doi: 10.14456/jiskku.2020.1

Development of Instructional Model Using Problem-Based Learning with Lateral Thinking on Isometric Virtual World to Enhance Creative Problem-Solving of The Undergraduate Students

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Received: June 22, 2019

Revised: January 6, 2020

Accepted: January 10, 2020

Abstract

Purpose of the study: to develop the instructional model using problem-based learning with lateral thinking on isometric virtual world to enhance the creative problem-solving of the undergraduate students.

Methodology: mixed-method research, which used the data collecting instruments such as interviews and evaluated form.

Main Findings: the research result found that the instructional model consists of 4 components contained by 7 processes.

Applications of this study: this study can be a helpful guide for using the isometric virtual world for educational and information science purposes.

Keywords: Problem-based learning, Lateral thinking, Isometric virtual world, Creative problem-solving

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วัตถุประสงค์ของการวิจัย: การพัฒนารูปแบบการเรียนโดยใช้ปัญหาเป็นฐานและเทคนิคการคิดนอกกรอบบนโลกเสมือนจริงแบบไอโซเมตริกเพื่อส่งเสริมความสามารถในการแก้ปัญหาเชิงสร้างสรรค์สำหรับนิสิตนักศึกษาระดับปริญญาบัณฑิต
วิธีการศึกษา: เป็นการวิจัยแบบผสมผสาน เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูล เช่น การสัมภาษณ์ แบบประเมิน
ข้อค้นพบ: ผลการวิจัยพบว่ารูปแบบการสอนประกอบด้วย 4 องค์ประกอบ มี 7 กระบวนการ
การประยุกต์ใช้จากการศึกษานี้: การวิจัยนี้เป็นประโยชน์อย่างมาก สามารถใช้เป็นแนวทางสำหรับการใช้โลกเสมือนจริงไอโซเมตริกทางการศึกษาและข้อมูลสารสนเทศ

คำสำคัญ: การจัดการเรียนรู้โดยใช้ปัญหาเป็นฐาน เทคนิคการคิดนอกกรอบ โลกเสมือนจริงแบบไอโซเมตริก การแก้ไขปัญหาอย่างสร้างสรรค์

Introduction

In the 12st century, the world has changed in many aspects including the economy and society. This led to adaptations to create competition capability in the developing world. Human resource development requires changes to prepare new people with sets of skills necessary to the 12st century. The Partnership for 12st Century Skills (2011) defines skillsets for the 12st century with the top priority is learning. Learning makes people being prepared for an increasingly complex working environment. The other important skillsets are creativity and innovation, judgment and problem solving, communication and cooperation. Problem-solving and creativity are essential for new people of the 12st century and also need to be encouraged for the working world and society (Wagner, 2008).

The reason behind creative problem-solving is put in the essential category is because in everybody's daily life there are many problems and challenges await. The conventional way of problem-solving may not suffice for new issues (Khammani, 2007). Therefore, people need to improve the creative problem-solving skill to address these problems with new ways of problem-solving. This requires knowledge and experiences

along with creativity to come up with new problem-solving methods, then using logical judgment to decide the most appropriate solution for each issue. The process not only solves the problems but also does it effectively. (Dianne, 2005; Malakul Na Ayutthaya, 1994; Phanmanee, 2014)

For the undergraduate level of creative problem-solving. Complementary environment and technology are required for developing said skill sets, especially technology that emphasizes collaborative learning and environment that enables learners to try and test the solving methods. The tools that answer to the development of creative problem-solving are Isometric Virtual Worlds: a virtual world that displays symmetric graphical objects, for example, cubic objects that interconnect like *Legos*. This allows users to create their virtual world by utilizing the problem-solving skills in certain situations in the virtual world or use the canvas to perform the Pixel Art style of the outcome with creativity and imagination (Short, 2012). Furthermore, learners can interact with others synchronously (Aldrich, 2009; Twinning, 2010) by stimulating the learners in a virtual environment to do activities by using their avatar. The learners can interact with the environment and objects digitally as if they are in the actual environment (Nonis, 2005). The open environment encourages people to step out and perform tasks and try out their thoughts leading to outputs. Communication, Cooperation, and collaboration also see an improvement with brainstorming and discussions to find a solution and a summary (Kapp and O'Driscoll, 2010). Challenges in Isometric Virtual Worlds offer a great way to engage students in creative problem solving and project-based learning. (Cipollone, et al., 2014) This process is complementary to the development of creative problem-solving skills for learners.

