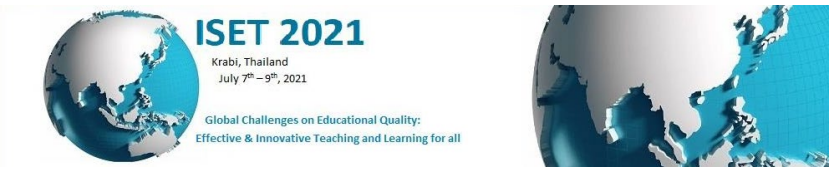
The Proceedings of

The 8th International Conference for Science Educators and Teachers

ISET 2021



Proceedings of the 8th International Conference of Science Educators and Teachers (ISET) 2021

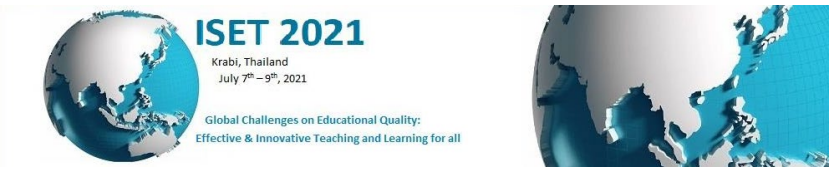
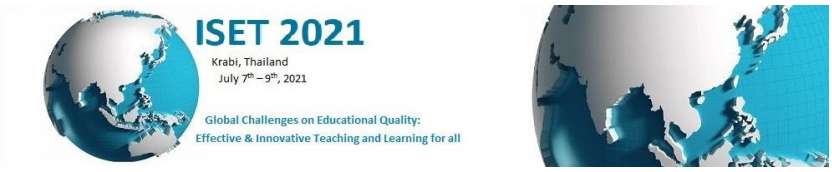


Table of Contents



Welcome Speech from the President of Science Education Association (Thailand) for the 8th ISET

Mr. President of Kasetsart University, keynote speakers, conference organizing committee, distinguished guesses, ladies and gentlemen; on behalf of Science Education Association (Thailand) I would like to welcome you all to the 8th International Conference for Science Educators and Teachers or the ISET 2021. This year our conference's theme is Global Challenges on Educational Quality: Effective and Innovative Teaching and Learning for all.

ISET is a yearly conference on science education and it was arranged successively from 2013 to 2019. Because of the global pandemic of covid-19, we need to skip the year 2020 conference. The virus outbreak have brought us so many new normal ways of life and that includes new normal procedures in education. Not only ISET conference but also normal face-to-face classrooms as well as scientific experiments in a laboratory are replaced by on line conference and on line teachings. It seem that on lines are the new normal major mean of education. I think that how to deliver good science educations to students is one of the challenges problem on education quality for science educators.

I would like to express my deep acknowledgement to Faculty of Education and Development Sciences, Kasetsart University at Kamphaeng Saen campus for her kind and excellent major host of ISET 2021. I also would like to pay my appreciation to Faculty of Education, Kasetsart University, Faculty of Education, Khon Kaen University, Ubon Ratchathani University, Rajaphat Phuket University and Science Education Center, Faculty of Science, Sinakharinwirot University for their co-hosts of the conference. Hardworking of every conference organizing committee to make the beautiful ISET 2021 become true is sincerely gratitude. Finally, I would like to pay a great thank to every single participant for his and her role of the conference. The conference never be completed without your participation.

Welcome again to the eighth International conference for Science Educators and Teachers, the first ISET online conference. I do believe that ISET 2021 will be a productive meeting for everyone.

Thank you

Nason Phonphok, Ph.D
President of Science Education Association (Thailand).

Conference Information

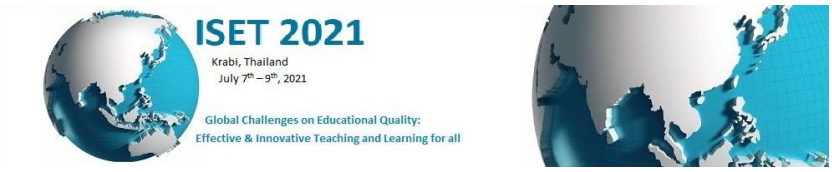
Conference Background

According to two academic meetings on science education in 2011, organized by Science Education Center, Srinakharinwirot University, the participants who were science educators, faculty members and experts from several universities and academic institutes in Thailand had discussed and exchanged ideas about the establishment of Science Education Association of Thailand. All participants are interested and realized the importance of establishment of the association. With the same direction of agreement, the association's goals and vision for development of science education are set.

Science Education Association (Thailand) commits to operate mainly for the sake of the commonwealth at both of national and international levels in order to improve science teaching and learning and to promote science literacy for all citizens. The committee of SEAT realize that researching and exchanging of experiences, knowledge and expertise among those who gets involved is a crucial path for the advancement of science education. Therefore, the International Conference for Science Educators and Teachers or ISET is set as one of regular main activities of SEAT.

The goal of ISET is to provide an opportunity for researchers, scholars, educational personnel and teachers from different countries to present their valuable researches, to exchange and discuss their experiences and point of views, and to initiate a strong network of cooperation.

- The 1st ISET (2013) "Science Education in the Hi-speed World" Organized by Science Education Center, Srinakharinwirot University at Pattaya, Thailand (9-11 May, 2013)
- The 2nd ISET (2014) "Science Education for the 21st Century: Transforming Classrooms for The Next-Generation Learners" Organized by Faculty of Education, Thaksin University at Phuket, Thailand (16-18 July, 2014)
- The 3rd ISET (2015) "On the rise of ASEAN, Science Education Superpower" Organized by Faculty of Education and Faculty of Education and Development Sciences, Kasetsart University at Phuket, Thailand (17-19 July, 2015)
- The 4th ISET (2016) "Bridging the Gap, Moving to the Future" Organized by Faculty of Education, KhonKaen University at KhonKaen, Thailand (3-5 June, 2016)
- The 5th ISET (2017) "The integrated Science Teaching and Learning in the 21st Century" Organized by Phuket Rajabhat University at Phuket, Thailand (6-8 June, 2017)
- The 6th ISET (2018) "Strengthening Science Education: Collaboration for a Brighter Future" Organized by Science Education Center, Faculty of Science, Sinakharinwirot University at Bangkok, Thailand (7-8 May, 2018)
- The 7th ISET (2019) "Science Education for Global Sustainability: Integration and Innovation" Organized by Rajabhat Rajanagarindra University at Pattaya, Thailand (7-8 May, 2019)



ISET 2021 Organizers

Kasetsart University

Science Education Association (Thailand)

Faculty of Science Srinakharinwirot University

Faculty of Education Khon Kaen University

Ubon Ratchathani Universi

Rajabhat Rajanagarindra University

Conference Venue

The 8th International Conference for Science Educators and Teachers will be held at the first ISET online conference at Kasetsart University Kampaengsean campus.

Editorial Board

The Effects of Gamification in Scientific Thinking Online Test Bank for Ninth Grade Students

Sirintra Ardhan, sirintra.sir@ku.th
Tussatrin Wannagatesiri
Witat Fakcharoenphol
Faculty of Education and Development Sciences, Kasetsart University (Kamphaengsaen Campus), Thailand

Abstract

The purpose of this research is 1) to develop a gamification in scientific-thinking-online-test-bank, 2) to compare scientific thinking skills before and after the use of the gamification in scientific-thinking-online-test-bank, and 3) to study satisfaction gamification in scientific-thinking-online-test-bank. The sample group was all 39 K-9 students from a small-sized school in Ayutthaya, Thailand. The research instruments consisted of 1) gamification in scientific-thinking-online-test-bank, 2) an online scientific thinking assessment, and 3) Likert scale satisfaction questionnaire on the use of gamification in scientific-thinking-online-test-bank. The gamification in scientific-thinking-online-test-bank lasted 8 weeks covering Living creatures, Substances and properties of substances and Energy. The scientific thinking scores between before and after the lesson of students with both scores were compared using dependent sample t-test. The results of the research were as follows: 1) the average scientific thinking score after the use of gamification in scientific-thinking-online-test-bank is significantly higher ($t(12) = 6.92$, $p < .001$) and 2) the satisfaction the gamification in scientific-thinking-online-test-bank is at satisfied level.

Keywords: Scientific thinking, Gamification, Scientific Thinking Online Test Bank

Introduction:

Nowadays, science plays an important role in human life. Various tools, appliances, equipment, and facilities are developed using science knowledge. To survive the pandemic, to live healthy, and to help solving global crisis, everyone needs to be science-literate. People need to understand how pandemic spread and how to fight scientifically. We need to be knowledgeable to take care of our body and our loved one. We need to be conscious of our activities harming and saving our planet. Science literacy requires not only the science knowledge, but also scientific thinking. Science is also a process to construct knowledge and to understand the nature through observing, experimenting, and rational analyzing. Human is capable for scientific thinking since they are infants, but they need to be trained to developed to their full potential in order explore the unknown. Both science knowledge and scientific thinking is needed for every citizen in 21st century.

With The Basic Education Core Curriculum (2008), both science knowledge and scientific thinking are expected to be developed in Science and Technology classes. The Science and Technology learning indicators aimed to build up students with science knowledge and science process skill. The indicators also emphasis on thinking and learning like scientists where students need to observe, to conduct the experiment, to interpret the data, to make the conclusion, as well as to explain scientifically. If students can pass all Science and Technology indicators, they should be science-ready for 21st century. However, reality is far from the expected goal.

Science knowledge and scientific thinking skill was expected to be developed in today's science teaching, but PISA and Ordinary National Educational Test (O-NET) scores indicated otherwise. In 2018, on PISA science literacy, Thailand scored only 426 with OECD average of 489. When look in the detail, 44.5% of Thai students scored below level 2 in science proficiency, where they are able to identify explanations of simple scientific phenomenon and barely able to undertake structured scientific enquiries with no more than two variables(OECD, 2018) This showed that half of Thailand K-9 students were lacking in terms of science knowledge and scientific thinking skill. In 2019, the O-NET average scores for science was 36.43 percent. These numbers suggest the need to improve science literacy in Thailand.

Researcher's School and School District Office currently have an educational policy to improve O-NET scores. The last test analysis suggested targeting to improve science indicators in the Standard W 1.1, Standard W 3.1, Standard W 3.2 and Standard W 5.1. These indicators are tested on scientific thinking skills. They required students distinguish science-related data from different situations, to analyze and interpret the data scientifically, as well as to provide valid and suitable explanation to the situations. Therefore, the researcher aimed to improve student's scientific thinking skill.

This research proposed the process of developing student's scientific thinking skills by using scientific thinking skill test bank. The questions used in the test bank required student to practice scientific thinking skill such as predict the result, interpreting data, and analyzing the results of experiments. The test bank was used as part of the gamification in science class, and it was available online through Moodle. This research explored the effect of Gamification in Scientific Thinking Online Test Bank for ninth grade students as well as the satisfactory of it.

Review of literature:

Scientific Thinking

Scientific thinking is a mental ability to seek knowledge and to understand the world around us with the focus on content of science as well as the processes of science (Khansuk, 2018; Kuhn, 2010; Maienschein, 1998; Sasivimol, 2016) It shares many characteristics with scientific reasoning (Dunbar, 2005) and problem solving(Zimmerman, 2013) Human has abilities needed to engage in formal scientific thinking since infants (Chaille and Britain, 1991; Gopnik, Meltzoff, and Kuhl, 2000) and scientific thinking can be developed naturally and can be matured systematically through reflecting metacognitively on the process knowledge acquisition and knowledge change(Kuhn, 2005) Scientific thinking can be categorized using cognitive processes into 3 categories: forming and refining hypotheses (by asking questions and developing and using models), investigation skills (by planning and carrying out investigations), and evaluating evidence (by analyzing and interpreting evidence and constructing explanations).(Zimmerman and Klahr, 2018) Scientific thinking is to think like scientists.

The development of scientific thinking can be contributed to natural children cognitive development as well as scientific practices. Through observing, asking questions, conducting experiment, evaluating evidence, constructing models, and generating explanation, students should learn like real scientist (Zimmerman and Klahr, 2018) For the scientific thinking to be mature, cognitive processes and scientific practices must be coordinated (Lemke, 2001; Zimmerman and Croker, 2014). Thus, to develop scientific thinking, students need to practice thinking like scientists.

Several research aimed to improve scientific thinking through learning activities that encourage the practices of science processes to simulate scientific thinking Intamong (2016)showed the increase of scientific analytical thinking skill through the use of 7E learning cycle that included analyzing, distinguishing, classifying and identifying visions. Khansuk (2018)used flipped classroom for students to conduct self-taught research and found improvement on scientific analytical thinking. Chaiyong (2009) use research-based learning where students learned by using research processes and analyzing the result of research and showed good levels in scientific thinking. Allowing students to practice and think like scientists is the key to improve scientific thinking.

Scientific thinking question test bank

To directly simulate situations that require scientific thinking, scientific thinking questions were used. These scientific thinking questions require either planning the experiment or analyzing and interpreting the data or constructing explanation and conclusion. The Ordinary National Educational Test (O-NET) in science must covers all learning indicators where several of them require scientific thinking skills such as observing, experimenting, explaining, analyzing, and applying on science contents(Ministry of Education, 2017) O-NET-styled questions that focus on scientific thinking skills were developed to create questions test bank on Moodle, an open-source online learning platform (Moodle, 2001) The questions were organized by learning indicators for easy use.

Gamification

Gamification uses techniques in the form of games to motivate learners to participate in learning in a fun way. Gamification apply basic principles such as points, levels, rewards, and leaderboards Simulate virtual gaming environment (Khunkmul, 2017; Srisomboon, 2016; The institute for the Promotion of Teaching Science and Technology(IPST), 2018)

Gamification has shown to improve attitude and behavior toward learning as well as the learning outcome. Choolarb (2018) showed that Gamification Model with Interactive Augmented Reality to Develop

Digital Literacy Skill were rated at very good level on the outcome. Khunkmul (2017) showed that gamification in the classroom enhanced the learning experience and, together with SQ4R techniques, it can promote reading abilities. Chanyam (2015) showed that challenge in gamification helped learners developing their critical thinking and expressing their opinions independently. Srisomboon (2016) showed that learning systems developed based on the gamification format using cloud technology (g-LMS on Cloud) could make students committed on learning as a team. In conclusion, Gamification is to apply the game's mechanics to the desired content to create a fun activity that motivates students to participate in learning, encourages learning behavior, and promotes learning as a result.

