J. Internet Comput. Serv.
ISSN 1598-0170 (Print) / ISSN 2287-1136 (Online)
http://www.jics.or.kr

A Study on the Technology Utilization for Smart Education in the 4th Industrial Revolution Era☆

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ABSTRACT

As the era of the 4th industrial revolution began, it is possible to provide smart education by utilizing various new technologies. This paper included 6 steps to prove that the educational satisfaction of students' can be improved by applying the technology of the 4th Industrial Revolution toward smart education. The first step is to review technologies of the 4th industrial revolution that could enable smart education. The second step is to define areas that smart education should include by adopting technologies of the 4th industrial revolution. The third step is to extract the keyword through literature review while the keyword can constitute the smart education for the defined areas. The fourth step is to present the research model by using the extracted keyword. The fifth step is to verify the proposed research model through questionnaires. The last step is to analyze the result of questionnaires to suggest better educational method. Consequentially, the purpose of this study is to verify the effectiveness of smart education by measuring students' expectation about smart education through questionnaire. As a result, students responded that the presented factors of smart education could maximize the effect of education by increasing the satisfaction of education. Therefore, it is necessary to utilize the technology of the 4th Industrial revolution in the education field and apply the smart education method for better education.

☞ keyword : the 4th Industrial Revolution, Smart Education, Big Data, Educational Software, Intelligent Feedback

1. Introduction

The 4th Industrial Revolution has been discussed in the media, academia, and industry most frequently since 2016. It has been focused that the future of the 4th Industrial Revolution has a speed, breadth, and depth of change that is unmatched what in present. Due to the advancement of many technologies and the development of diverse information and communication technologies (ICTs), significant changes and impacts in various fields are frequently discussed[1].

With the waves of breakthroughs in various domains, modern people gradually find themselves in the midst of the 4th Industrial Revolution which is driven by artificial intelligence (AI) and cyber physical systems (CPS). The 4th Industrial Revolution digitizes the entire organization's processes to achieve vertical integration and also achieve horizontal integration of all internal processes. It epitomizes a paradigm shift from 'centralized' to 'decentralized' form. In other words, the idea of consistent digitization and linking of all units in a system is emphasized in the 4th Industrial Revolution era[2].

In the field of education, technology of the 4th Industrial Revolution is also being applied. It is being transformed into the age of smart education by applying new technologies to the educational environment. Smart education is transformed from one teacher-centered education to all student-centered education. The relationship between the teacher and the students is horizontal rather than vertical, and all objects participating in the education are digitized and linked.

It is worth looking into the details of the 4th industrial revolutionary technology in the smart education field. Whether the integration of new technologies is truly bringing improvements in education, or whether it is merely changing

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[Received 7 May 2018, Reviewed 15 May 2018(R2 2 July 2018), Accepted 20 July 2018]
☆ This paper was supported by Samsung Research Fund, Sungkyunkwan University, 2017.
☆ A preliminary version of this paper was presented at ICONI 2017 and was selected as an outstanding paper.

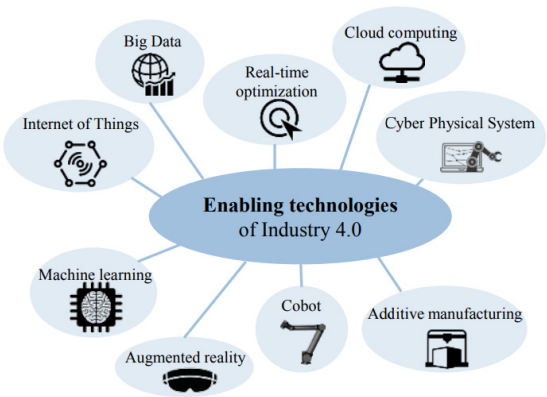
the form of education, the efficiency of education has not been improved.

Therefore, this paper considered what factors should have been examined to apply the 4th Industrial Revolution technology to smart education environment. We conducted a literature review on how elements constituted a new smart education method, and extracted keyword by creating a word cloud based on literature review. Then, research hypotheses were formulated based on the extracted keyword, and research models were verified. We proposed a smart education based on the results of the verification.

