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Research Article

Catch That Element: Development of a Web-based Educational Game on the Periodic Table of Elements for Grade 8 Learners

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Abstract. The Periodic Table of Elements in Grade 8 Science is often perceived by learners as abstract, content-heavy, and difficult to master using traditional instructional approaches. To address these challenges, this study aimed to develop a web-based educational game titled Catch That Element. Moreover, this study also determines the teacher evaluation, students' achievement, and students' perceptions towards the developed material. The study employed a developmental and quasi-experimental research design. The game was developed using the ADDIE model and incorporated interactive challenges, immediate feedback, scoring mechanisms, and increasing levels of difficulty to reinforce students' knowledge of element names, symbols, atomic numbers, and mass. The participants included 50 Grade 8 students for the implementation of the game, and eight Junior High School Science teachers for the evaluation of the developed game. Statistical analysis also revealed a significant difference between the pretest and posttest scores (normalized gain = 0.89) providing that the instructional material enhances students' understanding. Moreover, the game gained a rating of "very satisfactory" (mean = 3.72) in the teacher evaluation of content, instructional, and technical quality, indicating that the game meets curriculum standards and supports effective learning. Lastly, the students' perception of the developed game was "very high" (mean = 3.56) in interest/enjoyment, value/usefulness, and perceived choice. These results show that the game is engaging, relevant, promotes autonomous learning, and fosters positive affective and motivational outcomes. Overall, the results highlight the potential of the material in enhancing both cognitive and affective learning outcomes for teaching abstract and content-heavy concepts.

Keywords: Periodic Table of Elements; Student Achievement; Student Perceptions; Teacher Evaluation; Web-Based Educational Game

INTRODUCTION

Web-based educational games have been widely recognized as effective instructional tools that enhance student participation, motivation, and engagement, particularly in mastering complex and abstract subjects. Smiderle et al. (2020) emphasized that the integration of game elements into instructional activities increases learner engagement and sustains participation over time. Similarly, Wijaya et al. (2025) reported that students who learn through game-based approaches demonstrate higher levels of recall compared to those who rely on traditional memorization techniques. These findings suggest that embedding learning content within interactive digital games can significantly improve learning outcomes.

The Periodic Table of Elements (PTE) is a fundamental component of secondary chemistry education. It systematically organizes known elements according to atomic number, electron configuration, and recurring periodic properties, serving both as a reference tool and a conceptual framework for understanding chemical behavior. As a core component of the Science, Technology, Engineering, and Mathematics (STEM) curriculum, the PTE enables learners to identify patterns, predict element properties, and establish connections across various scientific concepts. According to Vermehren et al. (2025), the STEM field includes abstraction such as reduction, pattern recognition, generalization, interiorization, encapsulation, and coordination, which are supported by the structured organization of the PTE. In the Revised K-10 Curriculum of the Department of Education, competencies related to the PTE start in Grade 8, including "the current structure of the atom includes subatomic particles, their symbol, mass, charge, and location" and "the periodic table is a useful tool to determine the chemical properties of elements" (DepEd, 2023).

Despite its importance, many students find the PTE difficult to learn, particularly in recalling element names, symbols, and properties. Yang and Choi (2023) noted that a substantial number of secondary students struggle with memorizing the periodic table and applying its patterns meaningfully. Traditional instruction of the PTE often relies heavily on textbooks and rote memorization, which may not adequately address diverse learning styles. Visual and kinesthetic learners, in particular, benefit from interactive and hands-on learning experiences. Chowdhury (2022) observed that misconceptions regarding element arrangement and properties frequently arise when students are not provided with sufficient opportunities for active engagement.

In response to these instructional challenges, web-based educational games have emerged as an effective pedagogical approach. Digital or web-based educational games are digital learning tools that integrate instructional content with game mechanics and are accessed through internet-enabled devices without the need for specialized software installation (Gui et al, 2023). These games offer several advantages, including ease of access, platform independence, immediate feedback, and the ability to support self-paced and exploratory learning (Bakhsh et al., 2022). More importantly, these features directly address the challenges of memorization and recall in learning the PTE. For instance, immediate feedback helps students correct errors in identifying element names and symbols in real time, while repetitive gameplay mechanics provide continuous exposure to key information, reinforcing memory retention. The use of timed challenges, scoring systems, and progressive levels further encourages active recall, which is essential for mastering symbol and name relationships and other fundamental periodic concepts. Moreover, these instructional materials also enhance student motivation, engagement, and enjoyment (Saleem et al., 2021).

Web-based educational games are grounded in a blend of behaviorist (rewards/feedback), cognitive (scaffolding/feedback), constructivist (active problem-solving), social cognitive (self-efficacy/social modeling), and motivational frameworks (Khaldi et al., 2023; Li et al., 2024; Nadi-Ravandi & Batooli, 2022; Sailer & Homner, 2019). These theoretical perspectives collectively explain how game-based environments facilitate learning by reinforcing correct responses through immediate feedback, structuring information into manageable and progressively challenging tasks, and engaging learners in meaningful interactions that promote knowledge construction. Moreover, these games support the development of self-efficacy as learners experience repeated success and observe modeled responses within the game environment, which can enhance confidence in performing academic tasks. Game elements such as goals, rewards, autonomy, and progression foster intrinsic motivation and sustained engagement, which promote active participation, persistence, and positive learning behaviors, making them effective tools for teaching complex and abstract concepts.

