Design of Cloud-Based Adaptive Learning System to Promote Creative Problem Solving for the 21st Century Learners

Jitlada Kumnuansin [1], Jintavee Khlaisang [2], Prakob Koraneekij [2]

[1] *Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University, Bangkok, Thailand*
[2] *Center of Excellence in Educational Invention and Innovation, Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University, Thailand*

Abstract **– This research developed a cloud-based adaptive learning system to enhance the creative problem-solving efficiency of learners based on their ability levels. The difficulty level of learning activities in the system would be adjusted to fit the creative problem-solving ability of each learner, while there would also be knowledge sharing activities to create new ideas. This cloud-based adaptive learning system has six components, which are 1) adaptive learning system, 2) cloud tools, 3) topic of problem, 4) teaching and learning approach, 5) assessment, and 6) knowledge sharing. The system consists of four steps, which are 1) search (S), 2) solve (S), 3) create (C), and 4) share (S). The system was designed based on the survey results of 55 undergraduate lecturers and 478 undergraduates, then an experiment was conducted. The results showed that creative problem-solving scores after using the system were higher than the before using it, at a significance level of .05. The results were analyzed using F test and found a significance difference of the creative problem-solving scores, which after using the system were higher than before using the system at the significant level of .05**

Keywords **– Adaptive System, Creative Problem Solving, Cloud Tools.**

DOI: 10.18421/TEM114-29
https://doi.org/10.18421/TEM114-29

Corresponding author: Jintavee Khlaisang,
Center of Excellence in Educational Invention and Innovation, Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University, Thailand.
Email: Jintavee.m@chula.ac.th

Received: 04 June 2022.
Revised: 16 September 2022.
Accepted: 20 September 2022.
Published: 25 November 2022.

1. Introduction

Creative problem solving is an important skill for learners in the 21st century. Many universities have made this an essential skill for their students. Similarly, with the advent of the Education 4.0 era, learners are encouraged to become thinkers and innovators, to apply knowledge with creative integration, and to create innovations for society [1]. Moreover, a bachelor's degree is a fundamental requirement for a variety of professions, so it is necessary for students to demonstrate originality in problem solving, to be able to analyze a situation, and to solve a problem while following an organized plan. Students also need to practice with various scenarios to be able to share and employ knowledge appropriately within each situation [2], [3], [4].

Every student, however, is different in his/her perception, cognitive style, comprehension [5], and learning style [6]. These differences affect their behavior, especially in creative problem solving. A single teaching approach is not always suitable for all students; competency and knowledge levels need to be taken into account to seek the right techniques and activities for enhancing creative problem-solving skills [7]. Accordingly, teachers should consider the proficiencies and differences of each student when using education technology to maximize its efficiency in the teaching and learning process. An adaptive learning system is flexible and can be adapted to suit the needs and knowledge of each student [8] as well as learners' characteristics, interests, and others such as learning styles [9]. The system will analyze student data and recommend

suitable lessons based on characteristics and needs [9] to help improve learning skills. This system is appropriate for students with varying levels of knowledge, skills, and learning styles.

Today technology has reduced personal space and diminished the limitation of time and place, allowing students to engage in both self-learning and collaborative learning with others [10]. This learning technology takes into consideration the unique characteristics, social skills, and thinking skills of everyone. Cloud-based learning tools and computer networks have been developed to support sharing of information resources to which learners can get access from anywhere [11]. Cloud technology is also adaptable to user behavior, so it can answer the needs of different students and improve the efficiency of adaptive learning systems. Moreover, Cloud technology allows students to collaboratively develop and publish their work in a variety of styles [12], encourages collaboration between students [13], helps with problem solving, facilitates synchronous and asynchronous communication between students and teachers, and promotes opinion sharing [14]. In addition, students can present their work and content via cloud technology in the form of images, text, or animations. Most importantly, cloud technology is compatible with all types of devices, particularly mobile devices, which are extensively used in education in many countries [15]. Students can study anywhere and anytime via their mobile devices, helping eliminate limitations on students who study via distance learning or those with disabilities. Cloud technology works well with adaptive learning systems [16] and is suitable for enhancing creative problem-solving skills because, while such skills can be practiced independently, working in groups and sharing knowledge with others can generate new ideas and increase problem solving efficiency [17]. Therefore, this research paper developed a cloud-based adaptive learning system to enhance creative problem-solving efficiency in students based on their proficiency.

