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A STUDY OF EDUCATIONAL METHOD USING APP INVENTOR FOR ELEMENTARY COMPUTING EDUCATION

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ABSTRACT

With the fourth industrial revolution, software education has become much more important. In South Korea, Informatics will be taught as mandatory to middle school students; education program development and applications with block based programming languages are vivaciously conducted. Although App Inventor has various educational effects, it has not been studied enough. Based on advanced research, an education program was developed, it was applied to 12 elementary school students who were living in Cheongju. As a result of applying the 20th App Inventor education program, there was no significant difference in the creative problem-solving ability and self-efficacy of elementary school students. Those students thought that the App Inventor program was interesting and it is needed to allocate proper class hours by their grade level. Through this result, in the 2015 revised national curriculum, an educational method was conducted to take advantage of App Inventor effectively. This study shows how App Inventor educational programs should be developed and to energize software education.

Keywords: *Educational method, App inventor, Elementary school, Software Education, Programming education*

1. INTRODUCTION

Software(SW) and computing technology has stimulated the birth of new industry and field of study, leading the brave new world. At the World Economy Forum, this change was identified as the fourth industrial revolution, and AI, robots, and the Internet of Things are at the center of the fourth industrial revolution [1]. Thus, computational thinking (CT) has been paid tremendous attention, and each government has tried to cultivate people of ability on CT [2].

Due to the focus on CT, computing education has become more important. The United States, England, and Finland have already started to introduce CT into computing education curriculum [2]. In its 2015 revised national curriculum, South Korea made informatics subjects mandatory and they placed particular emphasis on CT. Academia and industry have collaborated on developing diverse education materials that enable computing education implementation to land softly in schools and classes [3].

South Korea's 2015 revised national curriculum states that block-based programming languages should be utilized by all levels of students. Programming languages, such as Scratch, Entry, and Snaps, have been studied so programs and educational materials can be developed and implemented in schools [4,5,6]. In addition, educational programs for block-based programming languages and textbooks on these languages are in development. In addition, teacher training is being established so it can be utilized at the school site. Therefore, other block-based programming languages has been implemented in the education field in accordance with the 2015 curriculum revision.

While App Inventor has been studied to develop programs, its application has not been examined thoroughly. However, education programs with App Inventor increased student motivation, creativity cultivation, and programming study [7,8]. If App Inventor was used in the revised curriculum's computing education, training CT-competent people would be accelerated. Also, since

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App Inventor can create real applications and check them through smart phones, it is effective in improving students' self-efficacy and learning motivation. In addition, through the application result, students are provided with substantive representations of programming and automation. Therefore, App Inventor has advantages over other block-based programming languages. Therefore, if App Inventor cannot be utilized with these advantages, and are only the existing block-based programming can be utilized, the development of computing education will be limited. To introduce App Inventor into the revised curriculum, education programs should be developed along curricula, and should be conducted based on that result [4]. In addition, the developed App Inventor education program should be implemented in elementary or middle schools' curriculum to analyze the effects of it.

Therefore, this study developed a new App Inventor educational program and executed it in elementary school students' curriculum to understand education methods for computing education in 2015 revised national curriculum. This research will examine the effect of app inventory training program on self-efficacy and problem-solving ability of elementary school students, their reactions to educational program, the changes that their opinions about App Inventor. Based on the results and analysis, educational methods of App inventor were deduced for the informatics of the 2015 revised national curriculum. In addition, it will be able to draw out how to utilize App Inventor in accordance with Korea's computing education curriculum.

2. BACKGROUNDS

2.1 2015 revised national curriculum

With global movements to introduce Computing education to the curriculum, the South Korean government has made informatics necessary, which was optional in elementary and middle school [2]. Thus, the content of it was also revised to focus on computational thinking, informatics culture and collaborative problem-solving ability [9]. Computing education was separated as informatics science in secondary and tertiary education; in the elementary school curriculum, it was included in practical arts; in details, 17 class hours are arranged for fifth and sixth grade students [3]. Students were taught to examine how SW affects society and to learn procedural thinking, input/output, sequence, and repetition structure, taking advantage of block based programming language. Scratch and Entry are utilized to develop educational programs with this change in curriculum. App Inventor is a block based programming language that has a variety of educational effects, but lacked research as a tool for software education in elementary schools. Therefore, it was necessary to devise a study for introducing App Inventor into elementary schools.

