*International Journal of Advanced Smart Convergence Vol.9 No.2 147-156 (2020)*
*http://dx.doi.org/10.7236/IJASC.2020.9.2.147*

**IJASC 20-2-17**

# Comparative Analysis of Elementary School Computing Achievement Standards in the U.S. and Korea

Kapsu Kim[1], Meekyung Min[2], Jungkyu Rho[3]*

*Professor, Dept. of Computer Education, Seoul National University of Education, Korea*[1]
*Professor, Dept. of Computer Science, Seokyeong University, Korea*[2]
*Associate Professor, Dept. of Computer Science, Seokyeong University, Korea*[3]
*kskim@snue.ac.kr*[1], *mkmin@skuniv.ac.kr*[2], *jkrho@skuniv.ac.kr*[3]

***Abstract***

*ACM's CSTA has drafted standards for computing curricula and recommended them to schools in the United States. The five core concepts of the US elementary school computing curriculum are computing systems, network and the Internet, data and analysis, algorithms and programming, and impacts of computing. In 2005, Korea prepared ICT education guidelines, including five fields, their subfields, and achievement criteria for each subfield. In the 2015 revised curriculum, software education was introduced and five achievement standards were set. The ACM CSTA has 18 achievement criteria up to K-2 and 21 achievement criteria up to K-5. If we compare the 39 achievement standards of the US to Korea, Korea's 2005 ICT education guidelines include 25 of these, and the 2015 revised curriculum includes 5 of them. In this study, we aim to study the CSTA achievement criteria that second graders should know and the achievement criteria that fifth graders should know. This is compared and analyzed with Korea's 2005 ICT Guidelines and 2015 Software Curriculum. In comparison with the number of achievement standards, the US elementary school's computing achievement standards are much higher than in Korea. Comparing with each standard, there are many areas that are not covered in Korean curriculum, and we can see that the 2015 curriculum has rather receded from 2005.*

***Keywords:*** *Computer Education, Elementary School, Software Curriculum, Computing Achievement, ACM CSTA*

## 1. Introduction

It is well known that the United States dominates the global information industry with a high level of information technology, and all other industries based on information technology. And the foundation of information technology dominated globally by the United States is computing education.

The United States sets standards for achievement in computing education at the national level. In the case of public schools, each school district selects and uses textbooks that meet these achievement standards, while private schools choose their textbooks independently. The computing curriculum in the United States can be

Manuscript Received: May. 3, 2020 / Revised: May. 6, 2020 / Accepted: May. 11, 2020
*Corresponding Author: jkrho@skuniv.ac.kr
Tel: +82-2-940-7753, Fax: +82-2-919-0345
Associate Professor, Dept. of Computer Science, Seokyeong University, Seoul, Korea

generalized based on Association for Computing Machinery (ACM)'s Computer Science Teachers Association (CSTA) curriculum [1]. Some schools do not follow ACM's CSTA computing curriculum. International Society for Technology in Education (ISTE) has created a curriculum from an educational engineering perspective [5], unlike ACM's CSTA, and many schools use this ISTE curriculum.

ACM CSTA proposed achievement standards for what to teach from elementary school to high school. In 2011, a primary school computing curriculum was created and proposed [2]. After revising the standard, the draft standard was published in 2016 and finalized in 2017 [3, 4]. As this represents computing education in the United States, we need to analyze it in detail to understand the computing education in the US.

In Korea, the Ministry of Education (MOE) is leading the creation of elementary school curriculum and textbooks. In preparation for the information age of the 21st century, in December 2000, as a guideline of the MOE, Information and Communication Technology (ICT) education was conducted for one hour a week from the first grade of elementary school [6]. At that time, there were many outputs such as developing areas that could utilize information and communication in various subjects. This is the information convergence education that is attracting attention these days. The Ministry revised the guidelines in December 2005, and since 2006, has created a new ICT education guideline that adds algorithms and information processing capabilities [7].

However, at the end of 2008, the ICT education guidelines were abolished, and after that, elementary computing education began to decline. In 2015, the MOE created a revised curriculum to allow 17 hours per week of software training, and only five elementary achievement standards for elementary schools [8, 9]. As a result, the computer skills of elementary school students in Korea were very low in the statistics of Programme for International Student Assessment (PISA) [10]. Fortunately, according to PISA's data studies on preliminary teachers, preliminary teachers for elementary schools are qualified for some degree of computing education [11].