2. Methodology

The researchers started by examining the problems and collecting opinions from 55 undergraduate lecturers and 478 undergraduate students regarding the current situations of teaching and learning for enhancing creative problem solving. The team then developed a cloud-based adaptive learning system and tested it with 61 undergraduate students. The developed system consisted of the following components.

2.1. Diagram

The cloud-based adaptive learning system to enhance creative problem-solving efficiency of undergraduate students consisted of six components and four steps, as shown in Figure 1.

Figure 1. Diagram

A. Components

1) Adaptive learning system – This flexible learning system could adjust to the abilities and skills of each student. The system would analyze students from existing data and recommend suitable lessons to help them improve their learning performance based on their proficiency.

2) Cloud tools – These internet-based computer resources consisted of five groups of tools, which were 1) collaboration tools, 2) data-gathering tools, 3) content creation tools, 4) presentation tools, and 5) communication tools.

3) Topic of the problem – The topics of problems were events, stories, news stories, or articles that would be assigned for students to read and find solutions for to practice creative problem solving. The chosen topics concerned 21st century skills, which were 1) global awareness, 2) financial, economics, business, and entrepreneurial literacy, 3) civic literacy, 4) health literacy, and 5) environment literacy.

4) Teaching and learning approach – This SSCS teaching and learning model consisted of four steps, which were 1) search (S), 2) solve (S), 3) create (C), and 4) share (S), and techniques to enhance creative problem solving.

5) Assessment – There were two assessment criteria used in this study. Firstly, a pre- and post-learning test was used to evaluate students' creative problem-solving skills before and after using the adaptive learning system. Students would be asked to answer questions about a given situation and their answers would be scored on a rubric in relation to these four traits: 1) the ability to identify a problem and choose a problem solving method, 2) the ability to solve a problem within a given timeframe with 2.1) fluency, 2.2) flexibility, and 2.3) originality, 3) the ability to choose a practical problem solving method, and 4) having a process of operations and choosing a problem solving method with reason. Secondly, a semantic differential scale was used to evaluate students' creative problem-solving skills regarding their works. The scale consisted of three dimensions and seven concepts; each concept had a seven-word bipolar semantic scale as a subscale.

6) Knowledge sharing – There would be opinion sharing between students as well as between students and lecturer to point out mistakes, encourage comprehensive thinking, and generate new ideas.

B. Steps

Step 1 Search: S – The lecturer assigned a general problem topic such as a real-life situation for students to collect information, examine the problem, and then present the problem via the word cloud tools.

Step 2 Solve: S – Students worked out a plan and solved the problem with a variety of methods. A problem presentation by each student would be different based on their creative thinking skills. Students were categorized into seven groups:1) students who need to improve fluency (C1), 2) students who need to improve flexibility (C2), 3) students who need to improve originality (C3), 4) students who need to improve fluency and flexibility (C4), 5) students who need to improve fluency and originality (C5), 6) students who need to improve flexibility and originality (C6), and 7) students who need to improve fluency, flexibility, and originality (C7).

Step 3 Create: C – Students created a presentation via the content creation tools to explain a chosen problem-solving method in Step 2. They could add text, images, or the researched information in the content creation tools.

Step 4 Share: S – Students shared what they found and their problem-solving methods with peers. The lecturer introduced a problem to discuss and encouraged students to exchange ideas. This sharing step could lead to new problems, while mistakes would also be examined. Then the students would review the work of their peers and explain how to improve their own work via the content creation tools.

2.2. System Structure

Two models of cloud system were used in this research: Platform as a Service (PaaS) and Software as a Service (SaaS). The adaptive learning system was developed on PaaS and SaaS were used to support teaching and learning activities. The system structure is shown in Figure 2.

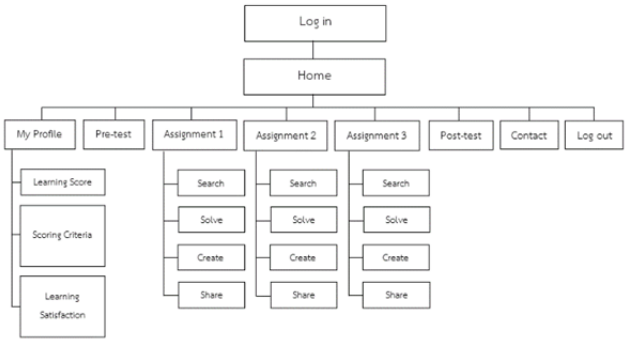

Figure 2. System Structure

2.3. Activity Flowchart

Student would be asked to do a pre-test and then categorized into seven groups based on the skills they need to improve. All students in each group would be given the same problem topic to start the learning activity, as shown in the following flow chart.

