Challenges and Perspectives of CS Education for Enhancing ICT Literacy and Computational Thinking in Korea

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Abstract

Objectives: The purpose of study is to suggest challenges and perspectives of Korean Computer Science education to overcome issues revealed in the result of International Computer and Information Literacy Study 2013. Methods/Statistical Analysis: We analyzed the educational contents and achievement standards suggested in the national curriculum of the United States, the United Kingdom, and Republic of Korea, based on 7 aspects of ICILS 2013 assessment framework and 7 computational thinking components. In addition, this study identified common elements and differences by analyzing teaching and learning strategies, including assessment methods, to accomplish the goals and achievement standard of CS education suggested in their curriculum. Findings: The results of the analysis showed that the Korean curriculum did not include enough contents about ‘Sharing information’ and ‘Creating information’ among ICILS assessment items in the aspect of educational contents and achievement standard, and also did not include ‘parallelization’ item among CT components. Moreover, compared with the US and UK curriculum, it turned out that Korean curriculum comparatively had smaller number of concrete achievement standards. Improvements/Applications: To prepare the smooth application of a new curriculum in Korea, policy efforts for the development and distribution of various teaching and learning materials are considered necessary.

Keywords: Computational Thinking, CS Education, ICT Literacy, ICILS

1. Introduction

During the past 20 years, ICT literacy has been regarded as an essential competency for all the people in modern and future societies. All the countries of the world have already recognized the importance of ICT literacy education and are preparing various support measures, forecasting that ICT literacy education will greatly affect not only the academic achievement of the students, but also their future occupations.

Based on such international attention, the International Computer and Information Literacy Study (ICILS), the first international comparative assessment on the ICT literacy of students, was conducted in 2013. According to the results of ICILS 2013, the Computer And Information Literacy (CIL) of Korean middle school students were ranked at the higher level, the 5th among 14 participating countries, but there was the highest percent of the lowest level students among top 5 performing countries, and the largest gap between the male and female students among the participating countries. The result of ICILS also showed that the infra level support of learning in Korean schools was lower than other participating countries, which is in contrast to the result of the ICT development index survey conducted by International Telecommunications Union (ITU) in 2012, where Korea ranked first among 157 countries.

Recently, the importance of Computational Thinking (CT), as well as ICT literacy, is being highlighted all over the world as core competencies that learners must learn.
to live in the 21st knowledge information society. CT, which means the thinking ability to see the problems from a computational perspective and solve them effectively and efficiently, is a core competency that all young students must learn in order to effectively participate in a future digital world and prepare for their future jobs. Therefore, many European countries, as well as the United States (US) and the United Kingdom (UK), are revising Computer Science (CS) curriculum to enhance the CT skills of elementary and middle school students, as well as conducting various policy measures and researches to support CT enhancement.

In line with this trend, Rep. of Korea recently recognized the importance of CS education and revised the national curriculum for the enhancement of the ICT literacy and CT of elementary and middle school students, seeking various ways for support. The 2015 revised curriculum will be applied to the first year middle school and high school students in 2018. This is a point in time when the ways of CS education improvement and support need to be discussed to overcome the problems in Korean education system revealed in the ICILS 2013 results and to enhance CT, which is being highlighted as a core competency in future world.

The aim of this research is to suggest the challenges and perspectives for Korean CS education system improvement. In particular, this study will discuss the improvement of educational contents and the achievement standard for the enhancement of ICT literacy and CT, including the major issues and methods for the improvement of teaching and learning strategies as well as assessment methods. For this purpose, this study first identified the current situation and issues of Korean CS education through an analysis of the major results of ICILS 2013 and conducted a comparative analysis of the trends of CS education in the US and the UK.

2. Backgrounds

2.1 Trends and Issues of CS Education: Computational Thinking

Unlike the past when emphasis was placed on the instrumental use of ICT, the emphasis is recently more and more placed on the application of problem-solving methods according to the fundamental concepts, principles, and perspectives of CS to our daily lives and various fields of study. Accordingly, the necessity of CT education to cultivate the thinking ability of the students to solve problems, design systems, or understand human behaviors according the fundamental concepts, principles, and perspectives of CS is being emphasized. For systematic CT education in elementary and middle schools, countries all over the world are revising and applying national school curriculum, and the US, the UK, and Korea are playing the leading role. Table 1 shows the current state and characteristics of the CS education of the countries that are focusing on CT.

