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The Use of Integrated 5Es of Inquiring-Based Learning and Gamification to Improve Grade 8 Student Science Learning Achievement

Pannarai Bantaokul

Faculty of Education, Maharasakham University

Mueang Maha Sarakham District, Maha Sarakham 44000, Thailand

Titiworada Polyiem (Corresponding author)

Faculty of Education, Maharasakham University

Mueang Maha Sarakham District, Maha Sarakham 44000, Thailand

E-mail: titiworada.p@msu.ac.th

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Abstract

The purposes of the study were to investigate the effectiveness of integrated 5Es of inquiring-based learning and gamification on grade 8 science learning achievement and to study students' attitudes toward science learning with the integration of the two principles. The participants were 40 eighth-grade students from a Thai public school. They were chosen using a cluster sampling technique with their section as the primary criterion for selection. The instruments were learning management designed using the integration of the 5Es of inquiry-based learning and gamification, a learning achievement test, and an attitude survey questionnaire. Data analysis employed both descriptive statistics (*e.g.*, percentage, mean score, standard deviation) and comparative statistics (*e.g.*, paired-samples t-test, and effectiveness index with the determining criterion of 80/80). The study's findings show that combining the learning activities of the 5Es of inquiry-based learning with the elements of gamification resulted in the development of participants' science learning achievement. Additionally, it offered an engaging and motivating learning experience which led to positive attitudes toward science learning.

Keywords: 5Es of inquiry-based learning, Gamification, Science education

1. Introduction

Sciences education roots itself in the fundamental of the education system around the globe. Students are expected to have scientific knowledge at a certain level before graduating from basic education. This is due to its importance in education as a fundamental subject and in life as the knowledge that helps people make reasonable decisions in daily routine. Moreover, science education could help learners to pursue decent careers in science and technology. According to Hasni and Potvin (2015), students who were interested in science and technology jobs are affected by the educational system. In daily life, scientific knowledge may aid in the selection of healthy objects, social decision-making, and the economy (Das et al., 2014). Therefore, it is not a surprise that the subject is included in core curriculums around the world.

However, instructing sciences would not be simple. First, despite the increasing importance of science and technology in all spheres of life in any society, many students appear to lose interest in them during their school years. This is particularly prevalent in highly developed societies. They appear to have developed mixed feelings about and perceptions of science and technology (Schreiner & Sjøberg, 2004). Moreover, it should be noted that to be a success in a science class, learners need supplementary skills to comprehend the concept of the subjects (Kaptan & Timurlenk, 2012). To illustrate, students who lack mathematical competence could be unable to comprehend the content of calculation-based physics and chemistry classes. Additionally, in context-based subjects such as biology, learners' lack of English proficiency and information-gathering abilities may prevent them from being exposed to knowledge outside the classroom. In addition, students also need inquiry learning characteristics in science class. It is critical to make learners learn skills that can help them engage in experience-based hypothesizing, genuine investigation, thoughtful discussion, and learning based on the application of one's findings (Reitinger et al., 2016). With these expectations, students could find themselves in a difficult situation in learning sciences.

As inquiry learning is an important characteristic in science education, employing an instructional method that could develop the learning behavior could be a solution to the problems. Students were encouraged to seek solutions to scientific questions and to build critical thinking abilities by using the 5E of the inquiring-based paradigm. The model combines cognitive psychology, constructivism, and STEM education. in establishing systematically inquiring behaviors on scientific concepts (Bybee & Landes, 1990). In this model, students gain benefits in developing potential learning behaviors in science education.

Additionally, learning motivation can also be noted as a problem in teaching science. Especially for young learners in junior high school who are not certain of their future careers, science is perceived as a difficult and tedious subject (Bozdoğan et al., 2018). In this case, using elements of games could be an alternative to improving attitudes toward science classes. At its most fundamental level, gamification can be defined as the incorporation of game elements into non-gaming contexts (Huber & Hilty, 2015). Considering the learning nature of new generation learners, using game elements in teaching science could bring about positive results in instruction.

Given the potential of the 5E of the inquiring-based learning model in developing beneficial learning characteristics in science classes and gamification in contributing class atmosphere that matches junior high learners, we made learning management by putting the two ideas together to help grade 8 students do better in science. The purposes of the study were to investigate the integration of 5Es of inquiring-based learning and gamification in improving grade 8 students' science learning achievement and to study students' attitudes toward science learning with the integration of the two principles.

