

The Analysis on Research Trends in Programming based STEAM Education in Korea

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Abstract

Background/Objectives: In this study, the trends in research of Science, Technology, Engineering, Arts and Mathematics (STEAM) education with programming were systematically analyzed. **Methods/Statistical Analysis:** Theses were collected from Research Information Sharing Service in order to analyze the trends. The keywords used in this process were “STEAM education” and “convergence education”. The collected theses were analyzed by the following standards: the year of publication; the method, design and subject of research; programming language; and physical computing device used. The results from the analysis were compared with the general trend of research in STEAM education. **Findings:** Upon analysis, research on general STEAM education has increased since 2010; however, STEAM education with programming accounts for less than ten percent of that research. In terms of the methods utilized, more than fifty percent used development/application research. The research on STEAM education with programming used qualitative and mixed research more than the general variety, which yielded different results than were compiled with general research on regular STEAM education. The majority of the focus of the general research in STEAM education was on literature, followed by research done by elementary school students, with the latter group providing the majority of the research done in STEAM education with programming. Scratch was used as the programming language in half of the research, while the percentage of searches that did not use physical computing devices was more than a half. The results from this analysis show the general trends in STEAM education and how programming in it has been employed. Furthermore, systematic analysis reveals the implications of programming in STEAM education. **Application/Improvements:** This research could be used to show the trend in research, as well as the direction of the teaching-learning program and educational model development in STEAM education.

Keywords: Convergence Education, Programming Education, Research Trends, STEAM Education, STEAM

1. Introduction

In contemporary society, due to the development of science and technology, a variety of subjects are converged to make a new subject. In addition, the volume of knowledge is now much larger due to its accelerated formation. Consequently, the society and industry have been rapidly changed; however, huge, complicated problems have emerged which cannot be solved with one single subject. For the sake of solving these problems, people who can creatively utilize new knowledge to converge diverse sub-

jects are needed¹. Accordingly, the United States, United Kingdom, Finland and Israel have instituted convergence education to foster creative and convergent human resources². Nevertheless, Korea has not followed this paradigm, since they still stick to education based on single subject. To solve this problem, STEAM education has been introduced to primary and secondary school curriculums to train students to be creative and convergent³. STEAM education is the result of the integration of STEM education, which is performed in the United States and United Kingdom, and art⁴. It fosters convergent think-

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ing, problem solving abilities, and interest in science and technology⁵. STEAM education, contrary to STEM education, is mainly driven by the government, so it has had a lot of short-term expansion through diverse research⁶. However, due to the misunderstanding of STEAM education, unnecessary convergence of subjects, and lack of teachers' expertise, it has been difficult to actually apply it in schools⁷. Accordingly, it is necessary for us to analyze the research trends of STEAM education in order to shed light on the future of STEAM education⁸. Research has been done focusing on childhood, science, technology, gifted-students, and mathematics. However, the research has not been performed based on programming⁸⁻¹³.

In modern society, computer science (robots, big data, and artificial intelligence) has been developed; thus, the integration of diverse fields and computing has been promoted¹⁴⁻¹⁷. Therefore, to foster human resources equipped in the programming capacity, programming education has become more important than before. In the United states, the Computer Science Teachers Association (CSTA) has developed 'CSTA K-12 computer science standards' to create human resources capable of computational thinking and computer scientific literacy, while the United Kingdom has changed the name of subjects involving computers from 'Information and Communication Technology' to 'Computing' and has allowed students from elementary school to high school to get a programming education based on computational thinking¹⁸. Following this trend, Korea has also changed the subject 'information' from an elective one to a compulsory one (in 2015), revised the curriculum, and modified the contents of subjects to include computational thinking, informational thinking, information culture, and collaborative problem solving¹⁹. To promote computational thinking, convergent problem solving is needed²⁰. Nonetheless, the research of STEAM education has not followed the global trend, so there is still a huge lack of research.

In this study, based on programming, the research trend of STEAM education was studied. To figure out the trend, utilizing the academic data base, STEAM education researches have been collected and, on the analysis criteria, the collected data have been analyzed. Furthermore, general STEAM education and programming integrated STEAM education were compared and analyzed. Moreover, the problems in present research and the future of STEAM education are suggested.

2. Related Works

2.1 STEAM Education

STEAM education is a mixture of STEM education and arts, which have different goals. STEM education was adapted to cope with low achievement in math and science, so basically, its purpose is to foster science-technology human resources for multiple industries²¹⁻²⁴.