As described in Table 1 above, after developing a standard CS curriculum for K-12 students in 2006 for the first time, the US suggested a revised CS standard in 2011, and more than 30 states are now operating CS after designating it as a mandatory subject in 2014. The UK changed the name of ICT subject to Computing in the national curriculum revised in 2013, and is now operating it as

| Country | Current State of CS Education |
|---------|-----------------------------|
| US      | - Development of K-12 Computer Science Standards by Computer Science Teachers Association (CSTA) 4  |
|         | - Development of Exploring Computer Science(ECS) Professional Development Model 5,6 |
|         | - Training of CS teachers through CS 10K project |
|         | - Promoting mandatory CS education by high schools in many states |
|         | - Operating government-led ‘Computer Science education week’ |
| UK      | - Carrying out Computing education for all school level students (aged 5–16) since 2014 7,8 |
|         | - Changed from ICT education focused on the use of application software to CS education focused on CT 2 |
| Israel  | - Operating CS as a high school regular subject since 1994 10 |
|         | - Pilot operation of CS in middle schools since 2010 11 |
| Estonia | - Expansion of government-led programming and CT education through the ‘Proge Tiger’ program in 2012 12 |
| Korea  | - CS education made mandatory in elementary and middle schools through the revised 2015 curriculum 2 |
|         | - Mandatory operation of Informatics subject in middle schools beginning in 2018 2 |
mandatory subject since 2014. Israel has been operating CS as a regular subject in high school for a longer period than other countries, and it is also operating CS as a regular subject in middle school since 2010. Estonia, which recently emerged as an IT power, is actively making efforts to expand the programming education under the leadership of the government. Korea also recognized the importance of ICT literacy and CT education at an earlier time and made efforts for improvement of systematic national curriculum but the opportunity for Korea students to receive ICT or CS education in their schools significantly decreased because CS was not listed in mandatory subjects. Such lack of CS education opportunity consequently brought the negative result in ICILS 2013. To solve this problem, Korea revised Informatics to a CT-focused subject in the national curriculum revised in 2015, and made elementary and middle schools operate it as a mandatory subject. The Informatics curriculum revised in 2015 will be applied to the first year middle school students in 2018.

2.2 Important Results and Implications of ICILS 2013

In ICILS 2013 carried out in 2013, CIL of 8th grade students (middle school 2nd graders) was measured. The ICILS 2013 fundamental knowledge assessment framework is composed of Strand and Aspect\textsuperscript{13,14}. Strand 1 is to assess students’ capabilities to collect and manage information including basic knowledge and skills related to the use of computers and it is composed of Aspect 1.1 Knowing about and understanding computer use, 1.2 Accessing and evaluation information and 1.3 Managing information. Strand 2 is to assess the ability to use computers as a tool for thinking, creation and communication, and it is composed of Aspect 2.1 Transforming information, 2.2 Creating information, 2.3 Sharing information and 2.4 using information safely and securely\textsuperscript{13,14}.

According to the assessment results for students’ CIL under ICILS 2013, Czech Republic (553), Australia (542), Poland (537), Norway (537) and Korea (536) ranked high among 14 participating countries\textsuperscript{13,14}. There are no statistically significant differences in the mean scores for CIL of the 2nd to 5th ranked countries\textsuperscript{13,14}, which means that students of these 4 countries have a similar level of CIL. In\textsuperscript{14} researchers calculated the percent of correct answers about 5 high-ranking countries under ICILS 2013 by CIL assessment aspects\textsuperscript{13,14}. The results are shown in Table 2.