In this study, we compare and analyze the United States' computing curriculum in terms of software education achievement standards in Korea's 2005 ICT Guidelines and Korea's 2015 Revised Curriculum. Section 2 describes Korea's 2005 ICT Guidelines and the 2015 Revised Curriculum. In Section 3, we describe the CSTA curriculum of ACM in the US, and in Section 4, we compare and analyze the curriculum of the US and Korea. In Section 5, we make a conclusion.

## 2. Elementary School Computing Curriculum in Korea

### 2.1 ICT Education Guidelines 2005

The MOE established the ICT Education Guidelines in 2000, and in elementary school, ICT education was given for more than one hour a week. The goal was *to develop basic information literacy skills in the creation, processing, analysis, and retrieval of information using ICT, and to actively use information and communication technologies to solve problems in learning and everyday life* [6].

In December 2005, the ICT Education Guidelines were revised and the following goals were set [7]: *ICT education is divided into literacy education and subject utilization education. Literacy education strengthens the field of computer science elements and information and communication ethics so that education goals can be effectively achieved through the link between literacy education and subject utilization education.* In particular, the elementary school operated a curriculum with a focus on the following goals [7]: *In elementary schools, students learn basic information about ICT and improve logical thinking to improve their problem-solving skills through basic computer manipulation. Students learn how to use application software and participate in the information society to help them form a proper awareness of information and communication*

*ethics*.

There are five fields of ICT education guidelines 2005 from the first grade to the sixth grade of elementary school, and each field has subfields. Table 1 describes five fields [7]: *Life in Information Society*, *Understanding of Information Devices*, *Understanding of Information Processing*, *Information Processing and Sharing*, and *Comprehensive Activities*.

In Table 1, each field has subfields for each grade level (grade 1-2, grade 3-4, grade 5-6) and each subfield has achievement criteria. The numbers in parentheses indicate the number of achievement criteria. There are 35 achievement criteria from first grade to second grade, 56 achievement criteria from third grade to fourth grade, and 61 achievement criteria from fifth grade to sixth grade, totaling 152 achievement criteria. The following are some examples of achievement criteria [7].

**Table 1. ICT education fields of elementary school in Korea (2005)**

| | Grade 1-2 | Grade 3-4 | Grade 5-6 |
|---|---|---|---|
| Life in Information Society | • Information society and life change (3)<br>• Meeting neighborhood with computer (2)<br>• Attitude of computer use (2)<br>• Etiquette in Cyberspace (1) | • Understanding cyber space (2)<br>• Netiquette and interpersonal ethics (2)<br>• Prevention of internet and game addiction (2)<br>• Information security and password (5)<br>• Protection from viruses and spams (2) | • Cooperating in cyberspace (2)<br>• Preventing cyber violence and damage (2)<br>• Understanding and managing personal information (3)<br>• Computer encryption and security program (3)<br>• Copyright protection(2)<br>• Information society and occupation (2) |
| Understanding of Information Devices | • Understanding computer components (2)<br>• Computer operation (3) | • How to use the operating system (4)<br>• Computer management (2)<br>• Understanding software (3)<br>• Utilizing utility programs (3)<br>• Use of peripheral devices (3) | • Understanding computer behavior (4)<br>• Setting up your computer (3)<br>• Understanding networks (6)<br>• Understanding and utilizing information devices (2) |
| Understanding of Information Processing | • Diverse world of information (2)<br>• Fun problems and solutions (2) | • Representation of numbers and characters(2)<br>• Understanding the problem solving process (4) | • Representation of multimedia information (4)<br>• Representing problem solving strategies (4)<br>• Understanding and basics of programming (3) |
| Information Processing and Sharing | • Life and information exchange (4)<br>• Meet with cyber space (5) | • Information retrieval and collection in cyber space (5)<br>• Editing documents and drawing (4) | • Creating, managing, and communicating in cyber space (4)<br>• Processing numerical data (4)<br>• Creating presentation document (4) |
| Comprehensive Activities | • Understanding information society (9) | • Collecting, creating and protecting information for solving of problems (13) | • Problem solving through responsible cooperative activities (9) |

Among the *Understanding of Information Processing* fields of grades 1 and 2 of the elementary school, there are two achievement criteria in the *Diverse World of Information* subfield:

- Recognize the type of information and describe the characteristics of the information.
- Describe how information is used in the field where it is handled

There are two achievement criteria in the *Fun Problems and Solutions* subfield:

- Understand problems and suggest ways to solve them.