However, STEAM in Korean education started to become a social and educational need. As science and technology developed, lots of problems could not be solved in a single academic field, so naturally, creative and convergent human resources capable of blending diverse subjects were needed. Thus, STEAM education has been granted more power to create creative and convergent human resources¹. Furthermore, checking the results of the Trends in International Mathematics and Science Study (TIMSS) of Korean students, the academic achievement of Korean students continuously stayed at a high level, while their interest, confidence, and understanding in science were lower than those of the other countries²⁵. STEAM education was demanded to deal with this, with support from the Ministry of education and Korea Foundation for the Advancement of Science and Creativity²⁶.

STEAM education has been defined in different manners by bounteous scholars; however, their definitions commonly include only education to promote convergent thinking, interest in science, and problem solving ability with real life problems²⁷. Meanwhile, Arts in STEAM education means not only drawing or music but also Fine arts, Language arts, Liberal arts, Physical arts, and Practical arts. STEAM education has mainly been driven by the government, and it has accomplished a lot⁸.

2.2 STEAM Education Research Trends Related Works

Kim, Cho and Kim have analyzed research trends in STEAM education of elementary schools to figure out how STEAM education should be applied in early-childhood education. Their research subjects were theses published from 2011 to 2013 in domestic academic journals on STEAM education, which were especially about elementary school students. Their results showed that program development was a main theme, and it was ana-

lyzed in a mixed method. Moreover, science, technology, and arts were major targets of analysis. The upper grade elementary school students were mostly targeted, and their understandings and attitudes were mostly studied¹¹.

Kwon and Ahn have analyzed theses published from 2000 to 2011, from journals of the academies of science and elementary science education, on research criteria, especially about convergence and integration. Examining the results of analysis, the major themes, related to convergence and integration in science education, were intra subject liaison, STS, and integration. The contents were mostly about analysis of effect and their research methods were quantitative, while their research targets were elementary school students¹².

Lee et al. analyzing research trends in integrated education with science, studied fields in science education and integrated education, individually. The theses were published in degree journals and academic journals on analysis criteria¹³.

Han has analyzed trends in development, studying 123 theses in degree and academic journals published from 2011 to 2013, to develop a STEAM teaching-study program in mathematics. Theses mainly targeted elementary school students, and the main subjects of the teaching-study program were science and technology. Geometry (in content) and calculation (in behavior) were at the foremost position, followed by understanding, deduction, and problem solving¹⁰.

Choi et al. have collected theses in five academic journals on technology education for studying the research trends in integrated STEM education, based on technology education. Their results showed that curriculum was the main research theme, and the most preferred number of subjects for integration was four. Quantitative design was mainly adapted, and literature review was a major research method⁹.

Anand Yoo have compared and analyzed researches on STEAM education and STEAM education for gifted children. The number of STEAM education researches has increased by year, and theses on STEAM education were mainly published in technology and general education journals. Elementary school students were a major research subject, and the themes were dominated by the development of programs and analysis of effect. In STEAM education for gifted children, the research theme was similar to that of the general STEAM education, and a program based on science was developed⁸.

3. Research Method

3.1 Research Procedure

To find out how programming is utilized in STEAM education, the literature review was performed, the analysis criteria was developed, and the results were collected from studies. Theses used were extracted from the academic database, and every STEAM education related study was collected. The analysis criteria were modified for the sake of this study. Through reviews of experts, the reliability of this study was achieved.

3.2 Research Data

Research subjects included programming and other general research on STEAM education. Research Information Sharing Service (RISS) from Korea Education and Research Information Service (KERIS) were used to collect theses. The search keywords were 'Convergence education' and 'STEAM education' (in Korea, STEAM education and convergence education are usually the same). Degree theses, poster and conference proceedings, and overlapping theses are excluded (483 out of 740 studies are left.) Theses were published before March 20th, 2015.