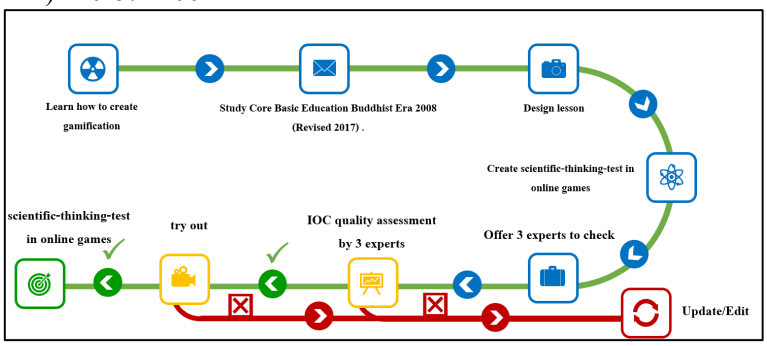
Objective:

1. To develop a gamification in scientific-thinking-online-test-bank
2. To compare scientific thinking before and after the use of the gamification in scientific-thinking-online-test-bank
3. To study satisfaction gamification in scientific-thinking-online-test-bank

Methods:

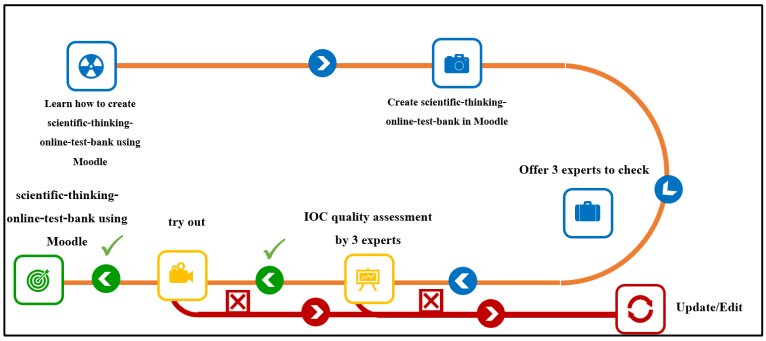
Research Design is Pre-experimental research is one group re-post test design. The students who participated in this research were ninth grade students in the second semester of the academic year 2020, including 39 students. A high school in Ayutthaya Province. The research instruments consisted of Gamification, online-test-bank and Likert scale satisfaction

An online scientific thinking assessment. There are 10 pre-test exams. And 10 post- test exams.It's a multiple choice questions. The exam is a concept of science. Shown as shown in Figure 2. Index of Item-Objective Congruence (IOC) is 0.67-1.00



Fugure 2 : Creating and determining The research instruments quality of Gamification

Create scientific-thinking-online-test-bank There are 4 sets of multiple choice questions in Moodle covering Organism, Substances and properties of substances and Energy. Shown as shown in Figure 3.Index of Item-Objective Congruence (IOC) is 0.67-1.00 and Take the test to try it out with 35 K-10 students in the same school in Ayutthaya Province in the academic year 2020. Then analyze the difficulty index (p) and Discriminant index (r) individually and selecting a test with a difficulty index between 0.3 – 0.7 and a classification power index of 0.3 or higher, and finding reliability of the entire test using the formula KR20 equal to 0.788.



Fugure 3 : Creating and determining The research instruments quality of test-bank

Satisfaction gamification in scientific-thinking-online-test-bank. Create Likert scale satisfaction questionnaire.Offer 3 experts to check the accuracy and properness of the Likert scale satisfaction questionnaire.

4. Data collection process

Table 1 Manage learning of Gamification in scientific-thinking-online-test-bank lasted 8 weeks

Week	Activity	Assessment
1		Pre-test scientific thinking minutes of testing.
2	Describe the activity and segment it.	
3	Online Training Students Unit 1 Living Creatures through the Moodle system, play end-of-week games, sub-awards in this competition, and collect points.	
4	Online Training Students Unit 2 Substances through the Moodle system, play end-of-week games, sub-awards in this competition and collect points.	
5	Online Training Students Unit 3 properties of substances through the Moodle system, play end-of-week games, sub-awards in this competition, and collect points.	
6	Online Training Students Unit 4 Energy through the Moodle system, play end-of-week games, sub-awards in this competition and collect points.	
7		Post-test scientific thinking 60 minutes of testing.
8	Awards for individual and team competitions.	Make a satisfaction assessment

Results:

To compare scientific thinking scores before and after the use of the gamification in scientific thinking online test bank, dependent sample t-test were used on 13 students who complete both pre-test and post-test.

Table 2 the comparison of scientific thinking score before and after the use of the gamification in scientific thinking online test bank. (13 persons who complete both pre-test and post-test)

	Score	$\overline{X}$	S.D.	**t**	**sig.**
before	10	2.38	1.04	-6.9202	.000
after	10	6.61	1.66		

$* \; sig < 0.05$

The average scientific thinking post-test score ($\overline{X}$ =6.61 and $S.D. = 1.66$) is significantly higher than the average scientific thinking pre-test score ($\overline{X} = 2.38$ and $S.D. = 1.0$). The average scientific thinking score after the use of gamification in scientific-thinking-online-test-bank is significantly higher ($t(12) = 6.92$, $p < .001$).

To study satisfaction of gamification in scientific thinking online test bank, the satisfaction questionnaire was used at the end of the lesson.

Table 3 Results of satisfaction gamification in scientific thinking online test bank. (35 persons)

No.	**Items**	$\overline{X}$	S.D.	Level
1	Students know the purpose of learning clearly.	4.39	0.70	satisfied

No.	Items	$\overline{X}$	S.D.	Level
2	Students know the criteria for pre-evaluation.	4.08	0.73	satisfied
3	Teachers give advice, help. Facilitate students to do activities.	4.44	0.66	satisfied
4	Teachers use a variety of methods for managing learning and using media.	4.25	0.89	satisfied
5	Fun and interesting learning management activities.	4.25	0.91	satisfied
6	Teachers give students a chance to question the problem.	4.42	0.81	satisfied
7	Students are gnaced by doing activities.	4.28	0.83	satisfied
8	Students can leverage their knowledge.	4.42	0.72	satisfied
9	Students love gamification in scientific thinking online test bank.	4.47	0.80	satisfied
10	Students are happy to do activities.	4.53	0.65	strongly satisfied
average		4.35	0.77	satisfied

The average satisfaction of gamification in scientific thinking online test bank is at satisfied level ($\overline{X} = 4.35$ and $S.D. = 0.77$). Moreover, students gave additional comments such as "the activities were useful and can help them be prepared for O-NET exam", "the activities was fun, and they want to study more", "The internet network is the problem", "I'd like to have this kind of activities in every course."

Due to the COVID-19 pandemic, the online learning was executed without enough preparation and resources for the students. Many students don't have the equipment as well as stable internet connection to learn online, as shown from their comments. As a result, the author was unable to get pre-test scores from many students. To test if the two groups of students performed differently prior to the course and after the use of gamification in scientific thinking online test bank, we compare their science GPA and their post-test score.

Table 4 The comparison of science GPA (4 is the maximum GPA) prior to the course between students who took pre-test and students who did not take the pre-test (39 persons)

	Average science GPA	S.D.	t	**sig.**
Students with pre-test (13 persons)	2.35	1.13	3.092	.004
students without pre-test (26 persons)	1.31	0.63		

$sig < 0.05$

The average science GPA prior to the course of students who took pre-test is significantly higher ($t(16) = 3.092$, $p < .01$) than the average science GPA prior to the course of students who did not take the pre-test.

Table 5 The comparison of scientific thinking post-test scores between students who took pre-test and students who did not take the pre-test (39 persons)

	Score	$\overline{X}$	S.D.	t	**sig.**
Students with pre-test (13 persons)	10	6.61	1.66	5.891	.000
students without pre-test (26 persons)	10	3.46	1.39		

$sig < 0.05$

The average post-test score of students who took pre-test ($\overline{X} = 6.61$ and $S.D. = 1.66$) is significantly higher ($t(21) = 5.89$, $p < .001$) than the average posttest score students who did not take the pre-test ($\overline{X} = 3.46$ and $S.D. = 1.39$). The data suggest that students who took pre-test exam scores can be considered better-prepared and online-ready students. That might be the reason for the difference in the posttest score.

Additionally, the correlation between number of practice tests student took and their scientific thinking posttest scores was analyzed. There are 13 practice tests covering Organism, Substances and properties of substances and Energy. The minimum number of practices is 1 practice test. The maximum number of practices is 12 practice tests. The data showed significant correlation between number of practice tests student took and their scientific thinking post-test scores ($r = 0.543$, $p < 0.001$). Thus, students who practice on more practice tests performed better on the scientific thinking posttest.

Conclusion:

Gamification in Scientific Thinking Online Test Bank can promote ninth grade students scientific thinking skill. The average scientific thinking posttest score after the use of gamification in scientific-thinking-online-test-bank is significantly higher ($t(12) = 6.92$, $p < .001$) than pretest scores. The results complies with the results of Khansuk (2018), Intamong (2016), and Chaiyong (2009) where students participated in activities requiring to use scientific thinking performed better on scientific thinking later. In this research, we found that practicing on scientific thinking practice test can improve scientific thinking skill.

Additionally, the students enjoy our instruments and no student complain on the practice tests which is normally expected to be considered boring. This might be due to the gamification during class that make students see the benefits and challenge from practicing with the scientific thinking online test bank.

Even though, majority of students did not take the pretest, they all experienced the Gamification in Scientific Thinking Online Test Bank. Thus, the satisfaction data from all students at satisfied level ($\overline{X} = 4.35$ and $S.D. = 0.77$) is valid.

However, due to the different characteristics between students who took the pretest and who did not take the pretest, our data is not enough to show if all students' scientific thinking skill could be improve using the Gamification in Scientific Thinking Online Test Bank. The data suggests that Gamification in Scientific Thinking Online Test Bank could improve scientific thinking skills for students who are better prepared prior to the course and who are online-ready.

Acknowledgement

This research has been approved for research on human subjects by Kasetsart University Research Ethics Committee with (research/proposal) ID : KUREC-SS64/019

Suggestions:

1. Add a variety of exam formats, such as having two answers in the same verse, and writing and filling in matching words.
2. Check the availability of samples and provide the necessary equipment to lend sufficient research.

References:

Chaiyong, Sarawut (2009). *Research-based Learning Provision for Developing Scientific Thinking in Basic Biology for Mathayom Suksa* 4 *Students.* (Master of Education (Educational Research and Statistics)). Chiang Mai University,

Chanyam, Phanisara. (2015). *DELOPMENT OF A LEARNING ACTIVITY PACKAGE USING GAMIFICATIONS AND ONLINE COLLABORATIVE GRAPHIC ORGANIZERS BASED ON PROJECT-BSED LEARNING TO ENHANCE CREATIVE PROBLEM SOLVING ABILITY IN*

BUSINESS ETHICS OF UNDERGRADUATE STUDENTS IN BUSINESS ADMINISTRATION PROGRAM. (Master). Chula;ongkorn,

Choolarb, Tunyaboon (2018). *Imagineering Gamification Model with Interactive Augmented Reality to Develop Digital Literacy Skills.* (Master). King Mongkut's University of Technology North Bangkok,

Intamong , Kamonchanok. (2016). *THE STUDY OF BIOLOGY ACHIEVEMENT AND SCIENTIFIC ANALYTICAL THINKING BY USING 7E LEARNING CYCLE WITH CONCEPT MAPPING TECHNIQUE ON PHOTOSYNTHESIS OF 11th GRADE STUDENTS.* (Master's). Burapha University,

Khansuk, Kuntida. (2018). *The development of scientific analytical thinking and group process by using flipped classroom techniques on web site about genetics of 10th grade students.* (Master). Burapha University,

Khunkmul, Natdanai (2017). *Development of a reverse classroom learning model using the SQ4R technique in conjunction with a gamification strategy. To promote reading comprehension and comprehension of Thai language subjects for Mathayomsuksa 1 students.* (Master's Thesis). King Mongkut's University of Technology Thonburi,

Kuhn, Deanna. (2005). *Education for thinking*: United States of America.

Kuhn, Deanna. (2010). What is Scientifi c Thinking and How Does it Develop? *In U. Goswami (Ed.), Handbook of Childhood Cognitive Development (Blackwell) (2nd ed.,* 2010)

Maienschein, Jane. (1998). *Scientific literacy* (Vol. 281). Washington

Ministry of Education. (2017). Basic Education Core Curriculum 2008 Revised 2017). Retrieved from https://www.moe.go.th/

Moodle. (2001). Moodle, Learning Management Systems(LMS). Retrieved from https://th.linkedin.com/company/moodle

OECD. (2018). Student performance (PISA 2018). Retrieved from https://gpseducation.oecd.org/CountryProfile?primaryCountry=THA&treshold=10&topic=PI

Sasivimol, Sanitboon. (2016). *The results of a 5-step quest (5E) learning management in conjunction with the use of analytical questions. Which are the glands of scientific thinking and critical thinking Of students in Mathayom Suksa 6 on atomic physics* (Master's Thesis). Burapha University, Chonburi.

Srisomboon, Paripas. (2016). *Development of Virtual Team Gamification Model via Cloud Technology to Enhance Teamwork Skills for Undergraduate Students.* (Doctoral). King Mongkut's University of Technology North Bangkok,

The Basic Education Core Curriculum. (2008). *The Basic Education Core Curriculum*. Agricultural Cooperative Assembly Printing Company of Thailand Srisa 79 Limited.

The institute for the Promotion of Teaching Science and Technology(IPST). (2018). Gamification. Retrieved from https://www.scimath.org/article-technology/item/8669-2018-09-11-08-06-48

Zimmerman and Klahr, D. (2018). Development of Scientific Thinking. Retrieved from https://www.researchgate.net/publication/324272107

Zimmerman, C., & Croker, S. (2013). *Learning science through inquiry In G. J. Feist & M. E. Gorman (Eds.), Handbook of the psychology of science*: Springer Publishing Company.

Development of Do It Yourself (DIY) Hands-On Activities on Earth Structure and Dynamics for Enhancing Eighth Grade Students' Design Ability

Chotika Srikamthai, chotika.sri@ku.th
Witat Fakcharoenphol
Tussatrin Wannagatesiri
Faculty of Education and Development Sciences, Kasetsart University
(Kamphaengsaen Campus), Thailand

Abstract

The purposes of this were 1) to develop Do It Yourself (DIY) Hands-On Activities on earth structure and dynamic topic, 2) to assess students' design ability through DIY Hands - On Activity, and 3) to measure eighth - grade students' satisfaction after studying with DIY Hands-On activity. The sample was 45 eighth - grade students selected by purposive sampling. The research instruments consisted of 1) DIY Hands-On Activity on Earth Structure and Dynamic topic, 2) design ability assessment rubric based on the assigned workpiece with an inter-rater reliability of 0.83., and 3) satisfaction questionnaire. During the DIY Hands-On Activity, the students were able to find additional information on their own to be used in designing their earth models. After analyzing the information, they must draw a draft of the Earth. Then, they selected the materials used in the model. Their selection fit quite well with the composition of each layer of the Earth, for example, water pipes for the earth core, slime for the mantle, and plastic ball for the crust. Overall, they were able to construct their earth model according to the information they read. Then, students' models were assessed for students' design ability. The student's average score on design ability is 10.33 out of 12 points (Excellence Level). Additionally, when the teacher pointed out the moving crust, the student designed models that the crust can move, but it was not accurate enough to explain the moving crust. This might be due to the level of students' design ability and available materials at hand. Overall, students satisfy with the DIY Hands - On Activity at a very good level.