2. Related Works

2.1 The 4th Industrial Revolution

The term Industry 4.0 (I40) has been proposed for the first time in 2010 by the German government as part of the "High-Tech Strategy 2020 Action Plan" to identify the 4th industrial revolution. I40 can be defined as the comprehensive transformation of the entire industrial production through the merging of Internet and information & communication technologies (ICT) with traditional manufacturing processes[3]. The following Figure 1 presents the afore described enabling technologies of I40[4].



(Figure 1) Enabling Technologies

From I40, the 4th Industrial Revolution technologies are expanded, and many researchers have published papers on the 4th Industrial Revolution while research on this trend has also been published. The Asia Pacific International Conference on Information Science and Technology (APIC-IST 2015) developed emerging Internet-related issues and invited prospective authors to submit research papers. Several papers showed expectation of a high impact on changing of the society in the future within the 4th Industrial Revolution. Chung and Kim analyzed the keyword from submitted manuscripts to APIC-IST 2015 based on their frequency of the issues[5]. The keyword frequency of main issues in APIC-IST 2015 was shown as Table 1.

(Table 1) The keyword frequency

Main Issue	Keyword Frequency
IoT / Wireless sensor network	15
Multimedia Processing	13
Distributed Computing and Control / Authenticated Security	12
SNS & Communications	9
Big Data	5

The five main issues with the highest keyword frequency were technologies that can achieve smart education by combining with education. By adopting IoT in the educational field, monitoring achievement of learning outcomes, monitoring effectiveness of own study habits, inspiring vitality with mixed reality, creating digital data, and offering continuous and immediate communication activities are available[6]. By applying multimedia processing in the educational field, satisfaction and effectiveness of education can be improved with using various multimedia materials. By reflecting the technologies of distributed computing and control towards education, distance learning for smart education is supportable. SNS and communications can make online tutoring system available. Big data is an essential issue in smart education to handle huge amount of data which are generated during educational process.

2.2 Smart Education

Nowadays progress of e-learning, new pedagogical techniques and approaches contribute to the formation of a new educational trend, which calls "smart education." Contemporary ICTs have the enormous influence in the area

of education, and smart education has gained increased attention due to the 4th Industrial Revolution[7]. Big data analytics and technologies could be applied for collecting multiform information concerning individual learning experience of many students. These data help to create exiting personalized courses full of actual knowledge in the context of smart education[8].

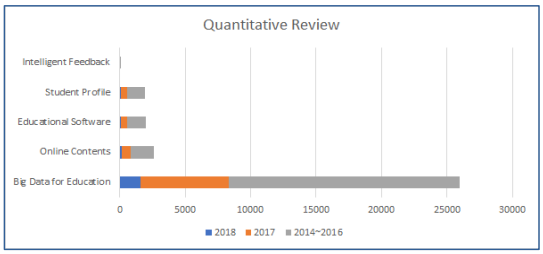
There are strength of smart learning: wired infrastructure resources, diversity of the curriculum, teacher's sense of duty, and educational environment based on the institutional level and propelling capacity. On the other hand, absence of smart learning contents and learning model, inadequate teacher training program related to smart learning, the lack of teachers' ability to use smart devices, and the low penetration of smart devices for education have been listed as the weakness of smart learning[9]. To compensate weaknesses, technologies of the 4th Industrial Revolution can be used. Augmented reality, cloud computing, and big data can provide various smart learning contents while machine learning can generate a proper learning model. Instead of conducting teacher training program related to smart learning, real-time optimization can help teachers and students for better smart learning environment. In the 4th Industrial Revolution era, the lack of teachers' ability to use smart devices may not be a big issue since cyber physical system can assist teachers to handle smart devices for the purpose of education. The low penetration of smart devices for education can be resolved by supplying education robot to accomplish smart education. Robots are not just simply used as smart devices for education, but are used to further enhance creativity and logical thinking of students[10]. Likewise, All the elements that hinder the utilization of smart education can be solved by the technology of the 4th Industrial Revolution.

3. Literature Review

Papers which contained in Education Resources Information Center(ERIC) were reviewed to extract keyword in smart education. Categorized subjects for smart learning are big data for education, online contents, educational software, student profile, and intelligent feedback.

