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Developing Inquiry Learning Characteristics of Grade 7 Students Using Integrated 5E's of Inquiry-Based Learning and Game-Based Learning

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Abstract

Inquiring learning characteristics are desirable learning behaviors that could lead to achievement in science education. The purpose of the study was to investigate the effectiveness of integrated 5E's of inquiring-based learning and game-based learning management on grade 7 students inquiring learning characteristics. The study was conducted in an action research approach consisting of two learning circles of planning, acting, evaluating, and reflecting. The participants were 8 7-grade students in Anukulnaree School, Thailand using the purposive sampling method. The participants were selected considering their lack of inquiry learning characteristics in class. The instruments were 1) integrated 5E's of inquiry-based learning and game-based learning management, 2) An inquiring characteristic observation form, 3) an interview form for inquiring characteristics. The data were analyzed by mean score, standard deviation, and effectiveness index with the criterion of 70. The result of the study indicated that at the end of learning circle 2, the effectiveness of integrated 5E's of inquiring-based learning and game-based learning management on grade 7 students inquiring learning characteristics was at 75/76.36 reaching the criterion set in the study. It could be interpreted that the integration 5E's of inquiry-based learning and game-based learning as a principle in designing learning management is beneficial in establishing inquiring characteristics in grade 7 students in learning science.

Keywords: 5E's of inquiry-based learning, Game-based learning, Inquiry learning characteristics, Science education

1. Introduction

Science is included as a fundamental course for students around the globe. The subject implants systematic thinking and allows learners to solve problems in both school and life using a reliable method involving data, experiments, and facts. To illustrate, in education, learners need scientific knowledge to progress in paths since the subject explains the mechanics and rationale behind the day-to-day operation of complex systems ranging from the human body to advanced modern modes of transportation. Learners can use the knowledge to comprehend new concepts that would allow them to make appropriate decisions and seek new interests (Centre for Education in Science & Technology, 2022). In life, scientific knowledge could be beneficial in selecting healthy objects, making social decisions, and the economy (Das, Amrita, & Singh, 2014). Moreover, it could not be denied that advances in science and technology account for the development of a nation. Therefore, the subject becomes prioritized in curriculums of educational institutions at all levels across the globe (Holbrook, 2010).

In learning science, students need a characteristic that allows them to access authentic exploration, critical discourse, experience-based hypothesizing, and conclusion-based transfer. At this point, inquiry learning characteristics take an important role in science learning. Reitinger, Haberfellner, Brewster, and Kramer (2016) suggested criteria for inquiry learning inventory. According to the authors, learning activities should encourage learners to discover open questions, share ideas, and present solutions. Moreover, the activities should be conducted in a motivating, meaningful, and joyful environment that drives learners to regulate themselves finding new knowledge with attention and effort. Therefore, it could be interpreted that learners with inquiry learning characteristics present motivation, attention, effort, and self-regulation in learning.

However, inquiring learning characteristics are not simply established especially in low motivated classes of science. According to Ogunkola and Samuel (2011), science is perceived as one of the most difficult subjects in school since students are demanded to deal with both calculation and context comprehension. Moreover, Kaptan and Timurlenk (2012) indicated that students' motivation and self-regulation are challenges found in science classrooms. According to the authors, students and science classes face difficulties as they also have problems in fundamental subjects like mathematics and English. In calculation-based classes of physics and chemistry, students who lack mathematic competence would find it impossible to comprehend the class content. Moreover, in the context-based subject of biology, incompetency of English and information searching skills could block learners from exposure to the knowledge outside the classroom. In the context area of the current study, Thailand has also faced difficulty in developing inquiring learning characteristics. Chaeyjaroen, Kongtong, and Klongphahon (2015) pointed out that Thai students still lack inquiry learning characteristics and alternative methods should be assigned in practical classes to develop the characteristics. This is also confirmed by the Thai students' PISA score that has not reached

the OECD standard since 2000 (The Institute for the Promotion of Teaching Science and Technology, 2020). Consequently, solving problems in promoting inquiring learning could be a solution in teaching science for Thai students.

