail rather than acquiring the coding program itself. Therefore, young children's coding play defines a work as a play in which children create what they want through a coding program and find a way to solve problems in the process.

Coding Play and Metacognition

Coding play can help to activate metacognition. First, coding is an activity that generates its own meaning by learners' judgment and choice. Metacognition is activated in the process of creating a work with coding, just as metacognition, which recognizes and regulates one's thinking, is activated in the process of writing (Hacker, Keener & Kircher, 2009).

Second, the coding program used in coding play has a characteristic of high interaction because it can check the result immediately after manipulation. During metacognition operation, young children need a double task of thinking about problem solving and simultaneously monitoring and control their thoughts. In coding play, learners focus on cognitive activities that perform coding tasks, and coding program plays a role in checking and evaluating learners' cognitive processes. In fact, students learning through highly interactive computer programs have become faster and more accurate over time compared to those who do not (Okita, 2008).

Third, commands in coding program are recorded completely visually. The coding program's commands are tools that allow young children to examine their cognitive processes because commands visually show traces of thought (Han & Choi, 2020). Since the goals and strategies used by young children are externalized through commands, errors can help monitor which parts are wrong, what their original goals were, and which strategies were used.

Finally, the coding program shows the results of the manipulation on the screen as they

are. For this reason, young children can check their understanding more immediately and objectively during the coding process (Han & Choi, 2020). Therefore, coding play that check objective results and grasp one's cognitive level can help determine accurate metacognition.

Method

Researcher Participants

The children participating in this study consisted of 13 five-year children(6 males and 7 females) at H Kindergarten in S city. They participated in coding play more than 15 times out of a total of 65 times. Overall, children participated passionately in coding play, and on average, 8-10 young children participated in the play a day. At the beginning of the study, children were very interested in playing with a new media, and in the course of the study, young children naturally shared play with their peers and became proficient in coding functions, creating new coding play. When young children particularly liked coding play, information of Viscuit coding program was shared at home at the request of young children, and children also performed coding play at home.

Before the start of the study, the contents of the study were explained to teachers and parents, and consent was obtained in writing. The names of participating children were guaranteed anonymity using pseudonyms. Most of young children who participated in the study experienced enough digital media including tablet PC in their daily lives, so they manipulated tablet PC skillfully. On the other hand, prior experience related to coding play differed depending on the degree provided by home. Most of males had experienced participating in a coding-based game called "Minecraft" at home. This prior experience reduced the trial and error of coding play, and was also used as a material for expression.

Vsicut Coding Program

In this study, Viscuit coding program was used to play coding with young children. Viscuit, developed by Yasunori Harada, a Japanese Doctor of Information Engineering, is provided

on the web(www.viscuit.com). Since there is no predefined form or movement in Viscuit, it can induce curiosity and interest, maximizing creativity. In addition, in Viscuit, movement can be made only with commands that look like glasses, so if young children know how to use it, young children intuitively access it without special language grammar(Han, 2019).

The operating characteristics of Viscuit that can function as digital play material suitable for young children can be presented in the following three ways. First, the Viscuit program allows free expression and various choices of young children. Young children can decorate their screen to express their thoughts, create objects with their own drawings, and add sounds, as shown in Figure 1. Second, Viscuit are suitable for young children because they can embody young children's intentions through simple grammar knowledge. As show in Figure 2, in Viscuit, an algorithm for an object can be implemented in commands that look like 'glasses'. The glasses command consists of a straight line connecting two circles and two circles. The left circle(hereafter denoted as "No.1 glasses lens") means before the change, and the right circle(hereafter denoted as "No.2 glasses lens") means after the change. Third, Viscuit can expand collaboration with others by sharing works made by young children. Young children can simply appreciate others' works, borrow key concepts from others' works, reflect them in their works, and modify them based on their own thoughts in others' creations.



