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Chem Piano Game to Increase Students Motivation and Retention of Learning Outcomes on the Periodic Table of Elements Material

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Abstract: The abstract nature of the Periodic Table of Elements necessitates interactive learning media to improve students' motivation and learning outcomes. This study aims to determine the effectiveness of the Chem Piano game as a learning medium in enhancing students' learning motivation, learning outcomes, and retention of learning outcomes related to the Periodic Table of Elements material. The research design employed was a pre-experimental approach using a One-Group pretest-posttest design. Data on students' learning motivation were analyzed using a Likert scale consisting of positive and negative statements. Chem Piano was categorized as meeting the criteria for good learning motivation if it achieved a score of ≥ 69%. The learning outcome test data were analyzed using descriptive statistics to examine the mean and percentage of achievement, and the Wilcoxon Signed Ranks Test was used to determine the significance of the increase in learning outcomes. The results showed an increase in learning motivation, with a shift in category from low to very high. The Wilcoxon Signed Ranks Test for student learning outcomes yielded a significance value of 0.00 (< 0.05), indicating a statistically significant improvement between the pretest and posttest scores. Furthermore, the retention analysis yielded a very high retention value of 92.3%, indicating that students' learning retention was stable. Based on the analysis and discussion, it can be concluded that the Chem Piano game is an effective learning medium for enhancing students' motivation and learning outcomes in chemistry, particularly in relation to the Periodic Table of Elements. Therefore, it is recommended that this medium be used as an alternative instructional tool to enhance students' motivation and learning outcomes, and that its implementation be further explored with a larger number of students.

Keywords: Chem Piano; Learning Media; Learning Motivation; Learning Outcomes; Periodic Table of Elements.

Introduction

Education is a process designed to help students adapt optimally to their environment, leading to positive personal changes that contribute to the betterment of society. Learning plays a crucial role in guiding this process, enabling the effective achievement of the intended educational goals. In general, students' growth and development are influenced by both innate characteristics and environmental factors that support the development of their potential. In this context, the environment refers to the school, which functions as a formal educational institution [1]. Creating an enjoyable and supportive learning environment is essential for fostering the development of students' potential [2].

Chemistry is a scientific discipline that demands a comprehensive understanding and mastery of its content. As a foundational field, it makes significant contributions to the advancement of other scientific domains. At the high school level, chemistry consists of numerous systematically organized and interrelated topics. [3]. However, students' motivation to learn chemistry remains relatively low. This is influenced by the perception that chemistry is a difficult subject and, therefore, less appealing, largely due to the numerous formulas and complex concepts that students are required to master [4]. This phenomenon indicates that many students perceive chemistry as a challenging and uninteresting subject [3]. Preliminary research data from SMA Kartika IV-3 Surabaya indicate that 82.8% of students consider chemistry a challenging subject to learn.

Some chemistry topics are abstract, such as atomic structure, which requires a high level of understanding [5]. The lack of students' understanding of atomic structure is particularly evident in the subtopics of the periodic table of elements and the periodic properties of elements [6]. This occurs because many chemistry terms tend to be memorized rather than understood in depth. Most chemical concepts, such as atoms, molecules, and ions, are difficult to visualize because they cannot be observed directly. In addition, many students also experience difficulties in comprehending chemical concepts [7]. Pre-research data from SMA Kartika IV-3 Surabaya also indicate that students struggle to learn chemistry because the learning media commonly used by teachers are limited to whiteboards, LCDs, and projectors.

According to Husain et al. [3], the low level of conceptual understanding in chemistry among students is caused by the limited use of learning media that support concept visualization, resulting in difficulties in understanding the material and a decline in students' interest in chemistry. Students' difficulties in understanding the Periodic Table of Elements are not only due to low conceptual understanding but also to the use of teacher-centered learning methods, which make students passive, less motivated, and easily bored. This non-interactive learning approach indirectly limits students' opportunities to

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explore the material more deeply [8]. Student learning motivation has a significant influence on the learning outcomes achieved. When learning motivation increases, learning outcomes also tend to improve, as highly motivated students are more active and engaged in the learning process. Therefore, to enhance learning motivation and outcomes, updates and improvements in learning media are necessary [9].