For the development of creative problem-solving using the Isometric Virtual World, it is set up based on problem-solving lessons. Learners will be required to use a technique to come up with new ideas outside of the box, which is a key element to creative problem-solving. The technique is "Lateral thinking" by De Bono (1970), the technique that tries to figure out a different approach to the problem. By using

environment, procedure, and the technique, this can be set as a class pattern that allows learners to face with the simulated virtual situations. The learners can practice by analyzing problems and cooperating with others which would result in a true understanding of the situations and clear overview of the choices and methods for the problem, creating curiosity, developing team and communication skills. All of this follows the principle of the study to improve the creative problem-solving skills of Torrance (Torrance, 1966) which would be developed for undergraduate students.

The previous paragraph shows the importance of developing a class using virtual technology for enhancing creative problem-solving skills. Therefore, this research aims towards the development of an instructional model using problem-based learning with lateral thinking on the isometric virtual world to enhance creative problem-solving. Components and procedures will be synthesized and developed into an instructional model and will be reviewed by experts for the practical and effective instructional model using problem-based learning with lateral thinking on the isometric virtual world to enhance creative problem-solving in the future.

Objective

This research is the research and development which consists of 2 objectives; 1) to develop the instructional model using problem-based learning with lateral thinking on the isometric virtual world and 2) to examine the quality of the instructional model using problem-based learning with lateral thinking on the isometric virtual world.

Research Methodology

The research methodology is separated into 2 phrases as followings; Phase 1: To develop the instructional model using problem-based learning with lateral thinking on the isometric virtual world that researchers' study, analyze, and synthesize the idea, theory, and research related to the problem-based learning, lateral thinking, isometric virtual

world, and creative problem-solving together. After that, we developed the master of the model to draft a model and passed to the experts for examination about the quality and certification that the content is relevant to the detail of the master model.

Phase 2: the study of an expert's suggestion by interview. After we presented the draft model from phase 1 to the 7 experts who have an experience of at least 3 years in educational technology and communications, teaching pedagogy, problem-based learning, lateral thinking, isometric virtual world, and creative problem-solving to analyze and share their opinion through interview method to improve and adjust the draft model as their advice. After that, the process of the model to inquire about the suitability of usage by evaluation form. Experts can provide diverse opinions, properly collected and analyzed, can yield rich evaluation information. We submit the draft model to 5 experts who have an experience at least 5 years, used to publish the academic paper and be acceptable in part of educational technology and communications, teaching pedagogy, problem-based learning, lateral thinking, isometric virtual world to consider and evaluate in term of communication, appropriateness of components.

The tools of research methodology and collective data are;

1) The research methodology tools consist of the master of a model which includes the objective, principle, basic development concept, the process of learning and elements which are collected the data by study, analysis, and synthesize the theory, method, related researches, and development into the draft model.

2) The data collecting tools consist of the structural interview where the tools and development processes are arranged with the draft model then compiled to be the question of each the process to allow the experts to consider and share their opinion in term of communication, content coverage, usage appropriateness, as well as the additional suggestion. Another tool is the certification model assessment of model suitability by setting the questions about issues of evaluation which covers the overall components and process of the instructional model using problem-based learning with lateral thinking on the isometric virtual world. The evaluation scales are divided into five

levels following the Likert rating scale ranging from entirely inappropriate to most appropriate.

For the data collecting process, the researchers presented the draft model to 7 experts to consider in part of the communication, content coverage, usage appropriateness as well as asking for advice about the component. The process of creating a draft model through an interview method was via created interview dialogue. Then, the researchers applied the draft model which has already adjusted as an expert's suggestion to 5 experts for evaluating and certification that consistent as the content about components appropriateness and process.

