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A study on the development of eleventh grade students' critical thinking skills and self-efficacy using active learning pedagogy with gamification

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ABSTRACT

The main objective of this research is to understand the development of the critical thinking skills and self-efficacy of eleventh grade students at a girls' school in Bangkok by using classrooms implemented with active learning pedagogy through gamification on the topic of elementary counting principles. The study uses a mixed method pre-experiment research design, which also acquires in-depth data from interviews. The study involved 29 out of 182 students retrieved from cluster sampling. The data was analyzed using descriptive statistics, including mean, percentage, and standard deviation. A t-test was chosen as the inferential statistic for data analysis. The results indicated that students' critical thinking skills were improved (Sig. (1-tailed) $0.011 < 0.025$), while self-efficacy remained unchanged (Sig. (2-tailed) $0.148 > 0.050$). The in-depth data from the interviews suggests that the students' self-efficacy did not develop because of the stress from their school life. As the findings revealed the effectiveness of active learning pedagogy with gamification toward critical thinking and self-efficacy, the use of this combined approach in schools and universities is recommended to promote the competencies needed in the 21st century. We also suggest further management of stressful academic environments, which will benefit both students and teachers. Furthermore, to obtain more practical data, a more specific context of self-efficacy and critical thinking skills could be used.

Contribution/Originality: This study investigated the effects of active learning and gamification as a combined approach toward female students' critical thinking and self-efficacy in Thailand. This research helps to close the gap in existing research by revealing how the combined approach affects the students' critical thinking and self-efficacy.

1. INTRODUCTION

The drastic shift in educational context from manpower to the use of technology in the 21st century has led to the requirement of the skills and attributes necessary to compete with machines used in industry and our everyday lives (Ait, Rannikmäe, Soobard, Reiska, & Holbrook, 2015). To ensure the production of competent students, necessary skills and attributes must be endorsed and implemented in Thai standard curriculum (Office of the Education Council, 2017). In establishing these attributes and skills, critical thinking and self-efficacy are very useful. Critical thinking can improve creativity, time management and logic, which results in better learning. Furthermore, it may prevent students from ignoring reasonable possibilities that could be useful in real-life situations (Karakoc, 2016) and developing other necessary life skills (Nor, 2021), while self-efficacy makes the connection between

knowledge and the action necessary to achieve certain outcomes (Ait et al., 2015). People with a higher level of self-efficacy tend to be more persistent when carrying out tasks for a prolonged period of time, which is important for providing services within their professions (Chen & Liang, 2022; Peifer, Schönfeld, Wolters, Aust, & Margraf, 2020).

Gamification is widely used in activity engagement since it can intrinsically motivate learners to achieve their goals and improve themselves as they proceed. It also provides a safe environment to practice based on feedback to improve the process of thinking (Herrewijn, 2018; Huang & Yeh, 2017). Hence, higher-order thinking, such as critical thinking, could be promoted (Bourke, 2019; Dwyer, 2018; Heliawati, Lidiawati, & Pursitasari, 2022; Tzelepi, Makri, Petroulis, Moundridou, & Papanikolaou, 2020). Its nature of engaging and providing students with feedback results in a more satisfactory experience when accomplishing a task, which is derived from self-efficacy (Polo-Peña, Frías-Jamilena, & Fernández-Ruano, 2021; Rajani, Mastellos, & Filippidis, 2021; Schunk, 1991).

Active learning is a teaching process that encourages ones to learn on their own under the guidance of instructors. The process requires logical and higher-order thinking to understand the process to reach an answer rather than focusing on the answer itself (Ford, 2010; Freeman et al., 2014; Gogus, 2012; Hartikainen, Rintala, Pylväs, & Nokelainen, 2019; Jodoi, Takenaka, Uchida, Nakagawa, & Inoue, 2021; Prince, 2004; Sukjaroen & Chobphon, 2022), and since it heavily emphasizes the process of thinking, it could positively impact critical thinking (Kusumoto, 2018; Nelson & Crow, 2014; Walker, 2003; Youngblood & Beitz, 2001). Moreover, learners are required to reflect on their obtained knowledge to form a sense of ownership and accomplishment, which can promote self-efficacy (Al-Mahaftha, 2020; Ballen, Wieman, Salehi, Searle, & Zamudio, 2017; Banfield & Wilkerson, 2014; Benawa, 2018; Fook et al., 2015).

The Ordinary National Educational Test (O-NET) has shown that out of the five main topics in mathematics, statistics and probability had the lowest score during 2018–2020. The elementary counting principle is the foundation of probability. It could be said that making sense of probability is impossible if one doesn't understand the elementary counting principle. According to the interview with an eleventh grade mathematics teacher at a school in Bangkok, students struggle to understand elementary counting principles. They lack the proper skills to question, explain and comprehend why one method simply is not suitable for a certain type of problem. They always demand shortcuts and answers directly from teachers and believe them without question instead of working out the answers themselves. These are clear signs of the lack of critical thinking. Furthermore, they did not believe that they could solve problems or certain tasks given to them, which hinders their self-efficacy development and potential as competent individuals.

Even though students clearly have problems understanding the elementary counting principle and developing critical thinking and self-efficacy, schools are highly competent, hence the nature of students is rather serious and competent. Gamification engages students in competition and fun (Cheunchomputh, Mahavijit, & Sangchan, 2020; Jodoi et al., 2021) and active learning that improves their skills in thinking and obtaining knowledge, but this takes time and effort (Drew, 2020). Active learning pedagogy combined with gamification should be effective in improving critical thinking and self-efficacy as they complement each other. As mentioned, critical thinking and self-efficacy are mandatory in modern education.

Unfortunately, in Thailand, not many studies combine the two approaches to explore the impact on critical thinking and self-efficacy, but rather they focus on the impact of the two separate approaches on particular critical thinking, such as mathematical critical thinking and learning achievement, not on self-efficacy. This reflects an enormous problem in Thai education that focuses on competition and outcome instead of competencies and necessary attributes for the 21st century (PimPa, 2018; Ratmanee, 2010).

