Gamification Using Visual Novel to Improve Chemistry Learning Motivation

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Abstract— **Learning Chemistry at the beginning of senior high school is difficult because of too much information that should be remembered, especially the periodic table. To reduce the difficulty of students' learning process, gamification could be helpful. In this study, gamification application in the form of a visual novel has been developed and focused on the periodic table material for 1st-year senior high school students. The motivation improvement had been measured using the IMMS (Instructional Materials Motivation Survey) questionnaire in the pre-test and post-test sections. Respondents filled in the pre-test at the beginning of the experiment, followed by a visual novel playing session for one week. After the playing session ended, the respondent filled in the post-test. The motivation score from the pre-test and the post-test result had been compared using paired T-test to see whether there was an improvement in learning motivation. It could be concluded that improvement in learning motivation happened due to the usage of visual novel, with an improvement of overall motivation score of around 18.61%. In the future, this study would be continued by applying user personalization according to learning style preference.**

Keywords— *learning motivation, improvement, gamification, visual novel*

I. INTRODUCTION

Learning Chemistry is difficult due to the old-school method of teaching used which often cannot pique the student's interest to learn by themselves [1]. Despite the good quality of the developed curriculum or the learning materials, unless the students have themselves motivated to learn, those contents would be in vain [2]. For the 1st year senior high school students, learning the periodic table is difficult due to the involvement of the ability to memorize lots of items on it, namely the chemical's name, period, atomic number, and electron configuration. Memorizing those items is not helpful for the student's long-term memories, and there is a tendency among students to forget them completely [3].

To reduce learning difficulties due to lesser learning motivation, gamification could be helpful. Gamification could be defined as the application of game-related elements to an activity that is nothing like a game [4]. Gamification can be applied anywhere, including education, to improve the eagerness of students in the learning process [5]. For Chemistry subjects, gamification had been done by several studies, such as [6], [7], [8], [9], [10], [11], [12]. Those previous studies were incorporating trivia games in their gamification process. Trivia game is a type of game genre that involves quiz answering within the time limit [13]. The given questions in trivia can have many forms, such as multiple choice, short answer questions, fill-in-the-blank questions,

matching pairs, or word sorting [5]. However, trivia game is very similar to quizzes students have in their classes, and it could make students less motivated to do the activity, and student performance improvement only could be seen in the students who were interested in playing trivia games [13].

On the other hand, digital storytelling which has been widely used in education could have improved students' engagement [14] and learning motivation [15]. Digital storytelling involves multimedia elements and digital media to convey the story [16]. Using digital storytelling in education has several benefits, such as conveying lesson material more creatively with lesser lesson delivery time [17], improving students' information retainment duration [18], and being the link between the new and the current knowledge [16]. Despite its ability, the effectiveness of digital storytelling to improve students' motivation only had been proven when students are involved in the process of creating digital storytelling products [15]. It is unknown about students' motivation that used the product from digital storytelling as the learning material, either it would be the same as reading the textbook or maybe better or even worse.

Combining both trivia games and digital storytelling into one application is possible. The combination result could be found in one of the game genres which is a visual novel. Visual novel is one kind of game that heavily focused on first-person digital storytelling with fewer game elements [19]. Visual novel provide several differences compared to the usual digital storytelling, such as storyline branching with player-centered options and multiple endings [20]. Player-centered options are one of the components of trivia games, while the digital storytelling component could be seen in the way a visual novel provides its story, excluding storyline branching and multiple endings. The combination of digital storytelling and trivia game would form a visual novel. The trivia element in a visual novel could give the user challenge while helping the user to retain the knowledge after studying [13], and the storyline provided in a visual novel could improve students' engagement to learn. Therefore, it is possible to improve student motivation to learn Chemistry using the visual novel.

