

IT Fusion-based Approaches to Education: Tackling the Problems of Global Education, Constructing Mastery Learning Model, and Creating Competitive-type Learning Games

Seong Baeg Kim

Department of Computer Education, Jeju National University, Jeju, 690-756, Korea
sbkim@jejunu.ac.kr

Abstract

As the fourth industry revolution is starting, most of the fields including education are rapidly being changed. In particular, research on IT or SW fusion in each field is being performed. This paper discusses novel approaches to improve previous education services through IT fusion.

First, I propose a way to converge IT into global education, which focuses on students of the college of education who are interested in becoming teachers. Due to internationalization demands in the field of education, the necessity of global education is increasing rapidly. However, a general consensus of the definition and model for global education is not clear yet and the actual performance falls short of our expectations owing to high cost, low effectiveness, and lack of persistence in the process of global education. To overcome the limits of global education and develop an efficient education system, this research suggests an IT-fusion-based education system for training global teachers.

Second, it is difficult for an instructor to grasp instantly how much learners understand learning content in class in a typical education environment. In case of a class, which consists of possibly dozens of students at various levels : trying to understand degree and learning achievement of the learners in a broad spectrum, depending on the learning contents. Therefore, it is almost impossible for an instructor to let all of the learners reach a specific learning objective. In this paper, I propose an approach that enables the arbitrary rate of learners, who reach a learning goal, to be set by an instructor. I describe an instruction support system combined with an instant response system, dynamic formative evaluation scheme, and confidence level. I expect that this approach can make an instructor set the ratio of learners, who reach the learning objective, as the instructor wants, and brings about effective instruction.

Third, this study proposes a new learning model for improving problem solving and programming skills. To solve a real world problem using IT, problem solving and programming skills are important. In this study, I describe a learning model that can help to improve problem solving and programming skills, based on computational thinking. The feature of the learning model proposed is to offer learners challenges and spur interest by presenting the questions into learning games of an inter-competition type after developing the questions that improve problem solving and programming skills. Another feature is to present the questions about algorithms and programming in various forms and generate them dynamically. Especially, by providing an inter-competition game type, due to increase of competition between learners, learners will feel relatively less difficulty in problem solving and programming, and enable them to naturally improve problem solving abilities and programming skills through the competition.

key words:

Global teacher education, teacher training, IT-fusion education, mastery learning, dynamic formative evaluation, instruction support system, instant response system, computational thinking, programming skill

Introduction

During the last few decades, due to the development of IT and the internationalization changes in the field of politics, economy, social, culture, and so on... global interconnection is being strengthened. Also, a variety of global issues are emerging at the same time [1]. Also, in the educational field, to improve the abilities of understanding and coping with this situation, the demand for global education has increased. However, there is no general consensus for the definition or a model of global education, yet. Especially, in case of institution that trains teachers who are in charge of spreading global education at the location of elementary and secondary schools, the work to build up a model of global education in order to meet the necessities of teacher training is urgent. In this study, I aim to propose a global education model using IT fusion, based on a dynamically formative evaluation scheme and an online mastery learning approach [2].

In general, formative evaluation is used to aim at checking out the necessity of additional learning and improving instruction methods through recognition of learning degree of learners during a teaching-learning process [1]. Compared with summative evaluation, formative evaluation is focused on the learning process rather than the learning effect or outcome. The formative evaluation in school includes various forms like questions, quizzes, learner's reaction, looking in learner's eyes, head nods, and so on. The results of the formative evaluations are being used for controlling learning pace, empowering learning, and improving a teaching-learning method, etc. However, even though such rough evaluation can help to find out the learning depth to some degree, it is so difficult to grasp fully each learner in detail on the spot in class. In other words, it will be hard for an instructor to achieve a learning goal set by the instructor by reflecting on the formative evaluation instantly in class, even though the formative evaluation could be reflected on during the next class. In addition, the instructor has inevitably some burden on the continuous analysis of the formative evaluations.

Recently, to solve the drawbacks, instant response systems, which can identify the learning degree of learners quickly and accurately, have been developed and are being used in the class where there are lots of students. In the instant response systems, an instructor can give formative evaluation questions to learners in class and then get the responses within a specific time period. The instructor can analyze the responses using a statistical software and get graph charts of the processed data, like answer rate. With the help of IT technology, the instructor has little burden on the analysis of the formative evaluations.