3.1 Quantitative Review

The number of papers published between 2014-2016 in the category of big data for education is 17,638 while the number of published papers in 2017 is 6,726 and 1,586 in 2018. Hence, the total of 25,950 papers have been published since 2014. For the category of online contents, 1,776 papers between 2014-2016, 675 papers in 2017, 139 papers in 2018, thus total of 2,590 papers have been published. For the category of educational software, 1,417 papers between 2014-2016, 456 papers in 2017, 94 papers in 2018, thus total of 1,967 papers have been published. For the category of student profile, 1,374 papers between 2014-2016, 450 papers in 2017, 116 papers in 2018, thus total of 1,940 papers have been published. For the category of intelligent feedback, 70 papers between 2014-2016, 27 papers in 2017, 4 papers in 2018, thus total of 101 papers have been published. It is shown in Figure 2.



(Figure 2) Number of Papers in ERIC

The category of big data for education was received the highest attention, while the category of intelligent feedback got the lowest attention among selected categories.

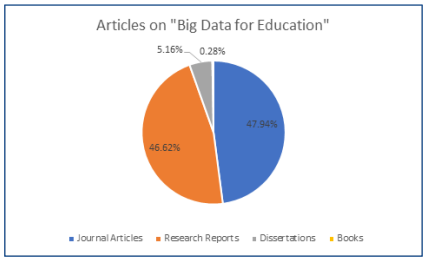
3.2 Big Data for Education

In smart education environment, huge amount of data are generated for various aspects. Numerous educational contents are created by many educators and registered in cloud system for contents sharing[11]. Teachers and students participate in the field of education. These two groups generate a various personal data dealing with education related subject.

3.2.1 Publication Type

Publication type of journal articles and research reports

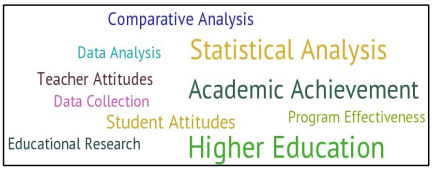
include almost papers in the category of big data for education. Figure 3 represents the pie chart of publication type for papers about big data for education.



(Figure 3) Publication Type for Educational Big Data

3.2.2 Word Cloud

By processing word cloud with published papers about big data for education, the most relevant phrase came up as 'statistical analysis' as shown in Figure 4. Authors of published papers were also interested in 'academic achievement' and 'higher education' from educational big data.



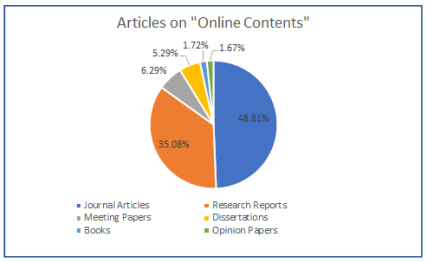
(Figure 4) Word Cloud for Educational Big Data

3.3 Online Contents

In smart education, educational contents are the core[12]. Since this study is to review smart education in the 4th Industrial Revolution, we treat online contents as educational contents. To create online contents, we need technologies of the 4th Industrial Revolution such as augmented reality, cloud computing, and big data.

3.3.1 Publication Type

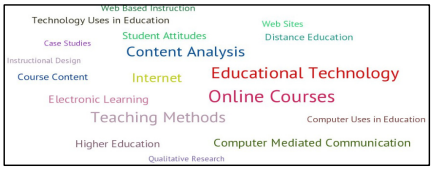
Journal articles is the majority publication type in the category of online contents. Figure 5 represents the pie chart of publication type for papers about online contents for education.



(Figure 5) Publication Type for Online Contents

3.3.2 Word Cloud

Since online contents are often used as online courses, 'online courses' was the most relevant phrase in word cloud. To manage online contents, educational technology is a basic requirement. To use online contents, computer mediated communication is required along with content analysis. This relationship is shown in Figure 6 as word cloud of online contents.

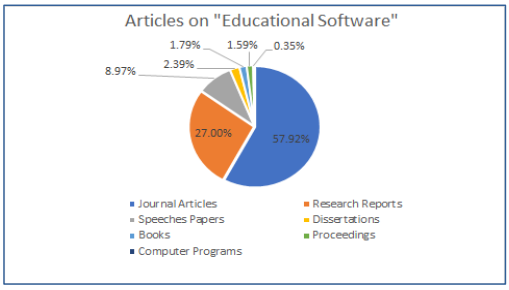


(Figure 6) Word Cloud for Online Contents

3.4 Educational Software

In smart learning environment, educational software can be a helpful teaching aid to empower the effectiveness of education[13]. Experiencing education software is not an option for certain educational materials, it is essential.