Inquiring-based learning has emerged as a method in teaching science. The method aims at both developing students' learning behaviors and learning achievement. Bybee (2009) suggested that five stages of learning management including engagement, exploration, explanation, elaboration, and evaluation could be beneficial for teaching science and establishing desirable learning behaviors in learning the subjects. Uno (1999) suggested that inquiring-based learning focuses on encouraging students to self-discovery and construct the body of knowledge throughout the scientific processes. In addition, L. B. Duran and E. Duran (2004) indicated that shifting from ordinary class to inquiring-based learning would empower students as a center of the learning environment. At this point, they could practice autonomy of their learning and reduce teacher dependency. It could be seen that Inquiring-based learning could be a potential method in developing learners' inquiring learning behaviors.

In addition to empowering students in learning through scientific processes in Inquiring-based learning, the processes of learning could be improved to be more preferable using game-based learning (GBL). Fu et al. (2006, 2009) indicated that GBL could be defined as an instructional method that encourages teachers to attract the students' attention using types of games. This is to let learners learn and acquire the expected skills in an authentic situation. Game-based learning has been discussed to be an alternative instructing method in the 21st century where learners are attracted to mobile devices and games. Especially, students in the early teenager life, using game-based learning as an integrating principle in teaching science could be an interesting idea.

In brief, inquiring learning characteristics are desirable behaviors in learning science. At a contextual level, students in Thailand are reported to lack characteristics, and it results in problems in science education in the country. The current study integrated inquiring-based learning and game-based learning to develop learning management to develop inquiring learning characteristics of grade 7 students. The sole purpose of the study was to investigate the effectiveness of integrated 5E's of inquiring-based learning and game-based learning management on grade 7 students inquiring learning characteristics.

2. Literature Review

2.1 Inquiring Learning Characteristics

Behaviors in learning could greatly affect the outcome of education. Apart from teaching quality, learners' strategies, characteristics, and styles of learning play an important role in deciding the success of an education setting. In science education, learners are expected to learn systematically along with scientific processes. Therefore, it is important to develop the students to access authentic exploration, critical discourse, experience-based hypothesizing, and conclusion-based transfer (Reitinger et al., 2016). To contribute to such learning components, class activities should be open, motivating, joyful, and meaningful. To simplify, learners should be encouraged to start discussions, ask questions, share ideas, and give and

receive comments. Moreover, learners should realize the purposes of each class and be instructed in a preferable environment. To achieve these goals, students should have the following characteristics in learning.

2.1.1 Motivation

Hoffman (2016) defined motivation in learning as a positive attitude in learning. Learners with motivation would eager to perform tasks and exercises. They also search further for information related to the subject matter. Motivation influences how learners manage their time and energy in doing given tasks, perceive tasks and put effort to complete tasks.

2.1.2 Attention

According to Estes (1976), attention in learning refers to the ability to concentrate on instruction. Students who pay attention in class do not distract peers and teacher instruction. They cooperate with learning activities and intent to put the best performance in tasks. The characteristic is important for inquiry learning which allows learners to take control of their learning.

2.1.3 Learning Endeavor

De Houwer and Hughes (2020), suggested that failure in learning is inevitable, and learners have to overcome the hardship to achieve their learning goal. Students with learning endeavors could cope with the problems in learning. They understand the failure and are ready to put effort to fix learning mistakes. The characteristic is important for science education where experiments are unpredictable and endeavor is needed.

2.1.4 Independent Learning

Independent learning has been discussed in the new era of educational management. To empower students and shift the role of teachers in class, learners need to be able to take responsibility in learning. Livingston (2012) defined independent learning as a state in which learners take control of their learning. They can set goals, choose the direction of learning, and monitor their progress of learning. Information searching and self-study are needed to achieve the goal of independent learning. This characteristic is desirable in most modern instructional approaches where student-center is emphasized.

2.2 5E's of Inquiry-Based Learning

It could be seen that inquiring learning characteristics are complicated and not simply established. In this case, the 5E's of inquiry-based learning could be employed to help learners adapt to a new learning environment and develop inquiring learning characteristics. In detail, the 5E of inquiry-based learning consisted of 5 stages of scientific learning. Each stage encourages learners to seek answers to scientific issues and develop critical thinking skills. According to Bybee and Landes (1990), the 5E's of Inquiry-Based Instructional Model is developed from cognitive psychology, constructivist theory in learning, and STEM instruction. Five stages of the model include Engagement, Exploration, Explanation, Elaboration, and Evaluation. The details of each stage are discussed below.