In this paper, I will examine an advanced approach to bring a better class through a new instructional support system of adding extended functionalities to the instant response systems. The existing instant response systems do not yet provide an instructor with the functionality to help to reach an instructional goal that the instructor wants. Also, they do not support an instructional method for an instructor to adapt, based on the response analysis instantly. As a solution for both of these limits, I introduce a method to make learners answer formative evaluation questions several times after generating the formative evaluation questions in various forms. It is necessary to reduce the burden for an instructor creating many formative evaluation questions by providing a generating system of formative evaluation questions. Furthermore, it is necessary to filter out the cases that a learner can correctly answer, even if the learner doesn't understand fully the question in a multiple choice question form. I suggest a dynamic formative evaluation system, which can relieve the boredom in repetitive evaluations as well as improve the learning achievement due to solving the repetitive questions. Also, it is possible to ask the confidence level to each question to gauge learners' understanding depth.

There are a few issues to be solved in order to enable an instructor to set a learning goal using the dynamic formative evaluation scheme, instant response system, and confidence level. First, it is critical to control the difficulty level among formative evaluation questions and solve the problem of guessing a correct answer due to the similarity between the questions [2]. Second, it is necessary to decide how to reflect on the result of the formative evaluation questions per each learner in the case of the learner answering several questions repetitively. Finally, it is necessary to propose on how to decide whether the condition of reaching mastery learning is satisfied or not, reflecting on the confidence level as well as the answer rate.

Therefore, this paper aims to help to make an instructor reach the learning objective using dynamic formative evaluation scheme and confidence level-based instant response systems by giving the solutions of the issues properly. In particular, I introduce a new concept called mastery instruction from the viewpoint of an instructor in contrast with learner-centered mastery learning. Mastery instruction is defined as the case where the rate of the learners, who understand the learning contents among the total learners in class, reaches a goal value set by an instructor beforehand. I propose an effective instruction scheme to bring mastery instruction set by an instructor.

Several effects are expected from this approach.

First, it is possible to boost the participation of learners and draw learning interests through the instant response systems and dynamic formative evaluation schemes. Second, an instructor can grasp more accurately the degree of understanding of learners by adding the confidence level. Third, the interaction between an instructor and learners can be improved by the repetition of the dynamic formative evaluation questions. Fourth, it is possible for an instructor to improve one's instruction method through the different concept called 'mastery instruction' which is quite a different approach from mastery learning. Finally, the scheme can be applied to question-solving-based classes in flip learning, which gives discussion and answering questions-centered instruction in class, previously learned material using learning material like videos.

As the information era in the 21st century becomes the norm, the computer is being closely related more and more with our lives. Recently, in handling most things, we use the computer. Due to such reasons, it is more important to know how to solve a problem given using computers. However, after the problem is given, it is difficult to learn how to resolve this on the computer. It's because the solution to solve using computers is not standardized, depending on the problem. Students, who are short of problem solving capability or programming skills, are unable to solve the given questions due to the non-standardized problem solving method. Therefore, it is necessary to develop a variety of questions reflecting the real-world problems and ways to train problem solving capability and programming skills. However, most of us have a vague sense of fear about programming and think of programming as difficult or a hard thing to work on. First of all, it is hard to understand the programming language when I first encountered it because the programming language is another language. When I first learned a new foreign language, the words were unfamiliar and hard to understand, and gave us a headache. The same applies to learning programming languages as well. Motivation is necessary to overcome the difficulties when we learn new things. This study seeks to improve problem solving capability and programming skills to solve problems using computers by giving a weight on the game specific elements through a competitive game to stimulate interest.

Related Work

In this section, I examine existing approaches and their limitations to global education for training global teachers. Recently, as globalization goes on in the world, global education is emerging as an important keyword in higher education. Also, as the necessity of global education increases, an

international office, which handles international affairs, has been set up to develop international exchange programs. A few universities are giving the benefits of global education to pre-service teachers through the international office and GTU centers focused on fostering global teachers.

However, the opportunities are given to only a few teachers, limited because the budget is not enough. Thus, to cultivate global teachers in the future, we have to extend global education programs to all pre-service teachers. As an approach that could benefit many students with the limited budget, online and social media based educational methods like MOOC(Massively Open Online Courses) are being revved up abroad [3][4]. However, there has been little opportunity for global online education due to jet lag and language barriers in the domestic sphere. Therefore, for global education diffusion in the future, online global education Korean-style schemes must be developed and fused with the humanistic approach and advanced technology.