Based on this explanation, innovative learning media are needed to increase students' motivation and learning outcomes. With technological advancements, it is now possible to utilize technology as an innovative learning tool. Research conducted by Safitri and Sa'dudin [10] shows that the use of visual media attracts students' attention more effectively and helps them understand the material more easily. Technology-based media also have a significant impact on the learning process [11]. Furthermore, research by Zuliyani and Marlina [12] A significant influence of learning media on students' learning motivation was found at SMKN 71 Jakarta, indicating that the effect of learning media on learning motivation is relatively high, with a correlation coefficient of 0.732, equivalent to 73.2%.

Learning media are supplementary tools or resources used by teachers to communicate with students. The purpose of using learning media is to help achieve basic competencies and expected indicators according to students' developmental domains (cognitive, affective, and psychomotor), as well as to stimulate their five senses [13]. The use of learning media in the teaching and learning process aims to enhance students' learning motivation and has a positive impact on their learning outcomes [14]. Learning media also help strengthen students' understanding and create a learning environment that supports knowledge retention. The selection of appropriate media must be aligned with the learning objectives so that its use can produce optimal results [3].

One type of media that effectively captures students' attention is games. Educational games can increase students' learning motivation because they are interactive and enjoyable. Games create a fun and challenging learning atmosphere, which encourages students to become more motivated and better understand the material being taught [15]. Game-based learning media are specifically designed to guide students in targeted learning, strengthen conceptual understanding, and provide learning experiences that develop skills and stimulate the desire to play [16]. Game-based learning combines interactive and engaging elements to support students' cognitive, affective, and psychomotor development. Games utilize challenges, feedback, and competition to increase students' focus and learning motivation [17]. This type of learning media allows students to learn while playing, making the learning process more enjoyable, increasing enthusiasm for participating in learning activities, facilitating material comprehension, and helping develop students' thinking skills, creativity, and activeness [18].

Research conducted by Hemaliawati [19] In Vocational High Schools (SMK), the integration of educational games in science learning significantly increased student engagement and motivation through elements of competition, rewards, and a positive learning atmosphere, while also enhancing their conceptual understanding. Furthermore, research by Ulimaz et al. [20] demonstrated that game-based learning has strong potential to increase student motivation by providing interactive and engaging learning experiences.

One educational game that can be utilized is Chem Piano, a game adapted from Piano Tiles. This game helps improve students' concentration and dexterity. Students are required to complete challenges by tapping the screen according to the instructions displayed within a specified time limit. Each level in the game contains a quiz that students must complete as an evaluation tool to ensure they have a solid understanding of the periodic table of elements. The Chem Piano game had previously been declared valid by three expert validators in the field of chemistry. The following is an example of the display used in the Chem Piano game.