2. Literature Review

2.1 5Es of Inquiring-Based Learning

Five stages of scientific learning comprised the 5E of inquiry-based learning. Throughout the processes of the instruction mode, students are encouraged to answer scientific questions and to improve their ability to think critically. In detail, the 5E's of the Inquiry-based Instructional Model were developed by Bybee and Landes (1990) using the integration of constructivist theory of learning, cognitive psychology, and STEM instruction. Students gain benefits from participatory learning in each session of the model. They are tasked with the responsibility of sharing ideas in meaningful learning discussions. Additionally, the potential of the method relies on how it allows students to take control of the learning process, meanwhile when needed, teachers intervene in the class to give advice. Therefore, scientific learning characteristics such as motivation, attention, endeavors, and self-directed can be expected (Reitinger et al., 2016). The detail of each stage of the model can be seen below.

Table 1. 5Es of inquiring-based learning

Stages	**Definition**	**Activities**
Engagement	Engaging in challenges and making a connection between the concept and their experiences	- Concept introduction - Asking leading questions - Sharing experiences - Direct instruction
Exploration	Searching for information on the concept learned in class	- Information searching - Doing experiment
Explanation	Summary of information searching or experiments	- Summarizing the results of the exploration process
Elaboration	Discussing the results with classmates and teachers	- Group or class discussion of the results of individual learning
Evaluation	-Evaluation of the expected outcomes	- Test - Bahavior observation

2.2 Gamification

The idea of using game-like elements to promote behaviors has been used in various kinds of human activities. In recent years, gamification, which is defined as the application of game mechanics, dynamics, and frameworks to encourage players to behave desirably, has made its way into a variety of fields such as marketing, politics, health, and fitness (Lee & Hammer, 2011). For example, customers can win rewards that can benefit when visiting real-world stores and "checking in" to the mobile phone application while using the service. This idea could be useful in education, especially for young learners who tend to prefer technology-based instructional methods (Blaschke, 2014). Gamification may be useful to drive them to learn more effectively and with a greater sense of urgency. According to Werbach and Hunter (2015), gamification consists of three elements of dynamics, mechanics, and components. To illustrate, the dynamics of the model are supported by the application of class content in the game-like learning environment. The mechanical element is related to activities that learners perform to gain rewards. Meanwhile, the components are game-like rewards such as Exp, badges, leaderboards, avatars, etc. According to Rincon-Flores et al. (2022), Gamification increases motivation on both an internal and extrinsic level. Offering prizes encourages extrinsic motivation, but overcoming a problem encourages intrinsic motivation. Additionally, It presents an opportunity to interact with rules, feelings, and obligations imposed by society. To explain, the features of gamification features utilize cognitive, emotional, and social components to develop learners' skills. A metacognitive process is initiated when the learner receives immediate feedback on many efforts. The emotional component occurs when a student is praised for their achievement, and the social component occurs when students work together to complete a goal or purpose.

2.3 Previous Studies

The benefits of the 5Es of inquiry-based learning and gamification in education interest scholars to employ the principles in research studies. With the utilization of the 5Es of inquiry-based learning, studies (*e.g.*, Abdi, 2014; Açışlı et al., 2011; Choowong & Worapun, 2021; Ong et al., 2018) found its potential in science education. For instance, in Açışlı et al. (2011) Turkish science students were found to gain benefits from learning with the 5Es of the inquiry-based instructional method as they could improve their learning achievement in movement and force issues. Ong et al. (2018) used the model to raise students' achievement in science in Malaysia. The inquiry-based learning has a positive effect on students' science achievement in the study. Choowong and Worapun (2021) demonstrated the efficacy of the model on students' learning behaviors as they could develop scientific reasoning skills after taking part in the study.

Gamification has also been included in science education, and studies (*e.g.*, da Rocha Seixas et al., 2016; Fleischmann & Ariel, 2016; Hursen & Bas, 2019) evidence of its positive effects on teaching science-related subjects. For example, Fleischmann and Ariel (2016) employed gamification in teaching the use of the microscope and found that students can use the equipment correctly and had positive attitudes toward the instructional method. da Rocha Seixas et al. (2016), and Hursen and Bas (2019) similarly found the students were motivated

in learning sciences with the application of game elements in class. Therefore, gamification has a beneficial effect on engagement, learning, and involvement.

The integration of the 5Es of inquiry-based learning and gamification could be seen in Maul (2016). The study utilized gamification and the 5E learning cycle (QuIVERS) with high school honors chemistry students. The results of the study indicate that the participants were confident and willing to learn the subjects as the instruction allowed them to make mistakes and learn from them. The results proved that positive effects of integrated learning instruction on student engagement, achievement, and motivation can be expected. It could be noted that the effects of integration of the 5Es of inquiry-based learning and gamification are underexplored. The current study seeks to elucidate the integration of the two principles in a science classroom, as stated in the study's objectives.