- Deal with simple problems in real life and recognize the problem solving process. (e.g. simple puzzle problems)

Among the *Understanding of Information Processing* fields of grades 5 and 6 of the elementary school, there are three achievement criteria in the *Understanding and basics of programming* subfield:

- Recognize the concept of programming.
- Recognize basic usage of programming languages.
- Write and run a simple program.

### 2.2 Elementary School Software Achievement Standards of 2015

The main content of the 2015 revised curriculum is to introduce software education to elementary schools. 17 hours of instruction are required for software training, setting the following five achievement criteria [8, 9].

[6Sil04-07] Find out how the software has been applied and understand its impact on our lives.
[6Sil04-08] Think and apply a sequence of problem solving by procedural thinking.
[6Sil04-09] Experience the basic programming process using programming tools.
[6Sil04-10] Design a simple program that enters data, performs the necessary processing, and outputs the results.
[6Sil04-11] Understand the structure of sequential, selection, and repetition in creating a problem solving program.

## 3. ACM CSTA Computer Science Standards

### 3.1 Overview

ACM's Computer Science Teachers Association (CSTA) identified computing education in five areas in 2011[4]: *Computational Thinking*, *Collaboration*, *Computing Practice and Programming*, *Computer and Communications Devices*, and *Community, Global and Ethical Impacts*. Accordingly, ACM CSTA recommends the Computing Curriculum by setting achievement standards for each area from kindergarten through high school.

In 2016, the 2011 Recommendation was revised to include five concepts: *Computing Systems*, *Networks and the internet*, *Algorithms and Programming*, *Data and Analysis*, and *Impacts of Computing* [3].

*Computing systems* has three subconcepts: *Devices*, *Hardware & Software*, and *Troubleshooting*. The *Networks and the Internet* concept includes subconcepts of *Network Communication & Organization* and *Cybersecurity*. The *Algorithms and Programming* concept includes *Algorithms*, *Variables*, *Control*, *Modularity*, and *Program Development* subconcepts. *Data and Analysis* includes *Storage*, *Collection Visualization & Transformation*, and *Inference & Models*. The *Impacts of Computing* concept includes subconcepts of *Culture*, *Social Interactions*, and *Safety law & ethics*.

In each section below we describe in detail the standards of the five concepts of ACM CSTA 2017. Although ACM CSTA sets the achievement criteria up to K-12, this paper considers only K-2 (grade 2) and K-5 (grade 5), which are elementary courses.

### 3.2 Computing Systems

■ **Grade K-2**

In the field of C*omputing Systems*, the achievement criteria for the 2nd graders are as follows [4].
[1A-CS-01] ***Devices*** Select and operate appropriate software to perform a variety of tasks, and recognize that users have different needs and preferences for the technology they use.
[1A-CS-02] ***Hardware & Software*** Use appropriate terminology in identifying and describing the function of common physical components of computing systems (hardware).
[1A-CS-03] ***Troubleshooting*** Describe basic hardware and software problems using accurate terminology.

■ **Grade K-5**

In the field of *Computing Systems*, the achievement criteria for the 5th graders are as follows [4].
[1B-CS-01] ***Devices*** Describe how internal and external parts of computing devices function to form a system.
[1B-CS-02] ***Hardware & Software*** Model how computer hardware and software work together as a system to accomplish tasks.
[1B-CS-03] ***Troubleshooting*** Determine potential solutions to solve simple hardware and software problems using common troubleshooting strategies.

### 3.3 Networks and the Internet

■ **Grade K-2**

Achievement criteria for the second graders in the field of *Networks and the Internet* is as follows [4].
[1A-NI-04] ***Cybersecurity*** Explain what passwords are and why we use them, and use strong passwords to protect devices and information from unauthorized access. *Cybersecurity*

■ **Grade K-5**

Achievement criteria for the fifth graders of elementary school in the field of *Networks and the Internet* are as follows [4].
[1B-NI-04] ***Network Communication & Organization*** Model how information is broken down into smaller pieces, transmitted as packets through multiple devices over networks and the Internet, and reassembled at the destination.
[1B-NI-05] ***Cybersecurity*** Discuss real-world cybersecurity problems and how personal information can be protected.