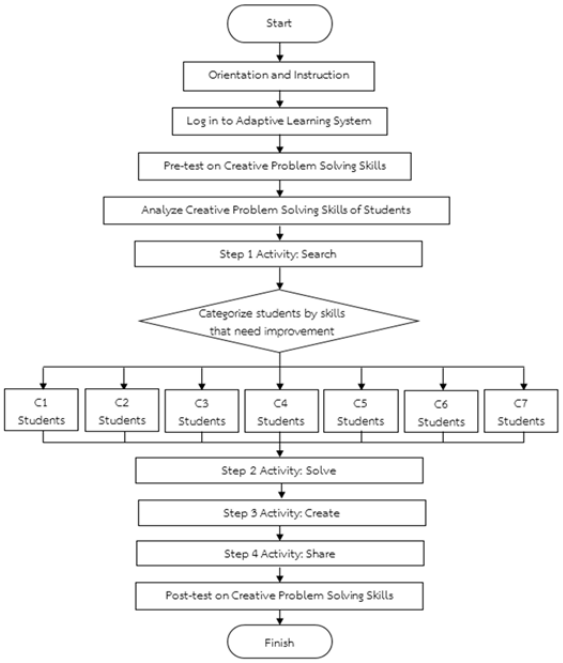

Figure 3. Activity Flowchart

C1 Students – Each student would start the Search activity by assessing the problem and its consequence. Then they would begin brainstorming in the Solve activity. The system would show a difficult level task, asking the student to provide 15 problem solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking instead for 10 problem solving methods within 10 minutes. The student needed to complete this task to move to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit, share opinions, and conclude the project. The student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C2 Students – Each student would start the Search activity by assessing the problem and its consequence. Then the student would begin the solve activity of attribute consideration. The system would show a difficult-level task, asking the student to provide three groups of solutions with at least three problem solving methods in each group within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide two groups of solutions with at least three problem solving methods in each group within 10 minutes. The student needed to complete this task to get to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C3 Students – Each student would start the Search activity by assessing the problem and its consequence. Then the student would begin the solve activity of changes. The system would show a difficult level task, asking the student to demonstrate 10 novel problem-solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 5 novel problem-solving methods within 10 minutes. The student needed to complete this task to get to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C4 Students – Each student would start the Search activity by assessing the problem and its consequence. Then the student would begin the solve activity of brainstorming. The system would show a difficult-level task, asking the student to provide 15 problem solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 10 problem solving methods within 10 minutes. The student needed to complete this task. After that, the student would begin the solve activity of attribute consideration. The system would show a difficult level task, asking the student to provide three groups of solutions with at least three problem solving methods in each group within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide two groups of solutions with at least three problem solving methods in each group within 10 minutes. The student needed to complete this task to get to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C5 Students – Each student would start the search activity by assessing the problem and its consequence. Then the student would begin the solve activity of brainstorming. The system would show a difficult level task, asking the student to provide 15 problem solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 10 problem solving methods within 10 minutes. After that, the student would begin the solve activity of changes. The system would show a difficult level task, asking the student to provide 10 novel problem-solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 5 novel problem-solving methods within 10 minutes. The student needed to complete this task to get to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The

student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C6 Students – Each student would start the search activity by assessing the problem and its consequence. Then the student would begin the solve activity of attribute consideration. The system would show a difficult level task, asking the student to provide three groups of solutions with at least three problem solving methods in each group within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide two groups of solutions with at least three problem solving methods in each group within 10 minutes. After that, the student would begin the solve activity of changes. The system would show a difficult level task, asking the student to provide 10 novel problem-solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 5 novel problem-solving methods within 10 minutes. The student needed to complete this task to get to the next activities, Create and Share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The student had to complete the Search, Solve, Create, and Share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