Keywords: Do It Yourself (DIY), Hands-On Activities, Design Ability

Introduction:

To compete with the rest of the world, Thai citizen need 21^{st} century skills. To achieve it, the educational system needs to promote the 21^{st} century skills starting with students in the educational system. The Thailand National Scheme of Education B.E. 2560-2579 (A.D.2017-2036), set the target of 21^{st} century skills for Thai citizen to be 3Rs + 8Cs skills, 3Rs include 1) Reading, 2) Writing and 3) Arithmetic and. 8Cs include 1) Critical thinking skills, 2) Creativity and Innovation, 3) Collaboration Teamwork and Leadership, 4) Communications, Information and Media Literacy, 5) Cross - Cultural Understanding, 6) Computing and ICT Literacy,7) Career and Learning skills, and 8) Compassion (Thailand. Office of the Education Council, 2017)

These target skills correspond with Policy of Ministry of Education and Policy of the Office of the Basic Education Commission to promotes educational management to develop students' competency and skills in inventions and innovations that increase competitiveness employment.(Ministry of Education, 2021; Offiice Of The Basic Education Commission, 2021) The Office of the Basic Education Commission has focused on learners to use their knowledge and science skills to solve problems and develop creative work with the design process.

During the recent curriculum reform, the Office of the Basic Education Commission modified the indicators to encourage learners to use their knowledge and to design and create innovations for solving problems in daily life. For example: previous indicators required students to analyze and describe the relationship of energy transmission of living organisms form food chains and food webs, but the new indicator required students to create a model to explain energy transfer in food webs: previous indicators required students to search and describes the relationship between the sun, earth, moon, and other planets and their effect on the environment and life on earth, but the new indicator required students to create models that describes the seasons, the movement of the sun, and phases of the moon.(Office Of The Basic Education Commission, 2017)

With new learning indicators, students must use the knowledge learned in class to design and create models on several topics, but these models do not reflect the competency and skills expected by the Thailand National Scheme of Education. For example, on the topic of Earth Structure and Dynamics.

Sangsee (2019) reviewed that most science teachers focus on lecturing the content instead of on the learning. As a result, students learned very little, and their academic progress fell short of the school's expectations. With the current learning activities to achieve the new learning indicators, students' models are usually copies of old design appeared on the interest. Thus, students cannot create and convey their ideas through their model design. This drag might be caused of the limited time schedule dedicated for designing and creating models as well as the level of design ability of the students.

To achieve the goal, students need to develop the design ability through dedicated time schedule during the hands-on activities with provided materials and tools. Papert (1993) believed that children learn best when building things on their own, pursuing their own interests. Consistent with Constructionism theory that emphasizes on the learners to build their knowledge through practice, hands-on activities allow students to do the real practice and learn from it. Also, hands-on activities can motivate students to be more interested in learning, and will encourage students to develop their skills while creating things. (Martin, 2020) With suitable design ability, students should be able to create and convey their ideas through their design and innovations. Also, with design ability, students should be able to broaden their perspective on the problems as well as to solve their problem systematically and successfully. Teachers must have to organize learning activities for learner to develop design skills. Learning activities must focus on enabling learner to practice and allow learner to learn and work with other. Thus, the Do It Yourself activity on the topic of Earth Structure and Dynamic was created to promote design ability for the eighth grade students.

Review of literature:

1. Constructionism Theory and Hands-on Activity

Papert (1993) believed that children learn best when building things on their own, pursuing their interests. Papert's Constructionism built upon Piaget's Constructivism in that learner is the one building their knowledge, not receiving the knowledge, However, Constructionism emphasizes the art of learning and learning while making things. (Ackermann,2011). Even though, Papert said that his Constructionism should be considered "much richer and more multifaceted, and very much deeper in its implication than could be conveyed by any such formula[learning-by-making] (Papert and Harel 1991)," learning-by-making has strongly defined Constructionism (Roussou,2004; Hoban, Nielsen & Carceller, 2010; Morado, Melo & Jarman, 2021; Ke, Clark & Uysal, 2019; Fields, 2020). Learning activities through making things such as hands-on activities should allow the learner to explore, experiment, and experience from the physical creation of objects and mental models.

Hands-on activity could be the direct interpretation of Constructionism, even though the terms hands-on activity varies. Haury (1994) various ideas of hands-on learning from different perspectives and concluded that "hands-on learning in science was any education experience that actively involves people manipulating objects to gain knowledge or understanding."

Hands-on activities can help the learner in many aspects. Admane and Mondhe (2021) used "Hands-on Workshop on Arduino" a blend of hands-on training with lecture-bases learning to improve their confidence, technical skills, teamwork, and bridging the gap between and bright students. Cakiroglu (2011) used "hands-on activity enriched instruction" about sense organs to improve student's achievement and attitudes toward science. (Choothai,2013) used hands-on activities on basic electronics to enhance student achievement and attitude toward learning science. Waraka's (2017) hands-on activity used simple paper-based devices to enhance grade 10 students' learning of protein-based and effectively developed students' scientific conceptual understanding and decision making. Shieh and Chang (2014) investigated the results of the hands-on activity of "creating a functional boat from scratch." They found that it enhanced creative skills and problem-solving abilities as well as collaboration. Jantha (2010) studied the results of using hands-on activities and found that it could increase the student's knowledge and understanding. These results suggest that hands-on activity can improve the knowledge and skills related to the activity.

2. Design Ability

Casakin (2020) defined design ability based on Cross (1990) as a multi-faceted cognitive skills reflecting specific ways of thinking and behaving that designer implement while solving ill-structured problems. Cross (1992) pointed out that design ability exists in every person but at a different level. However, design abilities can be developed through education or collaboration with others in society.

Cross (1992) defined the six aspects of design ability: 1) defining, identifying, or discovering problems, 2) problem structuring problem-solving techniques or tactics, 3) defining goals and constraints, 4) planning workflow of the solution concepts in stages, 5) thinking by drawing, and 6) intuitive reasoning. (Nigel Cross**,** 1992).

To evaluate learner's hands-on models, both physically and mentally, different assessment rubrics were developed. For physical models, Chianchana' s (2017) rubric included four criteria: 1) utility (students' work can be used for a variety of purpose), 2) feasibility (models can be guaranteed to the practical implementation, cost-effectiveness), 3) propriety (models operate according to the protocol, be ethical, does not affect others), and 4) accuracy (models can accurately describe various data). For the cognitive model, Ayşe Tekin-Dede' s (2018) rubric included six criteria: 1) understanding the problem, 2) simplifying, 3) Mathematizing, 4) Working Mathematically, 5) Interpreting and 6) Validating. Different kinds of model require different kinds of rubrics.

To assess design ability, Cross' s (1992) six aspects of design ability were used as a framework for the assessment rubrics. To assess the design ability through physical Earth model made by the students, a rubric was developed around the applicable leaning activities on the topic of Earth Structure and Dynamic. The design ability used in this research were as follows:

1. ability to search/collect/select the relevant information on Earth Structure and Dynamic (Cross's 1^{st} defining, identifying, or discovering problems and 2^{nd} Problem structuring problem-solving techniques or tactics)
2. ability to make a draft of the Earth model (Cross's 5^{th}) thinking by drawing
3. ability to set the target features of the model to represent the selected information on Earth Structure and Dynamics based on limited available materials and tools (Cross's 3^{rd}) defining goals and constraints.
4. ability to complete the final model as plan (Cross's 4^{th}, planning workflow of the solution concepts in stage and 6^{th} intuitive reasoning).

Objectives:

1. To develop Do It Yourself (DIY) Hands-On Activities of earth structure and dynamic topic.
2. To assess students' design ability through DIY Hands – On activity.
3. To measure the satisfaction of the eight - grade students after study with DIY Hands-On activity.

Methods:

1. This pre-experimental research was conducted using with one group pretest-posttest design**.**
2. The research instruments consisted of

2.1 DIY Hands-On Activity of earth structure and dynamic topic.

DIY Hands-On Activity is an activity that allows students to design their own earth structure models. Based on the information students collect, the different sources for designing the model students will need to design the materials that will be used to create the model, the materials chosen must correspond to the chemistry of each layer of the Earth. And students have to explain why they chose to use each material to create the earth structure model.

2.2 Organize activities of Do It Your Self (DIY) Hands-on Activities of earth structure and Dynamics. The process of the activity is as follows.

Step 1 Engagement: Stimulate students' interests by using everyday or real-life situations for students to observe and discuss questions that motivate students.

Step 2 Exploration: Finding information or preparing data for students to create information, classify and interpret the information.

Step 3 Explanation: The teacher goes on to detail the characteristics of each earth layer so that students can study the data and construct their own earth structure.

Step 4 Design and construction: Bring meaningful information to design Do It Yourself workpieces. From the resources provided by the teacher, students will select materials to use in the earth model.

Step 5 Elaboration and using knowledge: In the case of study area, students

participate in discussion and problem - solving methods.

Step 6 Evaluation: Assess students' understanding from a model. Teachers evaluate their pupils' design abilities. the outline of the work piece, the model, and the student's model presentation.

2.3 design ability assessment: Design ability is assessed based on the assigned workpiece. The results are assessed according to indicators and the answers are checked by grading according to the Specific scoring rubrics. The scoring criteria for each component were set to 3 levels: 3 points, 2 point and 1 point. Bring the assessment form for other teachers to assess student workpieces. And use the evaluation results to calculate the inter - rater reliability at 0.83 (Sukok 2014)

The results of the design ability assessment by 3 experts received item objective congruence index (IOC) in the range of 0.67-1.00 and modified according to expert advice.

Design ability assessing by teacher which is assessed from the student's design of earth structure model. The evaluation criteria are as follows,

Evaluation criteria of design ability

Element	**Level**		
	3 (satisfied)	**2** (moderate)	**1** (dissatisfied)
1. ability to search/collect/select the relevant information on Earth Structure and Dynamic	Collect information of the Earth Structure of all layers of the Earth completely.	Collect some information of the Earth Structure	unable to collect information
2. ability to make a draft of the Earth model.	Design work pieces in accordance with the information gathered. Complete details are shown with clear indication of the materials used.	The design of the workpiece is in accordance with the information gathered, showing details, some materials used are identified.	Design work pieces in accordance with One component of information that can be gathered and gives the right reasons for making a decision.
3. ability to set the target features of the model to represent the selected information on Earth Structure and Dynamics based on limited available materials and tools	Selected the materials that are suitable for each element of the earth.	selected a material that is only partially suitable for the composition of the earth.	selected materials that are not suitable for each element of the earth.
4. ability to complete of the final model as plan	The Earth structure has every element as complete as the information gathered and the pieces are colorful.	The Earth Structure piece lacks the integrity of the information gathered, and the piece is a little colorful.	The Earth structure has a lack of integrity based on the information gathered and the piece is lacking in color.

2.4 satisfaction questionnaire. The results of the design ability assessment by 3 experts received item objective congruence index (IOC) in the range of 0.67-1.00 and modified according to expert advice.

3. Data Collection Process

3.1 Design of Do It Your Self (DIY) Hands-on Activities for eighth grade students' design ability of earth structure and Dynamics.

3.2 Teacher used design ability assessments form to assess the student's work piece by group to measure students' design ability from the model.

3.3 Collect data on student satisfaction from the satisfaction questionnaire

4. Data analysis process

4.1 To develop Do It Your Self (DIY) Hands-on Activities for eighth grade students' design ability of earth structure and Dynamics.

4.2 Score of students' design ability on the use of Do It Your Self (DIY) Hands-on Activities is 12 score.

Interpretation			
average	10 – 12	means	Excellence
average	7 – 9	means	Good
average	8 – 6	means	Fair
average	5 – 1	means	improvement

4.3 Likert scale satisfaction questionnaire on the use of Do It Your Self (DIY) Hands-on Activities use rating scale.

5	means	strongly satisfied
4	means	satisfied
3	means	moderate
2	means	dissatisfied
1	means	strongly dissatisfied

Interpretation			
average	4.50 - 5.00	means	strongly satisfied
average	3.50 - 4.49	means	satisfied
average	2.50 - 3.49	means	moderate
average	1.50 - 2.49	means	dissatisfied
average	1.00 - 1.49	means	strongly dissatisfied

Results:

1. To assess students' design ability through DIY Hands – On activity.

Table 1 Result of students' design ability

Ability	**Mean** (total = 12)	**SD.**
1. ability to search/collect/select the relevant information on Earth Structure and Dynamic	3.0	0.00
2. ability to make a draft of the Earth model.	2.33	0.58
3. ability to set the target features of the model to represent the selected information on Earth Structure and Dynamics based on limited available materials and tools	2.67	0.58
4. ability to complete of the final model as plan	2.33	0.58
Total	**10.33** (Excellence**)**	
Average	**2.58**	**0.43**

Ability	Score
1	3
2	3
3	2
4	2

Figure 1 The draft and final model with the score on four abilities.

The score of 2 for the 3^{rd} ability was because the students also chose the material to make the Earth's core inconsistent with the data.

The score of 2 for the 4^{th} ability was because the crust is not complete yet and still unable to produce realistic motion. It's cannot be attached to the Earth.

Ability	Score
1	3
2	2
3	3
4	3

Figure 2 The draft and final model with the score on four abilities.

The score of 2 for the 2^{nd} ability was because the student's draft does not fully specify the material to be taken on behalf of each part of the Earth.

Ability	Score
1	3
2	2
3	3
4	2

Figure 3 The draft and final model with the score on four abilities.

The score of 2 for the 2^{nd} ability was because the student's draft does not fully specify the material to be taken on behalf of each part of the Earth.

The score of 2 for the 4^{th} ability was because the crust is not complete yet. It's cannot be attached to the Earth and the model still can't explain the phenomena caused by tectonic crust movement.

2. To measure the satisfaction of the eight - grade students after study with DIY Hands-On activity.

Table 2 Results of satisfaction of Hands - on activity. (12 persons)

No.	Items	Mean	SD.	Level
1	Learning activities are fun and interesting.	4.67	0.65	strongly satisfied
2	Learning activities make students better understand the content.	4.58	0.51	strongly satisfied
3	Learning activities provide students with enhanced design skills.	4.33	0.49	satisfied
4	Teachers help and guide students' activities.	4.67	0.65	strongly satisfied
5	Teachers give students a chance to question the problem.	4.75	0.45	strongly satisfied
6	Teachers provide additional information to help their activities.	4.75	0.45	strongly satisfied
7	Students gain experience from doing this activity.	4.75	0.45	strongly satisfied
8	Learning activities encourage students to work with friends.	4.92	0.29	strongly satisfied
9	Students learn new knowledge from this activity.	4.67	0.49	strongly satisfied
10	Students are happy to do this activity.	4.83	0.39	strongly satisfied
average		4.69	0.48	strongly satisfied

Conclusions:

1. The students were able to find additional information on their own to be used in designing their earth models. After analyzing the information, they selected the materials that fit the composition of each layer of the Earth, for example: water pipes for the earth core, slime for the mantle, and plastic ball for the crust. Overall, they were able to construct their earth model according to the information they read.