2.2.1 Engagement

In this stage, teachers lead the class by raising questions regarding prior knowledge. Instructional resources such as pictures, video clips, demonstrations, and kinetic activities could be used to encourage learners to share ideas and knowledge about subject matters.

2.2.2 Exploration

In this stage, students could be assigned to perform hands-on activities. They are encouraged to use prior knowledge to inquire, generate new ideas, and conduct a preliminary investigation of the phenomenon. At this point, prior knowledge is challenged, and a new idea is created.

2.2.3 Explanation

In this stage, students could be asked to present their understanding of the phenomenon. Teachers' feedback could be presented here as the correction of students' misconceptions. Formal definitions, notes, and labels can be explained in this stage.

2.2.4 Elaboration

In the elaboration stage, learners are encouraged to use new knowledge while reinforcing new skills. Experiments, product development, information sharing, and integration of other disciplines could be assigned in this stage to let learners elaborate their new understanding of the concepts.

2.2.5 Evaluation

In this stage, students' learning achievements are evaluated. Students are allowed to test the hypothesis of the concepts while teachers would have opportunities to evaluate student progress issued in learning objectives. Both formative and summative assessments could be employed in this stage. The assessment could vary from portfolios, performance-based assessment, concept maps, physical models, to journal logs.

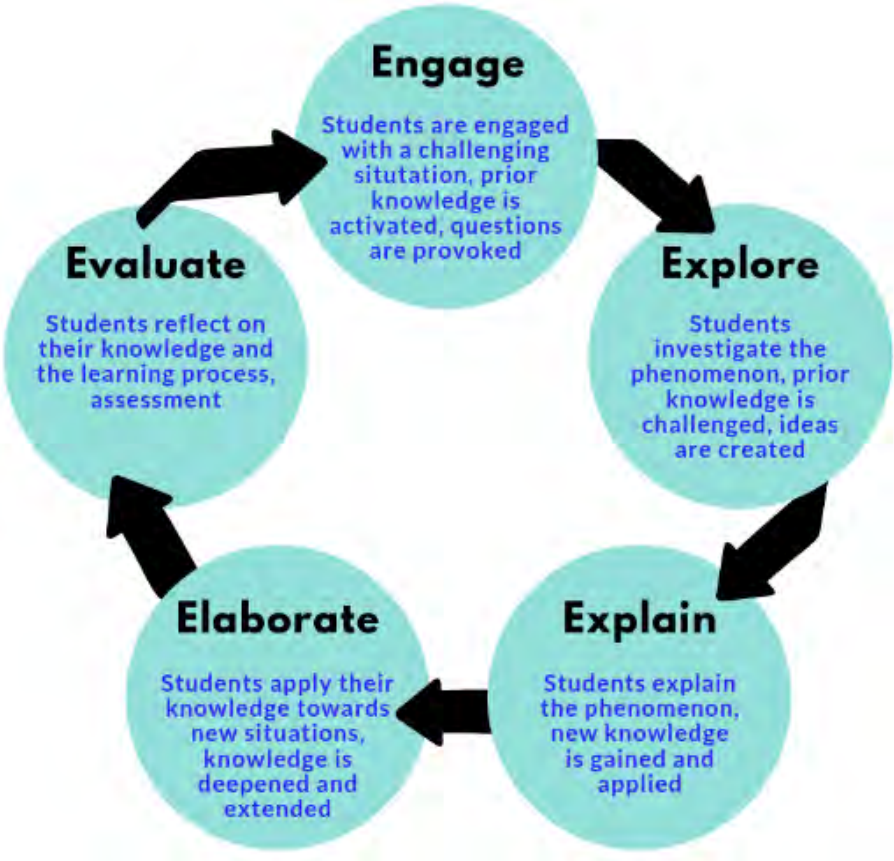

Figure 1. 5E's of inquiry-based learning (Northern, 2019)

It could be noted that the 5E's of inquiry-based learning is a potential instructional method in developing students' inquiry learning characteristics. In this model, learners take part in every stage of instruction. They are asked to share ideas and receive feedback. Moreover, it could be noted that the student is the side that controls learning processes while teachers only give advice when necessary. Therefore, students learning in the model could develop characteristics of motivation, attention, learning endeavors, and independent learning.