3.3 Analysis Criteria

The analysis criteria were modified from that of Kwon and Ahn¹². Their criteria consisted of journal, year, related theme, research methods, design, and subjects. In Kwon and Ahn, since science education related research trends were the focus, journal and related themes were included¹². However, in this study, how programming is applied to STEAM education research was a major target; thus, every STEAM education research were collected, but journal and related theme were cut out. Furthermore, programming language and physical computing devices were included, since, in other advanced researches, those were counted²⁸. Analysis criteria in this study consisted of year of research, research methods, research design, research subject, programming language, and physical computing devices shown in Table 1. The details of the criteria were: year of research from 2010 to 2015 and research methods consisting of analysis of effect, development/application, investigation of condition/awareness, and analysis of theory/contents. Research design consisted of qualita-

tive, quantitative, and mixed method research. Research subjects were elementary, middle school, high school and undergraduate, literature, etc. The original criteria included childhood, teachers, experts, and underprivileged; however, related theses have not been published, so they were out of our scope. The programming language was Scratch, NXT-G, App inventor, Python, Picoblock, Logo, etc. Finally, the physical computing devices were Lego Mindstorms NXT, Hands on sensor, Arduino, Helloboard, Roborobo, Pico cricket and No use. The area and details of analysis criteria are as follows:

Table 1. The analysis criteria

Domain	Detailed criteria
Publication years	2010 2011, 2012, 2013, 2014, 2015
Research methods	analysis of effect, development/application, investigation of condition/awareness, analysis of theory/content
Research designs	quantitative research, qualitative research, mixed method research
Research subjects	elementary school student, middle school student, high school student, undergraduate, literature, etc
Programming language	scratch, NXT-G, app inventor, python, picoblock, logo, etc
Physical computing device	lego Mindstorms NXT, hands on sensor, arduino, helloboard, roborobo, picocricket, no use

Note: Some studies might select for overlapped criteria in research subjects.

4. Result and Discussion

4.1 The Analysis of Publication Years

The result of analysis by year are as follows: The total number of theses on STEAM educations are 483 (5 in 2010, 25 in 2011, 96 in 2012, 160 in 2013, 167 in 2014, and 30 in 2015). In 2015, compared to 2014, the number was reduced; however, from 2010 to 2014, the whole number of theses has increased. The number of STEAM education researches in 2015 is only 30, since only those which had been published before March 30th were counted. Amongst all STEAM education researches, those which were combined with computing (computer science, programming, software, utilizing of application, smart device, digital handbook, game, and physical computing) were included, as follows: 2 in 2010(40%), 9 in 2011(36%), 27

in 2012(28%), 56 in 2013(35%), 68 in 2014(41%), and 14 in 2015(47%). The number of theses which were related to computing covers 40% of the total number of theses published about STEAM education. In addition, except of 2010, from 2011 to 2015, the ratio of theses about computing was augmented. Moreover, STEAM education with programming integrated was analyzed: 1 in 2010(20%), 1 in 2011(4%), 2 in 2012(2%), 8 in 2013(5%), 12 in 2014(7%), and 2 in 2015(7%). Through this result, amongst the total research, the portion of research related to programming was extremely small shown in Table 2.

Consequently, the number of STEAM education programs were augmented, and the ration of research related to programming and computing increased. The reason for this trend was due to software education having been highlighted in Korea. Information, in 2015, revised the curriculum to promote computational thinking through STEAM education and real-life problem solving²⁹. Nevertheless, the insufficient number of programming related researches was a problem. Thus, more research is needed to foster human resources capable of creative and convergent thinking that are equipped with computational thinking, which is the national educational goal.

4.2 The Analysis of Research Methods

Amongst all STEAM education research, the development and application (51%) were most performed which were followed by the analysis of theory/contents (29%), while investigation of condition/awareness (11%) and analysis of effect (9%) were rarely studied. The chronicle lack of the development of educational programs in STEAM education has promoted the research on development and application, and the government has also supported these Jung, Jeon and Lee³⁰. However, it has been quite a long time since the STEAM education was introduced to Korea. Therefore, analysis of effect from developed programs and awareness and attitude of students and teachers should be paid more attention to. The analysis of theory/contents has been continually performed; however, the definition of STEAM education is still unclear, and the test tool on convergent thinking has not been developed. Thus, to solve these problems, research on the essence of STEAM education is highly needed. Examining STEAM education, which was combined with programming, the development/application aspect was as dominant as it was in the total studies (77%). The analysis of content/theory was 12%, the analysis of effect 8%, and inves-

Table 2. The result of analysis of steam education studies by publication years

Number of studies (%)