There has been much research on instant response systems, which provides an instant interaction between an instructor and a learner [5][6][7]. One of most widely used instant response systems is the iClicker that is effective in large size classes at universities [5]. iClicker instant response system consists of a base station with RF(radio frequency), remote controllers or smart devices, and a software package. This system provides an instructor with the creation of a variety of questions like true/false or multiple choice and instant results of understanding the depth of all students in class using iClicker remote controllers, which communicates with the base station using a radio frequency. Also, other instant response systems like PingPong or Socrative are released and being used at schools or universities. These systems are based on a response app with a smart device.

The research on the instant response systems has been limited to improving interactions between an instructor and learners or showing the responses using a graph. Also, there has been little research on how an instructor can adapt an instruction method directly in class, depending on the degree of understanding of the learners.

Formative evaluation has been done since long time ago to identify a learning goal for learners. Traditional methods, like a paper-based formative evaluation scheme, have troubles in getting feedback instantly or processing the test when there are many students. With the introduction of instant response systems, formative evaluation becomes much easier and draws more interest because they enable to bring instant feedback from the test and there is no burden for processing the test. Currently, a way to create a question for a formative evaluation scheme has changed very

little, even if instant response systems have been introduced. I studied dynamic formative evaluation schemes for generating the questions of various forms using information technology in the past [8]. However, this research has no consideration of an instant response system. It focused on mastery learning from the viewpoint of a learner rather than mastery instruction from the viewpoint of an instructor. I will examine a solution to bring mastery instruction by combining an instant response system with a sophisticated formative evaluation scheme.

There have been many studies on programming capabilities. For example, there has been a study that indicates, it is possible to enhance programming skills by using a program called SCRATCH [9]. Also, one study examined how to develop a program to enhance programming skills [10]. Besides those studies mentioned, there has been a study on developing and applying an IDEAL-TRIZ learning program as a way to strengthen technical problem solving capability. According to the study, it should be able to draw the learners' interests to increase the learning effect [11]. Another research paper examined how to make an information education program to improve creative problem solving skills [12]. A theoretical review on the activity model to improve problem solving capabilities of students in rural areas and developing a program that fits the purpose has been conducted [13].

However, this study, unlike those studies introduced above, adds the game elements in the inter-competitive form and aims to draw the learning effect by stimulating competitive spirit among learners, and makes them feel a sense of challenge.

IT Fusions in Global Education

As the terms that represent global education, international education, global education, world-centered education, world prospect education, and so on have been mixed. So, the definitions for global education are quite different. Although the definitions of the related organizations abroad are quite different, all of them are emphasizing the three aspects of mutual understanding, world citizen education, and leader training. In general, global education learns about global problems and issues, the culture of each country in the world, society, economy, and politics, and means the advance education model that trains students to meet the requirements of globalization through vitalizing student exchange programs of domestic and abroad students.

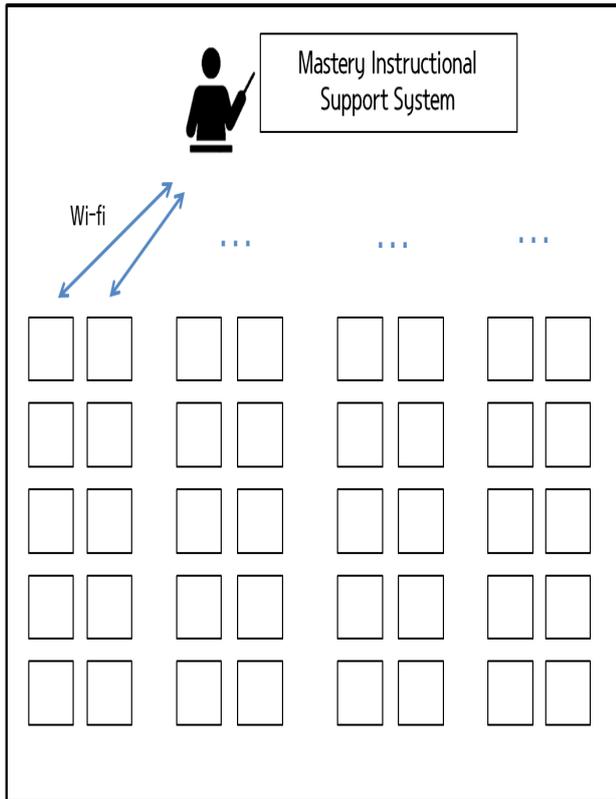
Let me show an example of a blended learning model. The total lecture of most courses consists of 45 classes during one semester. There are three