The data analysis from the interview can be considered by the content and essential issue consistency which obtains from the data collecting process to compare with the central concept. Then, we applied the expert's suggestions to improve and adjust the components and method of the model, the certificate model assessment, and analyze the assessment evaluation result of the content from the experts by calculating to find the mean and standard deviation (SD). After that, researchers applied the expert's suggestion to improve and adjust to complete the model.

Research Results

The draft model of the CU Creative Virtual World including 4 components as followings; 1) isometric virtual world, 2) problem-based learning with lateral thinking, 3) role of learner and facilitator, and 4) measurement and evaluation, which consist of 7 processes as followings; 1) Enter the Isometric Virtual World and Group Interaction, 2) Define the Problem Within the Group, 3) Collect Data From Online Learning Resources to Solve the Problem, 4) Considerate of Solutions to Solve the Problem Within the Group, 5) Create the Creative Works Together on the Isometric Virtual World, 6) Review and Presentation by Using Online Tools, and 7) Assessment in Learning, How to Solve Problem and Work. To assess the CU Creative Virtual World Certification Model found that this model was the most appropriate in part of usage.

Two issues of the CU Creative Virtual World Model are the component and development process. The four main components of CU Creative World Model consist of;

1. The Isometric virtual world is a type of a simulated world that displays symmetrical graphics in the form of an object or cube that interconnects like *Legos* or an 8-bit game that is contained in an open-world sandbox. This allows learners to create or build anything freely in this simulated world. Additionally, learners can interact with others through servers by entering a virtual world and perform problem-solving skills on given circumstances using the canvas to create a pixel art by creativity and imagination. This enhances the creative problem-solving skills of the learners by letting them create a visual answer to certain types of problems.

2. Problem-based learning with lateral thinking

2.1 Problem-based learning is an instructional model that lets the instructor provides various situations to the learners which may be one of the daily life problems of the learners themselves. The learners will search for broad knowledge and perform analytical skills that will result in a cooperative problem-solving activity to be able to see the overview and methods for the particular problem by following these steps 1) Group problem discussion and presentation 2) Information collecting from problem-solving data sources. 3) Group problem-solving methods evaluation 4) Summarize the answer or outcome 5) Review and present the answer or outcome 6) Problem-solving methods and outcome evaluation.

2.2 Problem-based learning with lateral thinking is a group skill development model that allows learners to self-instruct. The learners have to break outside of the box to find new ideas then use logical thinking to ensure its correctness and come up with new solutions to the problems. In situational practice, the learners will present, discuss and finalize the solution in groups. The learners then present their works from their collaborative activities into a visual Pixel Art, which is designing different types of buildings according to the problems of the group.

3. Roles of learner and teacher consist of;

3.1 Roles of learner consist of the active learner, a group member who will perform in the isometric virtual world and study the problem and other group members who will discuss and analyze the problem. The active learner will enter the virtual world, study the problem and present it to the group for discussion, evaluation, and summarization. Then the group uses the outcome to create a Pixel Art to present their solution to the problem. After class discussion and evaluation are then carried out.

3.2 The roles of the teacher consist of the role of preparing the environment on the isometric virtual world and design the instructional model using problem-based learning methods and lateral thinking to enhance creative problem-solving skills. The teacher also acts as a coordinator for the activity, supervise, monitor and record the learner's improvements.

4. Measurement and Evaluation consist of 3 tools;

4.1 Creative problem-solving measurement, the measurement, and evaluation that measures the capability of the learners during the instructional model on the 1st , 3rd and 5 th time by using a creative problem-solving using lateral thinking evaluation form by Gomolkittisak (2010), Songkram (2012), Chanayotha (2014), Torrance (1966), Cropley (1996). The form uses 4 rubric scale in the topic of 1) Knowing the problem 2) Understanding the problem 3) Considering possible solutions 4) New approaches to the problem 5) Choosing an appropriate solution logically 6) Defining the solution process 7) Efficiently performing the solution 8) Problem-solving in the assigned period,

4.2 Creativity evaluation, the measurement, and evaluation that measure the capability of the learners during the instructional model on the 1st, 3rd, and 5th time by using applied evaluation form from CPSS (The Creative Product Semantic Scale) developed by Besemer and Treffinger (1981). The form uses 7 levels of Semantic Differential in 3 dimensions which are novelty, resolution, elaboration and synthesis along with 11 concept points. The scale is a layout with opposite modifiers to describe the

concept. The participant evaluates the relation between the two and selects the appropriate level from least appropriate to most appropriate in this 7-level scale.

