Development of Gamification Learning Environment Model Using Design-Based Learning to Enhance Innovative Thinking of Undergraduate Students in Education

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Abstract: The objectives of this research were to 1) develop gamification learning environment model using design-based learning to enhance innovative thinking of undergraduate students in education; 2) study the trial results of the developed learning model; and 3) analyze the students' opinions on the developed model after learning. The samples were 30 undergraduate students at Nakhon Pathom Rajabhat University who enrolled the Educational Innovation Course in the second semester of the academic year 2021. The research instruments were an interview form of the experts, a website based on gamification learning, and lesson plans. The research instruments were an innovative thinking assessment form, work evaluation criteria, and an opinion questionnaire on the developed model. The arithmetic mean, standard deviation, and t-test were used for data analysis. The results of this research found that the model for gamification learning environment using design-based learning to enhance innovative thinking of undergraduate students in education consisted of six components, according to the development of learning model of Joyce, Weil and Calhoun (2009). There were 1) theory and principles, 2) objectives, 3) syntax, 4) social system, 5) principles of reaction gamification, and 6) support system. The process of design-based learning consists of seven steps: 1) learning innovation, 2) brainstorming and identifying problems, 3) challenging ideas and finding innovation, 4) summarizing innovation creation concept, 5) creating innovative work, 6) presenting work, and 7) evaluating work. Regarding the results of the model implementation, the students' innovative thinking ability after learning with the developed model was higher than before learning with the statistical significance level of .05. The students' opinion on the developed model was at the high level.

Introduction

According to the National Education Standards B.E. 2561 (2018) defined virtue, skills, and needed knowledge on the basis of shared values to the desired outcome frameworks of Education, which are the characteristics of the learners and learner's aptitudes. The self-development in order to have learner person characteristics to create job, good quality of life, have lifelong learning skills in order to catch up with the digital world and the future, have competency arising from knowledge skills. Having intellectual skills, 21st century skills, digital intelligence in order to co-create and develop technological and social innovations, and increase opportunity and value for oneself and society. Therefore, educational institute defined clearly framework and goals to producing and developing man power in varied field and curriculum which linked to nation competence ability and professional standard. Learning management in higher education level developed learning skills and professional competency, design skill, create research knowledge and develop innovation for the purpose of moving education quality in digital age.

Innovation is important to make a different in human success. Traditional methods or models don't last long. Therefore, the ability to innovate is very necessary. People who are unconventional and constantly create new approaches to solve problems are the ones who succeed in life (Maxwell 2009, 138-152). The key thinking skill that should be encouraged in humans today is the recognition of productivity differently from other people with a well-accepted expectation by society. After that thinkers will act until that idea is achieved with a new product. It is, therefore, essential to develop learners to have innovative thinking so they can innovate and develop innovation in their careers and succeed in the future (Bellanca,

2010: 52-94). In conclusion, learners need to develop innovative thinking skills. Accordingly, the 21st century learning framework has emphasized the importance of innovative thinking skills and identified them as one of the 21st century skills; learning and innovation skills, which learners should learn and co-create for successful innovative product. (Bellanca, 2010: 102-139).

One of the teaching approaches to enhance innovative thinking of learners in the digital age is gamification of learning environment. It enhances learners' motivation through an integrated process of game design, game mechanics, and game characteristics in different educational environments. Allowing learners use game dynamics to stimulate the develop innovative thinking. Gamification of learning environment does not only mean rewarding or medaling learners for completing the task, but also bringing other gamification attributes into the class. Both gamified external and internal factors are used. The external factors include grading, rewarding, and indicating the progress in learning; and internal factors include setting short- and long-term goals, creating a climate of fun in learning, creating challenges by increasing difficulty levels, and giving continuous feedback. By adopting the game mechanics, the teaching methodology changes from lectures to interactive activities with learner engagement (McGonigal, 2011; Pappas, 2013). The previous research has identified that modern-day learners have different backgrounds, compared to learners in the past, as a result of changes in media exposure behaviors. Modern learners have special technical skills, new concepts, and different ways of learning. For this reason, new teaching methods are needed to stimulate and attract learners' interest or digital engagement, which in turn creates learning motivation and the ability to create innovation. Later, design-based learning was initiatively used as proactive learning management. It is a form of learning aimed at engaging learners in the developing process, creating, and evaluating designed work. Design-based learning is a new learning approach. Work-oriented and design-oriented learning activities make learners proud of their learning achievement and also reassure them as thinkers, designers, and practitioners, which make benefit to their further education. (Koh, Chai, Wong, & Hong, 2015). To promote these learning activities, design-based learning approach should be applied. The process covers information acquisition, developing thinking, and creative design activities. There are consisted of eight main learning steps: 1) educating; 2) setting challenge goals; 3) exploring the design inspiration; 4) collecting data; 5) developing a draft; 6) designing a designed work; 7) displaying a completed work; and 8) evaluate a work piece (Doppelt, Mehalik, Schunn, & Krysinski, 2008). This process can greatly support the creation of innovative works.