3.4.1 Publication Type

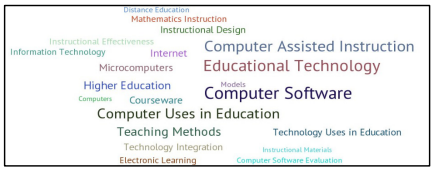


(Figure 7) Publication Type for Educational Software

Even though the journal articles as publication type are not exceeded 50 percent for entire publication in other categories, educational software counts more than 50 percent as shown in Figure 7. It is peculiar that publication type of education software includes computer programs.

3.4.2 Word Cloud

By processing word cloud with published papers about educational software, the relevant phrases came up as 'computer software,' 'educational technology,' and 'computer assisted instruction' as shown in Figure 8. In smart learning, computers are used as basic tools, and using computers implies that software required.



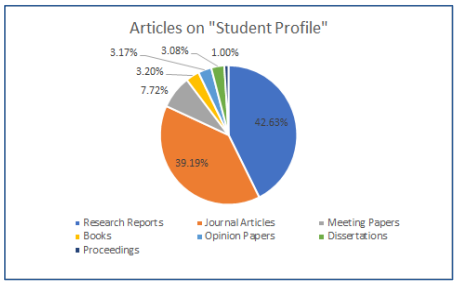
(Figure 8) Word Cloud for Educational Software

3.5 Student Profile

The information of students must be managed in any educational system. In traditional classroom system, teachers usually grasp tendency and information on students. However, in smart education environment, physical teachers may be absence at the scene of the education. Therefore, artificial intelligence must be a part of educational components to analyze the student profile[14]. For smart education, artificial intelligence, a fundamental element of the 4th Industrial Revolution, is an essential application.

3.5.1 Publication Type

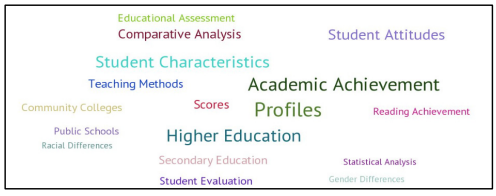
Publication type of research reports and journal articles cover up to 91% of published papers in the category of student profile. Figure 9 represents the pie chart of publication type for papers in student profile. An interesting point is that the number of 'opinion papers' is greater than that of 'dissertations' and that of 'proceedings papers.' It means verification system may be weak in the research area of student profile.



(Figure 9) Publication Type for Student Profile

3.5.2 Word Cloud

By processing word cloud for the published papers about student profile, the relevant phrases came up as 'academic achievement' and 'student characteristics' as shown in Figure 10. To establish student profile, 'academic achievement' is the key information to manage a study plan for the student. If the student responds low academic achievement and does not understand the contents of the learning, the students should be able to suggest the repeated learning about the learning contents rather than continuing the progress for the next learning contents. Generating proper student profile could increase overall learning effectiveness and satisfaction, and it could be the key factor of perfect student management system.



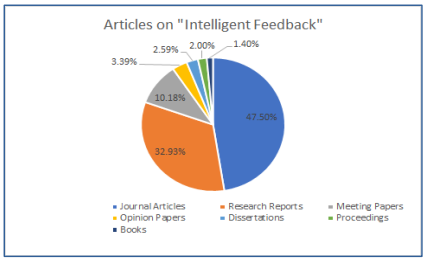
(Figure 10) Word Cloud for Student Profile

3.6 Intelligent Feedback

Since an actual teacher may be absence at the educational scene, students may have a difficulty to get appropriate feedback on their studying. Without appropriate feedback, desires to study are getting disappeared, and learning satisfaction is getting lowered[15]. Therefore, intelligent feedback is an important factor in education. Via machine learning, the intelligent feedback would be served at the educational field in the era of the 4th Industrial Revolution.