II. LITERATURE REVIEW

A. Learning Motivation

Motivation is the trigger for someone to attain goals regardless of any circumstances by combining one self's biological, emotional, social, and cognitive elements [21]. Motivation could be developed internally such as the willingness to do something or developed due to external factors like social situations or prizes from others. Learning

motivation could be divided into four factors [22], particularly attention (the ability to be focused on doing the learning activity), relevance (the perceived value by the learner to the learning materials in terms of solving real-world problems), confidence (the properness of learning difficulty compared to the given curriculum), and satisfaction (the expected value from the learner after the completeness of learning process). Malik [23] stated that each aspect of motivation could be well-enhanced using several activities. The attention aspect could be enhanced by developing unexpected situations which could raise curiosity using various learning media. The relevance aspect could be enhanced by using well-defined learning goals and compatible learning methods with learning motivation so the learned experiences could be correlated with real-life situations. The confidence aspect could be enhanced by giving requirements of performance along with the opportunity to complete the goal by using self-control ability on oneself. The satisfaction aspect could be enhanced by reinforcing self-motivation or giving rewards along with the completion standard that should be completely known by learners.

B. Gamification

Gamification is defined as the involvement of game elements in non-game activities [24] in many fields such as education, marketing, crowdsourcing, health, and occupation [25]. In gamification, the player has their avatar and its status and owned resources, living in an environment with a storyline, doing activities with another player within the environment's boundaries, and is usually given some feedback based on their actions [21]. Kiryakova et al., [1] explained that there are four strategies to make effective gamification to support the learning process, such as defining students' characteristics, defining learning outcomes, activities, and content development, and involving game mechanics along with game elements. Game mechanics should be involved to make the situation more interesting, and learners could be more immersed in the learning process [26]. Most of the time, the gamification process involves a quiz with several answer options that should be chosen to evaluate the learning progress. The displayed choices are mainly used to give the learner some feeling of competence, ability to handle the situation, motivated and perform better than before [27] Kapp et al. [28] explained that gamification could help instructors to create interactive learning sessions in forms, making time for learners to solve the problem within the session, therefore learners could have developed themselves new skills and finally, the learning motivation could be developed as well.

C. Visual Novel

Visual Novel is one kind of game genre that heavily focus on presenting a story from the first-person viewpoint using various multimedia elements with a little-to-none of game elements [19]. Multimedia elements incorporated in a visual novel such as the dialogue text, background images, character images, soundtrack, and sound effects worked together to improve the player's immersion [19]. From the outside, the visual novel looks similar to digital storytelling due to the usage of various multimedia elements. When it is investigated further, it is safe to say that visual novel is several steps ahead of digital storytelling. The visual novel involves lots of scenario branching with multiple endings depending on the player's progressions with various game mechanics like point and clicks, puzzles, or life simulation [20]. By implementing scenario branching and multiple endings, the visual novel would motivate the player in spending their time reading the visual novel repeatedly until they could unlock all the possible storylines and endings since the player feels like they have a personalized story created for them [29]. Due to its abundant focus on narrative presentation, some game designers considered that a visual novel could not be considered a game despite the game mechanics implemented in it, as the narrative component is better suited for game feedback rather than game mechanics [19].

III. Methodology

This study started by developing a visual novel based on the periodic table chapter from 1st year Indonesian senior high school textbook. The chosen periodic table group is group 1A until 8A. Contents such as quiz bank, storyline branching, and multiple endings are developed using Ren'Py Visual Novel Engine [29]. The game was developed for the PC platform and all contents would be written in Indonesian language. The story presented would let players focus on their role as the main character, and the quiz would make players remember that they should learn something as both the main character and real-life students.

In this study, research data were collected by using a questionnaire based on IMMS (Instructional Materials Motivation Survey) [20]. IMMS questionnaire had thirty-six questions to measure the learner's learning motivation based on the four aspects of ARCS, namely Attention, Relevance, Confidence, and Satisfaction. The Attention factor was measured by twelve questions which consist of seven positive questions and five negative questions. The Relevance factor was measured by nine questions which consist of eight positive questions and one negative question. The Confidence factor was measured by nine questions which consist of five positive questions and four negative questions. The Satisfaction factor was measured by six questions which consist of all six positive questions. Those four factors' scores above would be averaged to find the motivation scores of a respondent. Positive question choices had the scores scaled normally according to the choices; more negative choices gave lower scores and more positive choices gave higher scores. But in negative questions, the scores would be reversed, such as more negative choices giving higher scores and more positive choices giving lower scores. Each of the respondent's scores was calculated to find the mean scores, and each score was categorized into several groups [30], namely "Not Very Motivated" for respondents with mean scores of 1.00-1.49, "Not Motivated" for respondents with mean scores of 1.50-2.49, "Motivated Enough" for respondents with mean scores of 2.50-3.49, "Motivated" for respondents with mean scores of 3.50-4.49, and "Very Motivated" for respondents with mean scores of 4.50-5.00.