2.2 App Inventor

App Inventor is the programming language which was developed by Google, and it was designed to invent applications that are to function in Android OS. It is possible to program in web browsers, to check invented applications in simulators or to realize newly invented applications through USB and wi-fi in smart phones. Many studies had said that it was burdensome for Korean students since App Inventor does not support Korean; now, however, it does. Moreover, with continual updates, App Inventor has been more significantly developed so that it can be applied to schools [10].

App Inventor is divided into Designer and Block, while Scratch and Entry require a user to have a command of Sprite. In Designer, it is possible to design applications and arrange input/output using components; while in Block, it is possible to personally program which function would be performed by components in the

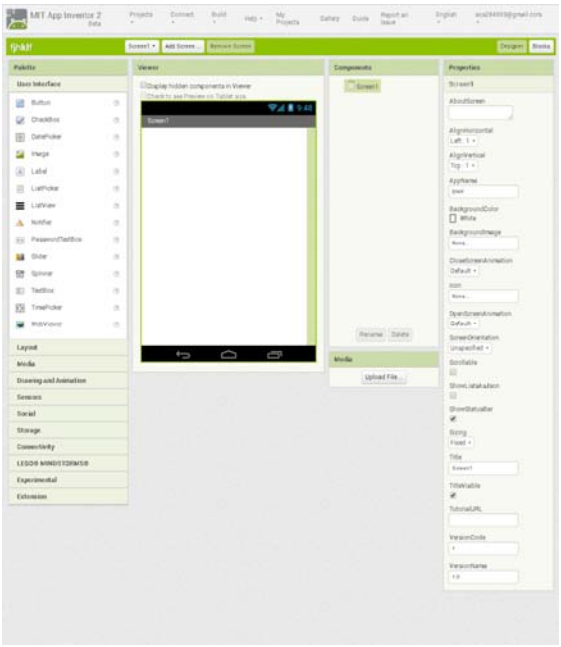

Figure 1: Development environment of App Inventor (1)

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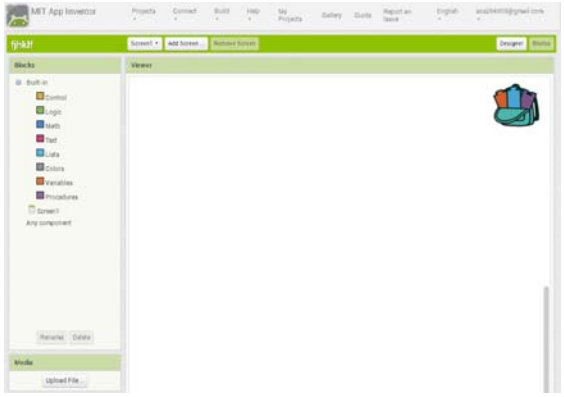

Figure 2: Development environment of App Inventor (2)

application. App Inventor is effective for students to cultivate more interest in programming and raise their confidence to solve problems since they can design and realize their own applications [11].

2.3 Literature Review

Since 2010, when App Inventor was invented, many researches have to applied it to computer science education in many countries. It has been possible to check its efficacy as an educational programming language through those researchers; in South Korea, diverse studies have been conducted since 2013.

Kim (2013) applied programming education with App Inventor to high school and college students and investigate changes to their interest in programming, computer and smart phone applications [12].

Han (2014) conducted project classes for high school students with Arduino and App Inventor and investigated how they were satisfied with classes [13].

Yoo (2014) applied educational programs with NXT robots and App Inventor to pre-service teachers and investigated their reactions. They answered their class with App Inventor was interesting and satisfactory [14].

Choi & Kim (2016) developed computing educational programs with Arduino and App Inventor based on the integrated learning model and CPS class model; he applied it to high school students and observed the change in integrated thinking power and creative problem-solving capability. As a result, integrated thinking power was not improved, while creative problem-solving capability was empowered [15].

An and Lee (2016) applied education programs with App Inventor to pre-service teachers and found out that Pedagogical Content Knowledge(PCK) of pre-service teachers was improved [16].

Kim and Lee (2017) applied App Inventor education program to pre-service teachers and analyzed the change in self-efficiency, problem solving capabilities and awareness of App Inventor: self-efficiency and problem-solving capabilities did not show significant change, while the possibility of App Inventor as a tool of programming education for pre -service teachers [6].