With regard to the ratios of correct answers for each CIL assessment aspects in ICILS 2013 average, the ratio of correct answers for 1.1 among 7 aspects showed the highest value of 63.3%. The other 6 assessment aspects except 1.1 in assessment framework are related with the utilization of information. The mean ratio of correct answers for Aspect 2.4 among information-related assessment aspects showed the highest value of 51.1%, and mean ratio of correct answers for 1.2 showed the lowest value of 28.2%. Most aspects showed the ratio of correct answers less than 50.0%. In other words, more than half the students of all participating countries fail to properly respond to information-related items. These results mean that students have more knowledge about the use of computer rather than the use of information.

In the ratios of correct answers by assessment aspects of high-ranking 5 countries, Korean students were found to be weaker to the assessment aspects related with Strand 2 than Strand 1. In particular, the ratios of correct answers for 2.1, 2.2 and 2.3 were low, compared with other 4 countries\textsuperscript{13}. Looking at the contents of Korean education about these 3 aspects to which Korean students were found to be weaker, around the 2009 revised contents of Informatics curriculum that is currently applied in Korea, none of the

| Aspect | Czech Rep. | Australia | Poland | Norway | Korea, Rep. of | ICILS 2013 average |
|--------|------------|-----------|--------|--------|----------------|-------------------|
| 1.1    | 71.0       | 75.7      | 68.4   | 75.8   | 75.6           | 63.3              |
| 1.2    | 40.1       | 40.3      | 38.8   | 38.1   | 40.2           | 28.2              |
| 1.3    | 45.4       | 50.0      | 49.5   | 52.7   | 52.9           | 42.6              |
| 2.1    | 59.0       | 51.0      | 49.8   | 50.5   | 49.3           | 38.7              |
| 2.2    | 71.4       | 59.1      | 63.4   | 57.9   | 57.8           | 43.1              |
| 2.3    | 54.1       | 58.1      | 55.3   | 54.4   | 53.1           | 42.3              |
| 2.4    | 59.9       | 58.9      | 61.0   | 59.4   | 63.4           | 51.1              |
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In contrast, Aspect 1.1, 1.3 and 2.4 with the high ratios of correct answers are intensively handled by current Korean curriculum shown in Table 3. Through a comparison of ICILS 2013 assessment framework and current curriculum and a research on 2015 revised Informatics curriculum that will be effective from 2018, it was identified that the aspects of ICILS 2013 framework, which were not handled before, are reflected shown in Table 3.

### 3. Methods

#### 3.1 Research Procedures

To identify the global trends and objectives of CS education, this study conducted an analysis of preceding researches on ICT literacy and CT. In addition, to suggest the challenges and perspectives of Korean elementary and middle school CS education to enhance Korean students’ ICT literacy and CT, this study conducted a comparative analysis of the educational contents, achievement standards, teaching and learning strategies, and assessment methods of the national CS curriculum of the US, the UK, and Korea.

#### 3.2 Analysis Subjects and Framework

The analysis subjects were CSTA K-12 Computer Science standards revised in 2011 of the US, the national curriculum for Computing of the UK, and the 2015 revised national curriculum for Informatics of Korea.

To identify whether the educational contents, achievement standards, teaching and learning strategies and assessment methods suggested in each curriculum are helpful to the enhancement of ICT literacy and CT, this study selected strands and aspects of ICILS assessment framework and 7 components of CT from CSTA and the International Society for Technology in Education (ISTE) as analysis standards.

In ICILS 2013, the CIL of the second-year middle school students (aged 14) of 14 countries was assessed, analyzed and compared. As previously described, the assessment framework developed for CIL assessment of the students in ICILS 2013 is composed of 2 strands and each strand has subcomponents about ICT literacy and CT. The assessment framework for international assessment was developed with the consent of all participating countries, and it can be used as a framework for comparative analysis of the curriculum in this study.

Though not included in ICILS 2013 assessment framework, the enhancement of CT is emphasized in all the curricula of analysis countries, and it can be used as a framework for comparative analysis of the curriculum in this study.