Figure 1. Object creation screen



Figure 2. Glasses command screen#

Data Collection

For 21 weeks from April 5 to August 27, 2021(excluding summer vacation from August 2

to August 8, 2021), a total of 65 coding plays were taken place during free play time. The participant observation has been performed at all times of play from 10 to 13, so that young children's daily lives or experiences could be naturally integrated with coding play. I minimized activities introducing specific functions of Viscuit and observed only 'play' that young children choose and start by themselves, not 'activities' planned and presented by teacher so that they can experience various experiences of metacognition while playing coding. I operated an additional space for coding play in the interest center of H Class, and guaranteed opportunities for free play and exploration by providing one tablet PC per child, a total of 4 at the same time. Like other play, small groups were not formed in advance, and young children freely participated in coding play according to their interests.

Various data, such as observation records, researcher's own journals, and informal consultation meeting records were collected. To record data more accurately, video recording, audio recording, small notebook memo, and tablet PC screen shooting were used. In particular, since young children's cognitive process was visually recorded on the tablet PC screen, tablet PC recording was an appropriate tool to examine young children's metacognition in a natural context. Young children's action was recorded in detail, such as where children stayed with the pen for a long time, what one put in command, where one was looking at by moving the screen. Based on this, the researcher, who is an outsider, tried to figure out young children's metacognition that occurs inside. Transcription was performed immediately after collection. A total of 65 transcription data collected through participant observation were A4 1401. A total of 17 informal interview text data, and a total of A4 83 researcher's own journals were transcribed during the study period.

Data Analysis

The collected data were analyzed in the stages of data organization, data categorization, category analysis, and semantic interpretation(Lee & Kim, 1998). First, in the process of organizing data, collected data such as observation data, researcher's own journals, and informal consultation meeting data were integrated and organized. Second, when the data were organized, the analysis unit was defined and data categorization process was performed while analyzing. Third, in the process of interpreting the meaning of the category, the

characteristics of the category were defined based on the semantic relationship.

Triangular verification process was performed to minimize the biases that qualitative research may have and increase validity(Mathison, 1988). Research data were collected in various ways, such as participant observation, consultation meeting, and research journals. And I tried to refer to various references and theories to interpret them.

Results

“I’ll just do it like this.” : Planning

Metacognitive planning can be further activated in coding play because young children create their own meaning through judgment and selection. In the process of creating something with a coding program, young children set expectations and desired goals by monitoring their emotions and motive responses. Young children went through the processes of articulating what was needed by planning, and planning further refined their fuzzy ideas. After drawing the object, Junho told me his thoughts on what expression he wanted to make.

Junho : (Putting the train up along the railroad) It goes like this, and then it(railroad) falls like this, stepping on this train and going down, I want to launch a rocket and make it fly like this.

Junho : The rocket launches and goes like this and then falls down and the rail falls down.

Junho : (Lines up the railroads endlessly. Carrying the yellow train up along the roads) I’ll just do it like this.

(Observation journal, July 14, 2021)

At the beginning of the play, Junho drew railroads, a train, rockets, and listed the railroads obliquely on screen. Then he told the story of the train meeting the rocket and falling, the story of the train flying up, and the story of train falling. As shown in the picture on the right of Figure 3, his thoughts on what he wants to make are not organized. Young children have numerous thoughts they want to express, but it is difficult to express with such unorganized thoughts. In order to play coding, young children have to choose which of these numerous thoughts is worth expressing. Emotional and motivational monitoring, which identifies