Among the studies using App Inventor, research conducted on elementary school students is as follows.

Kim and Chung (2016) developed curriculum and analyzed App inventor to examine the possibility of App Inventor as a tool of programming education in elementary and middle school. They found out that it is useful to understand basic components in programming and that students were content with their learning [11].

Rim (2013) has conducted classes for elementary school students where they could learn App Inventor and create their own application on various themes, and observed how students think through the changes of observers' thinking and peer testing. Education through App Inventor was useful in improving an active attitude to solve problems, a sense of accomplishment and the motivation of students in the class [17].

Seol and Son (2013)—based on problem based learning and STEAM theory—has developed App Inventor learning materials focusing on practice and real-life situations and applied them to elementary school students; students showed high levels of satisfaction and interest [18].

Lee and Yoo (2016) have developed programs for gifted children in mathematics to improve their self-directed learning capabilities. Applying their programs, students showed significant levels of change in their internal motivation, study opportunity and autonomy [7].

Kim and Kim (2015) have analyzed programs for pre-service teachers to develop Computing education programs for female students in elementary school. Based on analysis, educational programs taking advantage of App Inventor on the ADDIE model were applied; recognitions of calculations were significantly improved; however, creativity improved only in limited areas [8].

An and Lee (2014) have applied education programs for students and teachers in service to conduct educational methods for primary and secondary education utilizing App Inventor. Through these educational programs, the strengths and weaknesses of App Inventor, opinions of

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students and educational methods could be determined [19].

Shin, Choi, and Bae (2015) developed STEAM education programs using App Inventor to explain the exact concept of velocity in natural science and had experts verify the program [20].

Reviewing the literature, many studies have been conducted to investigate the educational merits of App Inventor based on a diverse teaching-learning theory. Moreover, those studies focused on the development of their programs and the reaction of students after putting it in the classroom; however, research on application through experiments is needed to prove the educational effect of App Inventor. Furthermore, problems in App Inventor that were identified in advanced research have been resolved through updates and the development and application of new programs with new versions of App Inventor. In our study, new educational programs were developed for the 2015 revised national curriculum and applied to students to prove its possibility.

3. METHOD

3.1 Research Procedure

In this study, App Inventor educational programs for elementary school students were developed and their effect was analyzed. Literature review was conducted to develop the program and proper testing tools were selected to prove their effect. Research objects were recruited to examine the effect of educational programs and pre- and post-tests were conducted before and after teaching the material to observe the effect of the educational program. Based on the results of the application, we derived a teaching method that utilized effective educational methods using App inventor to elementary school students in the 2015 revised national curriculum.

3.2 Research Subjects

In this study, 20 elementary school students in Cheongju were chosen as research subjects. Of these 20 students, those who did not take the pre- or post-test, including those who did not take both, were counted out. The resulting data of 12 students who took both pre- and post-tests were turned in and analyzed. Examining the characteristics of the research subjects, female students made up 83%, while male students were only 17%.