3.6.1 Publication Type

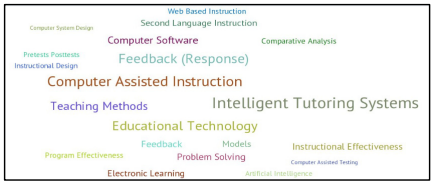
Publication type of journal articles and research reports cover almost 90% of published papers in the category of intelligent feedback. Figure 11 represents the pie chart of publication type for papers in intelligent feedback. As I mentioned in section 3.1, the number of published papers on the subject for intelligent feedback is only 101 since 2014. It means an active research is not yet under way. It may not easy to provide a suitable feedback technically for various educational situation hence depth research is needed in this area.



(Figure 11) Publication Type for Intelligent Feedback

3.6.2 Word Cloud

By processing word cloud for the published papers about intelligent feedback, the relevant phrases came up as 'intelligent tutoring systems,' 'computer assisted instruction,' and 'teaching methods' as shown in Figure 12. Supplying appropriate feedback is a main factor in teaching, and teaching method must include the method to provide feedback for students. In smart education, intelligent feedback would be a solution for it.



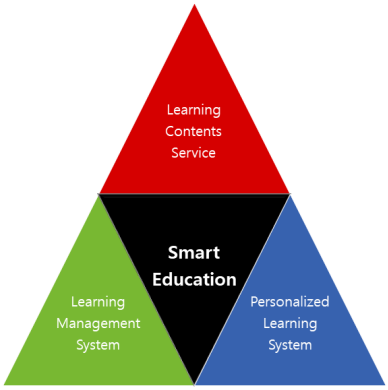
(Figure 12) Word Cloud for Intelligent Feedback

4. Smart Education Components

The 4th Industrial Revolution has not only changed the way of industrial production, but has also promoted change in human society as a whole. Although people get more benefits, they have to prepare more. Education is needed to prepare for the future. The three factors of education are the teacher, the student, and the content of the education. The amount of the contents to be learned is enormously increased, and the students have to learn new materials for lifetime while teachers can not possess every knowledge that they have to teach.

In this conflicted situation, the development of ICT and the technology related to the 4th Industrial Revolution are appliable, and they give a chance to overcome this problem by presenting the answer as smart education. In the smart education environment, it is not merely wanting to acquire knowledge, but also combining the capabilities required by this era. Students should fulfill following 7 abilities: ability of problem solving, ability of self-development, ability of communication, ability of resources management, ability of information acquisition, ability of global trend acquire, and ability of convergence thinking.

Integrating these 7 abilities with utilizing 5 technical categories in section 3 can suggest a model for smart education, and the conceptualized model is shown in Figure 13.

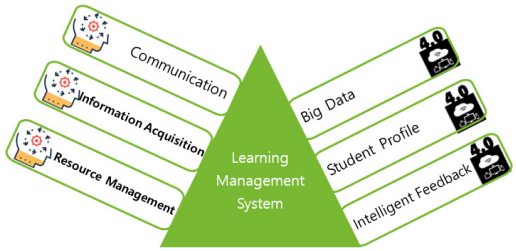


(Figure 13) Conceptual Model of Smart Education

4.1 Learning Management System

The proposed learning management system is a concept reflecting the u-Learning for the administration, documentation, tracking, reporting and delivery of educational courses

or training programs in ICT environment. The relationship between technical categories and thinking abilities for the Learning Management System(LMS) is shown in Figure 14.



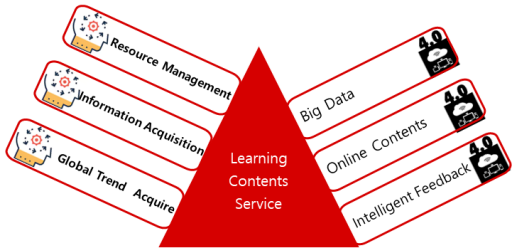
(Figure 14) Related Factors for the LMS

The LMS adopts big data, student profile, and intelligent feedback among categories of the 4th Industrial Revolution to handle unlimited students along with huge numbers of teachers. Learning through the LMS can develop students' abilities of communication, information acquisition, and resource management with the experience of using the system.