	2010	2011	2012	2013	2014	2015	Total
Number of STEAM studies with programming	1	1	2	8	12	2	26
	(20)	(4)	(2)	(5)	(7)	(7)	(5)
Number of STEAM studies with computing	2	9	27	56	68	14	176
	(40)	(36)	(28)	(35)	(41)	(47)	(36)
Number of STEAM studies	5	25	96	160	167	30	483
	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Table 3. The result of analysis of steam education studies by research methods

Number of studies (%)

	2010		2011		2012		2013		2014		2015		Total	
Number of STEAM studies with programming														
Analysis of effect	0	(0)	2	(17)	0	(0)	0	(0)	0	(0)	0	(0)	2	(8)
Development/ application	1	(50)	8	(66)	8	(100)	2	(100)	0	(0)	1	(100)	20	(77)
Investigation of condition/awareness	1	(50)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(4)
Analysis of theory/ content	0	(0)	2	(17)	0	(0)	0	(0)	1	(100)	0	(0)	3	(11)
Total	2	(100)	12	(100)	8	(100)	2	(100)	1	(100)	1	(100)	26	(100)
Number of STEAM studies														
Analysis of effect	0	(0)	0	(0)	6	(6)	20	(13)	15	(9)	4	(13)	45	(9)
Development/ application	3	(60)	14	(56)	41	(43)	86	(54)	86	(51)	15	(50)	245	(51)
Investigation of condition/awareness	1	(20)	4	(16)	6	(6)	20	(13)	20	(12)	3	(10)	54	(11)
Analysis of theory/ content	1	(20)	7	(28)	43	(45)	34	(21)	46	(28)	8	(27)	139	(29)
Total	5	(100)	25	(100)	96	(100)	160	(100)	167	(100)	30	(100)	483	(100)

tigation of condition/awareness 4%. The researches of STEAM education, which are integrated with programming, are heavily biased to development and application are shown Table 3. The reason for this is that the number of researches about programming is small, and the development and application of programs have been targeted as main goals.

Compared to the literature, the same result was obtained. In Kim, Cho and Kim(2014) and Kwon and Ahn, the analysis of effect was the major target (especially in Kwon and Ahn, where the portion of development and application was small, contrary to this study)¹¹⁻¹². In Cho et al. the number of literature reviews were huge⁹.

4.3 The Analysis of Research Designs

First of all, the major design of the research of STEAM education was a qualitative one (53%), which was followed by mixed research (30%) and the quantitative method (17%). The research of STEAM education integrated with programming has a similar ratio. In detail, qualitative research covered 12 theses (50%), 10 mixed (38%), and 3 quantitative (12%). Mixed and qualitative research methods were major in both general STEAM education and programming-integrated STEAM education, since the development (which should be studied in qualitative) and application (which should be studied in mixed method) were dominant in both fields. Additionally, analysis in

Table 4. The result of analysis of steam education studies by research designs

Number of studies (%)

	2010	2011	2012	2013	2014	2015	Total
Number of STEAM studies with programming							
Quantitative research	1 (33)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	3 (12)
Qualitative research	1 (33)	5 (41)	2 (50)	1 (50)	0 (0)	1 (50)	13 (50)
Mixed method research	1 (33)	5 (41)	2 (50)	1 (50)	0 (0)	1 (50)	10 (38)
Total	3 (100)	12 (100)	4 (100)	2 (100)	0 (0)	2 (100)	26 (100)
Number of STEAM studies							
Quantitative research	0 (0)	4 (16)	12 (13)	32 (20)	31 (18)	4 (13)	83 (17)
Qualitative research	3 (60)	14 (56)	62 (64)	81 (51)	78 (47)	19 (63)	257 (53)
Mixed method research	2 (40)	7 (28)	22 (23)	47 (29)	58 (35)	7 (23)	143 (30)
Total	5 (100)	25 (100)	96 (100)	160 (100)	167 (100)	30 (100)	483 (100)

Table 5. The result of analysis of steam education studies by research subjects

Number of studies (%)