The research was conducted in one class of senior high school freshmen, starting with a brief explanation of the study and followed by a pre-test motivation questionnaire. After the pre-test motivation questionnaire had been filled, respondents were given one week period to play a visual novel developed for this experiment. After the playing period ended, the research continued by distributing a post-test motivation questionnaire to the same respondents that had filled out the pre-test questionnaire. Gathered data from both pre-test and post-test questionnaires were compared and analyzed statistically using paired T-test with the help of statistical software to prove the hypotheses regarding the motivation improvement in learning Chemistry.

The hypotheses to be proven in this study were related to the impact of visual novel and student's learning motivation, including each aspect of the ARCS (Attention, Relevance, Confidence, and Satisfaction) as below:

1. Regarding the Attention aspect:

    a. Ho: There is no improvement in motivation according to the Attention score

    b. H1: There is an improvement in motivation according to the Attention score

2. Regarding the Relevance aspect:

    a. Ho: There is no improvement in motivation according to the Relevance score

    b. H1: There is an improvement in motivation according to the Relevance score

3. Regarding the Confidence aspect:

    a. Ho: There is no improvement in motivation according to the Confidence score

    b. H1: There is an improvement in motivation according to the Confidence score

4. Regarding the Satisfaction aspect:

    a. Ho: There is no improvement in motivation according to the Satisfaction score

    b. H1: There is an improvement in motivation according to the Satisfaction score

5. Regarding overall motivation:

    a. Ho: There is no improvement in motivation according to the overall motivation score

    b. H1: There is an improvement in motivation according to the overall motivation score

IV. RESULT

The experiment in this study was conducted by involving 17 respondents from one class of senior high school freshmen. The experiment started by explaining the procedures to the respondents. When the briefing session is done, respondents took a pre-test questionnaire about their motivation for learning Chemistry periodic table using non-game media such as textbooks or videos. After the pre-test is done, respondents were given time to play the visual novel developed in this study for one week. During one week of playing time, respondents should try to clear all the chapters and reach the game's ending as the requirement to join the post-test.

The visual novel respondents should play consisted of three major parts, mainly the story chapters, the learning session, and the quiz; as seen in Figure 1. Those major parts were available in the each of eight chapters, and each chapter provided learning material for periodic table group 1A until 8A. In the story, the main character named Willy disliked learning Chemistry despite his good grades in other lessons. Meanwhile, his school tried to find two candidates as the school's representatives in the Chemistry competition. His best friend named Cindy was selected to be the school's representative. On the other hand, Willy's rival named Eric is trying to compete with him to be one of the representations along with Cindy. Cindy who disliked that idea enforced Willy to join her in the competition. Willy who does not want

to disappoint Cindy had no other choice but to learn Chemistry with her.
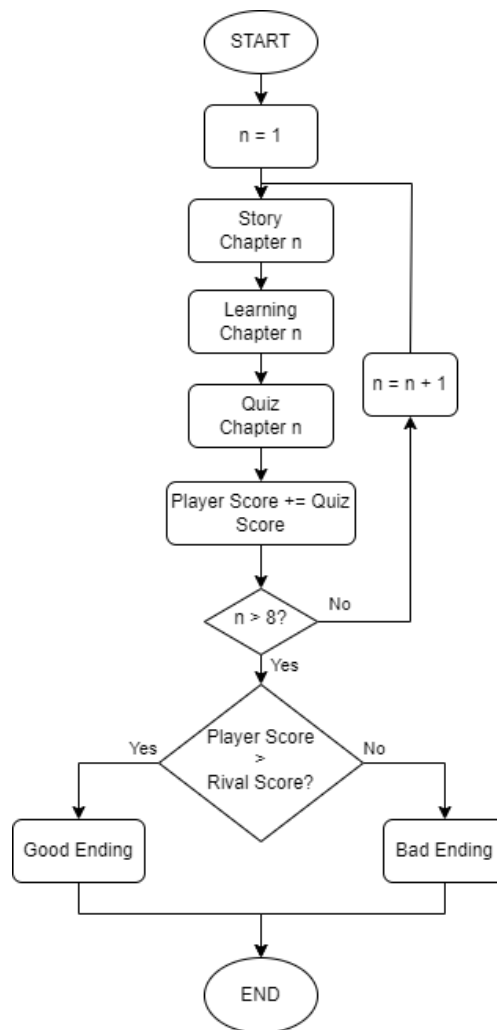