C7 Students – Each student would start the search activity by assessing the problem and its consequence. Then the student would begin the solve activity of brainstorming. The system would show a difficult level task, asking the student to provide 15 problem solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 10 problem solving methods within 10 minutes. The student needed to complete this task. After that, the student would begin the Solve activity of attribute consideration. The system would show a difficult level task, asking the student to provide three groups of solutions with at least three problem solving methods in each group within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide two groups of solutions with at least three problem solving methods in each group within 10 minutes. Then the student would begin the Solve activity of changes. The system would show a difficult level task, asking the student to provide 10 novel problem-solving methods within 10 minutes. If the student failed to complete the task, the system would adjust the difficulty level and show an easier level task, asking the student to provide 5 novel problem-solving methods within 10 minutes. The student needed to complete this task to get to the next activities, create and share. The student would create a work project, present it to peers for review and comment, edit the work, share opinions, and conclude the project. The student had to complete the search, solve, create, and share activities for all three assignments, otherwise they would have to start the activity again from the beginning. Finally, the student would be asked to do a post-test to finish the activity to enhance creative problem solving.

3. Results

3.1 Student System

The research team developed a cloud-based adaptive learning system to enhance creative problem-solving abilities with respect to the above-mentioned components and steps. The system was developed with a responsive design to ensure its compatibility across devices. The user interface of this learning system is shown in Figures 4-8.

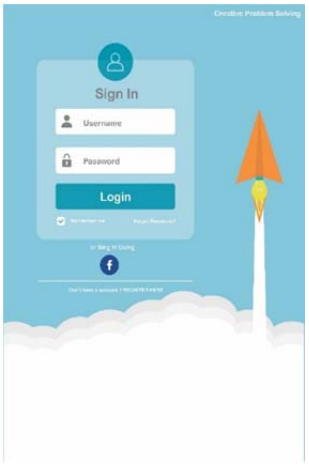

Figure 4. System Login

Figure 5. Search Activity

Figure 6. Solve Activity

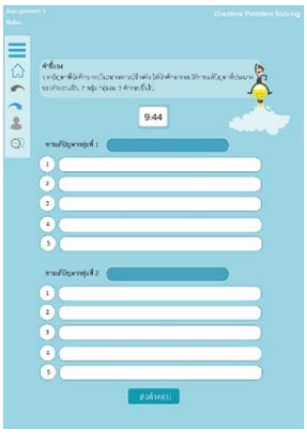

Figure 7. Create and Share Activity

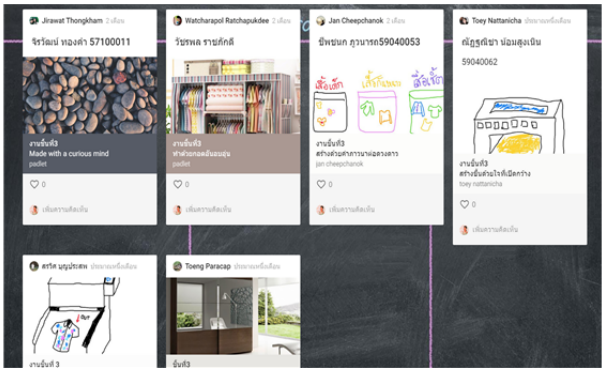

Figure 8. Examples of a Student's Works

3.2. Lecture and Administrator System

This adaptive learning system was developed on a Platform as a Service (PaaS) cloud model. Lecturers would be able to manage student profiles, add student names and Facebook accounts, categorize groups of students, and add a study level, grade point average (GPA), faculty of study, pre-test and post-test scores, and assignment scores for each student. Lecturers could see the answers of the students and save or print the data as an excel file, add URL links to the topic of problem of each assignment, and add links to other cloud tools. Lecturers could also input words they wanted to block to prevent students from answering repeated words in the problem solving originality activity. These were shown in Figures 9-11.