2. Students' design ability average is 10.33 points out of 12 points (Excellence level) after the use of the DIY Hands - On activity.

3. Students satisfy with the DIY Hands - On activity at very good level.

Discussions:

Students also have misconceptions regarding the structure of the Earth, as well as the natural events induced by plate motion. As a result, the students construct a model that is unable to describe the phenomena. The average score of students' design ability is excellent level. However, the model cannot explain the phenomenon due to the movement of the earth. Students have limited time and limited materials.

Suggestions:

1. Teachers should recommend more materials to students.
2. Teachers should clearly explain the characteristics of crust movement.

References:

Ackermann, E. K. (2011). Piaget's Constructivism, Papert's Constructionism: What's the difference?

Admane M, R., Mondhe P, J. (2021). Skill Development of Students through Hands-on Workshop. Journal of Engineering Education Transformations, 34.

Cakiroglu, J. (2011). Effective of Hands-on Activity Enriched instruction On Students' Achievement And Attitude Towards Science. Journal of Baltic Science Education, 10.

Casakin, H. (2020). Ideation and Design Ability as Antecedents for Design Expertise.

Chantra, A. (2010). Simple Experiment on Center of Mass and Moment of Inertia for Improving Students' concept. (Master of Science), Ubonratchatani University, Ubonratchatani.

Chianchana, C. (2017). Creating and Developing Model.

Choothai, B. (2013). Enhancing of Leaning Achievement and Attitude towards learning science using hands-on activity of basic electronics for grade 9 students (Master of science), Ubonratchatani University, Ubonratchatani.
Cross, N. (1990). The nature and nurture of the design ability. 11, 127-140.
Cross, N. (1992). Design Ability. The Open University Milton Keynes, USA
Fengfeng Ke, K. M. C., Seyda Uysal. (2019). Architecture Game-Based Mathematical Learning by Making. International Journal of Science and Mathematics Education.
Fields, D. A. (2020). Debugging by Design: Students' Reflections on Designing Buggy E-Textile Projects.
Garry Hoban, W. N., Charles Carceller. (2010). Articulating constructionism: Learning science through designing and making "Slowmations" (student-generated animations).
Haury, D. L. (1994). Perspective of Hands-on science teaching. The Ohio State University,
Martin, L. (2020). The Importance of Hands-On Learning in a Child's Education. https://blog.friendscentral.org/benefits-of-hands-on-learning
Ministry of Education. (2021). Policy and focus of the Ministry of Education 2021.
Morado, M. F. M., Ayelén Eva; Jarman, Angela. (2021). Learning by making: A framework to revisit practices in a constructionist learning environment. British Journal of Educational Technology.
Office Of The Basic Education Commission. (2017). The Basic Education Core Curriculum B.E.2551 (A.D.2008).
Offiice Of The Basic Education Commission. (2021). Policy of office of the Basic Education Commission.
Papert, S. (1993). The children s machine: Rethinking school in the age of the computer.
Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children.
Ruey-Shyy Shieh, W. C. (2014). Fostering Student' s creative and problem-solving skills through a hands-on activity. Baltic Science Education, 13.
Sangsee, K. (2019). The Development Of Lesson On The Subject Of The Earth Structire And Dynamic, Astronomy And Space, Grade 11.
Sukok, S. (2014). Intraclass Correlation. Khon kaen University,
Tekin-Dede, A. (2018). A Rubric Development Study for the Assessment of Modeling Skills. 27.
Thailand. Office of the Education Council, O. (2017). The National Scheme of Education B.E. 2560-2579 (2017-2036).
Waraka, P. (2017). Using a simple paper based deviceds for enhancing grade 10 students' learning of protein based on hands-on activity. (Master of science), Ubonratchatani University,

Development of Game Based Learning Activities in Biodiversity Enhancing Fourth Grade Students' Algorithms Design Skills.

Salinthip Bunloet, Salinthip.bu@ku.th
Kulthida Nugultham
Nantarat Kruea-In
Faculty of Education and Development Sciences, Kasetsart University (Kamphaengsaen Campus), Thailand

Abstract

This research aims to develop game based learning activities in biodiversity enhancing fourth grade students' algorithms design skills. The samples were 37 students from 2 classrooms, studying in fourth grade in the first semester, 2021. The research instruments consisted of 1) the game based learning activities in biodiversity 2) algorithm design skills assessment which has an inter-rater reliability as 86 percent. During the game based learning class, students are able to connect content, knowledge, logical thinking, planning and predict results to lead the problem solving step-by-step. After learning class, students had a very good level of algorithm design skills. They could design and create biodiversity games; for example, bingo games, decipher games, word search games, quiz games, matching games, snake ladder games, running games, collecting images games, random wheel games, and chasing games.

Keywords: Game based learning, Algorithms design skills, Biodiversity

Introduction

The global social context in the 21st century has changed economic, social, cultural, environment, scientific knowledge and advancement of technology. Together with the education management of National Education Act 1999 is based on 1) lifelong education for citizens 2) society is involved in the provision of education. 3) continuous development of knowledge and processes. In the year 2017, The Ministry of Education has an important and urgent policy is to improve and develop the Basic Education Core Curriculum, learning standards and indicators of science by adding Technology including design and technology, computer science, which focus on teaching students to be able to computational thinking, digital technology and media and information literacy. (Ministry of Education, 2017) The main goal is to develop students to have computational thinking ability, analytical thinking, system thinking and problem solving. (The institute for the Promotion of Teaching Science and Technology, 2017)

Teaching in the first semester, 2021 for fourth grade students at Opportunity expansion school in Lopburi, found that student's test score was lower than goals set by the school in especially Biodiversity and computer science. Observing and interviewing students, it was found that most of teachers focus on lectures teaching on science and technology. Because the content is complex, incomprehensible, and abstract. Correspond with Wichanee et al (2015) review that most science teachers teach lectures, focus on memorization more than taking any action and practice thinking process. In addition, a lot of lesson content causing not enough time. Causing the students to become bored, some people get stressed, the classroom atmosphere is tense. (Wichanee et al, 2015) In addition, computer science is a new course in the Basic Education Core Curriculum. So, teachers lack of teaching techniques and innovation to support teaching in the classroom. Courses with content are difficult for learners. It is necessary to study in the required steps. It makes students bored, not interested in content and remember more than think analytically. As a result, students misunderstand the content and cannot bring knowledge to further solve other related problems. (Suwanvapee & Kanjug, 2020). Those reasons causing the learning assessment result to be at a lower than the school's criteria level setting. From the above problems, enhancing algorithms design skills. It is the basic principle of computer science and it can promote effective learning of Biodiversity. It helps students to logical thinking, plan, solve problems, think systematically and leading to a step-by-step solution.

Integrated learning management encourages students to achieve course goals. Students could connect content, knowledge, concepts, skills together to achieve holistic learning in

biodiversity and technology. Students will truly understand, and they can solve the problem by themself. Using appropriate activities can achieve integrated learning management. Game Based Learning is the one of strategy to increase students' interest involvement. It can motivate students to actively participate in learning activities and have a potential to support development of Algorithms Design Skills. Games can be integrated in different school subjects as unplugged activities (without the use of technology) or in a digital form (Dlab et al., 2019). Game Based Learning refers to approach where games with defined learning outcomes are used to enhance the learning experience. It is believed that playing games is a natural way of learning for a child. Educational games stimulate imagination and creativity, enhance concentration, and improve memory. In addition, playing games students can gains skills for problem solving, logical reasoning, strategic thinking, and management. It is designed for the purpose of learning. Make students' knowledge and understand the contents (Qian & Clark, 2016). Moreover, Maneechai and Colleagues (2020) agree that the game stimulates and motivates learning engage students in a fun way learning. This will enable students to investigate, improve and find solutions to the problems.

From the above analysis, researchers are interested in development of game based learning activities in biodiversity enhancing fourth grade students' algorithms design skills in accordance with Basic Education Core Curriculum, the policy of the Ministry of Education and learning in the 21st century.

Objectives

1. Develop game based learning activities in biodiversity enhancing fourth grade students' algorithms design skills.

Review of literature

1. Algorithms design skills

1. 1 Algorithms is problem solving steps. (Phitthayasenee, Sittiwong, & Phumpuang, 2020) or working with a sequence of commands or a clear method to go through step by step in solving the problem. (Ministry of Education, 2017)

1.2 Algorithms design is the development of a step-by-step solution or create guidelines to take step-by-step in solving the problem. (King Mongkut's Institute of Technology Ladkrabang, 2019). The algorithms are written in the form of pictures or symbols. It is used to write in place of a procedure, a description of a text, a speech. And presenting the process of the work can be understood in the same way between stakeholders. The characteristics of a good algorithm should be accurate, easy to understand. (Ngamwongwan, 2019). Moreover, it is design work sequence or find ways to improve and produce results as specified. (Poonsawat & Dokprakhon, 2016). It is clear sequence of steps to solving problems that lead to the desired results or explain each element. (The institute for the Promotion of Teaching Science and Technology, 2017)

In this research, design of algorithms is design and develop a clear, step-by-step solution. Students can write solutions or work in the form of pictures or symbol that is used to write in place of a procedure, description, text, or speech.

1.3 Guidelines for promoting algorithms design skills at the elementary level.

Computer Science Unplugged or CS Unplugged is a teaching idea that build an understanding of the fundamental principles of computer science. Without the need to use a computer, students train to think, solve problems, think systematically by using fun activities, puzzles, games, board games, using various devices or activities that occur in daily life learning. The skills and knowledge gained from doing CS unplugged activities lead to step-by-step problem solving and can be further developed into program

development concepts or called computational thinking. (Phipattananan, 2020; Sangrum, 2020)

2. Constructivism Theory

Constructivism is a learning process. It focuses on the students to build their own knowledge. Perform activities by focusing on the investigation, allow students to discover the formula, the rules themselves. By having social interactions and being involved in the learning process, it can connect the same experiences with new knowledge to solve the situation and be able to solve the problem of other situations. A teacher is simply an environmentalist who is instrumental. (Garbett, 2011 ; Karakul & Nuangchalerm, 2016 ; Phomsorn, 2018)

3. Game based learning activities

3.1 Game based learning activities is an activity aimed at the players to achieve learning objectives. It also makes children enjoy and relax. It enhances students' physical skills, foster creativity, and collaborative learning. Game based learning activities are not just for entertainment by adding analysis, discussion. But also, students have knowledge and understanding of various contents. Through those activities, there are clear rules for the playing process. The player may be played alone or in group. The teaching process can be propose by 1) the teacher is the first creator, adjusted or modified of the game and bring it to the classroom 2) Students will design and develop games to suit the purpose and needs. (Sutthipittayasak & Robroo, 2020; Qian & Clark, 2016;Yamkuan, 2016)

3.2 Guidelines for promoting algorithms design skills using Game Based Learning Activities.

Game Based Learning Activities have been used as an educational tool at different academic levels, especially in primary education. (Jagust et al., 2018) It is enhanced to creativity, logical thinking, and problem solving skills (Hoic-Bozic and faculty, 2017). Activities for promoting algorithms design skills, it has to give students to think, rationalize and act on their own. It stimulates and motivates learning incentives for students where teachers design and create a learning situation involving everyday life or the content knowledge. The activity is flexible and adjustable the difficulty level as appropriate (Hoic-Bozic and faculty, 2019; Huang, 2020).

Methodology

1. This study was used pre-experimental research. The samples were 37 students from 2 classrooms, studying in fourth grade in the first semester, 2021.

2. The research instruments consisted of

2.1 The game based learning activities in biodiversity consist of 4 activities

- Activity 1 biological diversity
- Activity 2 plants classification using flowers.
- Activity 3 animal classification using the spine
- Activity 4 vertebrates classification

The results of the quality assessment by 3 experts received item objective congruence index (IOC) in the range of 0.67-1.00 and modified according to expert advice.

2.2 Algorithm design skills assessment was adapted and improved from the 69th student arts and crafts competition criteria academic year 2019 of occupations and technology (Office of student activities development, 2019).

The results of the quality assessment by 3 experts received an inter-rater reliability as 86 percent.

3. Collection process and data analysis process

3.1 Teaching with game based learning activities in biodiversity of fourth Grade Students for 4 hours. Each activity has the following steps.

Step 1 Engagement, students give examples, ask questions from the surrounding environment or various events.

Step 2 Teaching, the teacher is the creator of the game. And bring games that have been created, adapted, or modified into the classroom. The game's format focuses on logical reasoning, applying rules or conditions to solving a problem, working description and predict results.

Table 1: Game Based Learning Activities in Biodiversity

Activity	**objective**		**Game name**
	Science	Computational Thinking	
1.Biological diversity	Tell the same and differences in the characteristics of living things using the collected information.	Use logical reasoning to predict results.	The characteristics matching games.
		Solve simple problems using comparisons.	Creature grouping game.
2.Plants classification using flowers.	Tell the observable characteristics of flowering plants And plants without flowers Using the collected information	Different starts of work will produce different results.	OX games
		Solve problems easily by using trial and error.	Flipping cards game.
3.Animal classification using the spine	Identify the characteristics observed in vertebrates and invertebrates. Using the collected information	Solve problems easily by using trial and error.	Yes / NO / OK game.
		Show simple workflow or problem solving by using symbols.	Hunting game.
4.Vertebrates classification	Describe observable characteristics of fish, amphibians, reptiles, birds And mammals And give examples of living things in each group	Use logical reasoning to solve problems	Grouping game.
		Create a simple algorithm using commands.	Travel game.

Step 3 Summary and discussion, students bring information or results from playing games to discuss and conclude together along with writing flowchart.

Step 4 Evaluation, students check understanding using activities, exercises, and techniques.

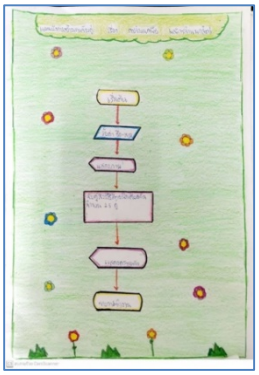
Step 5 Summary of concepts, students bring algorithm design skills. They could design and create biodiversity games.

3.2 Assessing learners' algorithm design skills from the flowchart and each learner designing and creating biodiversity games by using the Algorithm Skills Assessment after learning in the activities.

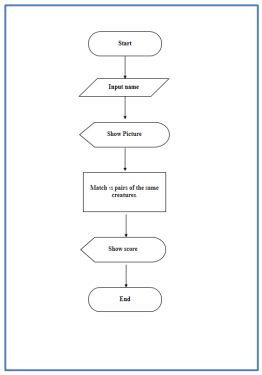
Result

After the students learnt in the classroom using game based learning activities in biodiversity. The students can design and create biodiversity games for example; bingo games,

decipher games, word search games, quiz games, matching games, snake ladder games, running games, collecting images, random wheel games, and chasing games. They improved algorithms design skills as follow.