4.3 The satisfaction measurement form which evaluates by 5 Likert scales;

The CU Creative Virtual World Model contains seven processes as the following;

1. Enter the Isometric Virtual World and Group Interaction. In this step, learners can practice using the isometric virtual world to prepare for the activity, including controls, avatar commands, and inventory management. The learners can explore the open world and try to interact with objects and other people in the virtual world, get familiar with other member's avatars and communication.

2. Define the Problem Within the Group. The group receives a problem to figure a solution. The group will define and understand the problem and its importance. Then together, the group members analyze and consider the problem's core component by using communication tools in the isometric virtual world

3. Collect Data from Online Learning Resources to Solve the Problem. The learners cooperate to study and search for information necessary to the problem by using online data sources. This is an individual process. After the information is gathered, the group exchange and discuss their findings using the communication tools in the isometric virtual world.

4. Considerate of Solutions to Solve the Problem Within the Group. The learners use information acquired from its members and consider a possible solution by presenting the information and ideas of the solution. Then the group evaluates and selects the preferred solution and predicts the outcome after the solution is applied using the communication tools in the isometric virtual world.

5. Create the Creative Works Together on the Isometric Virtual World. The learners work as a group to summarize the solution and plan the design to solve the problem. The group then explore the area to start working on the model in the virtual

world, they then create a model following the design using objects from their inventory to construct buildings according to their solution to the problem. The buildings in the virtual world are shaped like *Legos* that can connect and build into the desired structure. The environment in the virtual world includes forest, ocean, snow, and desert. The group works in real-time and communicates using tools in the virtual world leading to improvements to creative problem-solving skills.

6. Review and Presentation by Using Online Tools. This step will be carried out when the learners have finished their work in the virtual world. Each group presents their creative solution via video in the online channel to publish and exchange comments.

7. Assessment in Learning, How to Solve Problem and Work. This is the evaluation step to measure the capabilities of the creative problem-solving skill of the learners in the rubric scale using applied CPSS evaluation form developed by Besemer and Treffinger (1981). The evaluation is done on the 1st, 3rd, and 5th rounds of the instructional model to measure the level of problem-solving skills of the learners before and after using the model. The form also measures the satisfaction level of using the model as well.

The appropriate certificate evaluation assessment result which scores by five experts about the CU Creative Virtual World Model can be summarized as shown in Table 1.

Table 1 The opinion level of each expert to CU Creative Virtual World Model

Evaluation list	No. of expert					Mean	SD	Appropriate level
	1	2	3	4	5			
1) The model's objectives	5	5	4	4	5	4.63	0.55	Most Appropriate
2) The model's theories and principles	4	5	4	4	5	4.47	0.55	Appropriate
3) The model's components	5	5	5	4	5	4.73	0.45	Most Appropriate
4) The model's procedure	5	5	4	3	5	4.43	0.89	Appropriate
5) Tools used in the model	5	5	5	5	5	5.00	0.00	Most Appropriate
6) Study Evaluation	4	5	4	3	5	4.30	0.84	Most Appropriate
7) Practical appropriation	5	5	4	4	5	4.60	0.55	Most Appropriate
Overall Average						**4.60**	**0.55**	**Most Appropriate**

Table 1 shows that the experts conclude that the CU Creative Virtual World Model is most appropriate to apply for learning (Mean = 4.60). Moreover, they also suggest improving the learning model from their interview comments about the model's diagram that needs to be adjusted to be more clear and improve the process of using the isometric virtual tools to show the advantages of the tools to enhance the creative problem-solving skills.

The activities an environment in the virtual world needs to be appropriate with the creative problem-solving process. The learners are also required to use the tools and communicate with others in the virtual world. They need to be instructed and prepared for the virtual world. Orientation is recommended.

Creative problem-solving activities should open to both group and individual participants. A single learner can practice on their later thinking, while group learners can exchange broader views and ideas. With more ideas, learners can improve creative problem-solving skills even further. The roles of learners and teachers should be distinct.