This study proposes an intervention involving active learning pedagogy with gamification, which aims to (1) improve students' critical thinking that focuses on three subskills: recognition of assumption, evaluation of arguments and drawing conclusions; and (2) improve students' self-efficacy.

2. LITERATURE REVIEW

2.1. Critical Thinking and Its Components

From its early form as the Socratic method, which relies on asking questions (Paul, 1985), critical thinking has come a long way as a skill, even though its definition is very broad and continues to be argued to this day. Its core could be simply put as a thoughtful, reflective, reasonable and logical thinking process based on the evidence provided (Dewey, 1910; Dwyer, 2018; Ennis, 2011; Facione, 2011; Fisher, 2001; Fisher & Scriven, 1997; Thonney & Montgomery, 2019), and to activate this process, the task that requires critical thinking should be thought-provoking and engaging (Nor, 2021) and be able to promote thinking-related skills (Dogan & BAŞOL, 2021). The process of critical thinking allows learners to be cautious, thoughtful, and active thinkers who are aware of the stream and tide of information surrounding them.

Hence, the nature of critical thinking is naturally against those aligned with fake news and misinformation (Machete & Turpin, 2020). The importance of critical thinking to modern education and the environment in producing competent thinkers cannot be denied (Shamboul, 2022), but its broad definition and different opinions among educators on how to teach it might prove to be a major hindrance in its implementation. Thus, its components and measurement must be thoroughly investigated. To measure critical thinking, its components have been proposed by many.

Ennis (2015) identified four subskills for critical thinking: basic clarification, bases for inference, inference, and advance clarification, while Facione (2011) proposed six subskills of critical thinking: interpretation, analysis, inference, evaluation, explanation and self-regulation. Watson and Glaser proposed the critical thinking model, which is comprised of five subskills: inference, recognition of assumption, deduction, interpretation, and evaluation of arguments (Al-Ghadouni, 2021), but after determining the correlation among inference, deduction and interpretation, a new subskill, drawing conclusions, was proposed as a part of Watson and Glaser's new RED model that consists of only three subskills, namely recognition of assumption, evaluation of arguments, and drawing conclusions (Zulmaulida & Dahlan, 2018).

The model has been widely used as the industry standard for critical thinking tests for the past 40 years (AssessmentDay, 2021; Pearson TalentLens, n.d). To categorize the score yielded by each component, the critical thinking criteria of Firdaus, Kailani, Bakar, and Bakry (2015) were chosen.

2.2. Self-Efficacy and How It Works

Self-efficacy is the belief that a person is competent and can perform the required actions and obtain the knowledge and skills to solve problems (Ahmed & Jabeen, 2011; Bandura, 1977; Gallagher, 2012; Lippke, 2020; Ngo & Eichelberger, 2021; Peifer et al., 2020; Soysa & Wilcomb, 2015; Wilde & Hsu, 2019). It enhances learners' confidence in completing the given tasks, which results in them feeling more accomplished and learning from the consequences of their actions (Chen & Liang, 2022).

Feedback plays an important part in increasing self-efficacy, whether the feedback is regarding failure or success. A person with high self-efficacy tends to be more persistent and will put more effort into tasks or situations, while a person with low self-efficacy might avoid the tasks altogether (Peifer et al., 2020). An individual with sufficient self-efficacy may perceive themselves to be competent by watching peers carrying out the same task or being persuaded by words alone, which can also result in the enhancement of self-efficacy (Schunk, 1991). Success or positive feedback may enhance their self-efficacy, but failure or negative feedback may not necessarily degrade it since it will only be perceived as lack of effort, knowledge or skill that can be solved by self-improvement (Bandura, 1977; Lippke, 2020). It is stated that self-efficacy could be affected by the following aspects: mastery experience, vicarious learning, verbal persuasion, and affective state (Sari, 2021; Sheu et al., 2018). Although not entirely, it is stated that self-efficacy affects motivation and it is important to improve one's self-efficacy (Benawa, 2018; Rabideau, 2005).

2.3. Gamification and How it Affects Critical Thinking and Self-Efficacy

Gamification is an approach that harnesses the motivational potential to learn by conducting non-game activities or lessons in a game-like manner by using game design elements outside of its original purpose of entertainment and context to engage individuals, motivate performance, promote learning, and solve problems under the guise of fun and engaging activity (Chen & Liang, 2022; Deterding, Khaled, Nacke, & Dixon, 2011; Herrewijn, 2018; Kapp, 2012; Kim, Song, Lockee, & Burton, 2018; Kummanee & Wannapiroon, 2018; Sailer, Hense, Mayr, & Mandl, 2017). Participants are bound by a set of rules and are given certain goals to complete. By using reinforcement such as badges, rewards, points, virtual goods, levels and leader boards, participants' intrinsic motivation, e.g., eagerness to compete, fun and sense of success, can be enhanced. With enough time, participants will perform the necessary actions to achieve desirable outcomes, which will lead to feedback that they can review and reflect upon (Deterding et al., 2011; Kummanee & Wannapiroon, 2018; Sailer et al., 2017). To establish a robust gamification approach, its structure must be further explored. Kapp (2012) provided seven components as gamification structure: goals, rules, conflict, time, reward, feedback, and levels. But in practice, a more general structure of the approach could consist of only two components: mechanics, which determine the experience of the participants, and dynamics, which is what occurs during the activities (Kim, 2015; Klock, Gasparini, Pimenta, & De Oliveira, 2015; Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2015; Thiebes, Lins, & Basten, 2014). Although there are only two components of gamification in general, integrating them into a classroom without the intention to make it meaningful, challenging and fun would not yield a positive impact (Chu & Fowler, 2020). Gamification revolves around giving feedback (Welbers et al., 2019) and invoking intrinsic motivation, resulting in better learning and encouraging participants to learn from failure (Huang & Yeh, 2017; Wang, Hsu, & Fang, 2022). The approach's real-life, risk-free environment endorses putting feedback into practice to directly improve the process of thinking (Herrewijn, 2018). By focusing on the process of learning that involves many perspectives, judgements and thinking, instead of focusing on finding the correct answer, higher-order thinking, such as critical thinking, could be developed (Bourke, 2019; Dwyer, 2018; Heliawati et al., 2022; Tzelepi et al., 2020). The game design element that gradually increases in difficulty (Deterding et al., 2011; Kummanee & Wannapiroon, 2018; Sailer et al., 2017) provides engagement that maintains students' focus, and with constant feedback from the process it could also establish a sense of accomplishment, which may have a positive influence on self-efficacy (Polo-Peña et al., 2021; Rajani et al., 2021; Schunk, 1991).