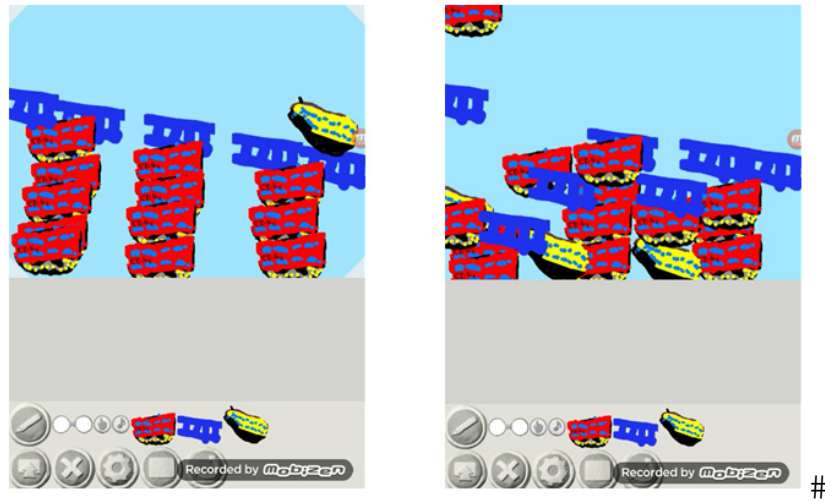


Figure 3. Junho's plan

elements of interest to themselves, is the basis for planning, and setting goals and targets for expression. Coding is a tool that allows young children to express what they imagine and what is meaningful to them. In the process of completing the work, young children decide everything, such as object creation, object placement on the screen, and command generation, according to their intention. In coding play, young children make their own decisions and actively implement what they want to do, experiencing metacognitive planning.

Planning also includes defining and negotiating roles for each child. In the coding play young children wanted to share their games with others and have fun together. Meta-communication was performed to set the play frame for social interaction among play participants also in coding play. Within the framework of coding play, young children were immersed in the game and interacted with the game. At the same time, as a high-level communication, which is a high-level cognition about play, play participants constantly negotiated and created game rules. In other words, high-level communication is communication about communication within the play frame, and the high-level communication ultimately a metacognitive process in a broad sense. The following is an example of Junsu and Dojin playing a car fight game. The car fight game is shown in Figure 4 and the red car disappears when hit by a blue arrow, and the sky blue car disappeared when hit by a red arrow. Each arrow is fired by pressing each color 23 button.

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Junsu : I won't do it yet. I'll do it when it's really dangerous.

Dojin : It's not dangerous yet.

Junsu : No, I almost got hit by the wheel.

Junsu : Ready, set, go. When it's really dangerous.

Dojin : I haven't done this for a long time, so it's not working.

Junsu : I already lost. Wait a minute.

Dojin : (Won) hahahaha.

<Omit>

Dojin : Red is mine now.

Junsu : Red is mine.

(Observation journal, June 9, 2021)



Figure 4. A car fight game

The red arrow moved better toward the location of the other car than the blue arrow. Dojin and Junsu realized that the red car was more advantageous while playing game, and they wanted to play the red car. Since this game was played on a tablet PC, who pressed the button first and the fastest was also important in winning or losing the game. The button was operated well when it was mainly done with a tablet PC.

Junsu dominated the red car and the tablet PC pen. After a few iterations of the game, Dojin told Junsu that it is his turn to play the tablet PC pen and the red car. At this, Junsu said that he will continue, and a conflict arose. Junsu compromised to press the red button,

which allowed him to fire arrows only when in danger. This communication explores issues of control and compromise outside the framework of play. Unlike dramatic play, coding play is not strict inside and outside the frame of play, but in addition to the interaction of immersing in play, there is an interaction that sets a promise for fair play in coding play too. During these discussions and negotiations, young children went through a metacognitive process. This was because, based on the evaluation of the play, an interaction that could establish the fairness of the next play was included. This high-level communication corresponds to a plan in that it negotiates the roles and demands of the play participants in the next play based on the evaluation of the play.