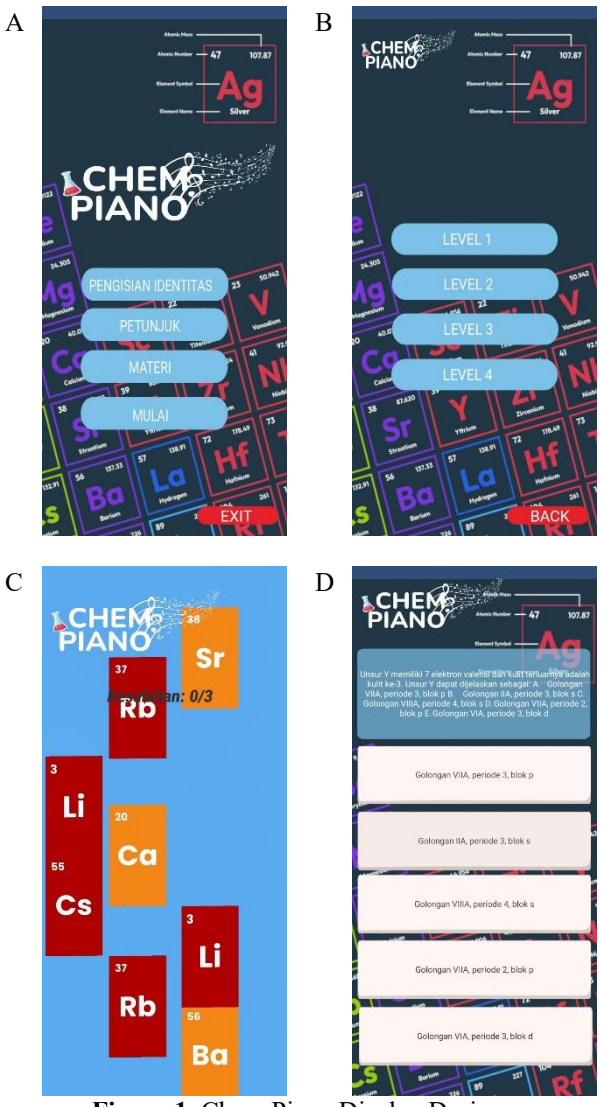

Figure 1. Chem Piano Display Design.
A. Home Page. B. Level View.
C. Piano Challenge. D. Quis

The purpose of this study is to enhance students' motivation and retention of learning outcomes by utilising the Chem Piano game as an interactive learning medium. By using Chem Piano, students are expected to learn chemistry in a more enjoyable and engaging way. This game not only helps students understand abstract chemical concepts but also encourages them to participate more actively in the learning process. Increased motivation and active

participation are expected to positively influence students' conceptual understanding and overall learning achievement [21]. In addition, Chem Piano encourages students to think critically and creatively when solving challenges in the game, thereby indirectly developing their thinking skills in the context of meaningful and enjoyable chemistry learning.

Research Methods

This study was conducted at a high school in Surabaya, involving one class of 20 students as research subjects. The research design employed a pre-experimental approach using a One-Group pretest-posttest design [22]. The Chem Piano game was validated by three experts, comprising two lecturers from the Chemistry Education study program and one chemistry teacher.

The hypothesis of this study was that the implementation of the Chem Piano game as a learning medium would improve students' learning motivation and learning outcomes.

The student motivation questionnaire was used to determine the increase in students' motivation after using Chem Piano. The questionnaire was administered before and after the use of the learning medium. The data from the motivation questionnaire were analyzed using a Likert scale consisting of positive and negative statements, as described in Table 1.

Table 1. Likert Scale Scores

Statement	Assessment Criteria	
	Positive	Negative
Strongly Agree	5	1
Agree	4	2
Neutral	3	3
Disagree	2	4
Strongly Disagree	1	5

The data obtained will be analyzed using the following formula.

$$\%\text{Effectiveness} = \frac{\text{Total item score}}{\text{Total ideal score}} \times 100\%$$

The results of these percentages are then interpreted using the following score table [23].

Table 2. Percentage of Learning Motivation Criteria

Percentage (%)	Learning Motivation Criteria
20 – 36	Very Low
37 – 52	Low
53 – 68	Medium
69 – 84	Fairly High
85 – 100	Very High

Based on the table, Chem Piano can be categorized as meeting the criteria for good learning motivation if it achieves a score of ≥ 69%.

Analysis of student learning outcomes was conducted using a paired sample t-test. Before performing the paired sample t-test, a normality test was carried out to determine whether the data were normally distributed. The Shapiro–Wilk test was used for assessing normality because the sample size was less than 50 (n < 50). If the data are not normally distributed, the paired sample t-test cannot be applied. Therefore, an alternative analysis was conducted using the Wilcoxon Signed Ranks Test. The Wilcoxon Signed Ranks Test is a nonparametric statistical technique used to compare two related data sets. This test is employed when the assumption of normality required for the paired sample t-test is not met [24]. The Wilcoxon Signed Ranks Test was performed using IBM SPSS Statistics 23 software. This test was used to evaluate the significance of the difference between pretest and posttest scores, thereby determining the extent of improvement in students' learning outcomes.

H_0 : μ posttest ≤ μ pretest, posttest score is less than or equal to pretest score.

H_a: μ posttest > μ pretest, the posttest score is greater than the pretest score.

The conclusion of the hypothesis test is determined based on the significance value, as follows:

If Sig < 0,05, then H_0 is rejected and H_a is accepted.

If Sig > 0,05, then H_0 is accepted and H_a is rejected.

Therefore, the use of learning media can be considered effective in improving student learning outcomes if the significance value is less than 0.05.

The analysis of individual mastery was aligned with the Minimum Mastery Criteria (KKM) established by the school where the research was conducted. Furthermore, classical mastery was determined based on the requirement that at least 80% of the students achieve individual mastery.