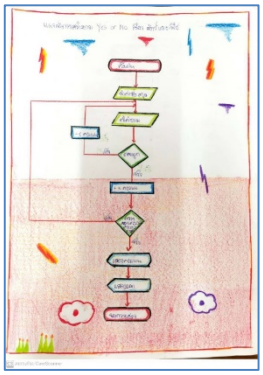


A1

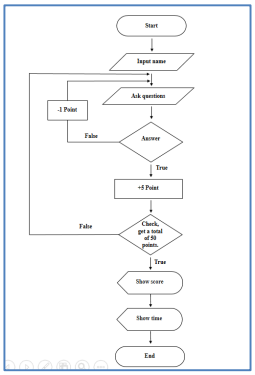


A2

Figure 1: Matching games. (The original student's flowchart, A1and the transforming flowchart to the standard view, A2)

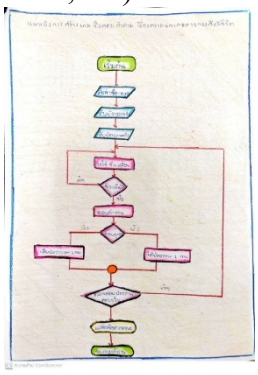


B1

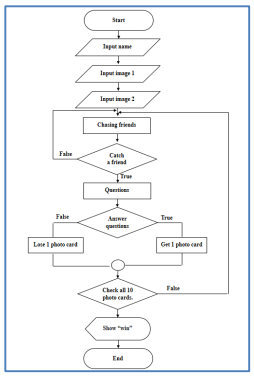


B2

Figure 2: Yes / NO / OK game. (The original student's flowchart, B1and the transforming flowchart to the standard view, B2)

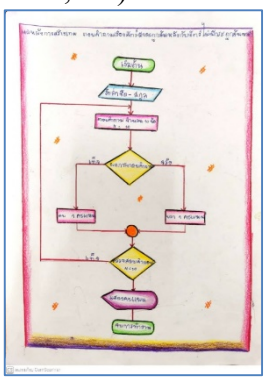


C1

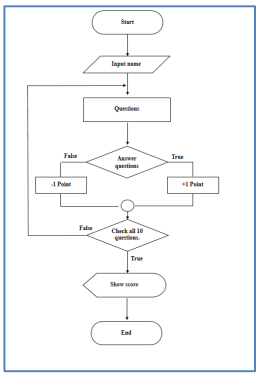


C2

Figure 3: Chasing games (The original student's flowchart, C1and the transforming flowchart to the standard view, C2)

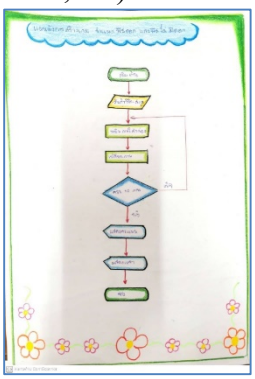


D1

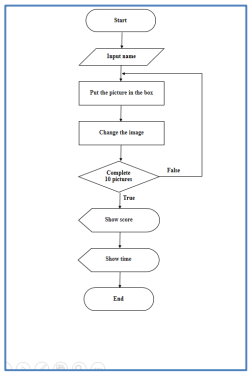


D2

Figure 4: Quiz games (The original student's flowchart, D1and the transforming flowchart to the standard view, D2)

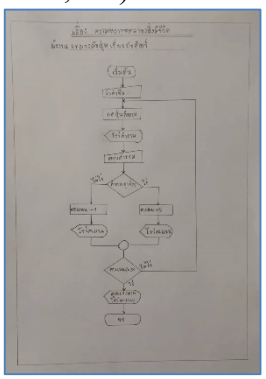


E1

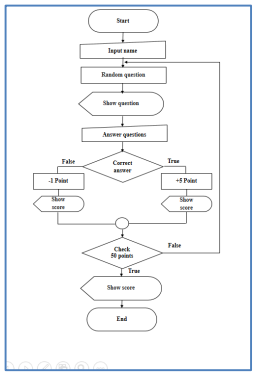


E2

Figure 5: Collecting images games (The original student's flowchart, E1and the transforming flowchart to the standard view, E2)



F1



F2

Figure 6: Random wheel games (The original student's flowchart, F1and the transforming flowchart to the standard view, F2)

Table 2 : Results of algorithms design skill about biodiversity. (37 persons)

Items (total score 24 Point)	$\overline{X}$	S.D.	%
1. Flowchart writing format	**2.76**	**0.44**	**92.06**
1.1 Write the correct algorithm operation steps.	2.82	0.39	94.05
1.2 Correct use of symbols	2.57	0.63	85.71
1.3 The messages in the flowchart are compact, easy to understand, consistent and meaningful.	2.89	0.31	96.43
2. Work piece design	**2.69**	**0.42**	**89.68**
2.1 Present new ideas and creative.	2.61	0.50	86.90
2.2 Algorithms are feasible in real-world use.	2.93	0.26	97.62
2.3 Enhancing development and intelligence.	2.54	0.51	84.52
3. Game	**2.74**	**0.39**	**91.07**
3.1 There are clear rules.	2.54	0.51	84.52
3.2 Has a starting point and the termination of the game.	2.93	0.26	97.62
average	**21.83**	**0.63**	**90.94**

Table 1 results of algorithms design skill about biodiversity is average total score 21.83, S.D. 0.63 and 90.94%.

Conclusion and Discussion

Game based learning activities in biodiversity able to enhance fourth grade students' algorithms design skills. Classroom activities could enhance logical thinking, planning and predict results. In accordance with the research of Dlab and colleagues said Game based learning activities can promote the skills for problem solving, logical thinking, strategic thinking, and management. The characteristics matching games, players must plan the same group of organisms with conditions by use all tables and do not repeat the same tables. OX games are activities that must be planned to delude competitors and understand that different starting will give the different results. Creature grouping game is a classification of creatures cards by comparing. Flipping cards game and Yes / NO / OK game, it is a simple solution, using trial and error. So it can be able to predict the answer. Hunting game and Travel game are travel planning activities to find a solution by using symbols instead of sequence of steps. for the last activity, students will practice writing flowcharts. To clearly observe the working process of various games, this process skills to lead the problem solving step-by-step.

Game based learning activities in biodiversity are teaching methods that incorporate science content into the game. It is a tool to help learners understand the content more easily. In addition, the nature of the content in biodiversity is the focus for students to observe, compare, classify, and categorize. So, it is the suitable content for training students to develop algorithms design skills. If students can think logically, predict results planning and work step by step. It will make learning biodiversity easier and able to link science and computational thinking together. It can be further developed and designed games about science that has the correct algorithm operation steps. The messages in the flowchart are compact, easy to understand, consistent and meaningful, possible in actual use, and enhanced development and intelligence.

Recommendation

1. The conditions of game based learning activities can be adjusted as appropriate for the learners.

References

Dlab, M. H., Hoic-Bozic, N., Andelic, M., & Boticki, I. (2019). *Digital games and tools for development of computational thinking in primary school*. University of Rijeka,.

Garbett, D. (2011). Constructivism Deconstructed in Science Teacher Education. Australian Journal of Teacher Education, 35(6).

Hoic-Bozic, N., Dab, M. H., & Prskalo, L. N. (2018). *Games for learning Algorithmic thinking-glat project.* GARI International Journal of Multidisciplinary Research, 4(2).

Hoic-Bozic, N., Mezak, J., & Tomljenovic, K. (2019). *Enhancing Teachers' Computational Thinking Skills Through Game Based Learning*.

Huang, W. (2020). *The design and implementation of "unplugged" game-based learning in computing education*. https://doi.org/10.31235/osf.io/ykq82

Jagust, T., Krzic, A. S., Gledec, G., Grgic, M., & Bojic, I. (2018). *Exploring Different Unplugged Game-like Activities for Teaching Computational Thinking.* doi:10.1109/FIE.2018.8659077

Karakul, R., & Nuangchalerm, P. (2016). *The Development of Science Activity Packages Based on Constructivist Theory for Mathayomsuksa 4*. Prae-wa Kalasin Journal of Kalasin University, 3(2).

King Mongkut's Institute of Technology Ladkrabang. (2019). *A workshop to promote learning to develop coding skills for the digital society in the future*

Maneechai, D., Sirijiraka, V. J., & Ruang-on, S. (2020). *Web Application Development Based on Gamification Technique to Enhance Learning Achievement and Learning Motivation of High School Students*. Journal of Technology Management Rajabhat Maha Sarakham University, *7(2).*

Ministry of Education. (2017). *Standards of learning and indicators of mathematics, science and geography subjects. In the learning subject group of Social Studies, Religion and Culture (revised version 2017) according to the basic education core curriculum 2008*. Bangkok: Office of the Basic Education Commission

Ngamwongwan, M. (2019). *Development of Instructional Packages on Flowchart Algorithms Writing for the 8th Grade Students.* Journal of Graduate School, Pitchayatat, *15(2).*

Office of student activities development. (2019). 69*th student arts and crafts competition criteria academic year* 2019.

Phipattananan, C. (2020). *CS Unplugged Learn Coding without a computer.* Retrieved from https://staging.starfishlabz.com/blog/80-cs-unplugged-%E0%B9%80%E0%B8%A3%E0%B8%B5%E0%B8%A2%E0%B8%99-coding-%E0%B9%82%E0%B8%94%E0%B8%A2%E0%B9%84%E0%B8%A1%E0%B9%88%E0%B9%83%E0%B8%8A%E0%B9%89%E0%B8%84%E0%B8%AD%E0%B8%A1%E0%B8%9E%E0%B8%B4%E0%B8%A7%E0%B9%80%E0%B8%95%E0%B8%AD%E0%B8%A3%E0%B9%8C

Phitthayasenee, M., Sittiwong, T., & Phumpuang, K. (2020). *Blended Learning model using gamification base to promote computational thinking skills of student' s teachers.* Lampang Rajabhat University Journal, *9(2).*

Phomsorn, P. (2018). *The Development of Web-Based Lesson under Constructivist Theory Concept to Encourage Analytical Thinking Skill in Topic of Computer in Daily Life for Seventh Grade Students.* Journal of Graduate School, Pitchayatat, 13(2).

Poonsawat, B., & Dokprakhon, P. (2016). *Visual Programming and Computational Thinking Game*. Journal of information science and technology, *6(2).*

Qian, M., & Clark, K. R. (2016). *Game-based Learning and 21st century skills: A review of recent research*. Computers in Human Behavior, *63*, *50-58.* doi*:10.1016/*j.chb.*2016.05.023*

Sangrum, P. (2020). *Independent study report a study of problems and needs to develop an unplugged coding teaching for teachers of computational science grade* 5 *at Ban Wan Yai School using guiding technique (Coaching).*

Sutthipittayasak, C., & Robroo, I. (2020). *Designing a Module of Game-Based Learning Activities for Enhancing Conceptual Thinking Skills of the 6th Grade Students in the Schools under the Uthaithani Primary Educational Service Area Office 1*. SSRU Graduate Studies Journal.

Suwanvapee, P., & Kanjug, I. (2020). *The Development of gamification learning environment to enhance problem-solving thinking skills in computing science courseson problem-solving topic for mathayomsuksa 1 students at nongwuasorpittayakhom school.* Journal of graduate research, *11(1).*

The Institute for the Promotion of Teaching Science and Technology. (2017). *Computational Thinking*. Retrieved from https://celt.li.kmutt.ac.th/mock/km/wp-content/uploads/2017/10/170802.1-Computational-Thinking.key.pdf

Wichanee, P., Sirisawat, C., Srisanyong, S., & Thavornna, L. (2015). *A study of learning achievement biology on "Kingdoms of Life" by using brain - based learning (BBL) with games for matthayomsuksa 4 students*. Veridian E-Journal, Silpakorn University, *8(2).*

Yamkuan, L. (2016). *The design and development of game-based learning for* 6*th grade mathematics.* (Master of Information Science), Suranaree University of Technology,

Development of Active Online Learning Activities for Enhancing Grade 4 Students' Learning Achievement of Living Things

Kamonchanok Ploytubtim, kamonchanok.plo@ku.th
Kulthida Nugultham
Nantarat Kruea-In
Faculty of Education and Development Sciences, Kasetsart University (Kamphaengsaen Campus), Thailand

Abstract

This research aims to develop and enhance the active online learning activities of Grade 4 students in relation to the thematic instruction involved in teaching living things. The sample used in this research study comprises twenty fourth-grade students during School Year 2020, First Semester who were selected through the purposive sampling technique. The research instruments consisted of: 1) active online learning activities of living things using the online teaching platform "Edpuzzle", 2) achievement test on science concept, and 3) satisfaction questionnaire. During the activities, students could interact and pay attention to science stories and questions quite well. After the activities, the student achievement average ($\bar{x}$= 16.25) is measured at a percentage of 81.25 which is significantly higher than the required 80-percent criteria for statistical significance of 10-percent (.01). This high-level achievement average related to this study's objective, i.e. developing and enhancing the active online learning activities in acquiring knowledge of living things, is therefore humbly considered remarkable.
Keywords: Active online learning, Living things, Students' achievement

Introduction

It is a well-known fact that, both in the present and future, science plays an extremely important role in human life because it is about everything: career, technology, tool, and product. When combined with creativity and other areas of knowledge, science helps humans to develop ways of thinking with probable reason, creativity, clear review, skillful research, systematic problem-solving, diversified decision and verifiable testimony. It seems true that everyone and everything must develop with the knowledge of how science affects life in order to have a better understanding of nature and man-made technology, most specifically. This knowledge can be applied rationally, constructively and morally.

A small school has to organize multigrade learning into a classroom where one teacher may be assigned to teach many subjects. Most of the science teacher have been teaching and learning as theoretical and content-based lecturer. This causes the learners to misunderstand or confuse the educational content, which later causes boredom in learning and affects the achievement. This turnout of event is shown in student scores which are lower than the school's criteria, as in the related learning achievement in grade 6 such as Banbornamphu School, Nakhon Pathom. The related average of 37.95 percent is classified as "needing improvement" by the standard of the National Institute of Educational Testing (a public organization) in the 2019 Academic Year.

For a classroom time management, it can be useful in organizing activities that can implement computer-aided learning strategies in term of active online learning. There are variety of communicating, media that include audio and visual contents for knowledge. In a way this learning system allows students to better understand what they are learning. The active online learning activities are teaching materials that allow students to take many learning forms, as they make learning management interesting from the various techniques and methods applied. In addition, the learning activities interact with learners and support learning in such a way that they help students gain knowledge of a subject matter according to their abilities and interests. They can also define and give focus on individual learning differences which researchers see as useful

in developing and improving student outlook. Aside from these, the active online learning activities could reduce or control problems related to learning efficiency and turn these problems into more useful learning form. With the perceived hands-on gaining of knowledge, students can realize their roles and duties which, eventually, can help them achieve favorable results in the future.