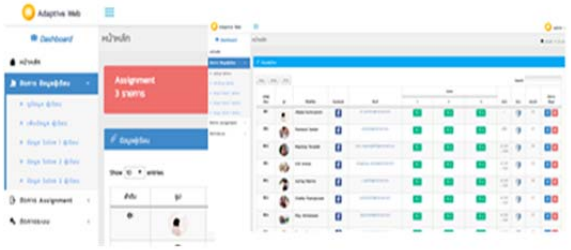

Figure 9. Student Profile Management

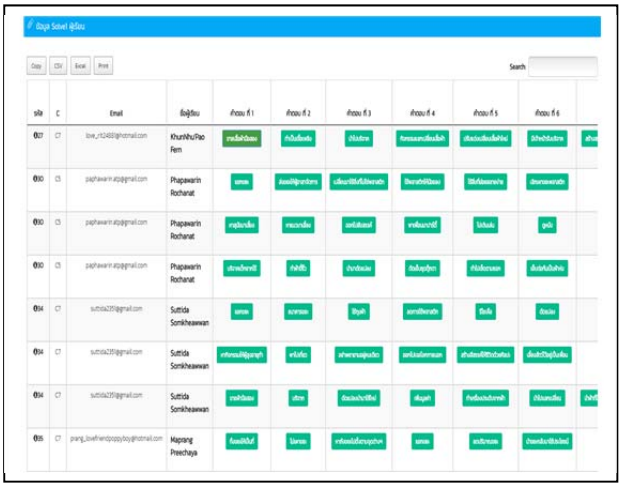

Figure 10. Display of Student Answers

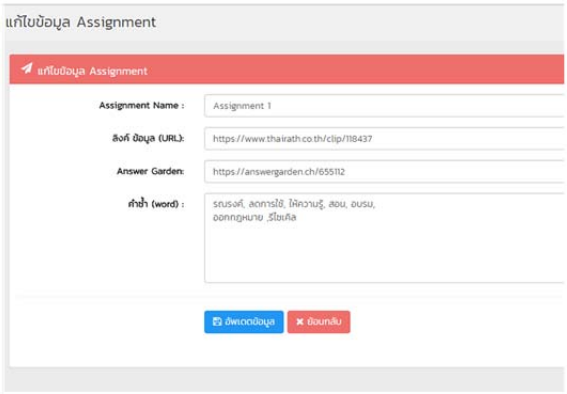

Figure 11. Cloud Tools Links and Blocked Words

3.3. System Test Results

The research team conducted an experiment with 61 undergraduate students for eight weeks to test the developed adaptive learning system. The results of the test were the following.

3.3.1. Pre-test and Post-test Scores

Table 1. Pre-test and Post-test Scores of Students

Creative Problem-Solving Score	Number	Mean	SD.	t	Sig.
Pre-test	61	23.84	3.07	-4.32	.000
Post-test	61	25.97	3.72		

Table 1 shows the pre- and post-test scores of the 61-student sample group. According to the dependent t-test statistics, the mean post-test creative problem-solving score was higher than the mean pre-test creative problem-solving score at a significance level of .05.

3.3.2. Comparison of Pre-test and Post-test Score of Each Student Group

Table 2. Comparison of Pre-test and Post-test Score of Each Student Group

GPA	Number	Mean	SD.	F	Sig
Pre-test Score					
C3	15	27.53	2.42	20.71	.000
C5	16	23.44	1.86		
C6	3	25.33	2.08		
C7	27	22.11	2.29		
Total		23.95	3.09		
Post-test Score				2.297	.087
C3	15	27.60	2.85		
C5	16	26.25	3.53		
C6	3	26.33	3.51		
C7	27	24.67	4.38		
Total		25.79	3.91		

Table 2 compares the pre- and post-test scores of each student group, categorized by the skills which need to be improved. The one-way ANOVA statistics showed that pre-test scores of students with different creative problem-solving abilities were different at a significance level of .05, while post-test scores of students with different creative problem-solving abilities were not different, at a significance level of .05.

3.3.3. Comparison of Scores of Assignments 1 and Assignments 3

Table 3. Comparison of Scores of Assignments 1 and Assignments 3

Assignment Score	Mean	SD.	T	Sig.
Novelty Dimension				
1) Initiative				
Assignments 1	5.13	1.15	-5.81	.000
Assignments 3	5.87	0.92		
2) Surprisingness				
Assignments 1	5.08	1.17	-7.31	.000
Assignments 3	6.08	1.17		
Resolution Dimension				
1) Significance				
Assignments 1	6.02	0.86	-5.60	.000
Assignments 3	6.58	0.78		
2) Discretion				
Assignments 1	6.39	0.90	-2.69	.008
Assignments 3	6.67	0.69		
3) Utilization				
Assignments 1	6.30	1.02	-4.41	.000
Assignments 3	6.75	0.59		
Elaboration and Synthesis Dimension				
1) Composition				
Assignments 1	5.46	1.09	-2.15	.033
Assignments 3	5.59	1.18		
2) Comprehensibility				
Assignments 1	5.52	1.04	-2.90	.004
Assignments 3	5.77	1.01		
Total Average				
Assignments 1	5.70	1.15	-6.56	.000
Assignments 3	6.20	1.02		

Table 3 compares the student scores from Assignments 1 and Assignments 3. The findings show that the student score from Assignments 3 was statistically higher than the student score from Assignments 1, at a significance level of .05.