classes per week. Two hours are given by face-to-face and one hour is given by customized mastery learning using smart devices. The face-to-face is master and the online learning is slave. The online learning is composed of dynamic formative evaluation and selective repetition learning. So, the online learning increases the degree of learning achievement by reaching mastery learning through assistance of the face-to-face classes. In global education, barrier elements are added like different time zones, language barriers, and culture differences. If an online class has been made, focusing on dynamic formative evaluation because offline class and online class should be closely coordinated, it improves the learning effect and reduces the learning time and boredom. It is because it lets learners do a self-formative evaluation through a dynamic formative evaluation scheme for face-to-face class contents and learn only the review and relearn the weak parts based on the self-evaluation.

To enhance the global competitiveness, domestic universities have been trying various international exchange programs through the partnership with abroad educational institutes. However, there are insufficient opportunities in practicum and there are very often the cases that have been made in the form of cultural experiences and language trainings because the objectives and strategies of international exchange programs have not been clearly established. To overcome these limitations and to internationalize the curriculum, first of all, I should establish the concept and model of global education in the viewpoint of teacher training. In addition, based on the proposed model, I must develop a teaching method, learning contents, and educational and cultural programs for global education and suggest how to apply the global education model. Therefore, in this study, I propose global educational methodology using blended learning-based teaching-learning methods and big data techniques. Based on this IT fusion education model, it is possible to expand the application of the global education model and to adapt and spread abroad the contents and methods of the global education through international exchanges like global volunteering to developing countries and practicum, in cooperation with abroad partners.

Mastery Instruction

Our support system for an instructor who wants to obtain an instruction goal can be useful in a smart classroom equipped with smart devices, as shown in Figure 1. Our support system for mastery instruction consists of an item authoring tool for a dynamic formative evaluation scheme, Wi-Fi, mastery learning organizer, and so on.



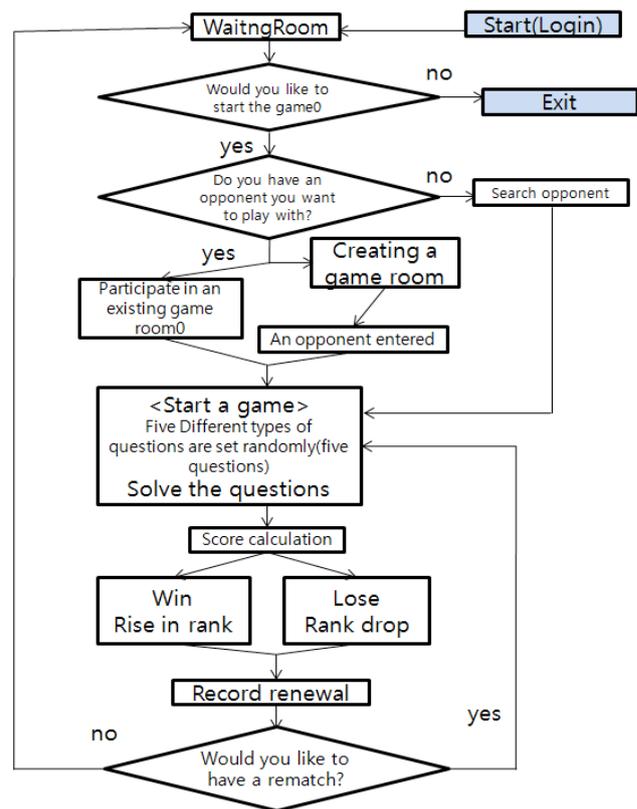
〈Figure 1. A smart classroom for mastery instruction〉

First of all, to bring mastery instruction satisfied by an instructor, it is necessary to create various items for a class. It's not easy for an instructor to make various challenging items. So, a tool to help to generate items easily without much effort is required. My basic idea to generate items is to convert choices of an item given by an instructor into a variety of multiple choice items. When items are generated, it is required to meet both learning enforcement through repetition and keeping challenge to test each item in spite of repetition. The mastery learning organizer helps an instructor to make a lesson plan for mastery learning in class. It has functions like arranging the generated items in sequence, setting an instructional goal for a class, adapting an instruction method depending on the situation, and so on.