### Table 3. ICILS 2013 assessment framework and informatics curriculum of Korea

| ICILS 2013 Assessment framework | Informatics curriculum of Korea |
|--------------------------------|--------------------------------|
| Strand                        | 2009 Revised                  | 2015 Revised                  |
| 1. Collecting and managing information | 1.1 Knowing about and understanding computer use | Architecture and Operation of Computer |
|                                | 1.2 Accessing and evaluation information | N/A | Information Society and Culture |
|                                | 1.3 Managing information | Information Representation and Management | Data and Information |
| 2. Producing and exchanging information | 2.1 Transforming information | N/A | Data and Information |
|                                | 2.2 Creating information | N/A | Data and Information |
|                                | 2.3 Sharing information | N/A | Data and Information |
|                                | 2.4 Using information safely and securely | Computer Science and Information Ethics | Information Society and Culture |

3 aspects is not handled in Korean education curriculum.
in connection with the achievement standard according to the analysis standard, and identify the similarities and differences.

4. Results

4.1 Contents and Achievement Standards

Table 4 show the classification of the achievement standard of ‘CS standards level 2 (grades 6–9)’ suggested by CSTA of the US according to the ICILS assessment framework and CT components. Looking at the result in more detail, the level 2 students subject in CSTA were supposed to achieve all the components required by ICILS assessment framework, but they had a relatively small number of standards in ‘Managing Information’ than other components. It also turned out that it included all the CT components, but the statement of achievement standard was mostly concentrated in ‘Algorithm and Procedure’ component. The uniqueness of the US CSTA standards different from other national curriculums is that it emphasizes the effect of CS on future society, career, economy,

| Standard Code* | ICILS 2013 Assessment Framework | CT Components |
|---------------|---------------------------------|---------------|
|               | Strand 1 | Strand 2 | Data collection, analysis, and representation | Problem decomposition | Abstraction | Algorithms & Procedures | Automation | Simulation | Parallelization |
| CT.L2-01      |        |        | √ | √ | |
| CT.L2-02      |        |        | | | √ |
| CT.L2-03      |        |        | | | √ |
| CT.L2-04      |        |        | | | √ |
| CT.L2-05      |        |        | | | √ |
| CT.L2-06      |        |        | | | √ |
| CT.L2-07      |        |        | √ | √ | √ |
| CT.L2-08      |        |        | √ | | √ |
| CT.L2-09      |        |        | | | √ |
| CT.L2-10      |        |        | | | √ |
| CT.L2-11      |        |        | | | | |
| CT.L2-12      |        |        | √ | √ | |
| CT.L2-13      |        |        | | | √ |
| CT.L2-14      |        |        | | | | |
| CT.L2-15      |        |        | | | | |
| CL.L2-01      | √ | √ | |
| CL.L2-02      | √ | √ | √ |
| CL.L2-03      | √ | √ | √ |
| CL.L2-04      | √ | √ | √ |
| CPP.L2-01     | √ | | |

Table 4. CSTA K-12 computer science standards for level 2 (Grades 6-9) in US: Mapped to ICILS 2013 assessment framework and CT components
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Table 5 shows the classification of the achievement standard of the national curriculum for Computing for key stage 3 (ages 11-14) in the UK according to ICILS assessment framework and CT components. Like the US, the UK curriculum included most of the components of ICILS assessment framework, but it does not deal with ‘Managing Information’ component in detail, and it never deals with the ‘Simulation’ and ‘Parallelization’ components among the CT components. The uniqueness of the UK curriculum different from other countries is that it includes the concept on binary numbers and Boolean logic as well as the ability to use them for circuit composition and programming.

Table 6 shows the analysis result of the achievement standard for Korea’s 2015 revised national Informatics curriculum for middle school. What is noteworthy is that it does not deal with ‘Creating information’ and ‘Sharing information’ among ICILS assessment framework. It does not cover the ‘Parallelization’ component among the CT components.