2.3 Game-Based Learning

In addition, it should be ignored that the use of instructional methods could be adapted to match the nature of learners. For learners born in the millennium, class activities should be designed to be joyful with the integration of technology and multimedia (Pinder-Grover & Groscurth, 2009). Game-based learning (GBL) is derived from such an idea. The method could be solely used to develop learners' skills or integrated into other disciplines to improve the method. According to Fu et al. (2006, 2009), GBL could be defined as an instructional method that encourages teachers to attract the students' attention using types of games. Games could vary from non-technology-based such as flashcards, board games, or crosswords to technology-based using consoles, computers, and network technology in the operation. Kirstavridou et al. (2020) suggested that the benefits of game-based learning rely on how games are utilized to help learners define learning objectives, ensure objective

practice, provide input, and keep up a record of social changes. Game-based learning was integrated into the 5E's of inquiry-based learning in this study since it could match the nature of learners of grade 7 students.

2.4 Previous Studies

The principles of inquiry-based learning and game-based learning are beneficial for learning in science education. Scholars in the area have also paid attention to the uses of both instructional models to develop students' in scientific classes (*e.g.*, Anderson & Barnett, 2011; Choowong & Worapun, 2021; Duran, 2003; Gillies & Rafter, 2020; Kennedy-Clark, Galstaun, & Anderson, 2011; Li, 2010; Ong et al., 2018; Nilsson & Jakobsson, 2011). In detail, the uses of 5E's of inquiry-based learning could be found across scientific dispensaries (*e.g.*, Choowong & Worapun, 2021; Duran, 2003; Gillies & Rafter, 2020; Ong et al., 2018). For example, Duran (2003) introduced the 5E's instructional model on the instruction of the brine shrimp topics in a school in the USA. The instruction started by introducing mysterious objects (brine shrimp eggs) and ended with a long-term evaluation of students' knowledge. The study indicates the benefits of 5E of inquiry-based learning on students' scientific learning. In Asia, Ong et al. (2018) employed the model in developing students' science achievement in Malaysia. The quasi-experimental study on 80 students indicates the benefits of the 5E of inquiring-based learning on students' science achievement. In Thailand, Choowong and Worapun (2021) found the effectiveness of the 5E of inquiry-based learning on students' scientific reasoning ability. Moreover, the instructional model also led to students' learning achievement in the study.

In addition, the use of game-based learning in science education could also be found in various circumstances (*e.g.*, Anderson & Barnett, 2011; Kennedy-Clark, Galstaun, & Anderson, 2011; Li, 2010; Nilsson & Jakobsson, 2011). For instance, Nilsson & Jakobsson (2011) used Sim City, a simulation game for managing metropolitan areas, in teaching environmental education for high school students. Li (2010) integrated the game entitled Scratch in instructing physics for an elementary school. Both studies found the benefits of games in students' learning.

The integration of inquiry-based learning and game-based learning was found in Kennedy-Clark, Galstaun, and Anderson (2011). The study employed game-based learning into inquiry-based learning in a workshop for teachers in Australia. It was found that the teachers participating in the program show a positive attitude toward the integrated instructional model. It could be noted that the study was only on a qualitative design, and there is still a need for the investigation of the integrated model in action. The current study employed the integration of inquiry-based learning and game-based learning to develop students' inquiry learning characteristics. The research question was—To what extent does the integrated 5E's of inquiry-based learning and game-based learning develop 7-grade students inquiry learning characteristics?

3. Methodology

The study was conducted in an action research approach (Kemmis & Mctaggart, 1992). It

was designed to be in two learning circles of planning, acting, observing, and reflecting. The processes of data collection could be seen below.