### 3.4 Data and Analysis

■ **Grade K-2**

In the field of *Data and Analysis*, there are three achievement criteria for the second graders of elementary school [4].
[1A-DA-05] ***Storage*** Store, copy, search, retrieve, modify, and delete information using a computing device and define the information stored as data.
[1A-DA-06] ***Collection Visualization & Transformation*** Collect and present the same data in various visual formats.
[1A-DA-07] ***Inference & Models*** Identify and describe patterns in data visualizations, such as charts or graphs, to make predictions.

■ **Grade K-5**

In the field of *Data and Analysis*, there are two achievement criteria for the fifth graders of elementary

school [4].
[1B-DA-06] ***Collection Visualization & Transformation*** Organize and present collected data visually to highlight relationships and support a claim.
[1B-DA-07] ***Inference & Models*** Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea.

### 3.5 Algorithm and Programming

■ **Grade K-2**

In the field of *Algorithms and Programming*, achievement criteria for the second graders of elementary school are as follows [4].
[1A-AP-08] ***Algorithms*** Model daily processes by creating and following algorithms (sets of step-by-step instructions) to complete tasks.
[1A-AP-09] ***Variables*** Model the way programs store and manipulate data by using numbers or other symbols to represent information.
[1A-AP-10] ***Control*** Develop programs with sequences and simple loops, to express ideas or address a problem.
[1A-AP-11] ***Modularity*** Decompose (break down) the steps needed to solve a problem into a precise sequence of instructions.
[1A-AP-12] ***Program Development*** Develop plans that describe a program's sequence of events, goals, and expected outcomes.
[1A-AP-13] ***Program Development*** Give attribution when using the ideas and creations of others while developing programs.
[1A-AP-14] ***Program Development*** Debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.
[1A-AP-15] ***Program Development*** Using correct terminology, describe steps taken and choices made during the iterative process of program development.

■ **Grade K-5**

In the field of *Algorithms and Programming*, achievement criteria for the fifth graders of elementary school are as follows [4].
[1B-AP-08] ***Algorithms*** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
[1B-AP-09] ***Variables*** Create programs that use variables to store and modify data.
[1B-AP-10] ***Control*** Create programs that include sequences, events, loops, and conditionals.
[1B-AP-11] ***Modularity*** Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process.
[1B-AP-12] ***Modularity*** Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
[1B-AP-13] ***Program Development*** Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences.
[1B-AP-14] ***Program Development*** Observe intellectual property rights and give appropriate attribution when creating or remixing programs.
[1B-AP-15] ***Program Development*** Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

[1B-AP-16] ***Program Development*** Take on varying roles, with teacher guidance, when collaborating with peers during the design, implementation, and review stages of program development.
[1B-AP-17] ***Program Development*** Describe choices made during program development using code comments, presentations, and demonstrations.

### 3.6 Impacts of Computing

■ **Grade K-2**

In the field of *Impacts of Computing*, achievement criteria for the second graders are as follows [4].
[1A-IC-16] *Culture* Compare how people live and work before and after the implementation or adoption of new computing technology.
[1A-IC-17] *Social Interactions* Work respectfully and responsibly with others online.
[1A-IC-18] *Safety Law & Ethics* Keep login information private, and log off of devices appropriately.

■ **Grade K-5**

In the field of *Impacts of Computing*, achievement criteria for the fifth graders of elementary school are as follows [4].
[1B-IC-18] *Culture* Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.
[1B-IC-19] *Culture* Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.
[1B-IC-20] *Social Interactions* Seek diverse perspectives for the purpose of improving computational artifacts.
[1B-IC-21] *Safety Law & Ethics* Use public domain or creative commons media, and refrain from copying or using material created by others without permission.

## 4. ACM CSTA 2017 vs. Korean Standards

Table 2 shows the results of comparing ACM CSTA Standards with Korea's 2005 ICT Guidelines and 2015 revised curriculum. The comparison is based on the achievement guideline. ACM CSTA standards have concepts and subconcepts. In the table, subconcepts are represented by numbers. This number is explained in Section 3. Achievement standards for Korea 2015 curriculum are also represented by numbers which are described in Section 2.