2.4. Active Learning and How It Affects Critical Thinking and Self-Efficacy

Rather than being a learning process, active learning is considered to be a teaching process that activates learning on one's own under the guidance of instructors. Learners are encouraged to challenge and critique their own knowledge or that of others, which requires logical and higher-order thinking and being active learners, further emphasizing the process of obtaining the answers rather than the acquisition of the answers (Ford, 2010; Freeman et al., 2014; Gogus, 2012; Hartikainen et al., 2019; Jodoi et al., 2021; Prince, 2004; Sukjaroen & Chobphon, 2022). In this manner, learners are held responsible for their actions and knowledge. They can explore and experiment on what they decide to be of importance in achieving their goals and improve themselves by reflecting upon their knowledge and actions during the process (Gogus, 2012; Hartikainen et al., 2019; Prince, 2004). To effectively manage active learning, instructors are advised to possess knowledge of the learners' backgrounds, when to employ necessary techniques to activate learners, and how to guide learners during their reflection (Palloan, Azis, & Hakim, 2021; Surakarn, Junprasert, Chaiakkarakan, Peungposop, & Boonlop, 2020). As mentioned, critical thinking is developed when we think logically based on the evidence provided, followed by inference, deduction, and argumentative discussion to verify the idea. Since active learning activates learners to think and learn by themselves, the learn to critique and challenge their/others' ideas. It can be said that the knowledge gained from active learning is similar to that from critical thinking, and it can positively impact critical thinking (Kusumoto, 2018; Nelson & Crow, 2014; Palloan et al., 2021; Sukjaroen & Chobphon, 2022; Walker, 2003; Youngblood & Beitz, 2001). As learners are yet to

learn and reflect upon themselves under an instructor's guidance, a conducive environment for promoting self-efficacy should be created. The reflective experience and the sense of accomplishment formed in this way may help develop positive emotions and satisfaction that are the key to enhancing self-efficacy, as mentioned by various authors (Al-Mahaftha, 2020; Ballen et al., 2017; Banfield & Wilkerson, 2014; Benawa, 2018; Fook et al., 2015; Jeong, González-Gómez, Gallego-Picó, & Bravo, 2019; Kuchynka, Reifsteck, Gates, & Rivera, 2021).

3. MATERIALS AND METHODS

3.1. Research Design and Sampling

This research was implemented through a pre-experiment design during February–March 2022 at a girls' high school in Bangkok, Thailand. The population comprised 182 eleventh grade Intensive English Program (IEP) students (four classes) in their second semester. According to the school's policies, IEP students in every class have mixed abilities since they were randomly assigned into their class.

3.2. Procedure

The content used to instruct students in this study includes factorial, linear and circular permutation, and combination. The intervention was implemented as active learning pedagogy with online gamification lessons via ZOOM for 12 periods (4 periods per week) during the spread of COVID-19. The online lessons were conducted according to our new combined approach procedure: engagement, activities, reflection and assessment (Felder & Brent, 2009; Keawpikul, 2012; Kiatcharungphan, 2016; Suvichian, 2018). Gamified questions that yield virtual currency as a reward were presented in the engagement and assessment steps, while the other two focus on the elements of active learning. The virtual currency can be used to purchase real goods, e.g., utensils, stuffed dolls, cloth bags and desk decorations. Firstly, the engagement step focused on encouraging students to think and making them question their prior knowledge by using ordinary gamified questions. This was followed by activities that had them participate in group activities featuring problems that required key knowledge to solve them. After reaching an answer, in the reflection step, each group exchanged their ideas, resulting in questions and critiques among the groups under the guidance of the teacher. Finally, the assessment focused on giving the students feedback on what they had learned with the help of learning platforms such as Kahoot! and Vonder Go. A critical thinking test and a self-efficacy questionnaire were given to the students before the implementation of the approach as a pre-test, and again after the final lesson was conducted as a post-test. After categorizing students into five levels according to the critical thinking skills criteria (Firdaus et al., 2015) (very poor, poor, fair, good and excellent), three students were selected from each level to be interviewed about how they felt during the classes after the post-test. Since no students were found to be in the very poor or poor categories, the total number of interviewees was nine instead of fifteen. Table 1 indicates the outline of the teaching approach.

Table 1. Outline of the teaching approach.

Time in minutes	Process of active learning pedagogy with gamification	Instruments or activities to support the development of critical thinking and self-efficacy
5	Engagement of students in the lesson by asking questions and showing a piece of new information to create cognitive conflict	(1) Critical thinking support (i) Engagement questions (ii) Assessment questions (iii) Probing questions (iv) Worksheet (2) Self-efficacy support (i) Virtual currency system (ii) Compliment (iii) Feedback from Kahoot! and Vonder Go (3) Critical thinking and self-efficacy support (i) Group activities (ii) Critique and discussion
30	Activities that promote thinking and the exchange of ideas	
	(i) Class activities	
	(ii) Group activities	
10	Students reflect and discuss the findings and results under the teacher's guidance	
5	Assessment that provides students with feedback	

Lesson 6 Activity: A circular permutation of n different things with clockwise and counterclockwise arrangements was chosen as the sample activity to show the development of critical thinking subskills and self-efficacy. Students were separated into groups of five or six to solve the problem presented in the activity, e.g., finding the counterclockwise version of each circular permutation given to them on Jam Board. "There are three different pairs of figures of circular permutation and each pair's members have a hidden relation. Find the members and their relation for each pair." The students were then assigned a problem for their individual worksheets that required knowledge from the group activity to solve. "Jenny was helping her mother to make bracelets in three different sizes (small, medium and large) to be sold at a local market. They require six, eight and ten beads of different colors, respectively. "Jenny found that the number of arrangements she had made greatly differed from what she retrieved from using the normal circular permutation taught at her school, which is much less. Did she do something wrong? If so, help her find the correct answers."