“Oh, I know what the problem is!” : Monitoring

Monitoring is the ongoing on-task assessment of the quality of task performance and the degree to which performance is progressing towards a desired goal. Young children were engaged in monitoring the degree to which performance is progressing towards a desired goal in coding play. The coding play process involves metacognitive monitoring as a process of expressing young children’s imagination and thoughts. Metacognitive monitoring during coding play continues without interruption until the work that meets children’s goal is completed. In order to make the desired expression with the command, it is necessary to constantly monitor the thinking process. The following is an example of monitoring during the process of completing the stamping expression by Jisoo

Jisoo puts yellow hair at No.1 and rainbow at No.2 glasses lens. She moves the yellow hair to No.2 glasses lens. She places several finger button at No.1 and sound buttons at No.2 glasses lens. She tries to put the finger button at No.2 glasses lens, but she doesn't put. She adds several sound buttons at No.2 glasses lens. She takes out the command. She puts rainbow, rainbow color hair at No.2 glasses lens. She puts finger button at No.1 and sound button at No.2 glasses lens. She presses the square button. She marks the stamp full of screen. She repeats one more time and takes out command.

(Observation journal, July 29, 2021)

The activity of stamping with sound should need finger button and sound buttons as well as commands. To make stamping activity, children should remember that finger button is



Figure 5. The command that Jisoo completed while monitoring it

placed on No.1 and sound button on No.2 glasses lens as shown in Figure 5. She repeated the action of trying to put button, take out and put it elsewhere. This is because she was constantly going through monitoring and making commands. Coding play helped children actively monitor in the process of performing tasks. Since commands in coding play are tools that make children's thinking visible, children were able to monitor performance or errors as well as their own thinking. In order to make the desired expression with commands, children have to go through the process of constantly monitoring their thinking process. In this way, repeating the process of monitoring and detecting errors in coding play corresponds to monitoring.

Young children made continuously the work that could not be completed in the previous session. At this time, looking at the command, they figured out how far they had gone and what commands they should make now, and then completed the commands following the last activity. Hajin began to create a work that became a poké ball when he pressed the car(Researcher's own journal, May 27, 2021). As shown in Figure 6, the command was created so that when he pressed the purple or sky blue car, it became a circle and a large square poké ball. He tried to make poké balls when he pressed a light green car in the same pattern. He made a command that the light green car turned into a large square poké ball. But he did not finish the light green car turning into a circle poké ball because it was time to leave kindergarten.



Figure 6. Previously created commands

On May 31, Hajin began to make a poké ball catching game following the previous time. The following is an example of Hajin's effort to monitor what he currently has to do to create commands continuously with his last activities.

I find Hajin's poké ball catching game that he saved last time. Hajin slowly lowers the screen to look at the commands he has made so far. He takes out command. He puts a red car at No. 1 glasses lens and organizes it again. He places a light green car at No.1 and an orange pocket ball at No.2 glasses lens. (...) He raises the screen and looks at the command carefully. He looks a little longer and takes out the command. He places the red car in No.1 and the orange pocket ball in No.2 glasses lens.

(Observation journal, May 31, 2021)

Hajin opened the work of the last activity and first looked at what commands he made. He figured out how far the poké ball game was made by looking at the command. This can be seen as an effort to examine where his current work is located and which part should be done in the overall process of making a pocket ball game. Because the coding program remains the commands made while performing the task, children can more easily grasp the progress of the task visually. In other words, coding program can help monitor the metacognition because young children understand what their achievements have been and what tasks should be done in the future though commands.

“Then let’s not jump high.” : Control

Control means a change in the way a task had been conducted as a result of cognitive monitoring. Young children constantly monitor and detect errors while creating commands. When an unexpected error is found as a result of monitoring, young children think about how to solve it and find a way. This process corresponds to control. At this time, young children are silent and try to find a solution to the error in their heads. Hajin wanted to create an expression that made bombs come out from the launchers on both sides. In the following example, he was first creating an expression in which the launcher on the left came out bombs.