Learning outcome retention was assessed using a second posttest administered 14 days after the initial posttest. Retention was then calculated using the following formula:

$$(\text{R}) = \frac{\text{Posttest 2}}{\text{Posttest 1}} \times 100\%$$

Based on this formula, if the R value is ≤ 60%, the retention rate is categorized as low. If the R value falls within the range of 60% to 70%, it is categorized as medium, while an R value greater than 70% is categorized as high retention [25].

The instruments used in this study included pretest and posttest sheets, as well as a student learning motivation questionnaire. The pretest and posttest instruments had been previously validated and were therefore appropriate for use in data collection. The motivation measured in this study was based on the ARCS model developed by Keller [26] which consists of four components: Attention, Relevance, Confidence, and Satisfaction.

Results and Discussion

The data in this study consisted of the results of a student learning motivation questionnaire, as well as pretest and posttest data. The hypothesis of this study stated that implementing the Chem Piano game as a learning medium would increase students' motivation and retention of learning outcomes. The Chem Piano game had previously been declared valid by three expert validators in the field of chemistry.

The analysis of the student learning motivation questionnaire data was based on a Likert scale consisting of

both positive and negative statements. The following table presents the results of the student learning motivation questionnaire before and after the use of the Chem Piano learning media.

Table 3. Results of the Student Learning Motivation Questionnaire

ARCS Criteria	Objective	Before Using Percentage/Criteria	After Using Percentage/Criteria
Attention	Knowing students' attention or focus	48% /Low	87% /Very High
Relevance	Knowing the enthusiasm of students in understanding the material on the periodic system of elements	47% / Low	88.5% /Very High
Confidence	To find out students' self-confidence in understanding the material on the periodic system of elements	49% /Low	84.5% /Very High
Satisfaction	Knowing students' feelings	46% / Low	82.5% /Fairly High

The ARCS Attention criterion, with the objective of "knowing students' attention or focus," showed an initial average score of 48%, categorized as low, while the average score after using the media increased to 87%, categorized as very high. The Attention component in the ARCS model emphasizes that to initiate the learning motivation process, students must first be interested in and pay attention to the learning material. As attention increases, students become more prepared and receptive to the material, more willing to respond to challenges, and participate more actively. This also reduces distractions from other activities and improves learning quality. Thus, the increase in the Attention score indicates that the Chem Piano media can stimulate optimal and motivated learning conditions, in accordance with learning motivation theory.

The ARCS Relevance criterion, with the objective of "knowing students' enthusiasm," attained an initial average score of 47%, categorized as low, and increased to 88.5% after using the media, categorized as very high. This aligns with Keller's findings [26], which state that relevance can be increased through instructional presentations that connect the material to students' real-life experiences, academic goals, or future aspirations. Therefore, it can be concluded that the use of Chem Piano significantly enhanced the relevance of chemistry learning for students, including their enthusiasm, engagement, and awareness of the importance of effort in the learning process.

The ARCS Confidence criterion, with the objective of "knowing students' enthusiasm," recorded an initial average score of 49%, categorized as low, and improved to 84.5% after using the media, categorized as very high. This improvement indicates that Chem Piano contributes to building students' confidence in their ability to master chemistry content, particularly the periodic table of elements. This is consistent with Keller's opinion [26], which states that students' self-confidence can increase when they are given opportunities to learn through enjoyable experiences, receive positive feedback, and feel capable of controlling their learning outcomes.

The ARCS Satisfaction criterion, with the objective of "knowing students' enthusiasm," initially scored 46%, categorized as low, and increased to 82.5% after using the media, categorized as high. This demonstrates that the use of Chem Piano provides a satisfying learning experience, increases students' desire to continue learning, and supports their intrinsic motivation. These findings align with Keller's theory [26], which states that student satisfaction can be enhanced through learning experiences that offer positive feedback, rewards, and the achievement of learning goals.

Based on the results of the learning-motivation questionnaire administered after using the media, the outcomes were categorized as very high, with percentage scores ranging from 82.5% to 88.5%. This indicates that students' learning motivation after using the media is classified as very high, as the motivation score reached ≥ 69%. The Chem Piano game is therefore considered successful in increasing student motivation for learning. The findings of this study are consistent with research conducted by Ulimaz et al. [20] who stated that game-based learning has significant potential to enhance student motivation. They also align with research by Zuliyani dan Marlina [12] who found that learning media has a substantial effect on student learning motivation at SMKN 71 Jakarta, showing that the influence of learning media on motivation is relatively high.