Table 2 indicates a part of the exchange between the teacher (T) and a student (S) that shows the development of critical thinking subskills and self-efficacy during the lesson using active learning pedagogy with gamification.

Table 2. Implication of active learning pedagogy with gamification.

	Step	Example of the use of active learning pedagogy with gamification
Self-efficacy	Engagement	T: If you were a psychic and could arrange 6 balls of different colors into a circle in the air in front of your classmates, how many ways are there for you to arrange them? The first three students who answer correctly will score 3,000 SCoin (virtual currency). S: 120 ways. T: You did a good job applying the formula from the previous class, do you believe that this is the correct answer? S: Yes, I am pretty confident that I'm using it right. T: What if I told you that your answer is not likely to be correct and the answer is actually 60 ways? S: It's 3,000 SCoin we are talking about, but I guess I'll have to try harder next time.
Drawing a conclusion	Activities (Group)	T: What is the relation between the circular permutations in each pair? S: Each pair consists of the clockwise and counterclockwise version of the permutation.
	Activities (Individual worksheet)	T: How many ways can Jenny arrange the beads into small, medium, and large bracelets, respectively? S: $\frac{5!}{2}$, $\frac{7!}{2}$ and $\frac{9!}{2}$. T: Does threading six beads into a bracelet in a clockwise manner yield the same result as threading them in the exact same order in counterclockwise manner? Why? S: Yes, it does. The two bracelets would look like the other if either of them is flipped. T: Then, what is the formula that could describe this kind of circular permutation? S: $\frac{(n-1)!}{2}$
Evaluation of arguments	Reflection	T: Why do you think, threading the beads in this manner will result in their number of arrangements being only half of normal circular permutation? S: If you thread the beads this way, half of the arrangement would look the same as the other half since you could flip them. T: Do you think your classmate's argument is logical? Why? S: Yes, it is. The back and the front may not look the same, but they're just different perspectives of the same arrangement.
Self-efficacy		T: Do you believe that your argument is logical? S: Yes, I carefully think about it. It must be logical! T: Indeed, your argument is logical! S: I knew it!
Evaluation of arguments	Assessment	T: If we thread 7 steel balls of different colors into a necklace, there would be 720 possible ways. Which of the following arguments is logical? A. No, it's impossible to thread the steel balls into a necklace.

	Step	Example of the use of active learning pedagogy with gamification
		B. No, the arrangements of the steel balls would look the same from clockwise and counterclockwise perspective. S: B. T: Why? S: Threading steel balls into necklace is considered to be circular permutation and the reasoning in B states exactly why the number of arrangements is halved.
Recognition of assumption		T: In arranging the passenger cars of different colors onto a Ferris wheel, there are 12 ways. Which assumption is acceptable? A. There are only 4 passenger cars. B. There are 720 different ways the passenger cars could be arranged into a line. C. There are 120 different ways the passenger cars could be arranged into a line. S: It's clearly C. T: Why? S: From the formula, there must be 5 Ferris wheels which could be arranged into a line in 120 ways.

3.3. Instruments

To explore the effect of the intervention on students' critical thinking and self-efficacy, the critical thinking appraisal and the self-efficacy scale questionnaire were developed accordingly. The critical thinking appraisal test contains 30 multiple-choice items to appraise recognition of assumption, evaluation of arguments and drawing conclusion subskills. The self-efficacy scale questionnaire (Chen, Gully, & Eden, 2001) comprises eight 5-point Likert scale questions. To explore the qualitative data more, the following interview questions were used to get students' feedback:

(1) What is your opinion on the difficulty of the content used in the lessons?

(2) How do you think the virtual currency system (SCoin) impacted your learning?

(3) In general, how do you feel about the lessons that were taught?

The content validity of the critical thinking appraisal test was assessed by three experts in mathematics education, while three education experts assessed the validity of the self-efficacy questionnaire. This was followed by the revision of the instruments based on the suggestions of the experts. The item objective congruence ranged from 0.67−1.00. The critical thinking appraisal test was pilot tested by 36 twelfth grade students from the same school; the results showed that the difficulty index and discriminative power ranged between 0.2 and 0.8, while its reliability was found to be 0.87 using Cronbach's alpha. Table 3 shows the sample test questions, which provide the opportunity to promote critical thinking, and Table 4 shows the questions presented in the self-efficacy scale questionnaire.

Table 3. Sample questions in the critical thinking skills appraisal test.

Critical thinking subskills	Sample questions
Recognition of assumptions	Statement: A certain stall always makes lemonade with a ratio of lemon juice to water of 4:10, but the sales are not good, so they change the ratio to 1:4 and the customers love it. Assumption: The customers love the new recipe because the lemonade is more concentrated. Assumption made Assumption not made
Evaluation of arguments	Statement: If we assign 20 passengers into cars, the cost of assigning 10 people into 2 cars is not so different from assigning 4 people into 5 cars. Argument: Yes, both ways would result in 20 seats for passengers. Strong argument Weak argument

Critical thinking subskills	Sample questions
Drawing conclusion (deduction, inference, interpretation)	Statement: Most of the stores in Nakhonnayok province will be closing around 19:00, while restaurants and pubs will remain open until late at night. Some business may make more profit in the morning, especially during public holidays. Conclusion: People will not be able to get food after 19:00 Conclusion follows Conclusion does not follow Statement: Warisa is going to break the world record for female short distance running. She is only 1 second away from breaking the record. Her coach believes that she is going to achieve her goal within a year if she continues her hard training. Inference: If she was 2 seconds faster, she would break the world record as long as no one breaks it before her. True Probably true Not enough information Probably false False Statement: Some bacteria could double within a certain period of time, e.g., the number of bacteria increases from 1 to 2 after an hour, 2 to 4 after two hours, 4 to 8 after three hours, and so on. This kind of self-multiplication is called binary fission, which could be denoted using the exponential function. Conclusion: For the bacteria in the statement, there will be 16 of them after 4 hours have passed. Conclusion follows Conclusion does not follow

Table 4. The self-efficacy scale questionnaire questions.