	2010	2011	2012	2013	2014	2015	Total
Number of STEAM studies with programming							
Elementary school student	1 (50)	8 (57)	7 (88)	1 (50)	1 (100)	1 (100)	19 (68)
Middle school student	0 (0)	1 (7)	0 (0)	1 (50)	0 (0)	0 (0)	2 (7)
High school student	1 (50)	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	2 (7)
Undergraduates	0 (0)	1 (7)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)
Literature	0 (0)	2 (15)	0 (0)	0 (0)	0 (0)	0 (0)	2 (7)
Etc	0 (0)	1 (7)	1 (12)	0 (0)	0 (0)	0 (0)	2 (7)
Total	2 (100)	14 (100)	8 (100)	2 (100)	1 (100)	1 (100)	28 (100)
Number of STEAM studies							
Elementary school student	1 (14)	5 (20)	20 (21)	57 (34)	50 (27)	10 (33)	143 (28)
Middle school student	1 (14)	1 (4)	6 (6)	26 (16)	25 (13)	2 (7)	61 (12)
High school student	2 (29)	1 (4)	9 (9)	12 (7)	17 (9)	1 (3)	42 (8)
Undergraduates	1 (14)	1 (4)	3 (3)	9 (6)	9 (5)	2 (7)	25 (5)
Literature	2 (29)	15 (60)	54 (55)	45 (27)	54 (29)	12 (40)	182 (35)
Etc	0 (0)	2 (8)	6 (6)	17 (10)	31 (17)	3 (10)	59 (12)
Total	7 (100)	25 (100)	98 (100)	166 (100)	186 (100)	30 (100)	512 (100)
	100	100	100	100	100	100	100

theory and contents are performed in the qualitative method is shown in Table 4. Therefore, due to the contents of research, research designs are heavily tilt to the qualitative method. The research education integrated with programming has shown the same result. Examining literature review, both Kim, Cho and Kim and Lee et al. have an analogous structure^{11,13}. Adversely, Kwon and Ahn and Cho et al. have cultivated totally different results^{9,12}.

4.4 The Analysis of Research Subjects

Research subjects are mainly literature (36%), followed by elementary school students (28%), middle school students (12%), etc. (12%), high school students (8%), and undergraduates (5%). In regards to literature, in 2013 and 2014, less than 30% of research was performed; however, in 2011 and 2012, 60% of them were performed and it was 40% in 2015. The reason why literatures are major subjects of research is that the basic research of STEAM education, like the analysis of curriculum, theme, and educational program, for example, are mainly done.

Meanwhile, the elementary school students were a major subject of previous studies. In Korea, pre- service elementary school teachers took courses in every subject. In addition, except for a few schools, almost all subjects in the regular curriculum were taught by only one teacher. Therefore, the limit of curriculum is much less than that of middle school and high school, so it is easy for them to apply STEAM education in their actual class. In the studies of reference³⁰, the difficulty of subject itself was the main obstacle in the application of STEAM education in real schools. Since elementary school curriculums are much easier than that of middle and high school, STEAM education was applied vivaciously in primary education.

The subjects of programming integrated with STEAM education are also mainly elementary school students. Except for them, middle school students cover 7%, high school 7%, literature 7%, undergraduates 4% and etc. 7%. The elementary school students were more studied due to the current curriculum of Korea. In Korea, the 2009 revised curriculum is utilized; however, in middle school and the high school, information subjects where students can learn programming are elective subjects³². Therefore, in most middle schools and high schools, information subjects are not taught. To apply programming-integrated STEAM education in secondary education, the time assigned to the other subjects is heavily needed, but it is hardly possible. However, in the primary educational

field, where practical courses include programming, it is easy to develop and apply STEAM education to the actual class. Additionally, since it is likely that many students have difficulty learning programming, block-based programming language has been frequently applied to STEAM education in elementary schools are shown in Table 5.

Han and Lee have pointed out that many teachers have stated that the development and distribution of STEAM education programs are needed for the smooth adaptation³³. However, the research subjects are excessively biased. Additionally, the lack of programming-integrated STEAM educations can lead to potential problems since, in the 2015 revised curriculum, information subjects were performed often.

4.5 The Analysis of Programming Languages

This study is about STEAM education research trends; thus, programming languages which were used in research were research subjects. The most frequently used language was Scratch (50%), followed by the other programming languages 15%, NXT-G 12%, App inventor 8%, KODU, 4%, Python 4%, Picoblock 4%, and Logo, 4% are shown in Table 6. The other programming languages include the cases where language was not clear and cases which used Arduino. The result is that the major form of programming language are block based programming languages like Scratch, NXT-G and App inventor. The reason why block based programming language was utilized most is due to its research subjects: elementary school students. Elementary school students are not familiar with programming and have lots of difficulty in learning programming language based on text, so a block based programming language was recommended to promote more interest in programming.