3. Methodology

3.1 Research Design

The study was conducted in a one-group experiment design. To design learning management activities, the integration of the 5Es of inquiry-based learning and gamification was assigned. The participants' learning achievement was assessed both during activities in the learning management and at the end of the process. Students' attitudes toward learning management were also assessed after using it.

3.2 Participants

The participants were 40 eighth-grade students from a Thai public school. They were chosen using a cluster sampling technique with their section as the primary criterion for selection. They enrolled in the General Science Course focusing on the concept of the world and changes. The participants took a semester (12 hours) learning with the learning management designed using the integration of the 5Es of inquiry-based learning and gamification. They were treated anonymously.

3.3 Instruments

The instruments were learning management designed using the integration of the 5Es of inquiry-based learning and gamification, a learning achievement test, and an attitude survey questionnaire. In detail, the learning achievement test consists of 30 multiple choice question items related to the class content. The validity (IOC = 0.6-1.0), difficulty (p = 0.43-0.90) ,discrimination (D = 0.20-0.63), and reliability (α = 0.88) of the test were at an acceptable level. The questionnaire consists of 10 positive statements related to learning science after using learning management. The statement validity (IOC = 0.8-1.0) and the questionnaire reliability (α = 0.59) were at a statistically acceptable level.

The learning management was designed to have integrated characteristics of the 5Es of inquiry-based learning and gamification. Game elements of questing, exp grinding, rewarding, and class promoting were used in the 5 processes of inquiring-based learning. It consists of 8 learning plans of 12 hours. The main content is related to the concept of the world and changes. The detail of each process of teaching could be seen below. In detail,

students can score exp points by answering questions, sharing opinions in the discussion, submitting class assignments, participating in the class, etc. Any mistakes such as joining the class late, being passive, and making mistakes in the class assignment would reduce their exp points. The exp points can be used to promote their gaming classes. The higher class students gain rewards or special abilities in class. The detail could be seen below.

Table 2. Gamification point system

Exp Points	**Conditions**
5 exps	- Coming to class (but not on time)
10 exps	- Coming to class on time - Answering relevant questions - Submitting assignments on time but making 4-5 mistakes - Submitting assignments late but making 1-2 mistakes
20 exps	- Submitting assignments on time but making 1-2 mistakes - Submitting assignments late but making no mistake
30 exps	- Submitting assignments on time and making no mistakes.

Table 3. Gaming class classification

Classes	**Required Exp**
King	100 Exp
Lord	890 Exp
Knight	780 Exp
Officer	670 Exp
Sheriff	560 Exp
District head	450 Exp
Village head	340 Exp
Merchant	220 Exp
Famer	100 Exp

3.4 Data Analysis

Data analysis employed both descriptive statistics (*e.g.*, percentage, mean score, standard deviation) and comparative statistics (*e.g.*, paired-samples t-test, and effectiveness index with

the determining criterion of 80/80).

4. Results

The first purpose was to assess the effect of the integration of the 5Es of inquiry-based learning and gamification on Thai grade 8 students' science learning achievement. The study's findings are discussed below.

Table 4. Process effectiveness of the learning management on the participants' science learning achievement

Effectiveness	Full mark	$\bar{x}$	S.D.	Percentage
Process effectiveness (E_1)	100	87.51	2.82	87.51
Outcome effectiveness (E_2)	30	26.73	1.40	89.08
The effectiveness index (E_1/E_2) = 87.51/89.08				

The result of the study indicates that participants' average score in exercises during the processes of the learning management was 87.51 out of 100 full marks (E_1 = 87.51) while the average score of the students after using the learning management was 26.73 out of 30 full marks (E_2 = 75.55). Therefore, the effectiveness index of the learning management was 87.51/89.08 meeting the determining criterion of 80/80. In theory, students who participate in learning management designed using the integration of the 5Es of inquiry-based learning and gamification can improve their learning achievement both during and after class.

Table 5. The comparison of students' learning achievement before and after the treatment

Learning achievement	N	$\bar{x}$	**S.D.**	%	df	t	Sig.
Pretest	40	13.98	**2.35**	46.10	39	28.09	0.000*
Postest	40	26.73	1.40	89.08			

Note. $P < .05$.