No.	Questions
1	I will be able to achieve most of the goals that I have set for myself.
2	When facing difficult tasks, I am certain that I will accomplish them.
3	In general, I think that I can obtain outcomes that are important to me.
4	I believe that I can succeed at almost any endeavor to which I set my mind.
5	I will be able to successfully overcome many challenges.
6	I am confident that I can perform effectively on many different tasks.
7	Compared to other people, I can do most tasks very well.
8	Even when things are tough, I can perform quite well.

3.4. Data Analysis Techniques

To analyze the qualitative data, i.e., the data obtained from pilot testing, experts' suggestions, observations during the classes, and the results of the interviews, content analysis was chosen as the method to examine the data. For the quantitative data from the critical thinking appraisal test and the self-efficacy scale questionnaire, the pre-tests and post-tests were tested for normality using the Shapiro–Wilk test with a p-value of 0.05. The results indicate normality for the pre- and post-tests for both instruments. A dependent t-test and descriptive statistics, i.e., mean, standard deviation, and percentage, were chosen as the tools to indicate the development in critical thinking and self-efficacy among the eleventh grade students, congruent to the hypotheses. The level of students' critical thinking skills was assessed by applying the critical thinking level criteria proposed by Firdaus et al. (2015) to give critical thinking skills scores as a percentage (see Table 5).

Table 5. Criteria of critical thinking skills.

Percentage range	Criteria
80–100	Excellent
60–79	Good
40–59	Fair
20–39	Poor
0–19	Very poor

4. RESULTS

4.1. Quantitative Data

The results of the critical thinking skills test in Table 6) indicate the mean (*M*), mean percentage (*MP*) and standard deviation (*SD*) for each subskill. Before the intervention, recognition of assumption (M = 6.828, MP = 75.862%, SD = 1.391) and evaluation of arguments (M = 6.655, MP = 73.946%, SD = 1.798) were good, and drawing conclusions (M = 6.517, MP = 54.310%, SD = 1.785) was fair. After the intervention, recognition of assumption (M = 7.103, MP = 78.927%, SD = 1.372) was good, while evaluation of arguments (M = 7.138, MP = 79.310%, SD = 1.866) shifted to excellent, and drawing conclusions (M = 7.276, MP = 60.632%, SD = 1.962) shifted to fair. Overall, all three subskills slightly increased, as shown in Table 6.

Table 6. Mean, mean percentage and standard deviation of critical thinking skills in the pre-test and post-test.

Critical thinking subskill	Maximum score	Pre-test			Post-test		
		M	MP	SD	M	MP	SD
Recognition of assumption	9	6.828	75.862%	1.391	7.103	78.927%	1.372
Evaluation of argument	9	6.655	73.946%	1.798	7.138	79.310%	1.866
Drawing conclusions	12	6.517	54.310%	1.785	7.276	60.632%	1.962
Overall	30	20.000	66.667%	3.674	21.517	71.724%	3.728

Table 7 indicates the number of students at each level. For the pre-test, there were 4 excellent students, 17 good students, 7 fair students, 1 poor student, and 0 very poor students. For the post-test, there were 11 excellent students, 14 good students, 4 fair students and 0 students at the poor and very poor levels. This shows a general improvement in overall critical thinking skills and the elimination of students with poor critical thinking skills.

Table 8 shows an increase of 1.517 in the critical thinking pre-test and post-test scores. The *t*-test affirms the significance in statistical difference between the pre-test and post-test (Sig. < 0.05), which indicates the improvement of students' critical thinking skills through the process of active learning pedagogy with gamification.

Table 7. The number of students at each critical thinking skills level in the pre-test and post-test.

Level	Number of students	
	Pre-test	Post-test
Excellent	4	11
Good	17	14
Fair	7	4
Poor	1	0
Very poor	0	0

Table 8. The results of the t-test in the critical thinking skills pre-test and post-test.

Difference	Df	Maximum score	Mean of difference	Standard deviation	*t*	*p*-value
Pretest–posttest	28	30	1.517	3.377	2.420	0.022

For the self-efficacy part of the study, Table 9 shows the mean and standard deviation for each question in the self-efficacy questionnaire.

Table 9. The means and standard deviations of self-efficacy scale questionnaire.

Questions	Pre-test		Post-test	
	M	SD	M	SD
1. I will be able to achieve most of the goals that I set for myself.	2.655	0.842	2.621	0.611
2. When facing difficult tasks, I am certain that I will accomplish them.	2.414	0.891	2.586	0.810
3. In general, I think that I can obtain outcomes that are important to me.	2.931	0.740	2.897	0.803
4. I believe that I can succeed at almost any endeavor to which I set my mind.	2.448	1.101	2.621	0.925
5. I will be able to successfully overcome many challenges.	2.172	0.874	2.414	0.720
6. I am confident that I can perform effectively on many different tasks.	2.138	0.937	2.345	0.957
7. Compared to other people, I can do most tasks very well.	2.034	0.765	2.276	0.979
8. Even when things are tough, I can perform quite well.	2.103	0.923	2.069	1.081
Overall	2.362	0.939	2.478	0.907

Table 10 shows that the increase in self-efficacy pre-test and post-test scores is 0.116. The *t*-test reveals that there is no significance in the statistical difference between the pre-test and post-test (Sig. > 0.05), which does not indicate the improvement of students' self-efficacy through the process of active learning pedagogy with gamification.