3.3.4. Results of Adaptive Learning System in Adjustment of Difficulty Level of Solve Activity

Table 4. Results of Adaptive Learning System in Adjustment of Difficulty Level of Solve Activity

Solve Activity	Number of Students	Students who completed the activity in the 1st attempt	Students who completed the activity in the 2nd attempt	Students who completed The activity after 3 attempts	SD.	t	Sig
Fluency							
ASSG 1	43	27	10	6	.80	12.62	.000
ASSG 2	43	33	8	2	.47	18.33	
ASSG 3	43	47	14	-	.39	19.75	
Flexibility							
ASSG 1	30	24	5	1	.50	13.40	.000
ASSG 2	30	27	3	-	.30	18.76	
ASSG 3	30	27	3	-	.30	19.75	
Originality							
ASSG 1	61	47	12	2	.51	19.31	.000
ASSG 2	61	55	5	1	.37	21.63	
ASSG 3	61	56	5	-	.23	23.56	

Table 4 shows the results of using the adaptive learning system to adjust the difficulty level of the solve activity. The findings show that the number of students who needed to complete a level adjusted activity decreased each time. The average number of students who completed each level of the activity was statistically significance at a level of .05.

4. Conclusion and Discussion

The cloud-based adaptive learning system to enhance creative problem-solving abilities of students consists of six components, which are 1) adaptive learning system, 2) cloud tools, 3) topic of problem, 4) teaching and learning approach, 5) assessment, and 6) knowledge sharing. The system contains four steps, which are 1) search (S), 2) solve (S), 3) create (C), and 4) share (S).

This system can be used with students of different creative thinking skills. This is because adaptive technology can adjust the information presentation, instructional media, recommendations, and suggestions based on the characteristics of each individual student and situation [18]. The adaptive learning system aims to adjust the content to suit the knowledge, goals, and other attributes of each user, and most importantly customize the content to fit different types of learners [19]. The adaptive learning system can enhance learning proficiency and help students achieve their goals by considering their

knowledge and background in order to attain students' learning satisfaction and motivation [18]. This is consistent with the results coming from our assessment of student satisfaction while using the adaptive learning system, which showed that most students had a high level of satisfaction, and that the adaptive system could indeed adjust to their learning at a high rate. Moreover, building the system on the cloud service can increase learning efficiency. The cloud-based learning system is compatible with all types of devices, so it can facilitate and encourage self-learning, independent learning, real-life learning, new learning as well as knowledge sharing via participatory learning [20]. Students will get new ideas and learning experiences [21], share opinions to improve understanding and comprehension, and collaboratively generate knowledge with efficiency [22]. Moreover, students can get access to content anywhere and anytime, which is different from traditional classroom lessons [23]. Students can share their opinions and comments, both positive and negative, at any time without limitation or obstruction. This will lead to a diversity of ideas, which can contribute to creative problem solving [24].

Acknowledgements

This work was supported by the research projects of "Cloud-Based Adaptive Learning System Based on SSCS Model to Enhance Creative Problem Solving of Undergraduate Students" funded by The 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund). The work was successfully conducted with the support of the Department of Educational Technology and Communications, and the Educational Invention and Innovation research unit, Faculty of Education, Chulalongkorn University.

References

[1]. Intelitek report.: *The Education 4.0 Revolution. Analysis of Industry 4.0 and its effect on education* (2018). Retrieved from: https://e4-0.ipn.mx/wp-content/uploads/2019/10/the-education-4-0-revolution.pdf. [accessed: 04 December 2020].

[2]. McWilliam, E., & Haukka, S. (2008). Educating the creative workforce: New directions for twenty-first century schooling. *British educational research journal*, *34*(5), 651-666.

[3]. Wood, D., & Bilsborow, C. (2014). " I Am Not a Person with a Creative Mind": Facilitating Creativity in the Undergraduate Curriculum through a Design-Based Research Approach. *Electronic Journal of e-Learning*, *12*(1), 111-125.

[4]. Mumford, M. D., Mobley, M. I., Reiter-Palmon, R., Uhlman, C. E., & Doares, L. M. (1991). Process analytic models of creative capacities. *Creativity Research Journal*, *4*(2), 91-122.