The functional requirements for the LMS are summarized as followed: 1) Enable integration with the human resources of teachers and students. 2) Manage student registrations and develop student profiles. 3) Provide access to content delivery in online within the method such as instructor-led or self-paced, and learner-choice. 4) Manage curriculum to provide outstanding contents for student choice. 5) Collect the results of student performance. 6) Provide and support authoring of assessments. 6) Support the individual student's learning progress. Along with fulfillment of the functional requirements, the utilization of technologies from the 4th Industrial Revolution can make the LMS as a tool for creating, distributing, tracking, and managing various types of educational and training materials for any level of students. Hence, the LMS can provide the basic required functions as well as advanced performance in the educational field.

4.2 Learning Contents Service

The proposed learning contents service is to provide useful learning contents according to the needs of the students in ICT environment. The Learning Contents Service (LCS) basically must guarantees the access from any kind of devices and any format of contents such as vides or massive open online courses(MOOCs). The relationship between technical categories and thinking abilities for the LCS is shown in Figure 15.



(Figure 15) Related Factors for the LCS

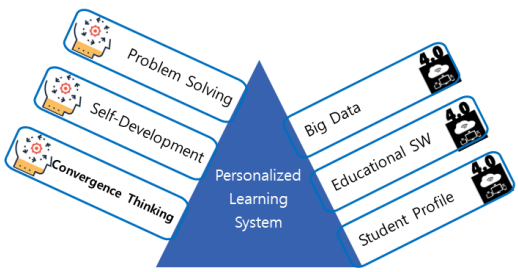
The LCS needs big data, online contents, and intelligent feedback among categories of the 4th Industrial Revolution to serve various learning contents for all potential learners. Due to deviation in learning performance, the LCS needs to cover various learning contents for the same subject. Since the LCS is for ICT environment, the service must deal with online contents and having numerous learning contents requires the technology of big data. Learners may have questions about learning contents, then the LCS must supply appropriate answers. To accomplish it, the LCS needs intelligent feedback to provide enhanced service.

By studying thru the LCS, learners can develop the resource management ability. When a learner uses learning contents, the learning contents becomes resource for the learner and the learner can strengthen the ability of resource management by simply studying with the LCS. Using the LCS supports knowledge acquisition ability by knowing new materials from the learning contents. Searching the new learning contents in the LCS may help to acquire the global trend. The LCS providers may want to offer the most recent subject along with the newest technology.

4.3 Personalized Learning System

The proposed personalized learning system is to assist learners systematically, so the learners can drive their own learning in learner-centered environments. The Personalized Learning System (PLS) is comprised of the compound

attributes for adaptive learning, blended learning, competency-based learning, differentiated learning, and individualized learning. The PLS is a learning system in which the pace of learning and the instructional approach are optimized for the needs of each learner. The PLS is to support various learner needs on learning objectives, instructional approaches, instructional content, and learning contents' sequencing. In the PLS environment, learning activities are made available that are meaningful and relevant to learners, driven by their interests and often self-initiated. The relationship between technical categories and thinking abilities for the PLS is shown in Figure 16.

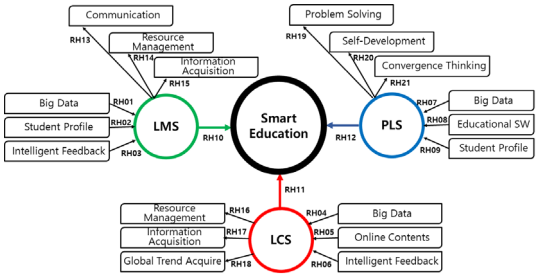


(Figure 16) Related Factors for the PLS

The PLS adopts big data, educational software, and student profile among categories of the 4th Industrial Revolution to provide a learning system that supported by technology. The PLS is to offer a path to effectively support the growing diversity of the population of students by understanding how individual learners learn best and actively engage, motivate, and inspire them with the right resources at the right time, in the right medium, and at the right pace. Therefore, when learners experience the PLS, abilities on problem solving, self-development, and convergence thinking can grow.

5. Research Model

The research hypotheses shown in Figure 17 are presented based on the related factors of smart education to prove that technology utilization in the 4th Industrial Revolution is the solution for the smart education.



(Figure 17) Model for Research Hypotheses

The statements for research hypotheses are followed.