The advanced researches show that block programming in STEAM education helped students to have better creativity, problem solving abilities, attitudes, and personalities; however, text based programming languages should be added for improving the educational effect of programming in STEAM education.

Examining programming languages used by year, Scratch was used every year, while Picoblock started to be used in 2010, and it turned out to be integrated with Scratch by that time. Moreover, NXT-G started to be used in 2012 and 2013, and Kodu, Logo, and App inventor

Table 6. The result of analysis of steam education studies by programming language

Number of studies (%)

	Scratch		etc		NXT-G		App inventor		KODU		Python		Picoblock		Logo		total	
Number of studies	13	(50)	4	(15)	3	(12)	2	(7)	1	(4)	1	(4)	1	(4)	1	(4)	26	(100)

Table 7. The result of analysis of programming language in steam education by publication years

Number of studies (%)

	2010		2011		2012		2013		2014		2015		Total	
Logo	0	(0)	0	(0)	0	(0)	0	(0)	1	(8)	0	(0)	1	(4)
Picoblock	1	(100)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(4)
Python	0	(0)	0	(0)	0	(0)	0	(0)	1	(8)	0	(0)	1	(4)
KODU	0	(0)	0	(0)	0	(0)	1	(13)	0	(0)	0	(0)	1	(4)
App inventor	0	(0)	0	(0)	0	(0)	1	(13)	1	(8)	0	(0)	2	(7)
NXT-G	0	(0)	0	(0)	1	(50)	2	(25)	0	(0)	0	(0)	3	(12)
Scratch	0	(0)	1	(100)	1	(50)	3	(37)	7	(59)	1	(50)	13	(50)
Etc	0	(0)	0	(0)	0	(0)	1	(13)	2	(17)	1	(50)	4	(15)
Total	1	(100)	1	(100)	2	(100)	8	(100)	12	(100)	2	(100)	26	(100)

Table 8. The result of analysis of steam education studies by physical computing devices

Number of studies (%)

	Lego Mindstorms NXT		Hands-on sensor		Arduino		Helloboard		Roborobo		Picocricket		No use		Total	
Number of studies	4	(15)	2	(8)	2	(8)	2	(8)	1	(4)	1	(4)	14	(53)	26	(100)

Table 9. The result of analysis of physical computing devices in steam education by publication years

Number of studies (%)

	2010		2011		2012		2013		2014		2015		Total	
Arduino	0	(0)	0	(0)	0	(0)	0	(0)	2	(17)	0	(0)	2	(8)
Hands-on sensor	0	(100)	0	(0)	0	(0)	1	(17)	1	(8)	0	(0)	2	(8)
Helloboard	0	(0)	0	(0)	0	(0)	0	(0)	2	(17)	0	(0)	2	(8)
Lego mindstorms NXT	0	(0)	0	(0)	1	(50)	3	(38)	0	(0)	0	(0)	4	(15)
Picocricket	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(4)
Roborobo	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	1	(50)	1	(4)
No use	0	(0)	1	(100)	1	(50)	4	(50)	7	(58)	1	(50)	14	(53)
Total	1	(100)	1	(100)	2	(100)	8	(100)	12	(100)	2	(100)	26	(100)

started to be used in 2013 in STEAM education is shown in Table 7.

4.6 The Analysis of Physical Computing Devices

Physical computing devices can promote more interest of students by instant feedback and interactive environment while utilized in programming education. Lots of devices like Robot and Arduino were used for this reason. Physical computing devices have become more important in computer education; so many studies for the application of physical computing have been done about robots amongst physical computing devices. This research studied how physical computing was applied in STEAM education research on programming. The result was that more than a half of STEAM education research was not used in physical computing devices. Examining researches which had used physical computing devices, LEGO Mindstorms NXT was used most. Hands-on sensor, Arduino, Helloboard, and Roborobo followed 8%, and Picocricet was the last, at 4% is shown in Table 8. Teachers can benefit from using physical computing devices and, in the 2015 revised curriculum, the use of physical computing devices started to be introduced in information subjects; nevertheless, more than half of studies have shown that physical computing devices were not used. Therefore, it is highly recommended to study physical computing devices for the effective application of STEAM education.

Analyzing by years, in 2010, Picocricet was used; and in 2012 and 2013, the number of researches where LEGO Mindstorms NXT was a dominant physical computing devices increased. From 2013, Hands-on sensor started to be used, and from 2014, Arduino, Helloboard, and Roborobo started to be used. The diversity of physical computing devices used in research has improved is shown in Table 9.