Regarding the background and importance mentioned above, it shows the possibility of developing a model for gamification learning environment with design-based process, a way to encourage learners' innovative thinking capabilities. The focus of this study and research is on the designing issue and gamification learning environment to enhance innovative thinking for maximizing teaching effectiveness.

Research methodology

Development of gamification learning environment model using design-based learning to enhance innovative thinking of undergraduate students in education

Phase 1 Research (R1) Study and Analysis Basic Information (Analysis: A)

Objectives: 1) to study and analysis basic information and instructors' teaching style via innovative thinking, 2) To analysis learners' innovative thinking ability and

gamification learning, and 3) to interview with experts about gamification learning environment model using design-based learning to enhance innovative thinking.

Personal Resource: consist of 1) 9 Instructors and experts in educational innovative, curriculum and teaching, and gamification; 2) 300 undergraduate students in Nakhon Pathom Province.

The instrument to collect data: consist of 1) documents analysis form, 2) an expert's structured interview, and 3) an undergraduate students' opinion questionnaire.

Phase 2 Development (D1) Design and develop gamification learning environment model using design-based learning to enhance innovative thinking to enhance innovative thinking of undergraduate students in education (Design and development: D&D)

Objectives 1) to develop an appropriate gamification learning environment draft model using design-based learning to enhance innovative thinking to enhance innovative thinking of undergraduate students in education, 2) to develop the instruments for collecting data, and 3) to check quality and assure suitability of the learning model and the instruments.

Procedure

1. Study the conception of basic information analysis from phase 1 and set the framework of gamification learning environment model.

2. Develop learning draft model according to Joyce, Weil & Calhoun's developed learning model (2009). This learning model consists of 6 components: 1) theory and principles, 2) objectives, 3) syntax, 4) social system, 5) principles of reaction gamification, and 6) support system.

3. Develop and design the website of gamification learning environment model according to the ADDIE Instructional Design Model. It was used to support design-based learning activities. The researcher built a web prototype on Localhost before deploying the system to the web hosting. Web infrastructure was developed and improved with Adobe Muse CC. The website supports HTML5 and has responsive infrastructure to support working across multi devices. Additional gamification and ancillary modules are available on the website and the MySQL database is used for data collection. The developed website was divided into 4 modules: communication module, activities module, support module, and gamification module. The appropriateness of the website was examined by three experts in educational technology and communication. The results showed that design based learning model was appropriate at the highest level (M= 4.75, SD = 0.17). Subsequently, the website was improved according to the recommendations of the experts and tested with one-to-one representative sample and with small group of 6 samples.

4. Develop lesson plans for Educational Innovation Course using gamification and design-based learning. Lesson plans consisted of 7 steps: 1) learning innovation, 2) brainstorming and identifying problems, 3) challenging ideas and finding innovation, 4) summarizing innovation creation concept, 5) creating innovative work, 6) presenting work, and 7) evaluating work.

5. Develop 3 instruments to evaluate the learning model: evaluative work form, an innovative thinking assessment form and a students' opinion questionnaire on the developed model.

6. Check and assure suitability of the developed model and lesson plans by three experts. The experts recommended that the elements of learning draft model consisted of theory and principles, objectives, learning process, assessment and evaluation and supporting system. Thus, the developed model and lesson plans will be perfectly and suitably in use.