Table 10. The results of the t-test in the critical thinking skills pre-test and post-test.

	df	Maximum score	Mean of difference	Standard deviation	*t*	*p*-value
Pretest–posttest	28	4	0.116	0.421	1.488	0.148

4.2. Qualitative Data

Nine students with excellent, good, and fair critical thinking skills participated in the interviews. The first question, *"What is your opinion on the difficulty of the content used in the lessons?,"* shows that seven out of the nine students thought that the content was on point and appropriate for them, and some were highly confident and they regarded the content as "easy" or "average" and they "demand more challenges". Even though the content was well received, some students mentioned technical difficulties during the online class, e.g., lag during Kahoot! and freezing in Jam Board. Some of the students' responses are as follows:

Excellent student 1: "The content was quite on point and easy enough for me to understand and apply it to the problems in a similar context."

Good student 2: "The content was too easy! I want something more difficult, like university entrance-level exam questions."

Fair student 2: "It was easier for me to understand than lessons full of exercises, but when I participated in group activity, Jam board always froze. I hate that."

The second question, *"How do you think the virtual currency system (SCoin) impacted your learning?,"* revealed that the virtual currency system was quite effective for students with high and good critical thinking. They felt more active and competitive and needed to achieve what they wanted as a team. Some even felt that they could answer the question correctly when they saw others doing it. The students with a fair level did not show much affection toward the virtual currency and being active and competitive. Some of the students' responses are as follows:

Excellent student 2: "It made me feel very motivated and I wanted to get some reward from answering your questions, and when I saw everyone answered your questions, it made me want to do that too! The group activities were also nice. It made the content a lot easier."

Good student 3: "It made me feel more competitive and I wanted to answer more questions since everyone was doing it."

Fair student 2: "I did not care much about it, and I expect that some of my friends also did not, but when my SCoin amount was lower than others, I would try to answer your questions and increase my amount."

The third question, *"In general, how do you feel about the lessons that were taught?,"* indicates that the students needed to work together to achieve their goals, which also resulted in better learning. Some students did not like the online activities, but in general, most of the students had positive feedback on the lessons. Some of the students' responses are as follows:

Excellent student 1: "It was fun and exciting since I got to do some activities with my classmates and scored some SCoins. When I could not comprehend the content, my classmates helped me to get through it, and sometimes I got to talk with my friends during the activities. Sometimes, I could not solve your problems, but it was fine."

Good student 2: "I loved it. It made me see things in a clearer context. The activities helped me and my classmates to work together, I like it!"

Fair student 3: "I really like the auction part where everyone bid for what they want; it made me feel like I was in the class again. I really miss that. Your lessons were good, but I just do not like online classes."

The data we obtained from the interviews and the class observation, in general, showed that even with some technical difficulties, struggles and personal preference that impeded their engagement, most of the students tended to enjoy our lessons. They believed that they were doing well in the classes, demanded more challenges, and could perform the tasks given to them. The virtual currency system was also well received and proved useful in engaging students. As self-efficacy is defined as *the belief that a person is competent and can perform the required actions to obtain the knowledge and skills to solve problems and overcome obstacles*, it was clearly shown during the interviews and classes that students had the essence of high self-efficacy, demanding more challenges, believing that they could do what their classmates did, being competent, and doing what was necessary, despite some struggles, to solve the problems (Bandura, 1977; Lippke, 2020; Schunk, 1991).

In the interviews, aside from providing qualitative data, some of the students mentioned that their school life involves *'stress'* and that *'what they are learning in school is too hard.'* For instance, Excellent student 1 said: "I am quite tired and anxious from studying at school. Thank you for letting me participate in your activities. They felt way more relaxing."

Self-efficacy can be developed by giving learners challenges that gradually increase in difficulty to establish a sense of accomplishment (Polo-Peña et al., 2021; Schunk, 1991). If they were faced with what they could not overcome outside our lessons, it might hinder the process of developing self-efficacy. Thus, seven additional questions about stress and the difficulty of what they are learning in school were added to see how what they mentioned affected their self-efficacy. Using cluster sampling, five students with excellent critical thinking skills were selected. If the students at this level face problems forming self-efficacy, the additional data obtained from them should be enough to summarize the situation that we want to explore.

The first question, *"On a scale of 0–10, how hard are your exams?"*, shows that the students perceive their exams to be very hard, and they were not fond of them. Some of the students' responses are as follows:

Excellent student 4: "7.5/10. It was very hard indeed. If the teachers do not give us any hint about what is going to be on the test, it is quite impossible to do."

Excellent student 5: "10/10. I think it is necessary for the exam to be this hard if we want to enter university, but I don't really know why it is so hard."

The second question, *"On a scale of 0–10, how stressed are you about your learning in school?"*, revealed that students felt very stressed about their school life. The primary reason for their stress seemed to correlate with what they learn in school. Some of the students' responses are as follows:

Excellent student 2: "7/10. The time given to us is very short. I need to stay up as late as 2 a.m. to do my homework and study."

Excellent student 3: "6.5/10. The content was too much to take in, let alone digest anything. The teachers just teach and give us work. We understand nothing and attain no learning process."

The third question, *"Do you usually finish all your homework?"* indicates that students always finished their homework, and they all agreed that it is very tiring. Some of the students' responses are as follows:

Excellent student 2: "As I said, I usually finish all of them around 2 a.m."

Excellent student 5: "I finish all of it, but after that I will immediately pass out. It is really tiring."

The fourth question, *"Do you feel stressed when you did your homework wrong?"* shows that four out of five students checked their answer with their friend before turning it in because they were afraid that they would lose marks. Some of the students' responses are as follows:

Excellent student 4: "Yes. I always check my answers with my friends. If I don't do that, I'd feel very worried about my score being reduced."

Excellent student 5: "No. I don't mind being wrong, but I don't like to lose marks if I am wrong."