Review of Literature

Concepts and Theories of Interactive Learning Management

1.1 Online learning management principles and their elements

Online learning management is encouraged learners to be educated anytime, anywhere via electronic devices. (Toikaew 2011) concluded that online lessons through a computer network are a part of the learning process. Students and teachers can interact with each other and take advantage features. The internet is a vast resource of various tools for knowledge and the World Wide Web is surely designed as a place for teaching and learning. Also (Pamutachaowapee 2014) noted that the Internet is a good medium for online teaching and learning. It is a learning medium between the instructor and the learners in the form of technology where lessons acquire multimedia characteristics without time limit. There is no limit to the place on an Internet network as a medium of broadcasting knowledge and of promoting effective teaching and learning. It has been developed and could classify the teaching and learning process.

Online learning principle is a flexible educational innovation. With the introduction of technology used in teaching and learning, learners will have the responsibility to educate themselves. Worathan (n.d.) explained that online learning is another form of educational innovation which can change the old ways of learning by using technology. In addition, another meaning for online learning is distance learning or web learning, as consistent with (Calder 1998)that noted those general definitions. It also defined online learning as open learning which accords with the learner's own time, requirement, and place. (Popadon 2019) also noted that online learning is a form of study with high flexibility. It is a preparation for learners who are keen to learn. For general students who are required to attend courses, learners in online learning need to take more responsibility for their studies than usual, as it is self-learning.

The components of online learning, namely the management of online teaching where teachers should choose according to the content of the lesson. We must take note that students can learn by themselves according to their potential and this may have various approaches to teaching and learning or may depend on the teacher's choice. Feedback should be provided so that students can assess their understanding. Online Learning or e-learning have four essential components, each of which must be designed in a systematic way and must work in harmony with each other (BANTHITABLOG n.d.):

1. The content of the lesson which is considered the most important thing.
2. Educational learning management system because online learning or e-learning is a study that encourages learners to study. Students can learn by themselves through a centralized learning management system that could be determined by the order of the content in the lesson. Teachers send lessons through a computer network to learners and evaluate the success of the lesson. Teachers could also control and support the delivery of all lessons to the learners.
3. Communication, online learning is considered another form of distance learning. But what makes e-learning unique and different from general distance learning is the implementation of a two-way communication model to increase interest and to improve awareness of the learners in the lessons. It is also used as a tool to help learners inquire, discuss and exchange ideas between students and teachers. The communication tools can be divided into two categories: a) real-time types: chat (message, voice), white board, text slide, real-time annotations, interactive poll, conferencing, etc. and b) non real-time types which include web-board, e-mail, etc.
4. Examination and Grading, Exams or assessments are a key component in making e-learning a complete learning experience, that is, some subjects need to measure the level of

knowledge before applying for admission. With that, students can choose to study in the most appropriate lesson or course that would make learning the most effective. When entering the lesson in each course, there will be a quiz at the end of the chapter. Then before the end of the course, a big exam must complete the learning management system. This exam will be greatly used for the test bank management system or Test Bank System, which contributes to the online learning management system.

1.2 Interactive learning management, process and their elements

Interactive learning management is the application of technology to various media which can effectively interact with learners and their peers. It is a way of learning where learners choose the contents according to their own interests and satisfaction. (Moolthong 2013) has mentioned the word "interaction" in research that studied multimedia. Such term as interactive is a feature that is unique to other media platforms because users can interact with each other. Learners can manually communicate and choose to access any part of the presentation according to their preference. Interactions can be connected to a variety of multimedia components. Moreover, interaction media as a medium that is more unique than other media. Its characteristics are similar to multimedia but with interaction with learners. It is a medium that brings many things to be applied together, such as video or audio systems. The slides, graphics and animations are also various means that learners can choose or use for their satisfaction (Srimuangsong, 2017).

An interactive model is an activity that can be applied to every step of the learning process, but it needs to be planned. There are various formats for designing and preparing interactive activities. (Sikabanthit 1998) noted that teachers can ask students questions and let them answer questions they don't understand. This teaching method involves analysis of common learning problems. The interaction between educators and students can be an activity of students inside and outside the classroom. It can also be in the form of a debate where there can also be an interaction between students and technology. It is an interactive way to seek knowledge by using a variety of educational technology tools that promote self-education. And then, there is also the interaction between teachers and technology that can also provide technologically related educational tools or teaching management. Therefore, the interaction between students and technology is one of the purposes of this study in order to improve student self-efficacy and satisfaction through the use of technology and related research.

The elements of interactive learning management require student participation both in teaching and learning. Students can create knowledge on their own, with activities that are held to reflect the knowledge content provided. Knowledge is created by creating self-knowledge of learners. It is composed of the following characteristics (Triphop Chansri 2010).

1. It is the effective teaching and learning that develops brain potential, including problem solving and knowledge application and emphasizes advanced thinking skills.
2. Learners build knowledge and learning process manually and provides an opportunity for the students involved in the learning process under the system organizers.
3. Students participate in the course, both in terms of building knowledge and interaction with the sense of cooperation rather than competition and learn to share responsibilities and work with discipline.
4. It is an activity developed by instructor that allows learners to integrate information, news or information and conceptual principles. Learners build and summary review from experiences through the knowledge.

1.3 Benefit of Active online learning activities

It is a program that suitable for teachers who prefer to use video materials for teaching also help to evaluate. Students and teachers can check the understanding that occurs during each video session. This creates a process of reflection during the video viewing of learners in a systematic way without the teacher having to struggle to press play or stop playing the video.

Reasoning feedback system and performance monitoring of students that help progress learning. Students can edit immediately. Standard assessment is more transparent and clear for learners. (Wannaketsiri, A. P. T. 2018).

Research Purposes:

1. To develop active online learning activities for enhancing Grade 4 students' learning achievement of living things
2. To compare learning achievement before and after using the active online learning activities for enhancing Grade 4
3. To study the satisfaction of active online learning activities for enhancing Grade 4 students' learning achievement of living things

Research Methodology:

Research design

This study is a quasi-experimental research with the One group Pretest - Posttest Design.

$$\mathbf{O_1 \quad X \quad O_2}$$

Where as O_1 is Pretest, O_2 is Posttest and X is the active online learning activities

Population and Sample

The populations were students in a small school of the primary education service area office 1 in Nakhon Pathom. The Sample of this study consisted of 20 fourth grade students who were studying in the second semester of the 2020 academic year in Banbornamphu school in Nakhon Pathom.

Instruments

Active online learning activities for enhancing Grade 4 students' learning achievement of living things was designed under The Basic Education Core Curriculum B.E.2008 revised edition 2017, Science Subject Substance 1 Bio science and cooperate studying from textbooks, supplementary textbooks for lesson content and related research.The living thing content consist of Tell the same and differences in the characteristics of living things using the collected information. Tell the observable characteristics of flowering plants and plants without flowers Using the collected information. Identify the characteristics observed in vertebrates and invertebrates. Using the collected information. Describe observable characteristics of fish, amphibians, reptiles, birds And mammals And give examples of living things in each group.It was presented in a variety of formats, images, animations and videos. Learners can learn more from external media active online learning activities. And learners have interactions together, such as creating a chat room to exchange knowledge, consult and talk, in which each unit of learning. The main activities are divided as follows: 1) pretest before learning each content 2) present content in various formats such as illustrations with explanations, videos, and students can learn more from the internet on the topic specified by the researcher 3) do exercises during the study 4) posttest after studying. The researchers selected programs to develop multimedia such as Canva and the Kine Master video editor then the active online learning was created by Edpuzzle. Teachers can set pop up questions while students watch a video and students can not skip the video must be answered to continue playing enabling virtual interactions in the classroom. Teachers can then check student progress in real time as they work through the given videos and their tasks throughout. Students can classify animals and describe the process of photosynthesis in plants. We also used Google Classroom for learning management system like a virtual classroom. The precision of achievement pretest and posttest was calculated by Kuder

Richardson KR20 method equal to 0.732. The active online learning activity quality was assessed by three experts in science education received item objective congruence index (IOC) in the range of 0.67-1.00.

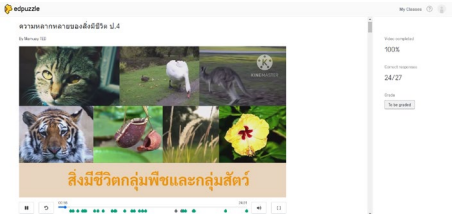


Figure 1: Video with edpuzzle and score correct responses

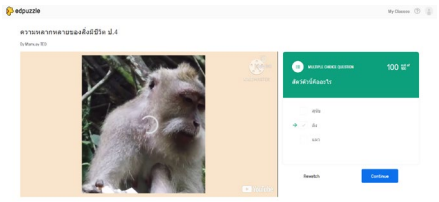


Figure 2: Multiple choice Question

Methods

Step 1: Introduce the classroom, teacher guides and show the students how to use the Google Classroom as learning management system and learn each the online learning units developed by Edpuzzle application.

Step 2: Check the basic understanding, learners take an achievement pretest, 20 questions, before studying to check their understanding in living things. The students did the test only one time via a link in Google Classroom for 60 minutes. The researcher has set the right answers to everyone by instant feedback and the score will be sent to the researcher's email.

Step 3: Initiate activity, learners interact directly with teachers who ask questions in the classroom along with doing exercises on each topic and proactively learn online lessons by themselves via a link set in Google Classroom. when teachers review the assignment, the learner can give the results.

Step 4: Take the test, when students finished learning all units, they have to take 20 questions posttest via a link in Google Classroom which is in Google Form. At this stage, it allows the learner to proactively interact with the learner and the online lessons.

Step 5: Give evaluation, student assesses their satisfaction assessment stage proactively with online lessons.

Results:

1. To compare learning achievement scores before and after the use of the active online learning activities for enhancing Grade 4 students' learning achievement of living things. The following results are taken into consideration:

Table 1 Results from the comparison of learning achievement scores before and after the use of the active online learning activities for enhancing Grade 4 students' learning achievement of living things.

Sample	Score	$\bar{x}$	S.D.	%	t	sig.
Pretest	20	9.20	2.17	46	12.931	.000**
Posttest	20	16.25	1.68	81.25		

*$sig < 0.01$

Table 1 results show the comparison of learning achievement scores before and after the use of the active online learning activities for enhancing Grade 4 students' learning achievement of living things. The average score $\bar{x} = 16.25$ and S.D. = 1.68 are higher than the average score before class which has average scores of $\bar{x} = 9.20$ and S.D. = 2.17 for the average learning achievement score after the use of active online learning activities for enhancing Grade 4 students' learning achievement of living things. These results are significantly higher ($t = 12.93$, $p < .001$).) as shown in the result of 81.25 percent from the expected 80 percent based on criteria of statistical significance.

2. To study satisfaction active online learning activities for enhancing Grade 4 students' learning achievement of living things, the following results are taken into consideration

Table 2 Results from satisfaction of active online learning activities for enhancing Grade 4 students' learning achievement of living things. (20 persons)

No.	Items	$\bar{x}$	S.D.	Level
1	The content defined in the learning activity is appropriate.	4.65	0.65	strongly satisfied
2	The practice tests are reasonable difficulty.	4.50	0.87	strongly satisfied
3	The time spent on the activity is reasonable.	4.55	0.74	strongly satisfied
4	Teaching activities are interesting.	4.55	0.67	strongly satisfied
5	The steps of student activities can be carried out.	4.55	0.74	strongly satisfied
6	Students practice their own thinking.	4.45	0.74	satisfied
7	Students learn from the environment around them.	4.65	0.79	strongly satisfied
8	Students apply their science knowledge in real life.	4.70	0.78	strongly satisfied
9	The students helped their peers to practice using technology.	4.50	0.67	strongly satisfied
10	Students enjoy learning and have fun.	4.70	0.56	strongly satisfied
Average		4.58	0.72	strongly satisfied

Table 2 results show the satisfaction of active online learning activities for enhancing Grade 4 students' learning achievement of living things which is defined at very strongly satisfied level ($\bar{x}$=4.58 and S.D. = 0.72).

Students are interested in science subjects and understand the content of living things, achieving goals set by teacher. They can apply their science knowledge in real life and enjoy learning under technology environmentally friendly.

Conclusion

Results of the use of the active online learning activities for enhancing Grade 4 students' learning achievement of living things after the activities show the students' achievement average of ($\bar{x}$= 16.25) which is 81.25 percent higher than 80 percent criteria of statistical significance at the .01 levels. Also the satisfaction result of the active online learning activities of living things was at a high level.

The active online learning activities about living things promote learning achievement that have been developed effectively and can be used as teaching materials, in order to develop learning, not only for the students but also for the teachers who can adapt the content and design that can further enhance their course lessons.

The active online learning activities about living things can improve learning outcomes even after the concerned level in this study, i.e. Grade 4. Students have knowledge and understanding of living things from the nature experiences. They can classify the types of organisms and practice using technology. Such activities make the learners learn happily with keen interest in developing themselves. The various points of this study can also lead the learners to research by themselves and teachers can frame the content in creating clearer lessons that suit the age of the learners. Teachers should take into account the differences between each learner and should provide a clear explanation of the use of proactive online learning activities. The manual and the lesson must be consistent and must be followed with coherence especially in conducting tests for effective teaching and learning.

References

References BANTHITABLOG (n.d.). "Online Learning (E-Learning)." from https://banthitablog.wordpress.com/Online Teaching/.

Calder, J. M., A. (1998). Open and flexible learning in vocational education and training. London, Kogan Page.

Moolthong, N. (2013). Interactive Multimedia Development Entitle Dinosaur in Thailand for the Prathomsuksa VI Students, Khon Kaen University.
Pamutachaowapee, N. (2014). Learning Achievement through Cartoon Media Support Online Lesson "Muang Takasila, Raising Conscious of Homeland Preservation" for Students in Mattayomsuksa 1 and Normal Study, Mahasarakham University. M.Ed.
Popadon, C. (2019). "Online Learning Management: New Normal of Education." Sikabanthit, S. (1998). Interactive Distance Learning. Bangkok.
Srimuangsong, W. (2017). The Development of Interactive Learning Tools for the Earthenware Community Learning Center at Ban Pak Huay Wang Nong,Ubon Ratchathani, King Mongkut's University of Technology North Bangkok.
Toikaew, U. (2011). The Development of Problem-base Learning Online Lesson to Improve Analytical Thinking Skill through the Course in C Language Programming for Mathayomsuksa 5 Students, King Mongkut's University of Technology Thonburi.
Triphop Chansri, ; Chaiyot Ruangsuwan and, Natchanok Jansawang (2010). "The Effects of Webbased Instruction on Learning Achievement and Attitudes towards Science in Science Learning Strand Entitled "Reproduction of All Living Things" of Prathomsuksa 5 Students." Rajabhat maha sarakham University Journal ; RMU.J. 4(3).
Wannaketsiri, A. P. T. (2018). *Science Formative Assessment*
Worathan (n.d.). "What is Online Learning?". from https://www.worathan.co.th/%E0%B8%A3%E0%B8%B2%E0%B8%A2%E0%B8%A5%E0%B8%B0%E0%B9%80%E0%B8%AD%E0%B8%B5%E0%B8%A2%E0%B8%94/5dce36b35005500012ea9c6b/%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B9%80%E0%B8%A3%E0%B8%B5%E0%B8%A2%E0%B8%99%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%AA%E0%B8%AD%E0%B8%99%E0%B8%AD%E0%B8%AD%E0%B8%99%E0%B9%84%E0%B8%A5%E0%B8%99%E0%B9%8C_Und_%E0%B8%84%E0%B8%B7%E0%B8%AD_Que_:!5dcbd7e45005500012ea849b _LP/5e71a1cb92d8170012f4593e?q=TP1

The Effects of Game-Development Based Learning Activities on 7th Grade Thai Students' Conceptual Understanding about Cells and Algorithm Design Ability

Tanaphon Thongnapo, tanaphon.th@ku.th
Nantarat Kruea-In
Kulthida Nugultham
Kasetsart University Kamphaeng Saen Campus, Nakhon Pathom, Thailand

Abstract

Game - development based activities about the Basic Unit of Living Organisms (Cells) were created to enhance students' conceptual understanding and algorithm design ability. Twenty- seven Grade 7 (aged 12-13 years old) students from a mixed ability classroom of a medium-sized public school in Bangkok were participated in this study. Data were collected during the second semester of the 2020 academic year (February-March 2021). All participants previously learned how to write algorithm flowcharts from a Computer Science Course. In this study, each group of the students were required to apply their conceptual understanding about cells to design a game then create a flowchart to graphically represent the algorithm of their own games. This unit was divided into 2 lessons and different game types were required to design; Cell Structure & Functions (computer games: using Word wall or PowerPoint) and The Microscope (board games). With teacher guidance, some groups still had some errors in writing algorithm flowcharts. Multiple-choice tests on learning achievement and algorithm design ability were used before and after the implementation of the game - development based activities. Pre-test and post-test scores were analyzed and compared by dependent sample t-test. Results revealed that the students gained conceptual understanding about cells and algorithm design ability at .01 statistically significance level.