### 4.2 Teaching and Learning Strategies and Assessment Methods

The teaching and learning strategies and assessment methods related with the achievement standard suggested by each curriculum was analyzed, and their similarities and differences were identified in this study. Table 7 shows the analysis results of teaching and learning activities of level 1 (grades K-6) and level 2 (grades 6-9) suggested CSTA K-12 standards of the US. Both the teaching and learning strategies and assessment methods suggested in level 1 and level 2 activities suggest various classroom activities (play, card game, worksheet completion, etc.) that do not use computers, as well as collaborative activities performed in groups or pairs. Most of the
### Table 5. The national curriculum for computing for key stage 3 (ages 11–14) in UK: Mapped to ICILS 2013 assessment framework and CT components

| Standard | ICILS 2013 Assessment Framework | CT Components |
|----------|----------------------------------|---------------|
|          | Strand 1                         | Strand 2      |
| **Strand*** | Description                      |               |
| CS       | Design, use and evaluate computational abstractions | √ | √ |
|          | Understand several key algorithms that reflect computational thinking |               | √ |
|          | **eUs two or more** programming languages to solve a variety of computational problems | √ | √ | √ | √ | √ | √ |
|          | Understand simple Boolean logic and some of its uses in circuits and programming |               |               |
|          | Understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems | √ |               |
|          | Understand how instructions are stored and executed within a computer system | √ |               | √ | √ | √ |
| IT       | Undertake creative projects that involve selecting, using, and combining multiple applications to achieve challenging goals | √ | √ |               | √ | √ | √ |
|          | Create, re-use, revise and re-purpose digital artefacts for a given audience | √ |               |               |               | | |
| DL       | Understand a range of ways to use technology safely, respectfully, responsibly and securely |               | √ | √ |               |               | | |
| **Total # of standards** | 4 | 1 | 0 | 1 | 2 | 1 | 1 | 4 | 1 | 2 | 2 | 2 | 0 | 0 |

* CS: Computer Science; IT: Information Technology; DL: Digital Literacy
### Table 6. 2015 revised national informatics curriculum for middle school (Grades 7–9) in Korea: Mapped to ICILS 2013 assessment framework and CT components

| Standard | ICLS 2013 Assessment Framework | CT Components |
|----------|-------------------------------|---------------|
|          | Strand 1 | Strand 2 | |
| Strand   | Description | | |
| IC       | Analyze the value and effect of the development of information technology and software on individual lives and society, understand the characteristics of relevant jobs, and explore careers suitable for one's aptitude. | | |
|          | Recognize the importance of the protection of personal information and copyright as a member of information society, and practice the method of personal information and copyright protection. | | √ |
|          | Understand the necessity of cyber ethics that should be adhered to by every individual in an information society, and practice the method of preventing cyber violence, including game, Internet, and smartphone addiction. | | √ |
| DI       | Understand the properties and characteristics of digital information, and express the data and information expressed in various forms in the real world and in digital forms. | | √ |
|          | Collect and manage the data for problem-solving using the Internet and application software, etc. | √ | √ | √ |
|          | Express real-world information by structuring it in various forms, such as table and diagram. | | √ |
| PP | Understand the current state and goal state of a problem in a real-world problematic situation and analyze the work that should be performed to achieve the goal state. | √ | |
| PP | Classify necessary and unnecessary elements for problem-solving. | √ | |
| PP | Understand the meaning and importance of algorithm, a logical problem-solving procedure, and draw up an algorithmic real-world problem-solving procedure. | √ | |
| PP | Explore and clearly express various methods and procedures for problem-solving. | √ | |
| PP | Understand the development environment and characteristics of the programming language to be used. | √ | √ | |
| PP | Create a program for input, processing, and output of the data in various forms. | √ | √ | |
| PP | Understand the concept of a variable and create a program using variables and operators. | √ | |
| PP | Understand the concept and principle of sequence, selection, and repetition, and create a program using those three structures. | √ | √ | √ | √ | √ | |
| PP | Design, develop, compare, and analyze the software for real-world problem-solving through collaboration. | √ | |
| CS | Understand the role of hardware and software, composing a computing system and analyzing their interrelationship. | | √ | |
| CS | Implement the data processing and motion control program using sensors. | √ | √ | √ | √ | √ | √ | √ |