The fifth question, *"Have you ever felt fatigued, sore or achy after doing your homework?"* revealed that students experience serious symptoms, such as back pain, wrist pain and finger joint pain, which makes their life harder than it should be. Some of the students' responses are as follows:

Excellent student 1: "Absolutely. I have chronic back pain, chronic finger joint pain and chronic wrist pain."

Excellent student 4: "Yes! I have back pain and wrist pain, and I feel soreness and tiredness in my eyes all the time. It's very hard for me to live my daily life."

The sixth question, *"Do you feel competitive all the time?"*, indicates that the students are all very competitive. Some students even viewed this as normal as they felt familiar with it. Some of the students' responses are as follows:

Excellent student 1: "Yes, we are some of the most elite students in this country, so I need to be very active all the time to attain good grades and catch up with others in the class."

Excellent student 5: "Not really or maybe I am too familiar with this environment. We ought to compete over grades, scores, and our places in the exam, but that is normal, isn't it?"

The seventh question, *"Have you ever felt so tired that you did not want to do anything else?"* shows that all of them felt tired at some point. Some of them said that the longest they slept is five hours, or they do not want to do anything anymore after school. Some of the students' responses are as follows:

Excellent student 1: "I once cried when I did my homework. I felt very stressed and disheartened. Studying with you was one of the most stress-free periods of my high school life."

Excellent student 3: "All the time, but I usually let it go at some point. I usually sleep five hours a day and that is the longest I could lie down in my bed."

Excellent student 5: "I don't want to do any homework. It is too much that sometimes I cannot take it, but I need to do it eventually. Your lessons are good, and I understand what you conveyed to us in class, but we will not be able to do the school exam, which is too hard."

5. DISCUSSION

The results obtained on active learning (see Table 6) indicate that students' recognition of assumption, evaluation of arguments and drawing conclusions improved. In the post-test, the evaluation of arguments subskill had the highest score, followed by recognition of assumption and drawing conclusions, respectively, while evaluation of arguments was the most improved subskill, followed by drawing conclusions and recognition of assumption. Even though drawing conclusions came second in its level of improvement, it scored the lowest among the other subskills in the post-test. One possible reason is that the test for this subskill consists of three sections, which contains a multiple-choice question that needed careful consideration and context-rich questions that might hinder their engagement in thinking about the question, as mentioned by Nor (2021). Table 7 shows that there were no longer any students at a poor level, while the number of students at an excellent level drastically increased.

Active learning encourages students to create cognitive conflict among themselves during classes, resulting in better and more reasonable concepts and knowledge, which promote critical thinking usually found during class

discussion. This is consistent with Debela and Fang (2008) and Makhrus and Hidayatullah (2021). It was also shown many times during the class that almost all the students had logical and reasonable thought behind their answers. Though sometimes they were wrong, it could be amended by giving them the necessary information for them to arrive at the correct conclusion. This is aligned with Debela and Fang (2008); Ford (2010); Devi, Musthafa, and Gustine (2015); Kusumoto (2018); Susiani, Salimi, and Hidayah (2018) and Wale and Bishaw (2020). Surakarn et al. (2020) and Palloan et al. (2021) mentioned that appropriate context and technique are mandatory to guide students during the employment of active learning. This is in line with our approach since we focused on the context of a girl s' school, which proved to be quite effective since the students could understand the concepts and answer our questions more clearly. Combining the lessons with gamification, which focuses on engagement, reinforcement and feedback, allows a safe space for students to learn from their failures, as it was shown during the classes that not as many students felt bad when they gave incorrect answers, but instead, they focused more on the important feedback given to them to answer the next question and obtain more virtual currency, for they saw our activities as only a game. This might help to form a safe environment for critical thinking to grow, which is consistent with Herrewijn (2018). According to the interviews, many students loved our approach since they had fun, felt happier, and understood more of what they were doing and the point of our lessons. Even fair student no.2, who disliked our approach, admitted that she was interested in the reward system since she desired the prices and did not want to have fewer SCoins than her classmates. Even as we increased the difficulty along the process, the students were still willing to collect their SCoins. This proves the effectiveness of gamification in motivating them to learn and solve more complicated questions that foster the process of higher-order thinking, such as critical thinking, to develop, which is aligned with Dwyer (2018); Bourke (2019); Novitaningrum and Lestari (2020); Tzelepi et al. (2020); Nor (2021); Heliawati et al. (2022) and Angelelli et al. (2023). Though the classes were online and the students were not very familiar with or fond of this circumstance, critical thinking could still be fostered using elements of both approaches online since it was shown that students' critical thinking skills, in general, were improved, as found by Tzelepi et al. (2020) and Palloan et al. (2021). Hence, both active learning and gamification have aspects that augment each other and could improve critical thinking, which is consistent with Jodoi et al. (2021).

From the quantitative results obtained on self-efficacy, Tables 9 and 10 show that the self-efficacy of the students remained unchanged, which is not consistent with Banfield and Wilkerson (2014); Fook et al. (2015); Ballen et al. (2017); Benawa (2018); Jeong et al. (2019); Al-Mahaftha (2020) and Kuchynka et al. (2021), who found that active learning is effective for enhancing self-efficacy. It is also not aligned with Schunk (1991); Polo-Peña et al. (2021) and Rajani et al. (2021), who stated that gamification could foster self-efficacy. This contradictory outcome was unexpected and bewildering as it opposes not only previous research, but also the qualitative data obtained during the interviews and class observation. This led us to question and elaborate on the reasons behind this occurrence. The interview results showed that all students thought that our lessons had appropriate content and were easy to understand, some even said that it was too easy, while in truth, it was not. Some students disliked our approach as it made them feel competitive, but the majority felt the opposite. They claimed that seeing their classmates answering our questions correctly, or even just simply answering, made them think that they could do it too. They were more competitive and believed that they could accomplish tasks with the help of their friends.