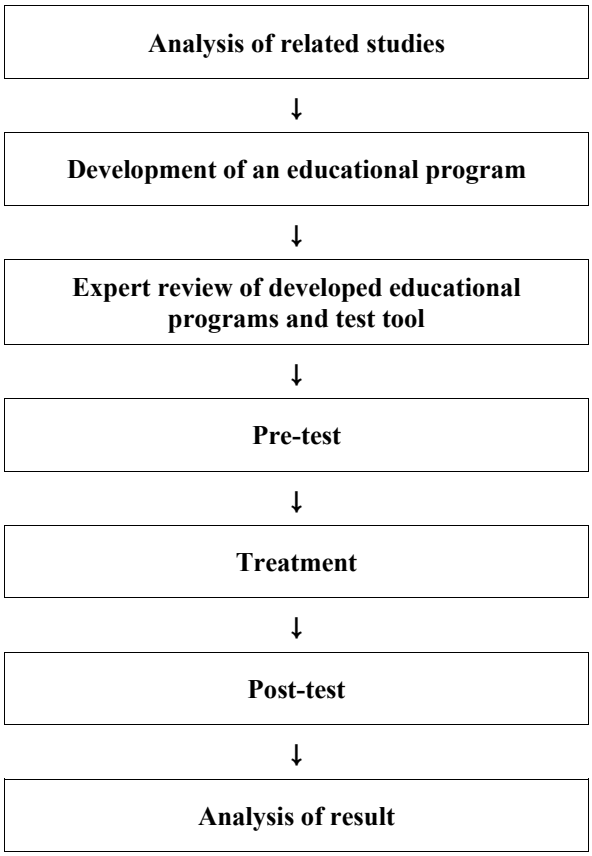

Figure 3: Research procedure

The fifth-grade students were the majority. Those who had previous experience in programming were only 50%; students who had interest in programming volunteered but not all of them had actual experience. The programming languages that these student subjects had experienced were Scratch (38%), Entry (25%) and App Inventor (38%). Every research subject had experienced block based programming language and had never been exposed to a test-based programming language.

3.3 Test Tool

In Practical Arts in the 2015 revised national curriculum, problem solving capabilities and creativity are highlighted [3]. Moreover, in advance research, educational programs with App Inventor have shown the of possibility improving motivation, attitudes to problem solving and interest in class [8, 15]. In this study, test tools were utilized to verify the change in those areas. The test tool to measure creative problem-solving capabilities is the same test tool that was used in advanced research. This tool was developed by MI psychology laboratory, Seoul National University, using a five score Likert scale [15]. The test tool

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consists of five sub-domains: "intelligence, thinking function, understanding of technology and proficiency in certain area (D1)," "divergent thinking (D2)," "critical and logical thinking (D3)," and "motivation components (D4)." The test tool chosen to measure self-efficiency is the tool that was invented by Jeong (1987); this tool was developed to measure how students study, how satisfied the student is, how much the student depends on private institutions and the confidence for elementary, middle, and high school students [21]. This tool consists of 26 questions using five score Likert scale. Furthermore, to collect opinions of students on programs, an additional four questions were included in the post-test: what they liked in the class, what they hated in the class, how to improve the class and what kind of struggles they had in the App Inventor class.

Table 1: Detailed information of research subjects (%)

Gender				
	Male		Female	Total
Number of students	2 (17)		10 (83)	12 (100)
Grade				
	5th		6th	Total
Number of students	9 (75)		3 (25)	12 (100)
Experience about programming				
	Yes		No	Total
Number of students	6 (50)		6 (50)	12 (100)
Experience about programming Language				
	Scratch	Entry	App inventor	Total
Number of students	3 (38)	2 (25)	3 (38)	8 (100)

3.4 Treatment

Through these classes, students could learn basic components about programming, beginning with learning the environment of programming development. With four projects, students gradually became more familiar with the components of the App Inventor and programming environment so that they could design and develop their own application and share it with their peers. An and Lee (2014) stated that it was effective for students to learn App Inventor in project-based classes where they can create their own application due to the characteristics of App Inventor. Furthermore, it is highly recommended that easy and familiar themes should be started first and difficult themes last for students to learn the entire program [19]. Classes designed by project were constituted referring to a revised Waterfall model of Seol and Son (2013). Different situations were given in each project and students had to ponder how to create their own applications for each situation. Children had the opportunity to operate their application and to modify it [18]. Considering the contents of the 2015 revised national curriculum and the grade level of each elementary school student, the algorithm of the application was explained by the teacher [17].

Table 2: Consist of test tool

Domain		***Content***	***Numbers***
Creative problem-solving capability	D1	Intelligence, thinking function, understanding of technology and proficiency in certain area	5
	D2	Divergent thinking	5
	D3	Critical and logical thinking	5
	D4	Motivation components	5
Total			20
Self-efficacy		How students study; how satisfied the student is; how much the student depends on private institutions and the confidence	26
Total			26

3.5 Analysis Method

Through the App Inventor education program, a change in creative problem-solving capabilities and self-efficiency was observed. To analyze these changes, the results of pre- and post-test about creative problem-solving capability and self-efficiency were analyzed on a paired t-test; therefore, it was possible to look into the effects of this education program. Additionally, answers from

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the students to the four essay questions were categorized to see their opinions on the App Inventor education program. Keywords were set to match with the answers of students so that they could be categorized. Some students answered with multiple keywords, therefore, the total number of answers was more than the number of students.