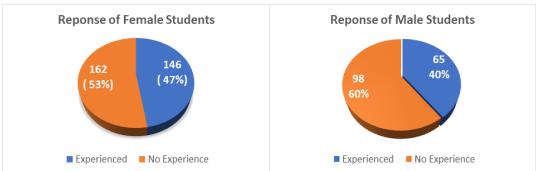
- RH01: The Big Data among the 4th Industrial Revolution Technology can be an influential factor for the Learning Management System.
- RH02: The Student Profile among the 4th Industrial Revolution Technology can be an influential factor for the Learning Management System.
- RH03: The Intelligent Feedback among the 4th Industrial Revolution Technology can be an influential factor for the Learning Management System.
- RH04: The Big Data among the 4th Industrial Revolution Technology can be an influential factor for the Learning Contents Service.
- RH05: The Online Contents among the 4th Industrial Revolution Technology can be an influential factor for the Learning Contents Service.
- RH06: The Intelligent Feedback among the 4th Industrial Revolution Technology can be an influential factor for the Learning Contents Service.
- RH07: The Big Data among the 4th Industrial Revolution Technology can be an influential factor for the Personalized Learning System.
- RH08: The Educational Software among the 4th Industrial Revolution Technology can be an influential factor for the Personalized Learning System.
- RH09: The Student Profile among the 4th Industrial Revolution Technology can be an influential factor for the Personalized Learning System.
- RH10: The Learning Management System can be a component of the Smart Education.
- RH11: The Learning Contents Service can be a component of the Smart Education.

- RH12: The Personalized Learning System can be a component of the Smart Education.
- RH13: Using the Learning Management System can improve the ability of communication.
- RH14: Using the Learning Management System can improve the ability of resource management.
- RH15: Using the Learning Management System can improve the ability of information acquisition.
- RH16: Using the Learning Contents Service can improve the ability of resource management.
- RH17: Using the Learning Contents Service can improve the ability of information acquisition.
- RH18: Using the Learning Contents Service can improve the ability of global trend acquire.
- RH19: Using the Personalized Learning System can improve the ability of problem solving.
- RH20: Using the Personalized Learning System can improve the ability of self-development.
- RH21: Using the Personalized Learning System can improve the ability of convergence thinking.

The questionnaire survey was conducted to verify the hypothesis. Before the survey, five categories related to the 4th ndustrial Revolution technology, which are Big Data, Online Contents, Educational Software, Student Profile, and Intelligent Feedback were explained.

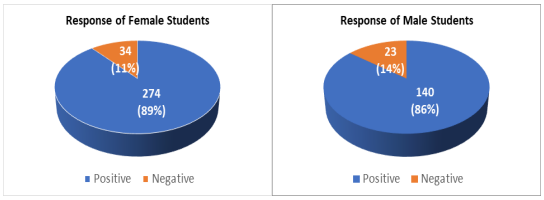
6. Results

There was total of 471 answers for the survey. The survey participants were college students who taking a software related course. To verify the questionnaire and to calculate statistics, R programming language was used.



(Figure 18) Experience of Smart Education

For numerical statistics, 308 female students and 163 male students were participated for the survey. Among 308 female students, 47%(146) students only experienced a part of smart education while 40%(65) male students experienced it as Figure 18. The questionnaire included an opinion on the 4th Industrial Revolution. 89%(274) female and 86%(140) male students responded positively like Figure 19.



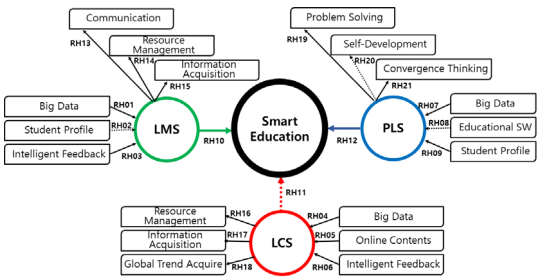
(Figure 19) Need the 4th Industrial Revolution

A measure of internal consistency of a questionnaire, Cronbach's α of the questionnaire survey was 0.9673333. Since it is greater than .8, the correlation measure shows high enough. P-values for each research hypothesis has been checked to confirm the acceptance of the hypothesis. The result showed as Table 2.