During the lessons, we always provided any information needed if asked while the students were participating in the group and individual activities so they could proceed and arrive at a conclusion by themselves. We supported them to actively think and accomplish their goal, which resulted in a more satisfying experience. The sense of difficulty might have been diluted as they were having fun cultivating new knowledge. This is consistent with Jeong et al. (2019); Al-Mahaftha (2020) and Kuchynka et al. (2021), which could answer why students viewed our content as easy. The integrated gamification elements, such as the reward system, virtual currency and challenges that keep increasing in difficulty, could draw out students' intrinsic motivation that led to competition that encourages them to engage and participate more in the classes. This explains that although some of the students did not like being

competitive, many of them did, which is aligned with Thiebes et al. (2014); Robson et al. (2015); Klock et al. (2015) and Kim (2015). The group activities implemented were also quite effective since the students spoke about their classmates helping them during the activities and persuading them to do the given tasks by themselves. They also believed that they could also do what their classmates did after seeing them do it. This is aligned with Schunk (1991), who stated that people believe that they can do the same things that their peers did by observing or being persuaded.

The qualitative data and explanations have shown that the essence of self-efficacy exists. Many students also showed that their self-efficacy was rather high and progressively improved throughout the process as they always demanded more challenges and did not back down after answering our questions incorrectly. It was also shown that they communicated and exchanged ideas more during our classes compared with traditional classes, which is not aligned with Ngo and Eichelberger (2021), who stated that students with low self-efficacy might avoid engaging in their given tasks. Although the groups comprised students with both high and low self-efficacy, this didn't present any issues. This might be due to the implementation of the combined approach that promotes critical thinking, since it yields more meaningful, engaging and fun learning that supports group working (Chu & Fowler, 2020).

One tends to develop self-efficacy when faced with tasks that they can overcome despite some struggles (Polo-Peña et al., 2021; Schunk, 1991). At first, we believed that online learning, which they were not familiar with or fond of, would be the reason for the occurrence, Jeong et al. (2019) and Rajani et al. (2021) demonstrated that online learning is effective in improving self-efficacy, and if they neglected online learning, improvement in critical thinking may not be possible. Thus, it makes sense for us to focus on the data obtained from the seven additional interview questions that focus on the "stress" mentioned by the students. According to the interviews, students described their school environment as "stressful" and "hard". They believed that what they learned would not aid them during the test, and they felt competitive and stressed all the time, and some thought of that as normal. They rarely fully rested during their free time and instead were forced to work on their assignments until late. Some even developed symptoms such as wrist pain, joint pain, and back pain, and claimed that our classes were the most stress-free period of their high school lives. This directly points to what occurred outside our control. When they did the critical thinking test, they may simply have gone through the process of thinking, but as they did the self-efficacy questionnaire, they needed to relate to their surroundings and context. This is aligned with Lippke (2020), who states that self-efficacy is context-specific, which means that it is formed and unformed under a specific environment, e.g., their school life. What this study discovered about self-efficacy and stress is aligned with Vaezi and Fallah (2011); Sebastian (2013) and University of Washington (n.d), who mentioned that self-efficacy involves personality study and stress vulnerability regarding the social pressures that people are under, that positive feedback will improve self-efficacy while despondency will degrade it, and that stress seems to have a negative relationship with self-efficacy. When feeling the effects of stress, depression, or anxiety, students may not be able to develop their self-efficacy.

The combined approach positively impacted both critical thinking skills and self-efficacy. Although self-efficacy did not statistically improve, what was observed during the classes and interviews proves otherwise. They showed many aspects and essences of high self-efficacy, but what prevents them from perceiving themselves as highly efficacious is the stressful environment surrounding them. Though we aimed to improve their self-efficacy under a carefully laid process, this study was only a small fraction of their school life.

6. CONCLUSION

This study examined the impact of active learning pedagogy with gamification on (1) students' critical thinking that focuses on three subskills: recognition of assumption, evaluation of arguments and drawing conclusion, and (2) students' self-efficacy. The quantitative results indicated that the students' critical thinking was improved but self-efficacy did not change. The qualitative results showed that the students had the characteristics of critical thinking, such as having logical and reasonable arguments, critiquing others' knowledge, and being able to arrive at a conclusion based on the information provided. They also enjoyed our lessons and preferred to learn in this manner

than in a traditional class. The content, activities and reward system were also well received. The students tended to help each other within their group, demanded more challenges, and believed that they could do what their classmates did. These aspects showed that the essence of self-efficacy is rather high, and the findings suggest that the unchanged self-efficacy in a quantitative manner was due to the stressful environment of their school life. Thus, we conclude that active learning pedagogy with gamification has a positive impact on students' critical thinking skills and self-efficacy.

7. RECOMMENDATIONS

7.1. Recommendations for Academic Professionals

The study shows that active learning pedagogy with gamification could be a great tool in developing students' critical thinking skills and self-efficacy. Thus, it could be of use to teachers who seek to improve students' competencies and skills. However, this study needed to be conducted through online classes due to the outbreak of COVID-19, so further research should be done as onsite classes while including students with more diversity, e.g., gender, age, and ethnicity.

7.2. Recommendations for Industry Practitioners

This study has shown the effectiveness of both active learning and gamification on critical thinking and self-efficacy, but also the relation between stress and self-efficacy. We recommend the use of this combined approach for industry practitioners to train the workforce and improve critical thinking and self-efficacy and reduce stressful environments. We also recommend using more gamification elements to engage in activities to promote more interpersonal interaction.

7.3. Future Implication

As the findings show that the combined approach has a positive impact on critical thinking and self-efficacy, we suggest the use of this combined approach in both online and onsite settings in schools and universities to promote the competencies needed in the 21st century. However, since stress hinders self-efficacy, we also suggest further management of stressful academic environments, which will benefit both students and teachers. Furthermore, the study focuses on critical thinking skills and self-efficacy in a general sense. To obtain more insightful data for practicality in the field of education, more specific approaches, such as mathematical self-efficacy or mathematical critical thinking skills, could be taken.

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