5. Conclusion

In Korea, STEAM education was presented in 2010. In this study, how programming in STEAM education is utilized was analyzed, as the importance of software is much bigger than before. For revealing the research trends in STEAM education integrated with programming, STEAM education theses were collected and analyzed on analysis criteria. Comparing and study-

ing general STEAM education and STEAM education integrated with programming, the following conclusion emerged: First, the research of STEAM education integrated with programming were few. The number of research on STEAM education has increased from 2010, and the research on STEAM education integrated with computing occupied 40%; however, only 5% of research was about STEAM education integrated with programming. Second, research on STEAM education was mainly about development and application. Examining the contents of STEAM education integrated with programming, development/application were dominant and analysis of effect, investigation of condition/awareness and analysis of theory/contents were rare. The contents of research on STEAM education had been excessively biased, so its research design was also biased to the qualitative and mixed structures.

Third, elementary school students were the main research subjects in STEAM education integrated with programming. In the previous curriculum, information subjects were electives, so it was unlikely to have many classes in middle and high school, while, in elementary school, it was relatively possible, since practical classes include some contents of programming; therefore, elementary school students were preferred to middle and high school students as research subjects. Naturally, the programming language was also a block based language, which is appropriate for teaching elementary school students and middle school students.

Lastly, the number of researches on STEAM education which used physical computing devices was much less than that which did not use physical computing devices. The physical computing devices are a useful tool to promote the interest and problem solving ability of students, since it provides instant feedback and an interactive environment; however, more than half of researches have shown that physical computing devices were not used and, in the case where physical computing devices were used, the most preferred device was LEGO Mindstorms NXT.

Consequently, the researches on STEAM education integrated with programming have shown their heavily biased research subjects, method, design and programming languages. Studying with symmetry amongst diverse research subjects, contents, and design is needed to foster creative and convergent human resources; furthermore, the lack of STEAM education integrated with programming in real schools could be an obstacle in spreading

STEAM education and programming education, also. Therefore, researches on STEAM education integrated with programming should be done more frequently, and in a diverse manner.

This study only gathers the research trend from 2010 to 2015. It is impossible to assure the research trend in 2015, since theses were collected only until March 30th, 2015. Additionally, the international academic research on STEAM education has not been done yet. In spite of these limits, every STEAM education research in Korea, where STEAM education was born and done most vividly, was collected and analyzed for analysis criteria. Thus, it is possible to say this study could tell the research trend of STEAM education, be made use of for the development or theory/application of STEAM education programs, and shed light on the future of STEAM education. Moreover, it is believed that the present situation and the future of research in programming and computing in STEAM education is becoming more important, as software becomes one of the most significant factors in education.