The following figure presents the results of the increase in student learning motivation.

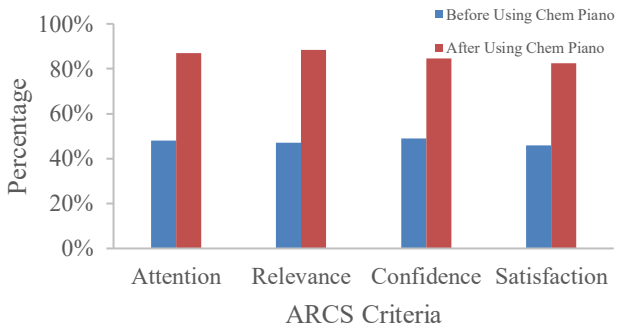

Figure 2. Increasing Student Learning Motivation

When comparing the results before and after the use of the media, the average level of student learning motivation increased.

Next, the students' pretest and posttest scores were analyzed to determine whether there was an improvement in their learning outcomes. After obtaining the pretest and posttest scores, a paired sample t-test was conducted. Before performing the paired sample t-test, a normality test was conducted to determine whether the data were normally distributed. The Shapiro–Wilk test was used because the sample size was less than 50 ($n < 50$). The following are the results of the normality test.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.145	20	.200*	.920	20	.101
Posttest	.365	20	.000	.721	20	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 3. Shapiro Wilk Normality Test Results

Based on the results of the normality test, it was found that the data were not normally distributed; therefore, the Paired Sample t-test could not be used. As a result, an alternative test was conducted using the Wilcoxon Signed Ranks Test. The Wilcoxon Signed Ranks Test is a nonparametric statistical technique used to compare two paired data sets and is applied when the normality assumption required for the Paired Sample t-Test is not met[24].

This test was used to evaluate the significance of the improvement between pretest and posttest scores, thereby determining the extent of the increase in student learning outcomes.

H_0 : μ posttest ≤ μ pretest, posttest score is less than or equal to pretest score.

H_a: μ posttest > μ pretest, the posttest score is greater than the pretest score.

The conclusion of the hypothesis test is determined based on the significance value, as follows:

If Sig < 0,05, then H_0 is rejected and H_a is accepted.

If Sig > 0,05, then H_0 is accepted and H_a is rejected.

Therefore, the use of learning media can be considered effective in improving student learning outcomes if the significance value is less than 0.05.

The following presents the results of the Wilcoxon Signed Ranks Test.

Table 4. Wilcoxon Signed Ranks Test Result

Test Statistics[a]	
	Posttest - Pretest
Z	-3.934[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the analysis using the Wilcoxon test, a significance value of 0.00 was obtained, which is lower than the α value of 0.05. This indicates that H_0 is rejected and H_a is accepted. This means that the posttest score is higher than the pretest score, showing an increase between the pretest and posttest results. Therefore, the use of the learning media can be considered effective in improving student learning outcomes if the significance value is less than 0.05.

Next, the pretest and posttest scores were analyzed to determine each student's individual achievement. These scores were adjusted according to the Minimum Completion Criteria MCC) established by the school where the study was conducted. Table 7 presents the individual completion scores for the pretest and posttest.

Next, the classical completion rate of the research class was determined. A class is considered to have achieved classical completion if ≥80% of students meet the Minimum Completion Criteria (MCC) set by the school, which is ≥78. Based on Table 7 above, it can be seen that the trial class met the classical completion criteria, with 90% of students achieving the required standard (Table 5). This result is consistent with research conducted by Lutfi et al. [27], which states that the use of games as a learning medium improves the completion rate of learning outcomes and increases students' motivation to learn actively.

Next, a comparison of student retention was conducted by comparing the posttest scores with the delayed test scores administered 14 days after the posttest (Table 6).