7. Check content validity and construct validity of the lesson plans, innovative thinking ability self-assessment form, and a students' opinion questionnaire by nine experts. The result showed that the lesson plans for Educational Innovation Course were appropriate at the highest level. ($M = 4.72$, $SD = 0.33$). The innovative thinking ability self-assessment form was appropriate at the highest level. ($\bar{x} = 4.52$, $SD = 0.48$). The students' opinion questionnaire was appropriate at the highest level. ($M = 4.66$, $SD = 0.45$) Therefore, the developed learning model, lesson plans, innovative thinking ability self-assessment form, and the students' opinion questionnaire had quality and can be used for collecting data.

The instruments to collect data consist of 1) gamification learning environment model, 2)10 weeks lesson plans, 3) innovative thinking ability self-assessment form, 4) a students' opinion questionnaire, and 5) website of gamification learning environment.

Phase 3   Research (R2) Trail of gamification learning environment model using design-based learning to enhance Innovative thinking of undergraduate students in education (Implementation: I)

Objective: to trail the developed gamification learning environment model using design-based learning to enhance Innovative thinking of undergraduate students in education.

Procedure

1. Population were 759 fourth-year students at faculty of education, Nakhon Pathom Rajabhat University who enrolled the Educational Innovation Course in the second semester of the academic year 2021. There were 29 classes.

2. Sample were 30 fourth- year students at faculty of education, Nakhon Pathom Rajabhat University who enrolled the Educational Innovation Course in the second semester of the academic year 2021.They were selected 1 class by using simple random sampling technique.

3. Trial the developed model, the objectives were to compare students' innovative thinking ability before and after learning the developed model.

4. The instruments and collecting data: the developed gamification learning environment model using design-based learning by the researcher, website of gamification, lesson plans, innovative thinking ability self-assessment form, and the students' opinion questionnaire

5. Trial the gamification learning environment model using design-based learning as follows:

5.1 Explain the procedure to the sample about learning objectives, learning activities, students' and instructor's rules, introduce how to use web gamification source of information, assess and evaluate criterion. To make sure that the students realized with innovative thinking ability self-assessment criteria.

5.2 Collecting data from the samples. Due to, the researcher was an instructor who taught the samples. The samples were 30 fourth-year undergraduate students who enrolled the Educational Innovation Course in the second semester of the academic year 2021. After that the researcher trialed and collected data for 10 weeks; 4 periods per week, total 40 periods, pre-test and post-test.

Phrase 4 Development (D2) Evaluation the effectiveness of gamification learning environment model using design-based learning to enhance Innovative thinking of undergraduate students in education (Evaluation: E)

Objectives: 1) To compare students' innovative thinking ability before and after using gamification learning environment model, 2) to study students' opinion with the gamification learning environment model.

Procedure

1. Evaluate the effectiveness of gamification learning environment, the researcher analyzed the scores in both quantitative and qualitative data as follows;

1.1 To compare students' innovative thinking ability before and after learning the developed gamification learning environment model using the dependent using t- test.

1.2 To study the students' opinion on the gamification learning environment model from analysis the comparison of the mean score with the set criterion.

2. To check and revise the results of using the gamification learning environment model; considering the appropriateness according to various components especially the procedure of learning in the 3rd step of the research, then was prepared as the gamification learning environment model.

Research results

1. The results of the development of gamification learning environment model using design-based learning to enhance innovative thinking of undergraduate students in education.

1.1 Regarding the study of basic information about gamification learning environment model with design-based learning to enhance innovative thinking of undergraduate students in education consists of six components according to Joyce, Weil & Calhoun (2009) learning model, consisted of 6 components: (1) Theory and principles, The applied learning between gamification learning environment and design-based learning promoted students' innovative thinking abilities to create educational innovation, (2) Objectives, to enhance students' innovative thinking ability, (3) Syntax, consisted of 7 steps; 1) learning innovation, 2) brainstorming and identifying problems, 3) challenging ideas and finding innovation, 4) summarizing innovation creation concept, 5) creating innovative work, 6) presenting work, and 7) evaluating work. (4) Social system, consisted of; 1) the role of instructor, a manager, promoted the students' innovative thinking skills in 8 steps. Managing every steps of gamification learning environment model during teaching, observed behavior, interviewed and took post-teaching notes, and 2) The role of students, learners, practiced every steps of activities by themselves, complied with rules and various conditions according to the tasks every week and practical activities. Set the working goals of tasks by themselves, co-operated to brainstorm, searched for ideas, collected data, designed draft, created works, presented work and evaluated work , teacher gave feedback every steps, improved work for completeness. (5) Principles of reaction gamification, managed gamification learning environment model, applied game mechanics, or game characteristics in teaching to stimulate and attract attention or participation of the students, such as assignments, leaderboards, fun, various rewards, competition, etc. (6)Support system consisted of 4 modules; communication module, activities module, support module, gamification module. This learning model was examined and recommended by nine experts. The components of the learning model were theory and principles, objectives,