Learning Games

Figure 2 is an overall learning flow diagram of a program designed in this study. You will be entering the waiting room when you first enter the user name and password to login. Then, you can participate in the game room already made if there is an opponent you want to play with, or make a game room and start the game when an opponent comes into the game room. If you are unable to find an opponent you want to play with, you can find an opponent whom has a similar rank using the partner search button and start the game. As you start the

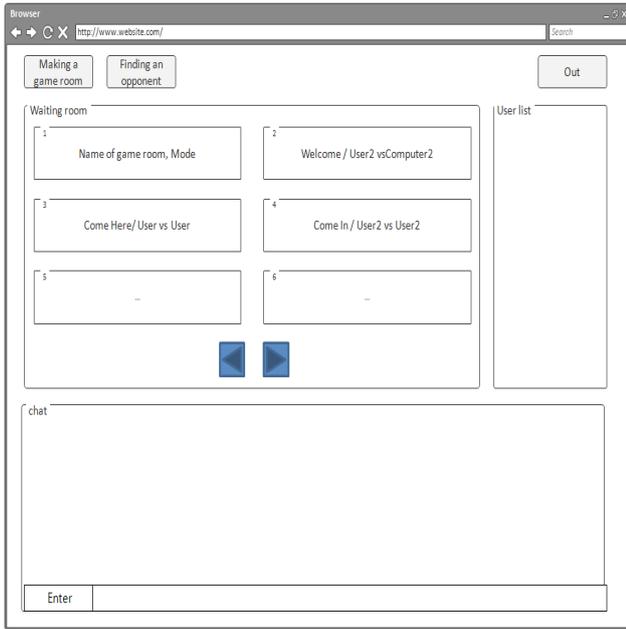
game, five questions that are dynamically generated in different question types will be set. After solving the problems, the score of you and your opponent will be compared and the one who earned a higher score will win. Rank will rise when you win, and the rank will drop when you lose. You can have a rematch or go back to the waiting room if you don't want a rematch. If you want to quit the game, please click the out button in the waiting room to finish the game.



〈Figure 2: Learning game flow diagram.〉

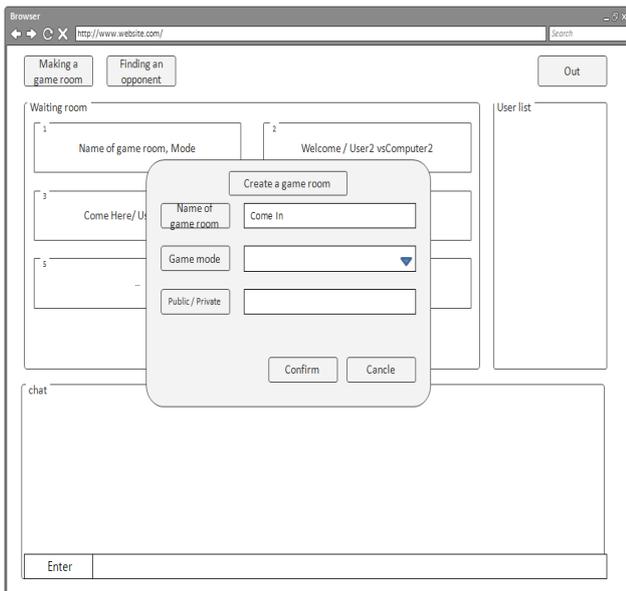
This educational game has its basis on the contents included in major subjects, such as, algorithms, Java, C-language, PHP, and data structure, associated college level problem solving and programming languages. The purpose of this educational game is to ensure mastery of the the basics of programming language using Java, C-language, and PHP and effectively learn data structure and algorithms to enhance problem solving capabilities.