Figure 2. Processes of action research

3.1 Participants

The participants were 8 7-grade students in Anukulnaree School, Thailand. The participants were selected using the purposive sampling method. The participants were selected considering their lack of inquiry learning characteristics due to a preliminary study. All participants were treated anonymously.

3.2 Instruments

The instruments were 1) integrated 5E's of inquiry-based learning and game-based learning management, 2) An inquiring characteristic observation form, 3) an interview form for inquiring characteristics. The learning management consists of 8 learning plans on the concept of heat energy using 12 hours of instruction. In detail, lesson plans include, 1) expansion and contraction of matter, 2) the benefits of expansion and contraction of matter, 3) heat balance, 4) heat conduction, 5) the benefits of heat conduction, 6) convection, 7) thermal radiation, and 8) heat transfer in daily life. The 1-4 lesson plans were employed in learning circle 1, and the 5-8 lesson plans were employed in learning circle 2. The learning management was evaluated by experts and the appropriateness was at a very high level ($\bar{x}$ = 4.62-4.66). The inquiring characteristic observation was designed in a rating scale having 4 aspects of motivation, attention, learning endeavors, and independent learning. The IOC of the rating scale item was at 0.60-1.0. The interview form for inquiring about characteristics was in a semi-structured design. The IOC of the questions was at 0.6-1.0.

3.3 Data Analysis

The data were analyzed using mean score, standard deviation, and effectiveness test with the criteria of 70. The qualitative data were analyzed using narrative analysis.

4. Results

The main purpose of the current study was to investigate the effectiveness of integrated

inquiring-based learning and game-based learning management on grade 7 students inquiring learning characteristics. In the current study, the effectiveness of the integrated instructional model was tested by the learning circles discussed below.

4.1 Learning Circle 1

Table 1. Student inquiry learning characteristics after learning in learning circle 1

n	No. of students who passed the criteria		No. of students who did not pass the criteria		Inquiry learning characteristics	
	n	%	n	%	$\bar{x}$	%
8	4	50	4	50	12.28	68.26

In learning circle 1, lesson plans 1-4 namely 1) expansion and contraction of matter, 2) the benefits of expansion and contraction of matter, 3) heat balance, and 4) heat conduction were employed. The data gained from the inquiry learning characteristics indicate that 4 out of 8 students (50%) were found to pass the criteria of 70. Moreover, the average inquiry learning characteristic observed from the students was 12.28 (68.26%). It could be noted that in learning circle 1, the inquiry learning characteristics were not established up to the criteria. The result from the interview could be considered to discuss the results of the study.

In terms of motivation, students cooperated to perform class activities. When asked what should be done in the activities. Most of the students answered, “We should not talk to friends”. In terms of attention, it was found that students paid attention to do tasks. However, they tend not to recheck their works before submitting them. Most students replied “Finish the job as soon as possible” in the interview. In terms of learning endeavors, it was found that students tried to finish their assignments by themselves. If there were obstacles, they either asked friends or consulted teachers. Most students replied, “Finish the job by myself. Sometimes, I asked friends and teachers”. Lastly, in terms of independent learning, students tried to read activities instruction. However, they did not search for useful information before the class. Sometimes, they search for information in the textbook and learning media. Most students replied, “Let’s start doing it” in the interview. The data were used in improving class activities in learning circle 2. The detail of evaluation and improvement could be seen below.

Table 2. Problems and possible solutions in learning circle 1

Problems	**Solutions**
1. Time constraint	Activity time should be adjusted to match the class time. Learning objectives were still prioritized.
2. Grouping	Grouping should be balanced. There should be spaces between groups to let each group member focus on their activities. Teachers had to try maintaining a learning atmosphere.
3. Incomprehension of learning material procedure	Teachers should try to explain tool instruction in detail. Close observation was recommended. Intervention and feedback should be done immediately when students did mistakes.