learning process, measure and evaluation and supporting factors for applying the appropriately and completely learning model.

The result of developing gamification learning environment model using design-based learning to enhance innovative thinking of undergraduate students in education as follows:

Table 1 Comparison of mean score of students' innovative thinking abilities before and after learning with the developed model using the dependent t-test (full score 30 points) (n=30)

Innovative Thinking Ability	M	SD	$\bar{d}$	$SD_{\bar{d}}$	t
Before using the model	13.72	4.41	12.28	1.19	10.37*
After using the model	25.58	3.02			

* Statistical significance at the level of .05

Table 1 shows that students' innovative thinking ability before and after learning with the developed learning model is different. Students' score of innovative thinking ability after learning (M= 24.58, SD = 3.02) is higher than before learning (M= 13.72, SD = 4.41) using gamification learning environment with design-based learning to promote innovative thinking of undergraduate students in education with statistical significance at .05 level.

Table 2 The average of students' opinions on gamification learning environment model using design-based learning to enhance innovative thinking

Opinion	M	SD	Level of Appropriateness
1. Gamification design	4.77	0.67	High
2. Learning process	4.59	0.62	High
3. Benefits from the developed model	4.45	0.71	High
Average	4.54	0.60	High

Table 2 showed that overall, the average of students' opinions on gamification learning environment model using design-based learning to enhance innovative thinking was at a high level (M= 4.54). The aspects in the descending order were gamification design, learning process, and benefits from the developed model. From the opened-end recommendation of students found as follow:

"Learning via web gamification by instructor assigned tasks in each week is very interesting. First, the instructor gave knowledge and each concept to create innovation. Then students went website in time the mission was opened, and was excited what kind of problems will get each time, Let's practice, analysis, interpret the problem, and design work pieces every week. And excited about scores and rank. This teaching approach lead us the knowledge to analysis the problems and saw the innovation clearly."

(the sample's opinion)

"The instructor asked questions to encouraged ,challenged students thinking for finding various answers. Who has ever studied how to solve these innovative problems? In Thailand and foreign? What kind of innovation will you get if you bring out the strengths of innovation to solve each problem? Let's re-thinking, What kind of innovation model? What does it look like? Challenging and fun to find out. The instructor inspires students to search from abroad, don't stick down the traditional innovation."

(the sample's opinion)

Discussion

From the research results, there are interesting issues for discussion as follows:

1. The gamification learning environment model using design-based learning to enhance the innovative thinking ability of undergraduate students in education was examined by the experts. The results of the gamification learning environment model met quality. The structure and content validity verified and appropriated for teaching, due to the developed model was developed and followed the systematic approach. Analyzed basic information, policy and education standard in higher education level B.E.2561, analyzed approach, theory, relevant researches in developing learning model due to basis of concept theory and learning in accordance with Joyce & Weil (2009: 13), Khammanee (2017: 475) concluded that learning and teaching style was a systematic teaching model which supported by theory. There is also a study of learning and teaching conditions and students' opinions. As well as to analysis students innovative thinking abilities be guideline for design learning model as the process of creating and developing model need various data in basic data analysis steps which consistent the researcher's opinion with gamification learning environment model using design-based learning to enhance the innovative thinking ability of undergraduate students in education. The result found that the developed learning model was a systematic learning management. The contents linked to the sequence of the learning activities. The gamification environment supported, encouraged students to study, challenged research. The analysis thinking was used to solve problems, creative innovation thinking and collaborative learning lead students have freely thinking.