| Total # of standards | 8 | 1 | 1 | 2 | 0 | 0 | 2 | 2 | 2 | 3 | 4 | 5 | 3 | 0 |

* IC: Information Society and Culture; DI: Data and Information; PP: Problem Solving and Programming; CS: Computing System
| Level    | Activity                                      | Topics                                                                 | Teaching and Learning Strategies                          | Assessment                                      |
|----------|-----------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------|
| Level 1  | A mystery play                                | Understand of basic logic ideas and its use to solve real-world problems | The play activity                                          | Discussion                                     |
|          | Battleships                                   | Basic understanding of a search algorithm                              | The card game                                              | Discussion                                     |
|          | Beat the clock                                | Understand how to sort data and information                           | The outdoor group activity                                 | Results assessment                             |
|          | Color by numbers                              | Using 0s and 1s to represent information                               | Worksheet coloring activity                                | Worksheet activity                             |
|          | Dancing Cat                                   | Recognize that software is created for controlling computer operations sequentially | Teacher models the activity Students build their own project | Describe projects and process Evaluation by peers Discussion |
|          | Ice cream stand                               | Understanding how to use the graph to represent problem states and solutions | Placing the stands for solutions                           | Discuss different strategies Evaluate each other's solutions |
|          | The orange game                               | Simple algorithms for network routing                                 | The group activity                                          | Achieving goal                                 |
| Level 2  | Connections inside and out                    | Understand the computer organization and networks                     | Watch the Video Complete worksheets and share information to the online Review and discuss | Evaluate worksheets Test                       |
|          | Culturally situated design tools-weaving      | Create the connection between mathematics and CS components           | Group create designs and deliver presentations             | Assessment of projects and work as a team      |
|          | Compare open source software with commercial software | The comparison of open source productivity software with its commercial counterparts | Complete a given task create a report on similarities and differences between commercial and open source software | Report Group discussion                       |
|          | Number systems                                | The connection between elements of mathematics and CS                  | Watch Video Activity with 8 penny or fingers Complete conversion exercises | Formative assessment of quiz Summative assessment of conversion exercises |
|          | Pass-it-on                                    | Collaborate with others using practices Design, develop, publish, and present products using technology resources | Complete pass-it-on projects collaboratively               | The closing discussion The pass-it-on Scratch projects : self-evaluation, peer-evaluation, and instructor-evaluation |
|          | Setting up a computer                         | Understand the computer organization and major components             | Complete tasks to set up computer system                   | Assess Student-created checklists Discussion and observation |
assessment activities are also composed of the assessment of the achievement process through group discussions or observations, and the assessment of the outcomes such as completed projects, works, and worksheets. The difference between level 1 and level 2 is that level 1 activities try to teach the students the basic concept of CS through simple games or classroom activities considering that the students are very young, but level 2 activities focus on the project performance or design and production activities using technologies.

Like those of the US, the teaching and learning strategies of the UK are also focusing on ‘computing without computers’ activities and ‘teaching programming’ activities. In most of the existing ICT class, computers were used. However, the basic concept and principle of computing can be clearly taught to the students, even without using computers, through various activities that can be reinforced through the actual use of computers in the future. The resources that can participate in such non-computer based tasks are provided by CS Unplugged (see www.csunplugged.org) and CS4FN (see www.cs4fn.org). The computing curriculum of the UK emphasizes the programming education, but its real purpose is not to teach students to become professional programmers. The UK considers it important to teach the students how to find and correct mistakes that may occur during the programming process. Therefore, the teacher’s support strategy in the stages of code debugging and testing that the learners experience in the process of programming is being emphasized. In addition, rubber duck debugging (see www.c2.com/cgi/wiki?RubberDucking) is suggested as a programming learning strategy.

As an assessment strategy, the use of ‘Assessment For Learning (AFL)’ techniques was suggested to solve such problems as how to assess the contribution of individual students in collaborative activities and how to assess the artifacts of individual students in each different form. For example, self-assessment was suggested as an efficient method of assessing the digital creations of individual students, and peer assessment was suggested as a method of assessing digital artifacts created through collaboration with other students. The examples of testing method using machine assessment were also suggested.