The experts have recommended that the duration of this model should be at least 5 weeks or more. This length is necessary for learners to improve their creative problem-solving skills.

The creative problem-solving evaluation should be conducted during the study, educational footprints should be recorded and evaluated after the activity. Periodic evaluation can reflect the overall performance of the learners more effectively. The researcher has developed the creative problem-solving evaluation form for both during and after the activity.

From the interview and study, the researcher has adjusted and improved the draft model refer to the expert's suggestion — the detail of the revised draft model as shown in figure 1.

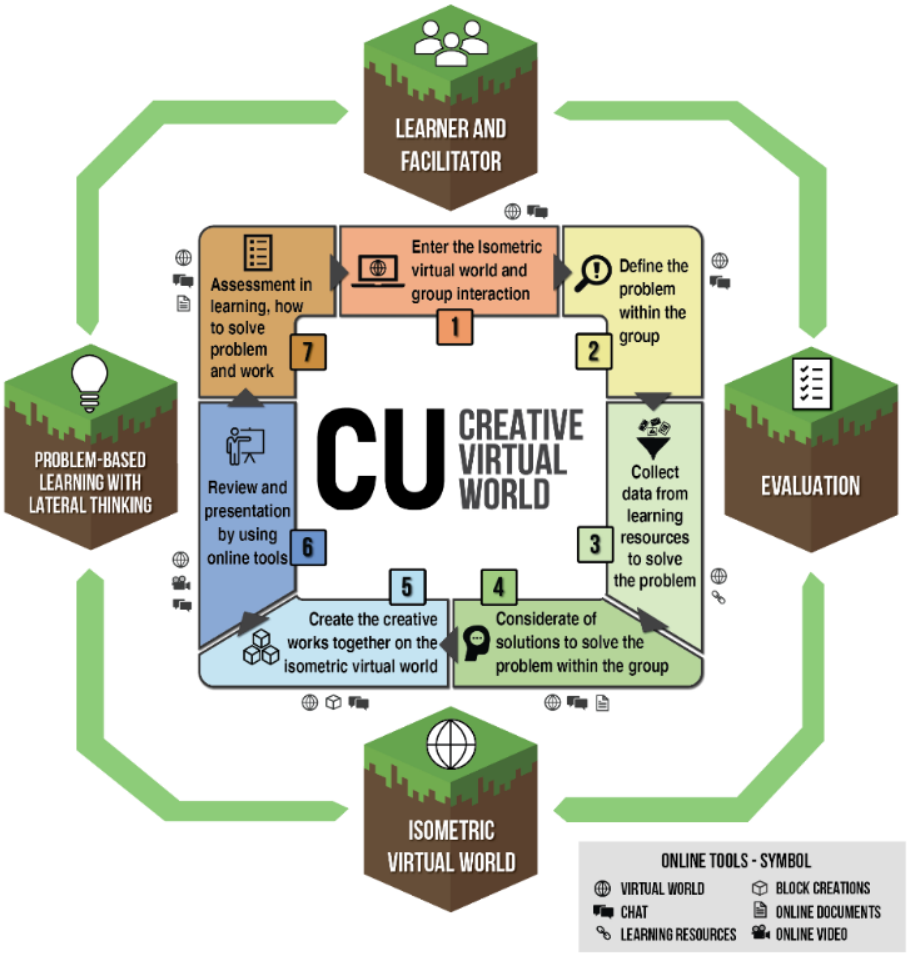


Figure 1 Draft model of instructional model based on CU Creative Virtual World Model

After the researcher developed the instructional model using problem-based learning with lateral thinking on isometric virtual world to enhance the creative problem-

solving skill of the undergraduate students, the researcher made an instructional model based on the draft with 7 processes with isometric virtual tools and creative problem-solving evaluation form according to the model as follows

Week 1: Orientation and tutorial on the isometric virtual world for learners. An instructor shows and explains how the isometric virtual world works, such as controls, avatar commands, inventory, exploration and creating a workspace where the learners can try and build a simple house. Then, the learners are instructed on how to search for information using online data sources to get ready for the next activity.