Competition form



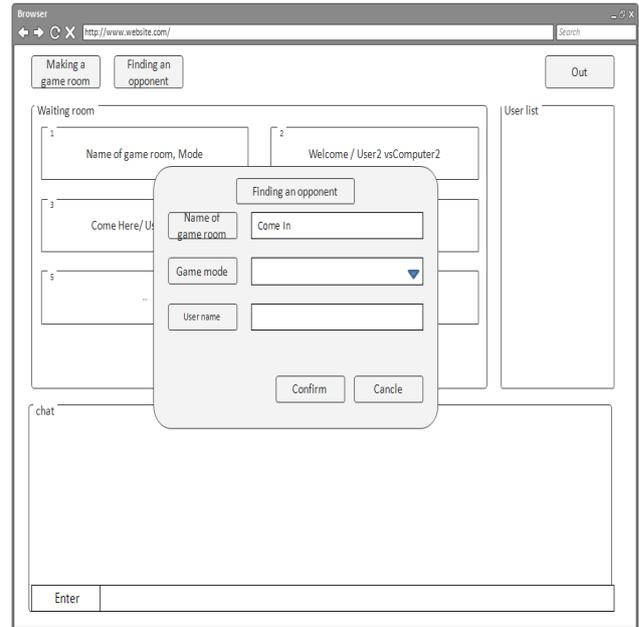
<Figure 3: Waiting room.>

As you login, you will see the screen as shown in Figure 3. This is a state to wait before you start the game. You can chat with other opponents, make a game room, or participate in a game room created by others. If you click the search button, you will be paired with an opponent who has a similar rank and entered into a game room.



<Figure 4: Making a room.>

Figure 4 describes the process to make a game room. You can set the room name, game mode, and whether to make the room public or private when you create a game room.



<Figure 5: Finding opponent.>

Figure 5 describes the process to find an opponent using the finding opponent button. If there is an opponent satisfies one of the conditions, name of the game room, game mode, or user name, it will move you to the game room made by the opponent.



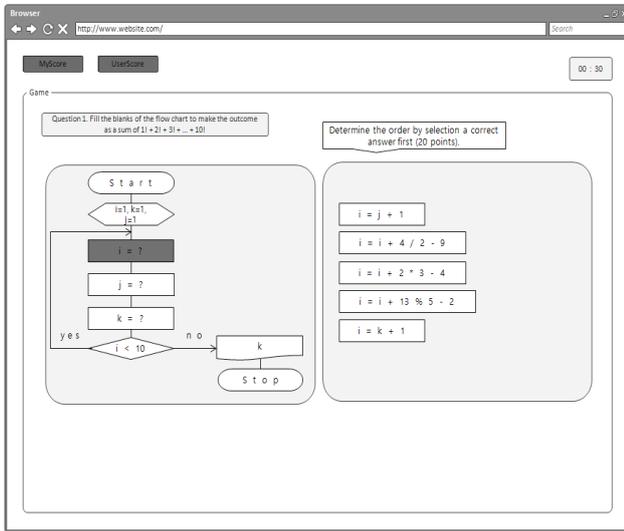
<Figure 6: Competing room screen.>

Figure 6 is a created game room screen. The learner who made the game room can start the game when ready, or can expel opponents if the learner who made the game room does not want to play the game with the opponents. When the game starts, random types of questions will be selected, and the selected questions that are dynamically

formed will be printed out. From now on, each question type will be described.

Types of questions

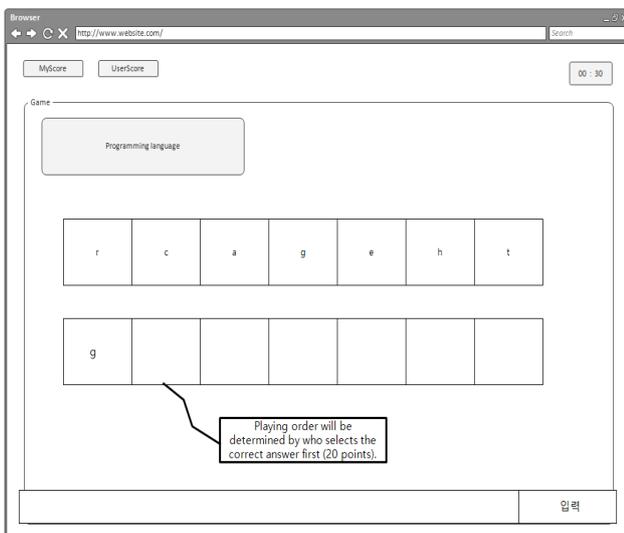
Type ①



<Figure 7: Filling a flow chart type.>

In this question as shown in Figure 7, the user first fills the blanks gets the next question ahead of the opponent. The user will be able to solve the next question continuously if the user gives the correct answer. If the user gives a wrong answer, the question will be given to the opponent. 20 points will be filled in the first blank, and 10 points in the second blank, and 30 points in the last blank. The way the points are given for each blank adds to the element of the game.