(Table 2) The Result of P-values for Hypotheses

Research Hypothesis		p-value	Accept
RH01	Big Data for LMS	0.4773	○
RH02	Student Profile for LMS	0.02383	X
RH03	Intelligent Feedback for LMS	0.1804	○
RH04	Big Data for LCS	0.4592	○
RH05	Online Contents for LCS	0.1328	○
RH06	Intelligent Feedback for LCS	0.2683	○
RH07	Big Data for PLS	0.6788	○
RH08	Educational Software for PLS	0.2732	○
RH09	Student Profile for PLS	0.6111	○
RH10	LMS toward Smart Education	0.1833	○
RH11	LCS toward Smart Education	0.06652	X
RH12	PLS toward Smart Education	0.1595	○
RH13	Communication from LMS	0.1175	○
RH14	Resource Management from LMS	0.2829	○
RH15	Information Acquisition from LMS	0.4367	○
RH16	Resource Management from LCS	0.1933	○
RH17	Information Acquisition from LCS	0.1513	○
RH18	Global Trend Acquire from LCS	0.09177	X
RH19	Problem Solving from PLS	0.5713	○
RH20	Self-Development from PLS	0.0594	X
RH21	Convergence Thinking from PLS	0.2583	○

4 research hypotheses have been rejected. When the P value is statistically significant at an alpha level of 0.1, the hypotheses are accepted in this research. However, RH02, RH11, RH18, and RH20 had the P-value less than 0.1, hence their hypotheses are rejected. The result of hypothesis testing is showed as Figure 20.



(Figure 20) The Result of Hypothesis Tes

7. Conclusion

The 4th Industrial Revolution has brought the changes in most areas. Educational field is not exceptional. Since a variety of new and advanced technologies are emerging from the 4th Industrial Revolution, the paradigm of education is being transformed into a new form combining new technologies. Smart education is one of the new forms of education. In the field of the smart education, five categories such as Big Data, Online Contents, Educational Software, Student Profile and Intelligent Feedback can be applied. By experiencing the smart education, seven abilities such as Problem Solving, Self-development, Communication, Resource Management, Information Acquisition, Global Trend Acquire, and Covergence Thinking can be improved.

In this study, we proposed a model of smart education by applying 5 categories and 7 capabilities to 3 components such as Learning Management System, Learning Contents Service, and Personalized Learning System. The proposed research model generated 21 hypotheses. A survey was conducted to verify the research model and 471 college students participated in the questionnaire. 53-60% of students surveyed that they did not experience smart education at all, while 86-89% students had a positive expectation for the 4th Industrial Revolution.

Four hypotheses out of 21 hypotheses were rejected in the questionnaire. Students who had already experienced learning contents thought no need for a separate Learning Contents Service. Students responded negatively toward Student Profile in the Learning Management System since this technology can automatically generate evaluation information about the learners. In addition, due to the difficulty on using software, applying Educational Software for Personalized Learning System was responded negatively. Finally, Personalized Learning System has shown a low response to its ability to improve self-development. It has been shown that there is a fear of self-development because students have been habituated to study under the guidance of the teacher rather than self-learning and self-development.

These results can suggest a direction for the future smart education. First, augmented reality or virtual reality should be combined with various Learning Contents, also educational contents should adopt the 3D printing technology so learners can realize how their thought can come into a real world. The educational contents of new technology that can not be provided by existing ways of educational contents, therefore, innovation on educational contents are required. Second, the educational evaluation system in Korea is focused to rank learners, hence students have a negative impact on Student Profile. A student's profile should not be applied as a technique for ranking students, but as a basic data to suggest a better learning method reflecting students' learning habits and learning patterns. Third, college students in liberal arts are very reluctant to use the software. If there is a burden on the use of software in the era of the 4th Industrial Revolution, it will make that student be a loser in the future. Education of software usage should be emphasized so that students do not have any reluctance to use software. Fourth, college students may have little experience of self-development. Education should be changed so that self-directed learning methods are frequently experienced, therefore, self-learning and self-development skills can be developed in education field. Consequently, we must all strive to make smart education be a student-centered education method even though the old-fashioned way of teaching was teacher-centered education.

Technology is already in front of us, but change must be accomplished by ourselves. It is the task of all researchers

and educators to apply new technology to make better education. If we can develop the proposed model for smart education, I believe that the day will come soon for all students to be happy and able to study perfectly.

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