Fig. 1. Visual Novel Flowchart

An example of the presented storyline could be seen in Figure 2. Characters' sprites were placed on the left/middle/right of the screen with the background scene behind those characters.
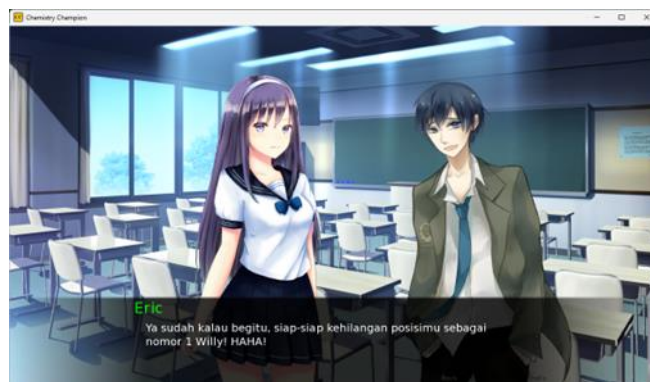

Fig. 2. The Storyline Section

After enjoying the story, the respondent would face the learning session. At the learning session, respondents could learn about the elements' components of each group according to the chapter number. Chapter 1 provided learning materials for elements in periodic table group 1A, and the list goes on

until Chapter 8 with the learning materials for elements in periodic table group 8A. Respondents should learn the material carefully to be able to answer the quiz at the end of the chapter. There is Cindy's sprite in the middle of the screen along with several buttons to be clicked, mainly the buttons for each element of the presented group in that chapter. When the button is clicked, information about the selected element were shown in the middle of the screen. The display of the learning materials selection could be seen in Figure 3.

Fig. 3. The Learning Material Selection

When one of the buttons got clicked by the respondent, the information regarding the clicked element would be displayed as seen in Figure 4. Each element from 1A to 8A would have information such as the element picture, the element's name in English and Indonesian, the abbreviated name, atomic number, period number, and some fun facts about the element. Respondent should click on the screen to continue reading and return to the learning material selection screen. When the respondent clicked the arrow button on the bottom right screen, the learning material screen would be hidden, and the quiz screen would be displayed.
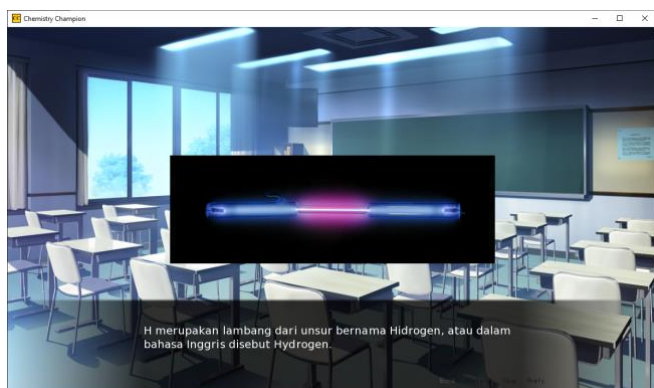