**Table 2. Comparison of CSTA and Korea**

| CSTA Standards | | | Korea 2005 | | Korea 2015 |
|---|---|---|---|---|---|
| Concept | Grade | Subconcept | Field | Subfield | Criteria |
| Computing Systems | K-2 | [1A-CS-01] [1A-CS-02] [1A-CS-03] | • Understanding of information devices (grade1-2) | • Understanding computer components | None |
| | | | • Understanding of information devices (grade1-2) | • Computer operation | |
| | K-5 | [1B-CS-01] [1B-CS-02] [1B-CS-03] | • Understanding of information devices (grade1-2) | • Understanding computer components | None |
| | | | • Understanding of information devices (grade1-2) | • Computer operation | |
| Networks | K-2 | [1A-NI-04] | • Life in information society | • Computer encryption and | None |

| | | | | | |
|---|---|---|---|---|---|
| and the Internet | | | (grade5-6) | security program | |
| | K-5 | [1B-NI-04] [1B-NI-05] | • Understanding of information devices (grade5-6) | • Understanding networks | None |
| | | | • Life in information society (grade5-6) | • Cooperating in cyberspace | |
| Data and Analysis | K-2 | [1A-DA-05] [1A-DA-06] [1A-DA-07] | • Information processing and sharing (grade5-6) | • Processing numerical data | None |
| | K-5 | [1B-DA-06] [1B-DA-07] | • Information processing and sharing (grade5-6) | • Processing numerical data | None |
| Algorithm and Programming | K-2 | [1A-AP-08] [1A-AP-09] [1A-AP-10] [1A-AP-11] [1A-AP-12] [1A-AP-13] [1A-AP-14] [1A-AP-15] | • Understanding of information processing (grade1-2) | • Fun problems and solutions | [6Sil04-08] [6Sil04-09] [6Sil04-10] [6Sil04-11] |
| | | | • Understanding of information processing (grade3-4) | • Understanding the problem solving process | |
| | K-5 | [1B-AP-08] [1B-AP-09] [1B-AP-10] [1B-AP-11] [1B-AP-12] [1B-AP-13] [1B-AP-14] [1B-AP-15] [1B-AP-16] [1B-AP-17] | • Understanding of information processing (grade5-6) | • Representing problem solving strategies | None |
| | | | • Understanding of information processing (grade5-6) | • Understanding and basics of programming | |
| Impacts of Computing | K-2 | [1A-IC-16] [1A-IC-17] [1A-IC-18] | • Life in information society (grade1-2) | • Information society and life change | [6Sil04-07] |
| | | | • Life in information society (grade5-6) | • Cooperating in cyberspace | |
| | K-5 | [1B-IC-18] [1B-IC-19] [1B-IC-20] [1B-IC-21] | • Life in information society (grade1-2) | • Meeting neighborhood with computer | None |
| | | | • Life in information society (grade3-4) | • Understanding cyber space | |
| | | | • Life in information society (grade5-6) | • Cooperating in cyberspace | |

The 2005 ICT Guidelines [7, 8] have fields and subfields. There are specific guidelines in the subfield, but the specific guidelines are omitted in this table. In the five CSTA concepts, there are 18 subconcepts in K-2 and 21 in K-5. According to Korea's 2005 ICT Guidelines, most of them were educated in the Korean curriculum. However, in the *Data and Analysis* area, there are fewer achievement guidelines covered by Korean curriculum than in other areas. In the 2015 revised curriculum, only the *Algorithm and Programmin*g (K-2) and *Impacts of Computing* (K-2) areas are included in elementary school education.

Next, in terms of the number of achievement standards, the number of achievement standards in the US CSTA curriculum is 18 in 1st to 2nd grade of elementary school, and 21 in 3rd to 5th grade. The achievement criteria of the 2005 ICT Guidelines in Korea were 35 in 1st to 2nd graders, 56 in 3rd to 4th graders, and 61 in 5th to 6th graders, totaling 152.

In the 2015 revised curriculum, only two areas are left: Algorithm and Programming and Impacts of Computing. In addition, it doesn't cover CSTA's K-5 educational standards and only deals with K-2

achievement standards. The number of achievement standards is 18 for K-2 and 21 for K-5 in the US CSTA curriculum, and 35 for Grades 1-2 and 61 for Grades 5-6 in the 2005 ICT guidelines. However, the 2015 revised curriculum has only five achievement standards.