4. RESULT & DISCUSSION

4.1 Result Of App Inventor Education Program Application

On creative problem-solving capability, the App Inventor education program did not show statistically significant changes. The pre-test result was M= 3.683, SD= .487 and post-test result was M= 3.717, SD= .642, t= -.349, p= .733. It was possible to confirm that the App Inventor education program did not have an effect on improving creative problem-solving capabilities. About sub-domains, there was no statistically significant change in D1, t= .272, p= .791. In D2, the result from the post-test (M= 3.267, SD= .593) was higher than that of the pre-test (M= 3.500, SD= .641); however, it was not statistically significant, t= .244, p= .812. In D3 (t= .164, p= .872) and D4 (t= -.1.521, p= .156), there was no noteworthy change. Through this result, it was possible to verify the fact that the App Inventor education program had no effect on creative problem-solving capabilities of elementary school students; however; it was effective on high school students [8, 15].

As far as self-efficiency, the App Inventor education program did not show a significant change among students. The self-efficiency was higher in post-test (M= 3.051, SD= .270) than that of pre-test (M= 3.019, SD= .287); it was not statistically significant (t= -.288, p= .779.) Through this result, it was possible to verify the fact that the App Inventor education program had no effect on the self-efficiency of elementary school students; however, it was effective on learning motivation and attitude in literature [7, 17, 22].

4.2 Opinions Of Students

To questions about what they like most in App Inventor class, 43% students answered that the class was interesting. 36% of students answered that it was helpful to have assistants in class; 14% of students pointed out that they could have the collaboration with peers and the other 7% of students answered that there was nothing they liked in the class. The advanced research had the same result that this study had [8, 17, 19].

In this study, assistants were put into the class and a number of students answered that they found them helpful; it is likely that that could help an App Inventor class to proceed effectively. Jeon & Lee (2014) stated that students like cooperating with peers to design applications [22]. To questions about what they hated in the class, 50% of students answered that the class was not long enough while the other students answered there was nothing they hated in the class. It is possible to assume that more hours are needed to teach the App Inventor class. To questions about what they struggled with in the class, 57% of students answered it was difficult to learn blocks; 14% of students answered that the amount of what they had to learn was to excessive and the other 29% of students there was nothing they struggled with. To questions about what they want to improve in the class, 46% of student answered there should be more time for class while 23% of students answered it would be better to have more time about game making; the other 31% of students did not answer. In reviewing these opinions, elementary school students liked the App Inventor class, especially, collaboration with peers and game making. Nonetheless, they needed more time to learn block programming so that they could digest the considerable amount of content in class. They also thought programming through block was difficult. These facts could produce a negative attitude from students toward the App Inventor

Table 3: THE RESULTS OF COMPARISON OF PRE- AND POST-TEST

Area		Test	*M*	*SD*	*N*	*t*	*p*
Creative problem-solving capability		Pre	3.683	.487	12	-.349	.733
		Post	3.717	.642	12		
sub	D1	Pre	3.833	.637	12	.272	.791
		Post	3.800	.698	12		
	D2	Pre	3.267	.593	12	-1.521	.156
		Post	3.500	.641	12		
	D3	Pre	3.783	.471	12	.244	.812
		Post	3.750	.801	12		
	D4	Pre	3.850	.604	12	.164	.872
		Post	3.817	.716	12		
Self-efficacy		Pre	3.019	.287	12	-.288	.779
		Post	3.051	.270	12		

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class and, finally, could be obstacles for students who want to make their own application or to do activities based on what they learned; therefore, it was not possible to observe any statistically significant difference in creative problem-solving capabilities and sense of self efficiency [23].

4.3 Methods Of Education With App Inventor As Programming Tool In 2015 Revised National Curriculum

The results of this application and previous research have led to the development of an app inventory training method to effectively teach elementary software education in the 2015 revised national curriculum. First, proper time allocation by the level of students is highly recommended. An & Lee (2014) stated that it was possible to institute App Inventor in elementary school in spite of App Inventor's difficulties; however, in this study, it was confirmed that students had difficulty programming with App Inventor [19]. Therefore, it is needed for students to have a personalized class design considering their experience about programming, preliminary knowledge and contents of the class. When designing a class for App Inventor, time for both application design and to assign different attribute to each component is needed. Moreover, considerable amounts of build time are needed to check the result; therefore, proper time allocation is necessary.