Keywords: Game - development based instruction, conceptual understanding, algorithm design ability

Introduction

Educational policy and problems from ordinary national educational test

The rapid advancement of information technology, education and society requires country development to overcome changes and prepare citizen to face the challenges of the global trends. To improve the quality of people, improvement of education is a key factor. Educating people to equip with knowledge of science is necessary in this era. According to Thailand core curriculum of basic education, B.E. 2551 (2008) stipulates that science plays a very important role in today's and the future world because science is concerned with daily life of human beings. Science can help humans develop ways of thinking; logical, creative, critical, and systematic problem. Therefore, everyone needs to be developed to know and understand science, subsequently apply scientific knowledge and thinking in their own lives with rationality, creativity, and morality (Ministry of Education, 2010).

According to results from national education quality assessment, scores of school science achievement has been continuously in a low level for years. The National Educational Testing Institute analyzed the basic statistics classified by subjects. At the Mathayom 3 level, from 352,867 students who took the ordinary national educational test, the average score was 29.89 out of 100. From ordinary national educational test result analysis, it was also found that student achievement in the topic of the essence of living things and life processes was very low. The common problem found was that science courses were overemphasized in memorizing the content, time spent on teaching and learning for related thinking and abilities may not be enough.

Basic knowledge of the basic units of living organisms is extremely important as it serves as the basis for biological science at the higher educational level.

Computational Science & Algorithms

From 2017, computational science has been announced as a compulsory subject in Thailand basic core curriculum. Algorithm design ability is part of the goals in the computational science course are essential to today's learning. According to the Science Strand 4.2, the learning indicators for Grade 7 states that students are able to design algorithms that use abstract concepts to solve problems or explain functions found in real life. Garber (2014) and Humppi (2015) defined algorithm based design processes, following to the Cambridge Dictionary, as a set of commands or mathematical rules that help in calculation or solving a problem. Algorithm design was defined similarly among Thai scholars as step-by-step of any process (Wichaiwongwat, 2019), steps in system design (Daodent, 2008), the process of step-by-step solution for a particular problem that is understandable and sequential (Riewthong, 2014). From reviewing of Thai literature, learning about algorithms has continuously been facing problems for years. Chaisuwan (2015) found that some Thai students cannot analyze problems and draw algorithms flowcharts because of learning for memorization and correct answers. Therefore, students lacked of problem solving skills and learning by searching for knowledge could not promote such skills. From the same study, Ameena also found that writing recursive algorithms could help students in reviewing lessons, increasing their systematical thinking.

Ideas for Game-Development based Learning

Game-Development based learning facilitates students engagement in social interaction by sharing their designs, helping each other (Kafai, 2005), and taking ownership of their own learning. As Reiber (1998, p. 6) states, "Children can become deeply invested in their learning when they feel empowered to choose what they learn and the ways in which they learn".

Nowadays, research studies on the effects of learning by playing games have been in a growing number. Games are used as an educational material with intention to promote players' (learners') problem solving process. Although games cannot cover all learning topics, but they can always attract learners' to learning activities. The learners in this millennium have become the Net Generation or gamer generation and digital natives who can access to knowledge from media through computer networks. Therefore, games or game-based learning is a type of learning medium which is usually designed to achieve the target of 'learning is fun' along with the acquisition of knowledge. (Jiraworapong, 2016: Online). Learning through game activities can support learning due to diversity of the game types which can promote interactive learning, thinking processes and motivation. (Thammabus, (2002). Creating games requires students to organize their thoughts on how they can use the content of the lesson to create the game so that they can play the game with pleasure and gain knowledge.

From a research study by Baytak and Land (2010), titled "a case study of educational game design by kids and for kids", the researchers conducted a follow study of 3 Grade 5 students to investigate how they learned and designed computer games. The classroom activities required students to participate in a game design project during learning in a unit on nutrition. These three students were selected based on diversity of gender and game design experience, as well as completeness of data, in order to capture a range of potential experiences with the game design task. During the study, how children designed computer games as artifacts that reflected their understanding of nutrition were investigated. The result showed that these students became active participants and problem solvers by designing their own games.

Rationale for the study

From the aforementioned reasons, teaching and learning styles are needed to change. We should adopt the change idea that about our students from recipient learners to active creators. We have to get students to use their science understanding through what they enjoy. Most students are enjoying games. All gamers might be active but usually not creative, so students should be game creators. The researchers therefore hope that providing opportunities for students to develop games applying the content being learnt would be interesting and challenging for them. This study yet extends student algorithm design ability in create a flowchart to graphically represent the algorithm of their own designed games.

Theoretical Framework

Teaching and learning about Cells by a student game development strategy is based on the constuctionist theory. Construction theory is a theoretical concept that focuses on learning through practice. Students learn better by bringing them to their favorite stories to do by integrating academic and learning topics (Paron, 2005). Constructionists believe that knowledge does not come from just teaching, students can create knowledge by themselves. In addition, learning will only happen when the learner has done it by himself. Construction of innovation can develop thinking process of the learner which is presented through his work. The teacher must connect what he already know to what to and allow him to take the initiatives according to his interest, present ideas, analyze their own learning process as well as exchange and learn with others with providing continuous working time. It puts learning through action rather than cognitive process with less emphasis on memorization (Ackermann, 2001). Understanding of scientific concepts can be learned and expressed during creating an artifact within a peer collaboration community. The framework of teaching and learning activity in this study extended from the 5E model (Engagement, Exploration, Explanation, Elaboration and Evaluation). The researchers created a game-development based learning to promote understanding about cells and algorithms design ability as the following steps:

1. **Engagement:** introduction to the lesson by linking previous and existing knowledge to new concepts to be learned. Games selected or designed by the teacher were used as learning media to stimulate students' interest and get them familiar with game platforms (Word wall/ PowerPoint/simple board games).
2. **Exploration:** activities or situations that allows students to have a collective experience in creating new knowledge. Students take actions to collect information or phenomena. In this step, students explore the characteristic of cell structure and function from samples and practice skills to use light microscopes with teacher's guidance.
3. **Explanation:** presentation and discussion of the obtained data from the previous step, and summary of the results in different ways or forms.
4. **Elaboration:** expansion of knowledge about cells and connect to a game-based development activity. It is the step where students apply their acquired knowledge to their own designed game and demonstrate their algorithm designed ability.
5. **Evaluation:** assessment of understanding about the learned science concepts, discussion strengths or weaknesses of designed games and validation check of algorithm flowcharts.

The framework of game development-based learning drawn from the constructionist theory, 5E inquiry learning model, and game based and game-development based learning. The activities aim to develop conceptual understanding about cells and algorithm design ability of Grade7 students is show as in the following diagram.

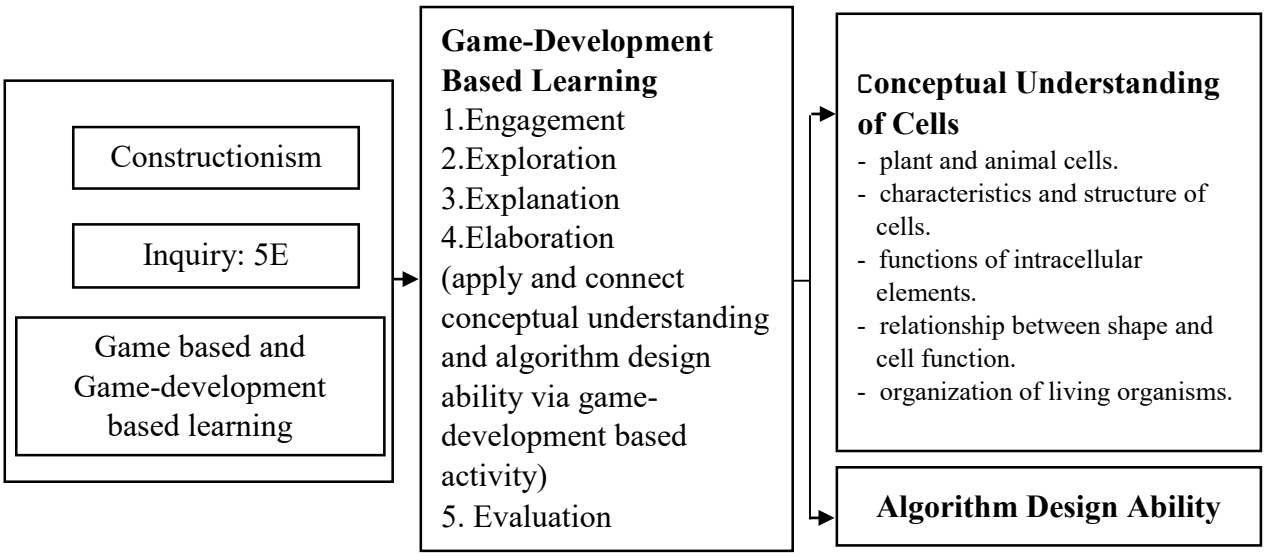


Figure 1: Theoretical framework

Objectives of the study

1. To develop game-development based learning activities to promote Grade 7 students' conceptual understanding about cells and algorithm design ability.

2. To compare mean scores of Grade 7 students' conceptual understanding about cells and algorithm design ability before and after implementing the game-development based learning activities.

The context and participants of the study

This research study was conducted at a medium-sized opportunity expansion school in Bangkok. Teaching and learning activities were done in 2 weeks, 4 hours per week. Class periods were drawn from 2 subjects; 3 hours/week of a science subject, and 1 hour/week of a computer science subject. Participants were 27 Grade 7 students from a mixed ability class. The students had studied algorithms in a computer science class for approximately 3 weeks (1 hour per week) before participating in the study. One of the researchers of this study was the teacher. She holds a bachelor's degree in science education. She has experience in teaching science for 2 years and 7 months and 1 year of teaching computer science.

Research Instrument

The Game-Development based Learning Activities

The learning activities were designed and divided into 2 class lessons; Cell Structure & Functions and The Microscope. The details of each lesson are shown below.

Lesson 1: Cell Structure & Functions

One main goal of the first lesson was to activate students to actively engage to entertaining learning. The lesson provided an opportunity for students to learn how to apply games in learning before creating games by themselves in the second lesson. The steps of learning activities are shown as the followings.

1) **Engagement.** Students sing a song named "Cell" from the website, then answer questions:
   - From the songs you have just sung, are there any words you do not know or understand
   - If there any, write down the words on the board.

   Then the teacher explained the words that students did not understand with pictures and brief annotation**.**

Figure 2: The "Cell" song video
(originally from: https://www.youtube.com/watch?v=2DOumLtl65o)

2) Exploration. Students were divided into groups and collaboratively studied cell structure and functions of plant and animal cells from the textbook and summarized the knowledge by constructing a mind map.

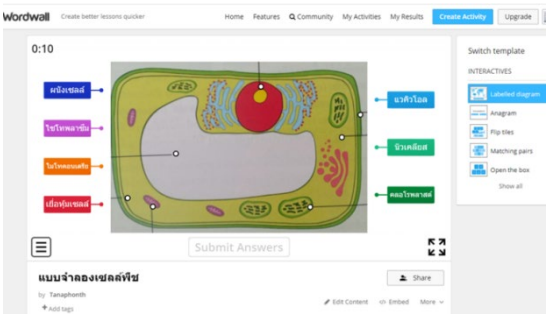
3) Explanation. Each group representative presented the concept map to the whole class. Students joined together to answer the following questions;

- Why do difference types of cells have different functions? *(Most neurons contain nerve fibers as the long branches carry nerve impulses to other distant cells. Root hair cells are root surface cells that have long protruding cell walls and membranes. They look like small hairs to increase the surface area to absorb water and minerals.)*.

- How do living things organize their body systems? *(Multiple cells combine together to form tissues. Several types of tissues join and work together as organs. Organs work together in living organisms.)*.

Then students and teachers together summed up the knowledge about cell structure and functions.

4) Elaboration. The teacher asked students to play a Word wall game about plant cells. The teacher encouraged all students in the group to work together to figure out the answer. Teachers and students worked together to write an algorithm for this game using the knowledge learned in computer science.



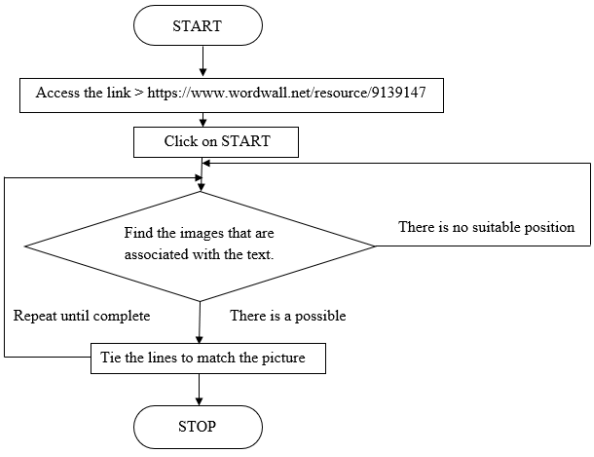


Figure 3: Plant cell word wall game and algorithm flowchart

5) Evaluation. The teacher announced and gave the prize to the winner group who got the highest score. The whole class summarized the knowledge and understanding again.

Lesson 2: The Microscope

In this lesson, the teacher gave a chance for students to create their own games and drew flowcharts to represent the algorithm of their game.