Table 8 shows the characteristics of the teaching and learning strategies and assessment methods suggested in the Korean curriculum. What is noteworthy in the Korean curriculum is that it defines the subject core competency and provides the goal, achievement standard, as well as the teaching and learning strategies and assessment methods for subject education. As such, teaching and learning strategies and assessment methods to enhance ICT literacy, the use of case study, discussion, and worksheet are suggested, and assessment through observation by teachers and peers using checklists is also suggested. As teaching and learning strategies and assessment methods to enhance CT, students are encouraged to learn the basic concept and principle of CS using play, games, or puzzles, and to design, organize, and program specific artifacts for themselves collaboratively through discussion, team projects, and pair programming. The artifacts created by the students are comprehensively assessed through rubrics, task assessment, summative assessment, etc.

5. Discussion and Conclusions

In ICILS 2013, the ICT literacy of Korean middle school students showed higher level, but there was a large gap.
between the higher-level and lower-level students, and between male and female students. In addition, the frequency of computer use for learning in schools showed comparatively lower value than other participating countries\textsuperscript{1,2}. Accordingly, educational and political efforts are considered necessary in order to solve such problems, to increase the frequency of ICT use for learning, and to enhance CT ability, as well as the ICT literacy. This study tried to suggest a method of CS education development for the enhancement of ICT literacy and CT of Korean students. For this reason, this study conducted a comparative analysis of the current state of Korean CS education with that of the US and the UK. The challenges and perspectives of the issues discovered as the result of analysis are as follows:

First, the comparison of educational contents and achievement standard with the ICILS 2013 assessment framework showed that both the US and the UK had insufficient educational contents regarding ‘managing information’, while Korea lacked in the educational contents regarding ‘sharing information’ and ‘creating information’. The ability to create new information and share it with the online community is one of the major elements of the ICILS 2013 assessment framework, and it is also one of the core competencies that people must have in a modern society represented by the online community. So, relevant contents need to be included in the middle school curriculum.

With regard to CT, the contents of the Korean curriculum include all the components, except ‘parallelization’, among CT components established as analysis standards, but compared with the US and UK curriculum, the number of achievement standards is comparatively smaller, and their contents have not been specified. This is the problem caused by the insufficient number of class hours in the Korean curriculum, which must be solved by securing a sufficient number of class hours for CT education.

Next, the comparative analysis of the teaching and learning strategies and assessment methods adopted by the national curriculum of each country showed that all the curriculums suggest a ‘computer class that does not use computers’ as a strategy to teach students the basic concept and principle of CS. The relevant teaching and learning strategies are composed of play activity, game activity and worksheet activity using paper and pencil. As strategies to learn programming, tasks suitable for the students’ level are given to the students, but problem-solving through collaboration is being emphasized. For assessment, various strategies were suggested such as how to assess the artifacts, achievement process, and individual contribution in collaborative project because of the characteristics of CS education.

Looking at the remarkable characteristics of each national curriculum, the US suggests teaching and learning methods in accordance with the characteristics of each school level. In other words, for level 1 student, emphasis is placed on teaching students the basic concept and principle of CS through simple games or classroom activities considering that they are young students. For level 2 students, emphasis is placed on project performance, design, or production activities using ICT literacy. The UK, as a teaching and learning strategy for programming education, emphasizes the importance of feedback strategy and teacher’s help, which support the debugging and testing procedure of the learners during the course of the programming performance. Korea is suggesting detailed teaching and learning strategies and assessment methods suitable for each core competency and educational contents. Although such various teaching and learning strategies and assessment methods have been suggested in the new Korean curriculum, a suitable educational environment should have been constructed in order to use such various strategies in actual school sites. Regretfully, however, the current Korean schools do not have practice rooms for CS education, and most school facilities have been deteriorated. Moreover, Korean schools have other problems such as lack of the number of teachers and class hours for CS education, including the lack of various teaching and learning materials. Therefore, an educational environment to apply various teaching and learning strategies and assessment methods needs to be constructed before 2018, the year when the new curriculum will be applied, and a policy support for the development and distribution of various educational materials is required.

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