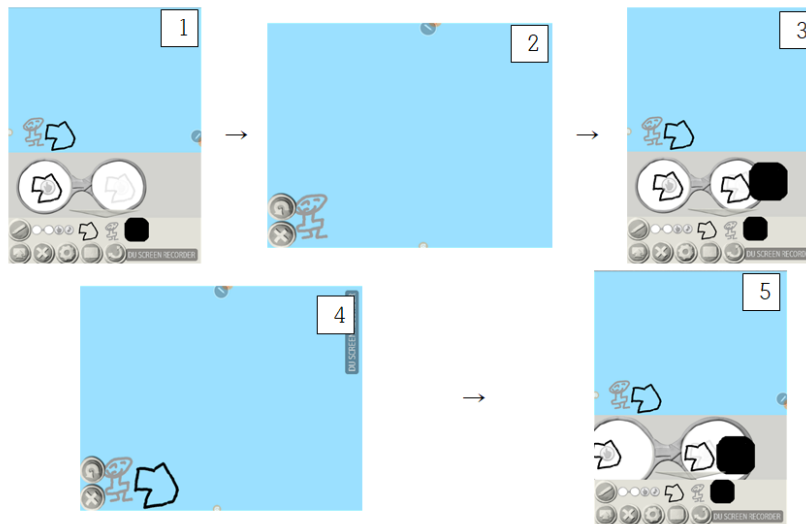


Figure 7. The process of Hajin solving the error

He wanted to make a bomb came out when he pressed the launcher’s left side next to the gray person, and the bomb would move to the right. At first, as shown in [1] in Figure 7, there was an expression in which the launch pad disappeared when pressed because nothing was placed on the No.2 glasses lens. He checked for errors by looking at [2] in Figure 7, and added a launcher and a bomb to the No.2 glasses lens, as shown in [3]. However, as shown in [4], the bomb fell out of the command, resulting in an error that prevented the bomb from coming out. An error occurred even correct commands, he stayed silent, still, and agonized for a long time. While silent, he found the cause of the error and came up with a way to solve

it, and finally completed the desired expression by moving the bomb that was out of the command into the command and moving it to the right, as in [5].

Young children went through the process of metacognitive control, which corrects strategies to solve monitoring results errors and successfully perform tasks. Because coding program appear on the screen as soon as manipulation, it is easy to determine whether young children are successfully correcting errors and which parts to correct again. Therefore, coding play can be a tool to help to actively utilize young children's metacognitive control in the process of performing tasks. In addition, coding program can reduce the cognitive double burden of young children due to immediate feedback. Young children should double-task to monitor commands and performance and resolve errors on their own. During metacognition operation, young children need a double task of thinking about errors resolution and simultaneously monitoring and controlling their thoughts. The coding program is a tool to monitor young children's thinking because they are visually recorded. That's why young children can focus more on solving errors.

However, there were cases where it was difficult to find errors even when looking at the command and looking back on one's own thinking process. At that time, young children sought help from others and tried to successfully perform the task. Asking for appropriate help is also a strategy of metacognitive control that successfully performs tasks. Dayoung hid the ribbon with a shield and tried to create an expression in which only the shield disappears by pressing the shield. However, when an error occurred, Dayoung asked Hasung for help.

(Dayoung puts the ribbon on the screen while trying to put it on No. 2 glasses lens. She places a purple shield on the top. She puts the purple shield on No.2 and moves it on No. 1 glasses lens. She watches for a few seconds the shield on the screen disappears immediately.)

Dayoung : Hasung. Hang on. What number should I put the finger button on?

Hasung : Let go of the finger button. Oh! But we have to cover this too.

(When Hasung tried to put a shield on the screen, the shield disappears.)

Hasung : Oh! It's here

Hasung : Did you cover the shield? Oh, but you should do the finger button, too.

(Dayoung puts the finger button on the top of the shield in No.1 command. She presses the square button.)

(Observation journal, May 20, 2021)

Dayoung placed a ribbon and a shield on the screen, and only a shield on the No.1 glasses lens. However, there was a problem that the shield disappeared immediately because the finger button was not placed on the No.1 glasses lens. Dayoung actually performed the task well except for putting the finger button, so it was difficult for Dayoung to judge what went wrong on her own while looking at the command. Then Dayoung asked Hasung for help. Hasung is a child who could skillfully create shield play by repeating it several times. Dayoung asked Hasung, a child who could be helpful to her, for help. And was able to complete the task with Hasung.