Second, it is required to have a class theme. To make an application, a long procedure is inevitable: algorithm design, application design, application programming, building, operation, modification and application are all factors [17]. Therefore, students need time to build applications and operate and modify them on their smart phones. It would be effective to proceed the class by making applications with themes familiar to students, rather than operating every single function of programming [19].

Third, collaboration is essential. Collaboration is the alpha and omega in computer science. In the United States, collaboration is one of the strands of the standards and framework of computer science [2, 3]. In the 2015 revised national curriculum of South Korea, collaboration is one of the most necessary abilities in collaborative problem-solving [2, 3, 4]. Furthermore, numerous students answered that it was great to collaborate with their peers; in advance research, learning motivation is elevated while students cooperate in an LT collaborative class. In this study, component classes were conducted individually while application presentations by team were conducted on a team basis [22]. It would be much more effective to make and operate their application through collaboration.

Above this, although not being compulsory, it would be much more helpful for students to be provided with materials about the content of class. Scratch and App Inventor share the principle of assembling blocks to program; however, in App Inventor, it is necessary to design in Designer and to assign different values to each component [6, 10]. This can lead to a situation where students stop or give up designing an application before they have the interest of developing an application through to programming. To prevent this situation, students should be provided with explanations about the components, the attribute values according to the components, and instructional materials that explain the contents of the classes. In addition, assistants, as well as teachers, can help students to implement more effective education with App Inventor.

5. CONCLUSION

Due to the 2015 revised national curriculum, this study examined the use of App Inventor as a programming language to teach software to elementary students. Through a literature review, an educational program was developed and implemented to create a teaching plan. The following conclusions were drawn.

First, the use of App Inventor in the educational program did not improve the elementary school students' creative problem-solving capabilities and self-efficiency, which differs from advanced research.

Second, the students thought it was interesting to learn App Inventor, but they stated that they needed more class time due to the difficulty of learning block in the App Inventor educational program.

Third, additional class, study, and collaborative study time was needed for the elementary school students to learn App Inventor. App Inventor is different from the other block programming. Therefore, the course plan for programming classes will not be effective in the use of App Inventor. Thus, the following three things should be considered: time and theme of class, collaboration,

However, the study had limitations. First, because the elementary school curriculum did not include computing education, it was difficult to recruit elementary school students who wanted to participate in the research. So, it was difficult to implement an education program using App

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Inventor. Only 20 elementary school students participated in this study. Eight students refused to participate. Therefore, the size of the study is a limitation. The study was small compared to other studies. To verify the effects of research, a follow-up study must apply the App Inventor education program developed in this study to a larger sample of elementary students.

Second, the study participants were students attending elementary schools in Cheongju, South Korea. As the research was conducted on elementary school students in one area, various factors, such as regional differences and socioeconomic factors, were not considered. Therefore, the results cannot be generalized to all elementary school students in Korea. To generalize the results, additional research that considers various factors, such as Students' interest about programming, socioeconomic factors, and region, is necessary. Therefore, it is necessary to carry out research considering these factors. In addition, the results of these studies should be analyzed through a systematic literature review to generalize the impact of the App Inventor training program on elementary school students.

Finally, no control group was included in the study. The study implemented the educational program during the students' vacation period to prevent the computer education program from affecting the students' formal education and to prevent the students from being influenced by education of other subjects. Because it was a vacation period, the students had varied schedules. Therefore, a control group was not obtained. We could not control some factors that affect the usefulness of this program. Therefore, a follow-up study should be conducted with a control group.

This study taught elementary students using the App Inventory education program. Based on the 2015 revised curriculum, block-based programming must be included in elementary and middle school curriculum. Therefore, the App Inventor education program should be implemented in elementary and middle schools to verify its effectiveness. In addition, block-based programming languages vary (e.g., Scratch, Entry, Snap, Code.org, and App Inventor). Many studies analyze the merits of App Inventor in existing research. However, no research has been done to compare its results with other block-based programming languages. Therefore, the differences in the effectiveness of various block-based programming languages educational programs should be studied to identify an educational programming language that meets the requirements of the 2015 revised curriculum and further promote the implementation of computing education. Finally, this study presented the App Inventor education method. Therefore, future studies do not need to develop or verify the effectiveness of educational programs that incorporate these educational methods.

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