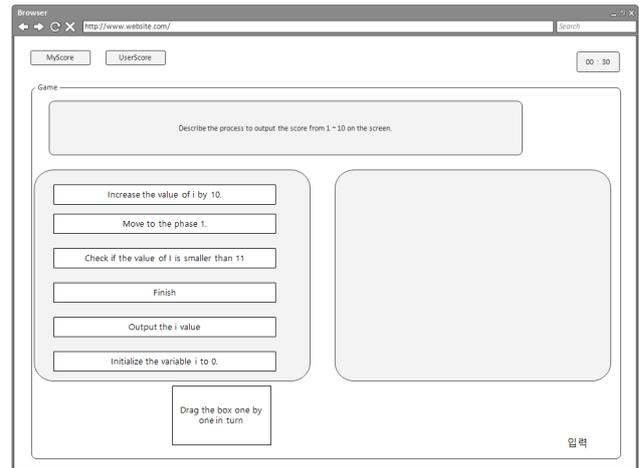
Type ②



<Figure 8: Programming language type.>

As shown in Figure 8, in this question, the user who first fills the first blank will be able to solve the next problem. The chance to play the next question will be given to the opponent if the user gives the correct answer or a wrong answer. 20 points will be filled in the first blank, and 10 points from the second blank. The way the points are given for each blank adds to the element of the game.

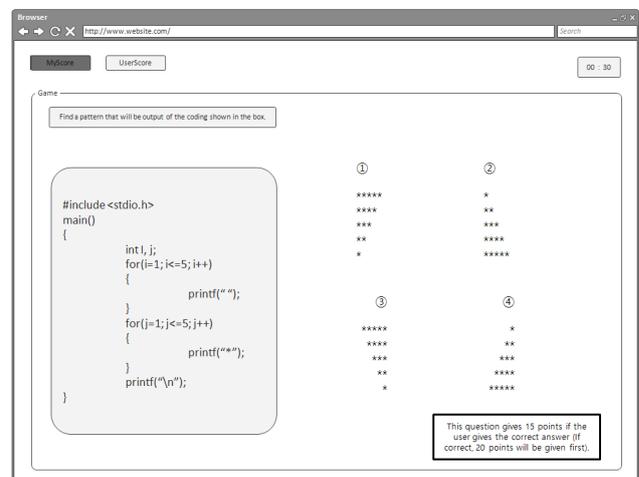
Type ③



<Figure 9: Algorithm step arrangement type.>

As you can see in Figure 9, in this question, you have to drag the sentence to be placed in the first place following the order. If you drag the correct sentence first, you can have a chance to place the answer for the next question. If you give the correct answer or a wrong answer, the turn will be given to the opponent. 20 points will be filled in the first blank, and 10 points from the second blank. The way the points are given for each blank adds to the element of the game.

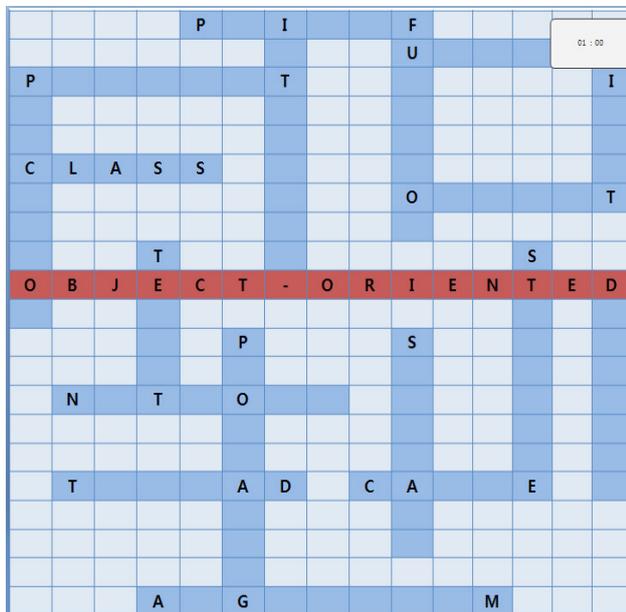
Type ④



<Figure 10: Output result confirmation type.>

As shown in Figure 10, this question is a simple one to rest user's mind. It's a multiple choice question given to each user. If correct, 10 points will be given. There is a time limit of 10~20 seconds.