The study's findings indicate that participants' science learning achievement improved after they learned with the learning management designed integration of the 5Es of inquiry-based learning and gamification. A paired samples t-test indicates that the participants learning achievement after using the learning management ($\bar{x}$ = 26.73, S.D. = 1.40) was significantly higher than their learning achievement before the treatment ($\bar{x}$ = 13.98, S.D. = 2.35), t = 28.09, p = 0.00. Therefore, it could be summarized that the learning management was effective in improving students' learning achievement in a science class.

Furthermore, the study tries to determine whether or not the participants are satisfied with the learning management. The findings of the study are presented in the following section.

Table 6. Students' attitudes toward the learning management

No.	Statement	$\bar{x}$	S.D.
	Positive attitude toward science learning		
1	I feel that science is a learnable subject.	4.88	0.40
2	I feel that science makes me understand living creatures and the processes of living creatures.	4.55	0.75
3	I feel that science is useful in daily life.	4.55	0.50
4	I feel that science is comprehensible.	4.53	0.55
5	I enjoy developing scientific knowledge.	4.20	0.76
6	I am eager to learn science.	4.58	0.71
7	I prefer science to other subjects.	4.43	0.75
8	I enjoy scientific activities.	4.65	0.58
9	I feel enjoy when search scientific knowledge.	4.68	0.53
10	I finish the science assignment myself.	4.58	0.59
	Overall	**4.56**	**0.61**

It can be seen that the participants' overall attitude toward learning mathematics after using the learning management was at a very high level ($\bar{x}$ = 4.56, S.D. = 0.61). In brief, after learning with learning management, the students perceive science as a learnable, useful, enjoyable, and comprehensible subject. They also reported that they enjoyed doing learning activities in science classes since they helped the participants to understand the nature of things and be comfortable in doing daily activities. Therefore, it could be interpreted that the integration of the 5Es of inquiry-based learning and gamification resulted in positive attitudes toward science.

5. Discussion

5.1 The Benefit of the Integration of the 5Es of Inquiry-Based Learning and Gamification in Science Education

The finding indicates that the integration of the 5Es of inquiry-based learning and gamification was beneficial in improving grade 8 students' science learning achievement in the concept of the world and changes. The finding is consistent with the previous works (*e.g.*, Abdi, 2014; Açışlı et al., 2011; Choowong & Worapun, 2021; Ong et al., 2018) that also

found the benefits of 5Es of inquiry-based learning in science education. It could be noted that the students gain benefits from the 5 processes of engaging, exploring, explaining, elaborating, and evaluating in the model. They were encouraged to connect the prior knowledge to the class concept using scientific elements such as experiments and information analysis. Gamification also makes it more preferable and challenging in participating in-class activities. Therefore, further research is needed to investigate how the integration of the 5Es of inquiry-based learning and gamification may be applied in the science education research area. Scholars could investigate its effects on both teaching science concepts and forming science learning behaviors such as scientific reasoning, inquiry characteristics, etc. Furthermore, qualitative approaches are encouraged because they allow for an examination of how learners progress through the learning activities.

5.2 Participants' Attitudes Toward the Learning Management

It seems that gamification played an important role in generating students' eagerness in learning science. Taking that gamification is derived from the idea to use computer game systems in designing a classroom environment, the result of the study is consistent with Blaschke (2014) who claimed that to succeed academically and professionally, millennial students prefer and have high expectations of learning environments and approaches that use digital technology such as social media and games. It also confirms the benefits of gamification in contributing to a motivating and engaging class atmosphere (Hursen & Bas, 2019). Therefore, the results support Mual (2016) as it also indicates the benefit of the integration of the 5Es of inquiry-based learning and gamification in science education.

6. Conclusion

The study's findings show that combining the learning activities of the 5Es of inquiry-based learning with the elements of gamification resulted in the development of science learning achievement in grade 8 students. Additionally, it offered an engaging and motivating learning experience which led to positive attitudes toward science learning. The findings could have educational implications, as science teachers may incorporate the 5Es of inquiry-based learning and gamification into their classes to help students improve their learning achievement. It should be noted that gamification is hardly considered to have a direct impact on students' learning. Therefore, it should be integrated into other instructional model utilization.

For the limitations of implementing the method in a dancing class, it should be noted that gamification should be employed in classes with learners who are familiar with games. Otherwise, the new system of scoring might be confusing rather than preferable. Likewise, teachers should have experience with games. The ideas of gaming exp, levels, classes, occupations, abilities, etc. should be learned before designing learning activities with gamification.

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