“This is perfect!” : Evaluation

Coding play is a play that uses coding to make what young children want, so while playing coding, young children created works such as games with rules and promises, and expression results. And they continued to evaluate the works by executing the work they made. Evaluation is a concept similar to monitoring, but in this study, monitoring is ongoing on-task assessment of the degree to which performance is progressing towards a goal, and evaluation is defined as reviewing task performance and evaluating the quality of performance. In other words, the evaluation of the work includes the matters that were evaluated by executing the created works and reflecting the evaluated matters in rules, commands, and objects.

In coding play, the objective level is one's own cognitive level and the play. Information about this objective level is received and evaluated continuously at meta level and evaluation is reflected in planning and execution. Dayoung started playing and planned, “I'm going to make it born from eggs.”(Observation journal, August 12, 2021). As shown in Figure 8, she made a command for birds to come out of sky blue egg. After that, she repeated to press all the eggs to make the bird come out several times. It is the process of repeatedly examining, checking the results, and determining whether her plan is being implemented properly.

She evaluated, “But I want my friend to come out, too.”, and “I need to make a heart outside.”(Observation journal, August 12, 20021). Her evaluation did not end with evaluation, but was reflected in the work by implementing it.

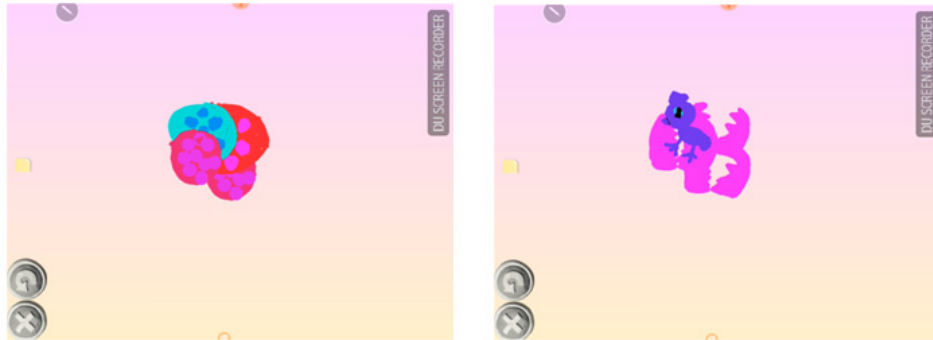


Figure 8. A work that bird emerge form an egg

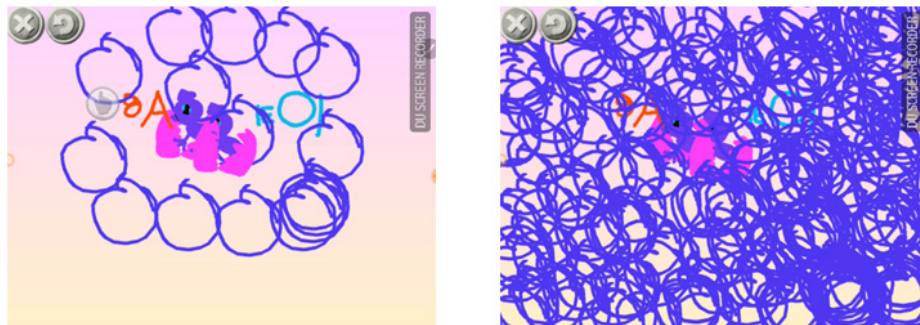


Figure 9. A work that reflects her evaluation

She was usually a quiet child, but when stamping, she got excited and explained the work in a loud voice. In addition, she showed her work to friend and introduced her work, saying, “This is a heart typhoon.”(Observation journal, August 12, 2021). Seeing this figure, it can be interpreted that she enjoyed the expression of increasing the number of hearts and gave meaning to it.