Week 2: Learners are assigned in groups with 3-4 members for each group. The teacher will assign a problematic situation to the learners which is “Create an environmentally friendly building”. The learner is faced with a problem that the workspace is in a forest area where there are wildlife and faunas in the area. The building has to affect the area as little as possible while also being suited to the natural landscape. The learners need to analyze and understand the situation and the problem then search for information to generate options from online data sources, such as, how to build an environmentally friendly building. After verifying the credibility and value of the information. The learners exchange their findings within the group using the communication tools in the virtual world, then consider and select an appropriate solution from the virtual world. In the summarizing phase, learners will present their work and describe the ideas to others for discussion and comments. They finally summarize the outcome together.

Week 3: Proceed with the same group from week 2 with the new problem “Create a modernized Thai architectured building”. The learners are faced with the dilemma of Thai architecture and modern design considering its features and utility.

Week 4: Proceed with the same group from week 3 with the new problem “Create an underwater royal palace”. The learners are faced with the problem of building underwater which is a major challenge in the real world. The learners have to plan their

structures for underwater use, water regulation, and leak holes while maintaining the royalty and luxury of a palace.

Week 5: Proceed with the same group from week 4 with the new problem “Creative bridge building”. The learners will be faced with the problem of creating a big, robust and geological appropriate bridge while also being practical.

Week 6: Proceed with the same group from week 5 with the new problem “Create a world-class amusement park”. The learners are faced with the problem of creating a unique, distinct and creative amusement park that never been seen before.

In each week, the learners will have to search for information individually then exchange their findings within the group. After the information is gathered, the group has to decide and create a solution. At this stage, lateral thinking plays a big role for the learners to come up with questions and answers for their solutions until they figure out an appropriate solution, for example, “If we do not cut down trees, can we build a house?” and the answer to that is building a single pole with a greater height than the trees as a foundation to build a house without affecting the forest below.

The examples and the from the instructional model are shown in figure 2:



Figure 2 Examples and results from the instructional model

To use the isometric virtual world for the instructional model, the teacher has to set up a server for the virtual world and the learners can connect to the server through the client to attend the activity. If the teachers or the academy do not have experiences in setting up a server, they can choose a free online isometric virtual world hosting service that offers full functionality and is easy to manage. An example of an isometric virtual world and a control panel for the teacher is shown in figure 3



Figure 3 Isometric virtual world and a control panel for the teacher

Conclusion and Discussion

During the research, we found that the components of the learning model used in the study can be classified into four elements 1) isometric virtual world, 2) problem-based learning with lateral thinking, 3) role of learner and facilitator, and 4) easurement and valuation.

The experts' opinion confirms that the number of components is appropriate to model when relying on CU Creative Virtual World Model which are 1) Enter the Isometric Virtual World and Group Interaction, 2) Define the Problem Within the Group, 3) Collect Data From Online Learning Resources to Solve the Problem, 4) Considerate of Solutions to Solve the Problem Within the Group, 5) Create the Creative Works Together on the Isometric Virtual World, 6) Review and Presentation by Using Online Tools, and 7) Assessment in Learning, How to Solve Problem and Work and suggest to adjust the name of each a process to be clear meaning.

From the literature review, it is found that creative problem-solving ability is a process that allows people to figure out a solution to everyday problems with new approaches, this requires knowledge, experiences, and creativity that lead to new, broad, logical and appropriate ways of solving problems. Not only the problems will be solved, but they are solved effectively. (Dianne, 2005; Malakul Na Ayutthaya, 1994; Phanmanee, 2014) Creative problem-solving skills should be encouraged to be provided to new Thai generations to prepare the country to be creative and innovative.

The enhancement of the creative problem-solving skill with problem-based learning with lateral thinking requires an environment and roles of the active learner in an open world sandbox that allows the learners to be collaborative in solving problems, have freedom of imagination and able to share their creative solutions with the others for discussions and comments. Lateral thinking makes learners be able to see a different, creative approach to the problem. The teachers play the role of providing the

environment, instructing and encouraging the learners the exchange their findings and ideas, leading to improvements in creativity and effective teamwork.