Table 5. Individual Student Completion Results

Name	Pretest	Completeness	Posttest	Completeness
AMM	20	Not Completed	100	Completed
APA	40	Not Completed	80	Completed
ARN	30	Not Completed	100	Completed
AJE	10	Not Completed	100	Completed
DDH	50	Not Completed	100	Completed
EPA	10	Not Completed	100	Completed
FAD	60	Not Completed	80	Completed
FH	40	Not Completed	70	Not Completed
HKC	30	Not Completed	100	Completed
IWH	50	Not Completed	100	Completed
LSW	10	Not Completed	100	Completed
MNA	40	Not Completed	80	Completed
MGA	20	Not Completed	100	Completed
N	20	Not Completed	70	Not Completed
NQI	60	Not Completed	80	Completed
RDP	30	Not Completed	100	Completed
RAR	50	Not Completed	100	Completed
SAR	30	Not Completed	100	Completed
SSJ	20	Not Completed	90	Completed
ZDR	60	Not Completed	80	Completed

Table 6. Comparison Results of Posttest 1 and Posttest 2 Scores

Score	Number of Students	Average Score	Retention Value
Posttest 1	20	91.5	92.3%
Posttest 2	20	84.5	

The results of the student retention analysis showed a score of 92.3%, indicating a high level of retention of student learning outcomes. Furthermore, three students obtained higher posttest 2 scores than they did on posttest 1. This may have occurred because they were interested in playing Chem Piano outside of class. This finding aligns with research by Lutfi et al. [25], which showed that increased retention of learning outcomes can be attributed to students' continued engagement with game-based media after the learning activity is completed.

This improvement suggests that the knowledge gained through the learning activity can be retained by students for a certain period. These results demonstrate that the Chem Piano learning media is not only effective in improving initial understanding but also helps students retain learned concepts and encourages them to revisit the material through gameplay after the lesson. According to Sudjana [28], learning success is measured not only by immediate improvements in learning outcomes but also by students' ability to retain knowledge in the long term.

These findings are consistent with research conducted by Safitri and Sa'dudin [10], which shows that the use of visual media attracts students' attention and facilitates better understanding of the material. The use of technology-based media has a significant impact on the learning process. In addition, the results are also in line with research by Hemaliawati [19] in Vocational High Schools (SMK), which demonstrated that the integration of educational games into science learning significantly increases student engagement and motivation through elements of competition, rewards, and a positive learning atmosphere, while also improving students' conceptual understanding. This improvement indicates that game-based learning not only creates an enjoyable learning environment but also effectively supports cognitive mastery of the material.

Thus, the results of this study reinforce previous findings that innovative media, such as Chem Piano, can serve as an effective alternative in chemistry learning, particularly for abstract topics like the Periodic Table of Elements. However, the findings of this study should be interpreted with consideration of several limitations. This study involved a relatively small sample size and did not include a control group for comparison; therefore, the generalizability of the results remains limited. Accordingly, future research is recommended to involve a larger number of participants and employ a more robust experimental design to examine the effectiveness of Chem Piano more comprehensively and in greater depth.

Conclusion

Based on the analysis and discussion results, it can be concluded that Chem Piano is effective in increasing students' learning motivation. This is evident from the results of the student motivation questionnaire, which initially showed a low motivation category with a percentage range of 46%–49%, and then increased to 82.5%–88.5% after the use of Chem Piano, indicating an improvement from the low to the very high category. Additionally, student learning outcomes demonstrated a significant increase, as indicated by the pretest and posttest results, with a Wilcoxon Signed Rank Test significance value of 0.00. Individual student mastery was achieved according to the Minimum Mastery Criteria, allowing classical mastery in posttest 1 to be declared achieved with a percentage of 90%. The retention of student learning outcomes was 92.3%, which falls into the high category. These findings have important implications for learning theory, particularly constructivism and game-based learning, which emphasize the importance of active student engagement in constructing knowledge through interactive and enjoyable learning experiences. The use of Chem Piano has been shown to facilitate such engagement, thereby supporting deeper conceptual understanding and improved learning retention. Furthermore, the results of this study offer practical implications for educators, indicating that game-based learning media, such as Chem Piano, can serve as an innovative alternative in chemistry instruction, particularly for abstract topics like the Periodic Table of Elements. For future research, it is recommended that studies involve a larger sample size, include a control group, and examine the impact of Chem Piano on other learning outcomes, such as critical thinking, creativity, or problem-solving skills, to enable a more comprehensive evaluation of the effectiveness of this media.

Author's Contribution

E. N. Salfiah: responsible for the research implementation, data collection, and media development. A. Lutfi: validation and final manuscript.

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