Young children also evaluated their level of command while executing it. In other words, it is to review what you have learned or evaluate the task. Usually, young children’s evaluations refer to all forms of measurement to know what young children know and can do. In coding play, the young children’s evaluation was made by young children themselves rather than by others. While doing the assignment, young children naturally learned what they knew and did not know. In creating expressions, monitoring occurred to observe and evaluate their current cognitive state, and received information from monitoring to make

judgements about their cognitive levels. Metacognitive judgements about one's level include feeling of knowing. Metacognitive judgements about oneself appeared to be confusing when making commands in coding play, thinking about the object between No.1 and No.2 glasses lens, and saying "You don't have to tell me this time."(Yang Hajeong, observation journal, June 3, 2021). Whether metacognitive judgements are accurate or not can be confirmed only by putting it into practice.

Errors in creating expressions with commands provide opportunities to identify areas that young children have determined to know. Young children could monitor the degree of their understanding immediately and objectively since the results of the manipulation were shown on the computer screen. Dojin was making a secret painting. The secret painting is a game in which a grape is covered on the screen with a light green shield and then disappears when the light green shield is pressed to make a command that only grapes remain. He made an expression that made it disappear by pressing the screen with me. After that, Dojin organized all the drawings and commands he made with me and said, "I want to do it alone now."(Observation journal, May 18, 2021). The follow is an example of Dojin implementing the part I taught him on his own.

(Dojin tries to put a light green shield on No.1 glasses lens and then cleans it up. He tries to put a sky blue shield on the screen and organizes it. He places the zombie on the screen and covers it with a sky blue shield. He was going to put a light green shield on No.1 glasses lens, but he organizes it. He places a sky blue shield on No.1 glasses lens. He places the sound button on No. 1 glasses lens, and presses the shield on No.1 glasses lens several times. Shield in No.1 glasses lens doesn't change.)

Dojin : No. Teacher.

Me : Oh, that's the sound button. Let's organize the sound buttons. A finger button.

(Dojin puts the finger button on No.1 glasses lens. The shield on No.1 glasses lens he presses doesn't change.)

Dojin : No.

Me : Check it out with the square button. (Dojin presses the square button.) Press it. (Shield disappears when I press it.) Done?

(Observation journal, May 18, 2021)

Because Dojin made commands by looking back on his memories, he repeated the action

of “trying to let go” while thinking rather than being sure. Instead of the finger button, the sound button was placed, and when the shield in the command was pressed without pressing the square button, an error occurred that did not work as desired. Dojin learned how to make commands from me and then reviewed what he learned on his own and made it on his own, but an error occurred. Through this process, he was able to accurately monitor which part he did not know. He reviewed which part he didn’t know and learned about it again from me. After that, he once again made commands on his own.

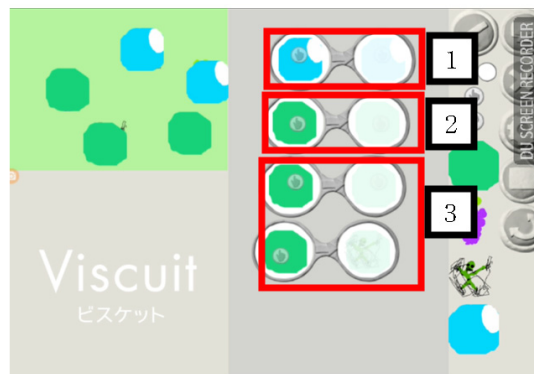


Figure 10. Commands Dojin created by monitoring what he has learned

[1] in Figure 10 is a command I told Dojin, and [2] is a command that I told Dojin what he didn’t know while executing. [3] is a command made by Dojin himself. He is not used to making commands yet, so he made the command in [3] of Figure 8 while hesitating. [3] is not necessary to make the game with overlapping contents with [1] and [2], but Dojin made it to monitor what he learned and see if he could make it properly. He successfully created [3] commands without repeating the last errors. Metacognitive ability in problem solving process plays an important role in grasping one’s cognitive level(Brown, 1980), and Dojin was able to accurately evaluate what he did not know and what he knew through the problem solving process. Self-evaluation identifies what one doesn’t know and makes it an opportunity for new learning.