Using isometric virtual world for the problem-based with lateral thinking instructional model in the virtual world allows the learners to face with problems that they need to figure out a solution as a group by searching for information and exchange their findings to come out with an appropriate solution. This helps improving creative problem-solving skills (Al-Washmi et al., 2014; Hanghoj et al, 2014). The challenge is applying the isometric virtual world which is a new form of a virtual learning tool to the undergraduate students in Thailand to enhance their creative problem-solving ability.

Acknowledgment

This article is a part of a dissertation of the Doctor of Philosophy degree in Educational Technology and Communications Program, Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University. This research was supported by The 100th Anniversary Chulalongkorn University Fund for Doctoral Scholarship.

References

Aldrich, C. (2009). **Learning online with games, simulations, and virtual world: strategies for online instruction.** San Francisco: Jossey-Bass.

Al-Washmi, R., et al. (2014). Design of a math learning game using a minecraft mod. **Proceedings of The European Conference on Games Based Learning** (110-17). New York: Curran Associates.

Arthur, Cropley. J. (1996). Recognizing creative potential: An evaluation of the usefulness of creativity tests. **High Ability Studies, 7**(2), 203-219.

Besemer, S. P., & Treffinger, D. J. (1981). Analysis of creative products: Review and synthesis. **The Journal of Creative Behavior, 15**(3), 158-178.

Bishop, J. (2011). **Partnership for 21st century skills (P21)**. Retrieved from https://www.imls.gov/assets/1/AssetManager/Bishop%20Pre-Con%202.pdf.

Chanayotha, P. (2014). **Open educational resources development based on service learning approach to enhance public consciousness and creative problem solving for rajabhat university students.** Doctoral dissertation, Chulalongkorn University.

Cipollone, M., et al. (2014) Minecraft as a creative tool: A case study**. International Journal of Game-Based Learning, 4**(2), 1-14.

Cochran, W. G. (1977). **Sampling techniques** (3rd ed.). New York: John Wiley & Sons.

Dianne, D. (2005). **Primarily problem solving: Creative problem solving activities**. Texas: Prufrock.

De Bono, E. (1970). **Lateral thinking: creativity step by step**. Harper & Row.

Gomolkittisak, N. (2010). **An analysis of the effects of creative problem-solving process on creative problem solving ability, teamwork skills, and selfesteem of lower secondary school students: a time series experiment.** Master thesis, Chulalongkorn University.

Hanghøj, T., et al. (2014). Redesigning and reframing educational scenarios for minecraft within mother tongue education. **Proceedings of The European Conference on Games Based Learning** (182-190). New York: Curran Associates.

Kapp, Karl M. & O'Driscoll, T. (2010). **Learning in 3-D: Adding a new dimension to enterprise learning and collaboration.** San Francisco, CA: Pfeiffer.

Khammani, T. (2007). **Teaching science: Knowledge for effective learning process management.** (In Thai). Bangkok: Chulalongkorn University Press.

Malakul Na Ayutthaya, P. (1994). **Creativity: a talent that can be developed.** (In Thai). Bangkok: Faculty of Education, Chulalongkorn University.

Nonis, D. (2005). **3D Virtual learning environments (3D VLE).** Educational Technology Division, Ministry of Education, Singapore. Retrieved from http://iresearch.osprey.url3.net/iresearch/slot/u110/litreviews/3d_vle.pdf.

Phanmanee, A. (2014). **Practice the creative thinking.** (In Thai). Bangkok: Chulalongkorn University Press.

Short, D. (2012). Teaching scientific concepts using a virtual world--minecraft. **Teaching Science, 58**(3), 55-58.

Songkram, N. (2012). Effect of organizing active learning and hybrid learning on design of virtual field trip and to enhance creativity for undergraduate education students. (In Thai). **Journal of Education, Silpakorn University, 10**(2), 82-95.

Torrance, E. P. (1966). **Torrance tests of creative thinking—norms technical manual research edition—verbal tests, forms A and B—figural tests, forms A and B.** Princeton: Personnel Press.

Twining, P. (2010). **When educational worlds collide.** New York: Nova Science Publishing.

Wagner, T. (2008). Rigor Defined. **The journal of expecting excellence, 66**(2), 20-25.