Fig. 4. The Learning Material Content Display

There is a quiz that should be answered by the respondent as seen in Figure 5. The quiz that would be faced by the respondent consisted of the question zone, answer zone, score, and time. The question was shown at the bottom of the screen, and the respondent should answer it by typing the answer in the answer zone which is below the question zone. Pressing Enter after answering made the quiz system decide whether the answer is right or wrong. One right question would add ten points, and one wrong question would reduce the score by five points. When the time limit reached zero, the quiz stopped generating questions randomly from the quiz bank, and the respondent could move into the next chapter. When the wrong

answers given were more than the right answers and the answered questions less than ten, Willy gave a negative response in his dialog, and vice-versa when the wrong answers given is less than the right answers and the answered questions more than ten. Scores from each chapter's quiz were used to determine the story's ending for the player.
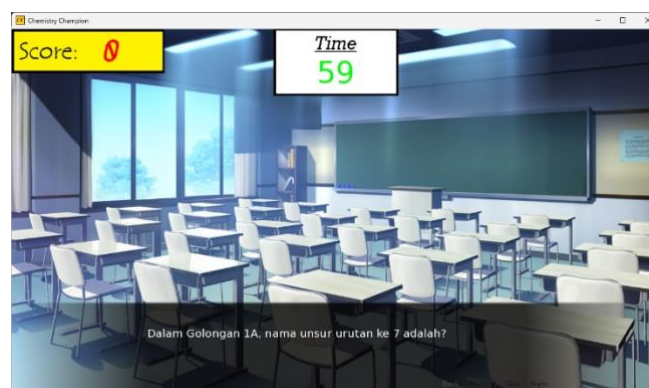

Fig. 5. The Quiz Section

At the end of chapter eight, scores from all quizzes from Chapter One to Eight were accumulated to decide the ending of Willy's learning journey. When Willy's accumulated score is higher or equal to 500, the good ending for Willy would be unlocked. The good ending told the player that Willy got accepted as the representative of his school for the Chemistry competition along with Cindy. When Willy's accumulated score is lower than 500, the respondent unlocked the bad ending instead. The bad ending told the player that Willy got rejected from the representative seat and Eric got accepted, but Cindy refused to be the representative of her school along with Eric. She chose to teach Willy about Chemistry instead of joining the Chemistry competition.

After playing time is over, respondents took the post-test questionnaire regarding their motivation of learning Chemistry periodic table using the trivia game they played in their last one-week period.

Due to the paired pre-test and post-test used in this research, the gathered data would be analyzed using paired T-test. The results from the pre-test were compared to the post-test to see whether the visual novel have any impact on their motivations. The scores for each of the ARCS Motivation Factor and overall motivation score could be seen in Table 1.

TABLE I.   PRE-TEST AND POST-TEST MOTIVATION RESULT

Motivation Factor	Pre-test	Post-test	t-value	Significance (2-tailed)
Attention	3.3725	3.9216	-4.261	0.001
Relevance	3.4575	3.8105	-4.012	0.001
Confidence	3.1111	3.9281	-7.641	0.000
Satisfaction	3.4020	4.1471	-4.737	0.000
Overall	3.3358	3.9518	-6.536	0.000

From Table 1, it could be seen that pre-test scores for overall motivation and each of the ARCS Motivation Factor could be categorized by [30] as "Motivated Enough". But in the post-test, those scores were gaining up one scale of category from "Motivated Enough" to "Motivated". With the degree of freedom 16 and the significance value of 0.05, the critical t-value for each motivation factor should be ranged from -1.746 to 1.746. Based on Table 1, the t-value for each

score of ARCS Motivation Factor and overall motivation is smaller than the critical t-value. Any motivation factor's t-value that is less than the critical t-value would let the alternate hypotheses be accepted. Furthermore, the p-value for each ARCS Motivation Factor and overall motivation were less than 0.05. Finally, it could be said that visual novel brought positive change to students' Chemistry learning motivation.

V. CONCLUSIONS

This paper tries to see the improvement of students' Chemistry learning motivation by implementing visual novel as learning media. This study has used IMMS (Instructional Materials Motivation Survey) to collect the data of students' motivation scores in both pre-test and post-test. By comparing the pre-test and post-test results, this study would like to see the motivation improvement of students. could be seen as reflected by each ARCS factor's score and overall motivation score. The result from this study has shown that there is an improvement in students' Chemistry learning motivation as the impact of the visual novel played between the pre-test and post-test period.

Despite the good result of this study, this study has not embraced the trend of current gamification. One of them is adaptivity to one's learning style preferences [31]. In future works, the visual novel should be enhanced using an adaptive gamification framework and it would be compared with the traditional learning method related to its effectiveness in terms of learning motivation improvement.

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