1) Engagement. The teacher showed pictures of unicellular organisms (such as paramecium and amoeba) from a permanent slide prompting students to recognize that these organisms were only one cell. The teacher then asked students to play a picture game. Once the picture was shown, students were asked to decide whether the organism in the picture is a unicellular or multicellular organism and gave reasons for their answers (all pictures were unicellular organisms). After the game, the teacher led the discussion about multicellular organisms by asking students to think about their own bodies, animals and plants so they caught the conceptual understanding of multicellular organisms.

2) Exploration. The teacher divided students into groups of 4 - 5 students. Each group observed plant cells (pulp), *Hydrilla verticillata* cells, onion cells and animal cells (buccal mucosa) from permanent slides under microscopes. They drew picture of cells, identify cell shapes and component of the cells.

3) Explanation. Students discussed the results and summarized the activity that cells are in different shapes. Common plant cells are polygonal and animal cells are in amorphous shapes. Plant cells are composed of cell wall, cell membrane, cytoplasm and nucleus. Green plants, such as skunk algae, have many green pigments, called chloroplasts, floating in the cytoplasm. Animal cells share the same components as plant cells: the nucleus, cytoplasm, and cell membranes, but without cell wall and chloroplasts.

4) **Elaboration**. The teacher asked each group of students to apply the knowledge gained from the lesson to design a game and drew a flowchart to represent algorithm of their own game. All groups of the students decided to create a picture lottery game which required players to guess the answers. Even they created the same type of game but each group chose different pictures. After finishing game creation, each group drew an algorithm flowchart to indicate the rules of their game. Group 1 could drew a complete algorithm flowchart correctly explained the rules of their game. Group 2 used alternate process symbols incorrectly in the steps of "Catch of the lottery" and "Look at the picture to guess the answer". While these two steps were missing from the Group 3's flowchart.

5) **Evaluation**: Students played the game created by the other group. The teacher observed and assessed student gained knowledge from the lessons.

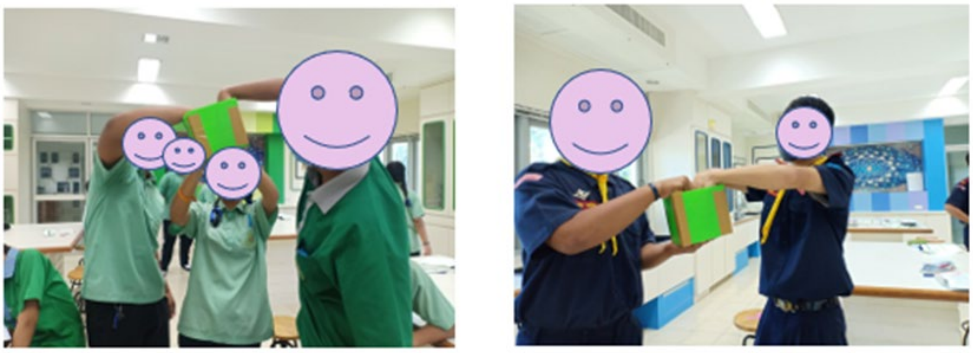


Figure 5: Students played the guessing games in class

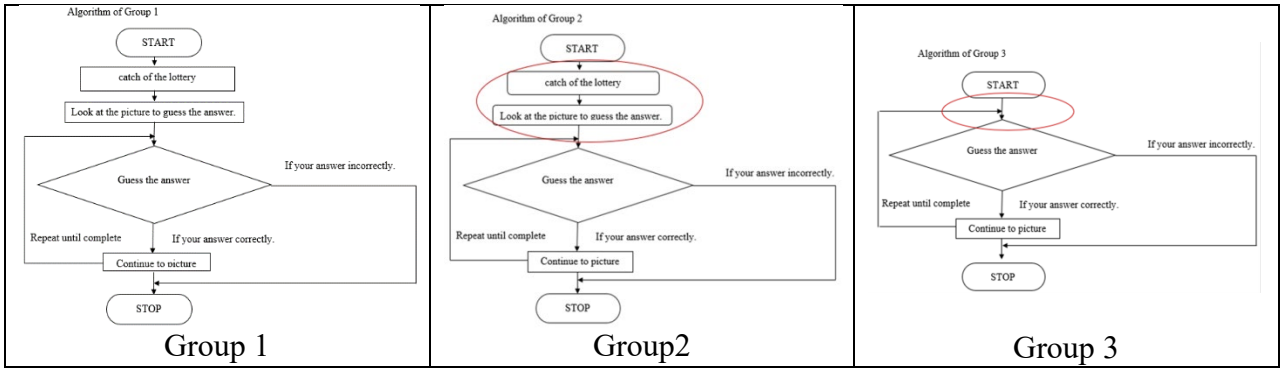


Figure 6: Algorithm flowcharts of the guessing games

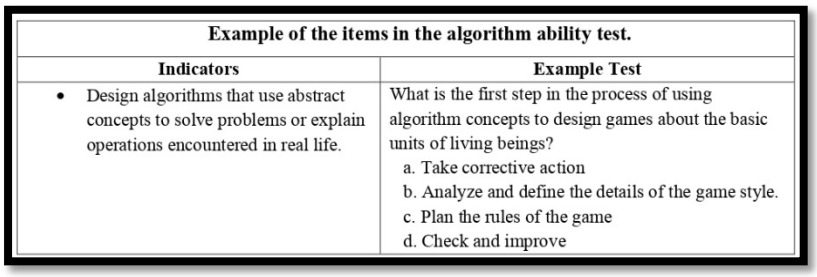
Conceptual understanding test and algorithm ability test

The draft items of the conceptual understanding test and algorithm ability test were selected from school test item bank. From item selection, the first draft of the conceptual understanding test and the algorithm ability test consisted of 25 and 20 questions, respectively. The tests were validated by experts; 2 experienced science teachers and 1 computer teacher. All experts gave index of item – objective congruence= 1 for every test item. Then, the tests were tried out with 36 Grade 8 students. After tryout, difficulty index (p), discrimination (r) and reliability were calculated. There were 20 items of the conceptual understanding test (p =0.30-0.78, r =0.25-0.56, KR_{20} = 0.82) and 15 items of the algorithm ability test (p=0.30-0.76, r=0.25-0.56, KR_{20} = 0.85) could be used for collecting data from the participants.

Example of the items in the conceptual understanding test.

Indicators	Example Tests
• Compare the shape, appearance and structure of plant and animal cells and describe their functions of cell walls, cytoplasm, nucleus, vacuoles, mitochondria and chloroplasts.	How are plant cells different from animal cells? a. Has a cell wall and vacuoles b. Has a cell wall and mitochondria c. Has cell wall and chloroplast d. Has chloroplast and mitochondria
• Using light microscopes to study cells and their structures.	When using a microscope, the student will place the slides on which components? a. Eyepiece b. Objective lens c. Object plate d. Coarse adjustment button
• Explain the relationship between shape and function of cells.	What is the function of the cells in the picture?  Image: Encyclopedia Britannica, Inc. a. Destroy foreign objects b. Photosynthesis c. Controlling substances in and out. d. Making proteins
• Describe the organization of living organisms. starting from cells, tissues, organs, organ systems until being a living thing.	A group of tissues that coexist and perform a specific function together. a. Body b. Organs c. System d. Cell
• Explain the processes of diffusion and osmosis from empirical evidence and give examples of diffusion and osmosis in daily life	What factors do you need to make diffusion occur quickly? a. Low temperature of the substance. b. High density of the medium. c. Large substance particles d. Different densities between particles

Figure 7: Example of the items in the conceptual understanding test.



Example of the items in the algorithm ability test.	
Indicators	**Example Test**
• Design algorithms that use abstract concepts to solve problems or explain operations encountered in real life.	What is the first step in the process of using algorithm concepts to design games about the basic units of living beings? a. Take corrective action b. Analyze and define the details of the game style. c. Plan the rules of the game d. Check and improve

Figure 8: Example of the items in the algorithm ability test.

Data Collection and Analysis

The researcher, also the teacher, informed the objectives of the study and explained briefly about the game-development based learning activities to promote understanding and algorithms design ability to the participant students. They were asked to take a pre-test for 1 hour 30 minutes. After the game-development based activities were implemented, the students were asked to take a post test, identical to the pre-test. Scores obtained from the pre-test and post-test were analyzed and compared by T-test for dependent sample.

Results

The results of comparative analysis of Grade 7 students' conceptual understanding about cells and algorithm design ability before and after the game-development based learning activities are shown below.

Table 1: Comparison of pre- and post-test scores on students' conceptual understanding (N = 27)

	Score	$\overline{X}$	S.D.	t	sig.
before	20	7.26	1.77	-21.144	.000
after	20	16.41	1.60		

$sig < 0.05$

Table 1 shows the result of comparative analysis of students' conceptual understanding about cells. The average score of the post-test ($\overline{X}$ =16.41 and S.D. = 1.60) is higher than the average score of the pre-test ($\overline{X}$ = 7.26 and S.D. =1.77) at 0.01 statistical significant level. From the students taking the exam after class, it was found that most of the questions had pictures of different cells. Most of the students answered correctly. Maybe because there are games related to pictures. The test that most students fail to do is calculate the magnification of the camera, which may be due to the lack of mathematical fundamentals among students.

Table 2: Comparison of pre- and post-test scores on students' algorithm design ability (N = 27)

	Score	$\overline{X}$	S.D.	t	sig.
before	15	6.11	2.42	-11.297	.000
after	15	12.89	1.81		

$sig < 0.05$

Table 2 shows the result of comparative analysis of students' algorithm design ability. The average score of the post-test ($\overline{X}$ =12.89 and S.D. = 1.81) is higher than the average score of the pre-test ($\overline{X}$ = 6.11 and S.D. =2.423) at 0.01 statistical significant level. During the activities, it was found that some students lack of basic skills in writing algorithms and have misunderstandings about the use of flowchart elements. The teacher, therefore, had to review the foundation of writing algorithm flowchart, especially flowchart elements, for the whole class before allowing them to write a flowchart from their own games. Some students with unclear understanding could not writing flowcharts correctly. The most difficult activity was getting

students to design a game because they needed to use creativity and it was time-consuming. This problem had been solved by the teacher provided guidelines or examples of games for students to try out before designing their own games.

Conceptual understanding about cells that most students incorrectly answered in pre-test, and after learning they still could not get the correct answer was item 8. This item asked students to do a simple calculation of the overall magnification of a microscope with a 40X objective lens and a 10X eyepiece which requires mathematical knowledge. For the algorithm design ability, in pre-test and post-test, most students failed to provide the right answer for definition of "abstract concept". The answer was "systematic problem-solving concept identifying details of each problem". Although most of the students did not choose the same wrong choice, it showed that students still did not have an adequate understanding of abstract concepts. This reflected in teaching of algorithms needed teachers to be aware of promoting theoretical concepts as well as practical tasks to enhance skills in drawing algorithm flowcharts.

Conclusion and Implications

From this study, Grade 7 students' conceptual understanding about cells and algorithm design ability can be improved by game-development based learning activities. Unfortunately, in this study, the students spent very long in designing their own games. Their designed games were in the same type. Teachers should be aware of promoting an enjoyable learning atmosphere. Learning activities aiming students to creatively design and construct artifacts normally take longer time. Teachers should manage time well in teacher-led activities, so students can sufficiently take their time for creativity and completion of their work. Implications from findings of this study come to an agreement of the implications of findings for educational practice suggested by Baytak and Land (2010) that:

1) From observations during study of this study, students must understand material they are learning so they would be able to create games. Teachers should allow students to represent their understanding in concrete and personally meaningful ways.
2) Students must learn to ask for and provide help. In this study, the group that knew how to ask for help could save a lot of time and successfully designed their game sooner than the other groups. Scaffolding could be occurred by teachers and also peers.
3) Designing games might encourage diversity of ideas in a classroom community. In this study, different groups of students were excited and interested in the game of other groups.
4) Designing games can lead to meaningful engagement of participants and enhanced sense of classroom community. From this study, brainstorming to make the best of their games was found.
5) Game design can be highly motivating to students and learning through design can reflect integrative, authentic, and long-term curriculum units in target subjects.

References

Ackermann, E. (2001). *Piaget's Constructivism, Papert's Constructionism: What's the difference future of learning group publication*. Retrieved from http://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf

Baytak, A. and Land, S. M. (2010). *A case study of educational game design by kids and for kids*. Procedia Social and Behavioral Sciences 2, 5242–5246. Retrieved from https://www.researchgate.net/publication/248606866.

Chaisuwan, A. (2015). Development of learning materials for writing circular algorithms. Research *Journals and development Valaya Alongkorn under Royal Patronage, 10 (3),* 43-51. Retrieved from https: //so06.tci-thaijo.org ›view

Daodent, K. (2008). *The development of computer lessons for practicing computer programming successfully using algorithms for 3rd year students of industrial computer technology, Faculty of Industrial Technology Uttaradit Rajabhat*. Research report. Uttaradit Rajabhat University.

Garber, R., (Ed.) (2014). *Bim Design: Realising The Creative Potential of Building Information Modeling*. John Wiley & Sons Ltd. 248 p.

Humppi, H., 2015. *Algorithm-Aided Building Information Modeling: Connecting Algorithm-Aided Design and Object-Oriented Design.* Master thesis. Tampere University of Technology.

Israsena Na Ayudhya, P. (2005). *Knowledge Based Society by Constructionism*. Bangkok: Personnel Management Association of Thailand.

Jiraworapong, P. (2016). *Games Based Learning: New learning media in Thailand*. Retrieved January 9, 2021, from http://nuybeam.blogspot.com/2010/08/game-based-learning.html

Kafai, Y. B. (2005). The classroom as "living laboratory": Design-based research for understanding, comparing, and evaluating learning science through design. *Educational Technology*, January-February, 28-34.

Ministry of Education. (2010). *Basic Education Core Curriculum 2008*. Bangkok : Samphan Printing House Agricultural Cooperatives of Thailand Limited.

Reiber, L. P., Luke, N., & Smith, J. (1998). Project KID designer: Constructivism at work through play. Meridian: *A Middle School Computer Technologies Journal*, 1(1). Retrieved August 18, 2021 from http://www.ncsu.edu/meridian/jan98/feat_1/kiddesigner.htm

Riewthong, R. (2014). *Development of learning achievement in loop programming using methods Organized SSC learning together with animation algorithms for grade10 students*. Master's degree Science Education Faculty of Science Ubon Ratchathani University.

Sawatpol, S. (2017). *Building basic computer games*. (2nd edition). Bangkok: Wang Aksorn.

Thammabus, M. (2002). Developing Learning Quality Using BL (PROBLEM-BASED LEARNING). *Academic Journal, 5, February*, 11-17.

Wichaiwongwat, P. (2019). *Enhance your algorithmic skills with games (Grade 4).* Thesis B.Sc. (Computer Science). n.p: graduate school Kanchanaburi Rajabhat University. Retrieved January 9, 2021, from http://coms.kru.ac.th/tee/Projects/ShowPdf?name=637223786340139046.pdf&chk=False