2. Regarding the implementation of gamification learning environment using Design-based learning model to enhance innovative thinking of undergraduate students in education, the results as follows:

2.1 The students' innovative thinking ability after learning was higher than before learning with statistical significance at .05 level. The result shown that gamification environment learning model using design-based learning enhance creative innovative thinking. It is due to the gamification learning environment enhancing learners' motivation through an integrated process of game design, game mechanics, and game characteristics in different educational environments allowing learners to use game dynamics as a stimulus to innovation development. The stimulation includes grading, rewarding, and indicating the progress in learning, setting short- and long-term goals, creating a fun climate of learning, creating challenges by increasing difficulty levels, and giving continuous feedback. By adopting the game mechanics, the teaching methodology changes from listening to lectures to interactive activities with learner engagement (McGonigal, 2011; Pappas, 2013). Simoes, Redondo, & Vilas (2013) said that game learning activities should give learners the opportunity to do activities repetitively until they reach their set goals. There should be alternative ways to succeed in which learners can make their own choices to complete the activity in their own way. The workload needs to be adjusted to skill levels. Good games should have a clear goal to encourage learners to believe that they are more likely to succeed. The level of difficulty should increase when the learner's skills increase. The adjustment of difficulty of the workload when the learner has a higher skill is necessary because when the learner is better, their expectations will also be higher. Additionally, Gardner, Marie Olson, Komarek (2012: 317) stated that design-based learning allows students to identify problems and needs for design, select problem-solving approaches, set alternative solutions, and create innovation prototypes. This is in accordance with Seitamma-Hakkarainen, Viilo, Hakkarainen (2011: 109-136) who said that design-based learning is a learning management approach

focusing on activities. It is a combination of formal and informal education. The two main concepts were knowledge searching and idea development dimension and work creation dimension. Examples of innovative works include prototypes, work pieces, and product models. The Australian National Training Authority (2001) identified that the innovative thinking skills of students should be developed in six aspects: ability to interpret contexts, ability to generate ideas, ability to collaborate with others, ability to reflect, ability to present, and ability to evaluate success. In conclusion, the developed learning model consisted of activities that lead to innovative thinking ability of undergraduate students in education.

2.2 Regarding the implementation of gamification learning environment using design-based learning model to enhance innovative thinking of undergraduate students in education, the results showed that students' innovative thinking ability after learning with the model was higher than before learning in all aspects. This is due to the model for gamification learning environment with designed-based learning enhances students' enthusiasm and challenges in learning through gamification website developed by the researcher. Moreover, students learn innovation creation according to design-based learning. This is in line with Wichai Wongyai & Marut Patphol (2019, pp. 6-7) who said that the instructor can improve learner's innovation creation by designing learning activities to challenge ideas and respond to nature, needs, and interests of learners. When they feel challenged and the topic is of their interest, students will make use of their own ideas as much as possible. Additionally, learners are encouraged to use artificial intelligence technology as a tool to innovate and create new ideas for public benefit. This is in line with Caton & Greenhill (2013). They studied the results of gamification under the framework of rewarding and punishing. Students learn collaboratively using project-based learning according to constructivist learning theory. In this research, gamification learning was tried out in the Game Production course. The results showed that rewarding and punishing help develop class attendance and when class attendance increase students' grading also increase. Furthermore, rewarding and punishing help improve team working competency

3. Regarding the students' opinions on the model for gamification learning environment with design-based learning to promote innovative thinking, it showed that the model was appropriate at a high level. This is in accordance with McGonigal (2011) and Pappas (2013). The research identified that modern-day learners have different backgrounds, compared to learners in the past, as a result of changes in media exposure behaviors. Modern learners have special technical skills, new concepts, and different ways of learning. Gamification learning environment helps stimulate and attract learners' interest or digital engagement, which in turn makes students feel fund and challenged, as well as creates learning motivation and ability to create innovation.

Conclusion

The gamification learning environment model using design-based learning to enhance the innovative thinking ability of undergraduate students in education were systematically developed and experimented with the sample group. The experimental result showed that the model can enhance innovative thinking ability for undergraduate students in education. Some effective conditions were supporting and mentoring by teachers, the gamification learning environment to learn with the online learning creating understanding, promoting, and creating innovation that successfully integrates the developed online learning lessons,

promoting the online learning implementation through all channels, and promote the creation of educational innovations for use in teaching management of students.

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