4.2 Learning Circle 2

Table 3. Student inquiry learning characteristics after learning in learning circle 3

n	No. of students who passed the criteria		No. of students who did not pass the criteria		Inquiry learning characteristics	
	n	%	n	%	$\bar{x}$	%
8	6	75	2	25	13.78	76.63

In learning circle 2, lesson plans 5-8 namely 5) the benefits of heat conduction, 6) convection, 7) thermal radiation, and 8) heat transfer in daily life were employed. Class activities were adjusted along with the data gained in learning circle 1. The data gained from the inquiry learning characteristics indicate that 6 out of 8 students (75%) were found to pass the criteria of 70. Moreover, the average inquiry learning characteristic observed from the students was 13.78 (76.63%). It could be noted that in learning circle 2, the inquiry learning characteristics were established reaching the criteria of 70. The result from the interview could be considered to discuss the results of the study.

In terms of motivation, students were encouraged to answer and ask questions. They were motivated to join class activities, and most students answered, “I am eager to listen to what the teachers say in class” in the interview. In terms of attention, students attended class activities. They revised before submitting class works. However, loss of attention and talking could still be spotted sometimes, but they did not interrupt the processes of the class. The students answered. “I recheck before submitting my works. In terms of learning endeavors, students tried to put the best effort into tasks. They could finish the work themselves with friend assistance sometimes. Students replied, “I try to finish my work myself first and consult my friends sometimes”. In terms of independent learning, when students did not

understand activities instruction, they search for information in books and learning material. They also consulted teachers and friends. They replied, “I check for more information in textbooks and other sources” in the interview.

5. Discussion

All in all, the results of the study indicate the improvement of students’ inquiry learning characteristics after learning in the integrated 5E’s of inquiry-based learning and game-based learning management. In learning circle 2, 75% of the participants showed inquiry learning characteristics, and the average score of the students was 76.63%. These numbers reach the criteria of 70% set in this study. The results of the study join previous studies indicating the benefits of 5E inquiring-based learning and game-based learning (*e.g.*, Anderson & Barnett, 2011; Choowong & Worapun, 2021; Duran, 2003; Gillies & Rafter, 2020; Kennedy-Clark, Galstaun, & Anderson, 2011; Li, 2010; Ong et al., 2018; Nilsson & Jakobsson, 2011; Worapun, 2021). In this study, students were allowed to take control of their learning throughout the 5 stages of engagement, exploration, explanation, elaboration, and evaluation. In learning heat energy, students were engaged by the learning media. They were encouraged to present their understanding of the concepts. Teachers, then, explained the content and let the students tune their understanding of the concept. The game activities were assigned to let students elaborate their knowledge and teachers evaluated in the last stage of learning. These processes contributed to motivation, attention, learning endeavors, and independent learning characteristics in students learning.

Moreover, success in establishing the learning characters in student learning could be because of the processes of the action research approach. Kemmis and Mctaggart (1992) suggested that the advantage of using circles is the opportunity to review learning activities and improve the instructional processes. In this study, the activities were adjusted after learning circle 1, and it led to the expected outcomes in the end.

It could also be noted that learner empowerment in inquiry-based instruction led to the desired learning behaviors in the study. This could confirm the importance of learning behaviors that could lead to success in science education. According to Kaptan and Timurlenk (2012), learning behaviors are crucial problems in the science classroom. Therefore, fixing learning characteristics in class could result in learning achievement in science education.

6. Conclusion

In the end, it could be concluded from the results of the study that the integration 5E’s of inquiry-based learning and game-based learning as a principle in designing learning management is beneficial in establishing inquiring characteristics in grade 7 students in learning science. The result of the study could be implicated in science education as stakeholders in education should consider applying 5E’s of inquiring-based learning and game-based learning in science class to develop student inquiring learning characteristics. It should be noted that motivated learners with attention, learning endeavors, and learning independence would progress in science classes. Moreover, scholars who seek to investigate the effect of 5E’s of inquiry-based learning and game-based learning should note that the

integration of the two principles could bring about learning management that leads learners to learn systemically and joyfully.

Further studies should employ 5E's of inquiry-based learning, game-based learning, or the integration of the two principles in developing students' learning characteristics in other areas. Other learning strategies, characteristics, and behaviors could be the outcomes of the model. In addition, learning achievement could be developed using the principles. Further studies could employ instruments such as tests and observation to assess students' learning achievement. Moreover, further studies should employ the model in the experiments with a greater number of participants to provide more reliable outcomes in the quantitative aspect.

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