6. References

- Kim W. Building conceptual framework to bring up talents capable of creative fusion: From the perspective of fusion between science and technology and art. *The Journal of the Korean Society for the Gifted and Talented*. 2012 Apr; 11(1):97-119.
- Kim J. STEAM Education. Paju: Yangseowon; 2012.
- Park H, Kim Y, Noh S, Lee J, Jeong J, Choi Y, Han H, Baek Y. Components of 4C-STEAM education and a checklist for the instructional design. *Journal of Learner-Centered Curriculum and Instruction*. 2012 Dec; 12(4):533-57.
- Kim J. A cubic model for STEAM education. *Korean Technology Education Association*. 2011 Aug; 11(2):124-39.
- Baek Y, Park H, Kim Y, Noh S, Park J, Lee J, Jeong J, Choi Y, Han H. STEAM education in Korea. *Journal of Learner-Centered Curriculum and Instruction*. 2011 Apr; 11(4):149-71.
- A comparative study on the STEM education policy in the united states and the STEAM education policy in Korea. 2016. Available from: <http://library.chonnam.ac.kr>
- Lim Y. Problems and ways to improve Korean STEAM education based on integrated curriculum. *The Journal of Elementary Education*. 2012 Nov; 25(4):53-80.
- An H, Yoo M. Analysis of research trends in STEAM education for the gifted. *Journal of Gifted/Talented Education*. 2015 Jul; 25(3):401-20.
- Cho J, Choi Y, Lee S, Kim Y. The analysis on research trend of domestic and foreign integrated and STEM curriculum. *Korean Technology Education Association*. 2011 Dec; 11(1):210-27.
- Han H. The analysis of research trends on STEAM instructional program and the development of mathematics-centered STEAM instructional program. *Communications of Mathematical Education*. 2013 Nov; 27(4):523-45.
- Kim M, Cho H, Kim D. An analysis of the status of the unifying Science, Technology, Engineering, Arts and Math education method known as STEAM in domestic primary schools with a view to the direction of early childhood education. *Journal of Early Childhood Education*. 2014 Aug; 34(4):139-61.
- Kwon N, Ahn J. The analysis on domestic research trends for convergence and integrated science education. *Journal of the Korean Association for Research in Science Education*. 2012 Apr; 32(2):265-78.
- Lee H, Kwon Y, Kim S, Son S, Han W, Park B, Jeon J. An analysis of the trends of domestic research related to integrated education in science. *Journal of Research in Curriculum and Instruction*. 2014 Jun; 18(2):295-319.
- Gross M. The unstoppable march of the machines. *Current Biology*. 2015 Mar; 25(7): 255-8.
- Melekhova A, Vinnikov V. Cloud and grid. Part I: Difference and convergence. *Indian Journal of Science and Technology*. 2015 Nov; 8(29):1-10.
- Puri GD, Haritha D. Survey big data analytics, applications and privacy concerns. *Indian Journal of Science and Technology*. 2016 May; 9(17):1-8.
- Bhatia MPS, Kumar A, Beniwal R. Ontologies for software engineering: Past, present and future. *Indian Journal of Science and Technology*. 2016 Mar; 9(9):1-16
- Sung J, Kim H. Analysis on the international comparison of computer education in schools. *The Journal of Korean Association of Computer Education*. 2015 Jan; 18(1):45-54.
- The school curriculum of the Republic of Korea (Publication no #2015-74). 2016. Available from: <http://www.ncic.re.kr/nation.kri.org4.inventoryList.do>
- Jeon Y, Kim T. The understanding of software education by the analysis of international trends. *Proceedings of the Korean Association of Computer Education; Korea*. 2014. p. 137-42.
- Brown R, Brown J, Reardon K, Merrill C. Understanding STEM: Current perceptions. *Technology and Engineering Teacher*. 2011 Mar; 70(6):5-9.
- Merrill C, Daughy J. STEM education and leadership: A mathematics and science partnership approach. *Journal of Technology Education*. 2010 Apr; 21(2):21-34.
- Sanders M. STEM, STEM education, STEM mania. *The Technology Teacher*. 2009 Jan; 68(4):20-6.

24. Zollman A. Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics*. 2012 Jan; 112(1):12-9.
25. Dong H, Lee I, Shin J. Characteristics of science achievement of Korean students in TIMSS 2011 and NAEA 2011. *Journal of Educational Evaluation*. 2013 Dec; 26(5):1091-114.
26. Kim J, Ando K. Possibilities and prospects of STEAM education based on the convergence of science and art: Principles of STEAM education in Korea and designing its practices. *Art Education Research Review*. 2013 Apr; 27(1):123-52.
27. Kim SW, Lee Y. The analysis on research trends for STEAM education in Korea. *Proceedings of EdMedia: World Conference on Educational Media and Technology*; Canada. 2015. p. 1797-802.
28. Ahn S, Seo Y, Lee Y. A review and synthesis of research in educational programming language. *Proceedings of the Korean Society of Computer Information Conference*; Korea. 2012. p. 139-42.
29. Lee E, Kim K. Research and policy issues for supporting implementation of informatics curriculum revised 2015. *Proceedings of the Korean Association of Computer Education*; Korea. 2015. p. 3-7.
30. Jung J, Jeon J, Lee H. Domestic and international experts perception of policy and direction on STEAM education. *Journal of Science education*. 2015 Dec; 39(3):358-75.
31. Geum Y, Bae S. The recognition and needs of elementary school teachers about STEAM education. *The Journal of Korean Institute of Industrial Education*. 2012 Sep; 37(2):57-75.
32. The school curriculum of the republic of Korea (MEST Publication No. #2008-160). 2016. Available from: <http://ncic.kice.re.kr>
33. Han H, Lee H. A study on the teachers' perceptions and needs of STEAM education. *Journal of Learner-Centered Curriculum and Instruction*. 2012 Sep; 12(3):573-603.