Type ⑤



〈Figure 11: Puzzle type.〉

It is a question type that the user who solves more questions first earns more points, as shown in Figure 11. Each user will have a question on the screen, and the user who solves more questions in a limited time will earn more points. If the user solves all the questions on a screen, bonus points will be given to the user.

Five kinds of questions of each question type will be selected randomly. All the questions are dynamic, so it can be changed a little by using the problem or answer.

Conclusions

Recently, due to the demands of globalization in the field of education, the necessity of global education for training global teachers is being emphasized. In this research, I proposed an approach to IT fusion global education to solve the problems like high-cost, low effectiveness, lack of sustainability, etc., and to provide an efficient global education method. For this, I analyzed a global education curriculum, discussed the necessity of online/offline teaching-learning method based on IT fusion, and proposed a guideline to global learning contents including how to analyze the linkage between education and culture programs. In particular, I derived a blended learning model using IT fusion.

I proposed a novel approach to mastery learning

by combining instant response system, dynamic formative evaluation, and confident level together. The support system for mastery learning has been designed to set an instructional goal that an instructor expects and to achieve the goal efficiently. The system helps to boost interactions between an instructor and learners and enables the concept and goal of mastery learning centered on an instructor during teaching.

This study provides five kinds of question types as providing the learning model in the form of a competitive game to enhance programming skills. The constantly changing questions help to draw learners' sense of accomplishment and contribute to stimulating motivation by drawing out learners' competitive spirit and sense of challenge through the competitive game. The game design is currently completed, and a prototype is on development. The effect of this learning model will be tested by applying the game after the prototype is completely developed.

For further study, there is need to apply the approaches to a smart classroom. Also, it's necessary to examine the possibility of applying the scheme to item solving-based flipped learning.

Acknowledgement

The financial support from Jeju Green Environment Center (JGEC, Korea) is gratefully acknowledged.

References

- Shin, H. (1995) 'Theoretical View of Global Education', *Journal of Comparative Research*, Vol. 5, No. 1, pp. 85-110.
- Kang, J., Kim, M. H., and Kim, S. B. (2014) 'An Online Mastery Learning Method Based on a Dynamic Formative Evaluation', *World Academy of Science, Engineering and Technology, International Science Index* 86.
- Rutherford, A. G., and Kerr, B. (2008) 'An Inclusive Approach to Online Learning Environments: Models and Resources', *Turkish Online Journal of Distance Education – TOJDE*, Vol. 9, No. 2, pp. 64-68.
- Khan Academy, <https://www.khanacademy.org>
- 5. iClicker, <http://www.iclicker.com>
- 6. Socrative, <http://www.socrative.com>
- 7. PingPong, <http://gogopp.com>
- 8. Kang, J., Kim, M., and Kim, S. B. (2014) 'Developing a Video-based Smart Mastery Learning through Adaptive Evaluation', *International Journal of Multimedia and Ubiquitous Engineering*.
- 9. Ahn, K. M., Sohn, W. -S., and Choi, Y.-C. (2011) 'The Effect of Scratch Programming Education on Learning-Flow and Programming Ability for

Elementary Students', Journal of Korea Association of Information Education, Vol. 15, No. 1.

10. Choi, J. W & Lee, Y. J. (2014) 'Development of Education Programs for Improving Programming Learning Skills', Proc. of 2014 Summer Conference of the Korean Association of Computer Education, Vol. 18, No. 2.

11. Lee, J. G & Choi, Y.-H. (2010) 'The Development and application Effect of IDEAL-TRIZ Learning Program to Improve Technological Problem-Solving Capability for Elementary School Students', Journal of the Korean Association of Practical Arts Education, Vol. 23, No. 2.

12. Lee, Y., Lim, U. & Lee, E. (2010) 'Development of Information Education Program for Enhancing Creativity', Journal of the Korean Association of Computer Education, Vol. 13, No. 1.

13. Jeong, E., Moon, C., Hong, S. & Park, J. (2010) 'A Study on the Development of Activity Model and Program for Enhancing Creative Problem Solving Capability of the Students in Jeju Area', Journal of Korea Academia-Industrial Cooperation Society.