Discussion

In this study, in order to explore what role coding play plays in young children's metacognitive process, young children's metacognition expressed during coding play was investigated. The findings of this study are as follows. Young children's metacognition in coding play was categorized into 'I'll just do it like this. : Planning', 'Oh, I know what the problem is! : Monitoring', 'Then let's not jump high. : Control', and 'This is perfect! : Evaluation'.

First, metacognitive planning can be further activated in coding play while young children create their own meaning through judgement and selection. In the process of creating something with a coding program, young children set expectations and desired goals by monitoring their emotion and motive responses. Children went through the process of articulating what was needed by planning. Negotiations and rules between play participants through meta-communication were also included in planning.

Second, children are engaged in monitoring the degree to which performance is progressing towards a desired goal. Since commands in coding play was a tool that made children's thinking process visible, children could activate to monitor peer performance of errors as well as their own thinking process(Han & Choi, 2020).

Third, metacognitive control actively appeared in coding play while children changed ways of conducting tasks. Because the results of the coding program appear on the computer screen, the coding program helps children utilize control to modify strategies and adjust goals in order to successfully perform tasks(Chase, Chin, Oppezzo, & Schwartz, 2009; Dennett, 1989).

Fourth, children review task performance and evaluate the quality of performance in coding play. Metacognition includes the cognitive processes at the meta-level and the objective level(Nelson & Narens, 1994), and in coding play, the objective level was one's own cognitive level and the play. Information about this objective level was received and evaluated continuously at meta level and the evaluation is reflected in planning an execution. Children could monitor the degree of their understanding immediately and objectively since the results of the manipulation were shown on the computer screen(Han & Choi, 2020).

In conclusion, metacognition helps young children effectively control their cognitive

processes to create the desired work. Coding work has to go through a series of continuous and complex cognitive processes that require planning, making commands, and correcting them. Metacognition is important in that it monitors and controls these cognitive processes. In addition, there are many ways to help young children activate metacognition, but among them, coding play is one of the most useful methods. Young children were able to execute metacognition more actively because of the visual traces of young children's thinking process, the opportunity to engage in activities that reflect individualized interests, and immediate feedback.

This study is meaningful in that coding play is a tool that enables young children to know their thoughts and goals and how to express them, to monitor errors and which performance is progressing towards a goal, to regulate strategies or their emotions and motivations, and to review own learning and rate the quality of performance. Despite these implications, this study has the following limitations. This study examines young children's metacognition through observation. Based on young children's interactions, behaviors, and contexts during coding play, young children's metacognition was analyzed. Since direct self-report on metacognition is difficult at young children level, I, as an outsider, had no choice but to infer young children's metacognition based on young children's interaction and context. This is because it is impossible to visually identify the process of metacognition. In the whole process of the study, meticulous efforts were made not to miss each clue of young children's language and behavior, but I still feel insufficient.

In addition, this study analyzed young children's metacognitive patterns in coding play, focusing on metacognitive regulation among the metacognitive components. In this study, metacognition that appeared in the coding play process was classified into the categories of planning, monitoring, control, and evaluation, but in reality, it is difficult to artificially divide metacognition according to the categories. This is because metacognition is as action that occurs in the head, and in one instance several categories of metacognition occurred simultaneously. In addition, the category of this study does not explain the stages of the metacognitive process, but actually performs cognitive tasks and appears to be complex. In this study, focusing on the process of performing cognitive tasks, this study classified metacognitive regulation as the center. However, in reality, metacognitive knowledge, metacognitive regulation, and emotional/motivational regulation are cyclically performed, so

further researcher is needed to take a deeper look according to the components of metacognition.

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