## 5. Conclusion

In this study, the achievement criteria of the 2017 ACM CSTA Computing Curriculum were compared with those of the 2005 ICT Guidelines of Korea and the software achievement criteria of the 2015 Revised Curriculum of Korea. The point of analysis is whether the US education guidelines can be met when following the 2005 ICT guidelines and the 2015 revised curriculum of Korea. Analyzing these achievement standards helps us recognize the state of Korean software education and determine its direction for the future.

ACM CSTA's core curriculum of computing education includes Computing Systems, Networks and the Internet, Algorithm and Programming, Data and Analysis, and Impacts of Computing. On the other hand, Korea's 2005 ICT Guidelines cover four concepts: Computing Systems, Networks and the Internet, Algorithm and Programming, and Impacts of Computing. Data and Analysis area is partly covered by the guidelines.

As a result of this study, we conclude that Korea's ICT education is lack of achievement standards compared with the United States', and it seems that 2015's is weaker than 2005's. In Korea, elementary and secondary schools has begun software education since 2019, emphasizing the importance of software technology. However, establishing a proper curriculum for basic ICT education should be done prior to spreading out software education.

## References

[1] CSTA Standards Task Force, A Model Curriculum for K-12 Computer Science: Final Report of the ACM K-12 Task Force Curriculum Committee, ACM CSTA, 2002.
[2] CSTA Standards Task Force, CSTA K-12 Computer Science Standards: Revised 2011, ACM CSTA, 2011.
[3] CSTA Standards Task Force, CSTA K–12 Computer Science Standards: Revised 2016, ACM CSTA, 2016.
[4] CSTA Standards Task Force, CSTA K–12 Computer Science Standards: Revised 2017, ACM CSTA, 2017.
[5] ISTE Standards for Students, Redefining Learning in a Technology-Driven World, ISTE Report, 2016.
[6] MOE, Guidelines for Operations of Information and Communication Technology Education Guidelines in elementary and secondary schools, MOE, Korea, 2000.
[7] MOE, Guidelines for Operations of Information and Communication Technology Education Guidelines in elementary and secondary schools, MOE, Korea, 2005.
[8] MOE, Revised National Curriculum 2015-74, MOE, Korea, 2015.
[9] MOE, The revised national curriculum 2015 for Primary and Secondary Schools, Vol. 2015-75, No. 10, MOE, Korea, 2015.
[10] Kapsu Kim, "A Study on ICT Competences of Korean Students Focus on PISA 2009 and 2012", Journal of The Korean Association of Information Education, Vol. 19, No. 2, pp. 233-242, 2015. DOI: http://dx.doi.org/10.14352/jkaie.2015.19.2.233.
[11] Organization for Economic Cooperation and Development (OECD), PISA 2015 Technical Report, OECD publishing, Paris, 2016.
[12] Hye-Sook Kim, Han-Sung Kim, Jin-Sook Kim, and An-Na Shin, "Trend Analysis of ICT Accessibility and Utilization Levels of Korean Students based on OECD PISA Data," Information Policy, Vol. 24, No. 4, pp. 17-43, 2017.
[13] Kapsu Kim and Meekyung Min, "Comparative Analysis of ICT Accessibility and Usability of Korean Students," International Journal of Internet, Broadcasting and Communication, Vol. 12, No. 1, pp.73-80, 2020.

DOI: http://dx.doi.org/10.7236/IJIBC.2020.12.1.73.
[14] Kapsu Kim, "An Analysis of Software Curriculum of Korean Elementary Teacher Education School," Journal of the Korean Association of Information Education, Vol. 21, No. 6, pp. 723-732, 2017.
DOI: http://dx.doi.org/10.14352/jkaie.2017.21.6.723.
[15] Kapsu Kim and Meekyung Min, "A Study on ICT Competency of Preliminary Teachers Based on PISA 2015 Data," Journal of The Korean Association of Information Education, Vol. 22, No. 2, pp. 239-249, 2018.
DOI: http://dx.doi.org/10.14352/jkaie.2018.22.2.239.
[16] Woochun Jun, "A Study on Privacy Issues and Solutions of Public Data in Education," International Journal of Internet, Broadcasting and Communication, Vol. 12, No. 1, pp. 137-143, 2020.
DOI: http://dx.doi.org/10.7236/IJIBC.2020.12.1.137.