[5]. Yaman, H., Dündar, S., & Ayvaz, Ü. (2015). Achievement motivation of primary mathematics education teacher candidates according to their cognitive styles and motivation styles. *International Electronic Journal of Elementary Education*, *7*(2), 125-142.

[6]. Alsobhi, A.Y., Alyoubi, K.H. (2020). Learning Styles and Dyslexion Types - Understanding Their Relationship and its Benefits in Adaptive E-learning Systems. *International Journal of Interactive Mobile Technologies*, *14*(15), 25-43.

[7]. Kilgour, M., & Koslow, S. (2009). Why and how do creative thinking techniques work?: Trading off originality and appropriateness to make more creative advertising. *Journal of the Academy of Marketing Science*, *37*(3), 298-309. https://doi.org/10.1007/s11747-009-0133-5

[8]. Brusilovsky, P. (2001). Adaptive hypermedia. *User modeling and user-adapted interaction*, *11*(1), 87-110. https://doi.org/10.1023/A:1011143116306

[9]. Shute, V. J., & Zapata-Rivera, D. (2012). Adaptive educational systems. *Adaptive technologies for training and education*, *7*(27), 1-35.

[10]. Huang, S. L., & Shiu, J. H. (2012). A user-centric adaptive learning system for e-learning 2.0. *Journal of Educational Technology & Society*, *15*(3), 214-225.

[11]. Lim, N., Grönlund, Å., & Andersson, A. (2015). Cloud computing: The beliefs and perceptions of Swedish school principals. *Computers & Education*, *84*(1), 90-100.

[12]. Packer, D. L. (2012). *Experimental Effects of Online Collaborative Tools on High School Student Motivation to Learn* (pp. 1-171). Northcentral University.

[13]. Denton, D. W. (2012). Enhancing instruction through constructivism, cooperative learning, and cloud computing. *TechTrends*, *56*(4), 34-41. https://doi:10.1007/s11528-012-0585-1

[14]. Barak, M. (2017). Cloud pedagogy: Utilizing web-based technologies for the promotion of social constructivist learning in science teacher preparation courses. *Journal of Science Education and Technology*, *26*(5), 459-469. https://doi.org/10.1007/s10956-017-9691-3

[15]. Zhang, X., & Bi, J. (2018). Design of a College English Mobile Learning System Based on CAD Model. *International Journal of Emerging Technologies in Learning (iJET)*, *13*(4), 139-149. https://doi.org/10.3991/ijet.v13i04.8477

[16]. Huang, YM, & Tan, Q. (2009). Adaptive Approaches to Mobile Learning. *International Journal of Interactive Mobile Technologies (iJIM)* , *3* (1), 4-5.

[17]. Mitchell, E. W., & Kowalik, F. K. (1999). Creative Problem Solving. Retrieved from https://www.academia.edu/8707593/Creative_Problem_Solving_Mitchell_and_Kowalik [accessed: 04 December 2020].

[18]. Dagger, D., Wade, V., & Conlan, O. (2005). Personalisation for all: Making adaptive course composition easy. *Journal of Educational Technology & Society*, *8*(3), 9-25.

[19]. Brusilovsky, P., Eklund, J., & Schwarz, E. (1998). Web-based education for all: a tool for development adaptive courseware. *Computer networks and ISDN systems*, *30*(1-7), 291-300. https://doi.org/10.1016/S0169-7552(98)00082-8

[20]. Huang, Y. M., Chen, H. C., Hwang, J. P., & Huang, Y. M. (2013). Application of cloud technology, social networking sites and sensing technology to e-learning. In *Reshaping learning* (pp. 343-364). Springer, Berlin, Heidelberg.

[21]. Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The internet and higher education*, *7*(2), 95-105. https://doi.org/10.1016/j.iheduc.2004.02.001

[22]. Mazman, S. G., & Usluel, Y. K. (2010). Modeling educational usage of Facebook. *Computers & Education*, *55*(2), 444-453. https://doi.org/10.1016/j.compedu.2010.02.008

[23]. Wu, L. J., & Hsiao, H. S. (2004, August). Using a knowledge-based management to design a web-based creative problem solving system. In *International conference on web-based learning* (pp. 225-232). Springer, Berlin, Heidelberg.

[24]. Ray, D. K., & Romano, N. C. (2013). Creative problem solving in GSS groups: do creative styles matter?. *Group Decision and Negotiation*, *22*(6), 1129-1157. https://doi:10.1007/s10726-012-9309-3