Web-based and digital chemistry games are increasingly used to make concepts more engaging, support remote teaching, and improve motivation and learning. Research consistently demonstrates that web-based educational games can enhance student motivation, engagement, and conceptual understanding across various chemistry topics and educational levels (Da Silva Júnior et al., 2022; De Boni et al., 2024; Irmita et al., 2025). Although previous studies have established the benefits of game-based learning in science education, there remains a limited number of accessible web-based tools specifically designed to comprehensively support learning of the Periodic Table of Elements. Existing educational games often focus on a limited subset of elements, lack alignment with formal classroom instruction, or require software downloads that reduce accessibility. Hassan and Shafiq (2023) emphasized that while game integration in chemistry instruction improves student interest and academic performance, there is still a need for well-designed, web-based educational games that effectively support mastery of the PTE.

RESEARCH QUESTIONS

It is in this context that this study aims to develop a web-based educational game titled Catch That Element. Moreover, this study also determines the teacher evaluation, students' achievement, and students' perceptions towards the developed web-based educational game. Specifically, it aims to answer the following questions:

1. How will the web-based educational game on the Periodic Table of Elements be developed?
2. What is the normalized gain in students' pretest and posttest scores on the Periodic Table of Elements when exposed to the developed web-based educational game as a stand-alone material?
3. Is there a significant difference between the pretest and posttest scores of the students when exposed to the developed web-based educational game as a stand-alone material?
4. What is the teachers' evaluation of the developed web-based educational game on the Periodic Table of Elements in terms of content, instructional, and technical quality?
5. What are the perceptions of the student participants towards the developed web-based educational game on the Periodic Table of Elements in terms of interest/enjoyment, value/usefulness, and perceived choice?

METHODOLOGY

The quantitative study employed a development and quasi-experimental research design. This study was conducted in a Level 3 PAASCU-accredited basic education unit of a private university in Ozamiz City, Misamis Occidental, Philippines, in the second quarter of the academic year 2025-2026.

Participants

During the implementation of the activity, a total of 50 Grade 8 students, of the same section, currently enrolled in the identified school, were utilized as the main research participants using purposive sampling. These students have no prior knowledge of the PTE, as the subject matter is first introduced at this grade level in accordance with the national curriculum. Likewise, the study used eight Junior High School Science teachers from the aforementioned school in the evaluation of the developed web-based educational game. The teacher-participants were either graduates of, or currently enrolled in, a Master's program in Science Education, and its related fields, and had more than five years of teaching experience.

Research Tools

To evaluate the developed game, a one-group pretest–posttest design was utilized. Prior to exposure to the web-based educational game, the student participants were administered a researcher-made test questionnaire designed to measure their prior knowledge of the Periodic Table of Elements, including element names, symbols, and atomic numbers. The 15-item questionnaire was validated by two content experts, both university-level chemistry faculty members holding master's degrees in the field, pilot-tested and yielded a Cronbach's alpha reliability coefficient of 0.89. The test questionnaire was used both as a pre and post-test instruments for student achievement.

After the pretest, the students were given access to the developed web-based educational game, which was implemented as a stand-alone learning material. Students were allowed to interact with the game within a specified period, during which no direct instructional intervention was provided by the teacher. Upon completion of the game-based activity, the same achievement test was administered as a posttest to measure learning gains attributable to the material.

The teacher evaluation of the developed web-based educational game was done using a questionnaire adapted from the Department of Education (DepEd) Learning Resources Management and Development System's evaluation rating sheet for non-print resources. The questionnaire consists of three criteria: content, instructional, and technical quality. Content quality refers to the material aligning with the DepEd Learning Competencies and presenting accurate, up-to-date content organized logically and coherently. Moreover, the criterion looks into promoting critical thinking and real-life application while remaining free from cultural or social bias. Lastly, it also identifies the language as appropriate for the target learners, and the content reinforces learning objectives while fostering positive values. On the other hand, instructional quality assesses that the material clearly defines its purpose and effectively achieves its learning objectives through engaging and appropriately challenging activities. The criterion identifies the usage of visuals and multimedia elements to support instruction and encourages creativity, active participation, and self-paced learning. Feedback is timely and constructive, and the lessons build on learners' prior knowledge and experiences. Lastly, technical quality evaluates the material being technically sound, with clear audio narration, synchronized visuals, and well-designed screen displays that enhance comprehension. It also recognizes the use of graphics and multimedia elements that are accurate, engaging, and easy to interpret, while navigation is intuitive and supports independent use.

In addition, an activity perception questionnaire was utilized to identify the students' perceptions towards the developed web-based educational game adapted from Palisbo et al. (2022), which is categorized into three subscales: interest or enjoyment, value or usefulness, and perceived choice. The first criterion of the tool assesses the interest or enjoyment that participants experience during the implementation of the developed web-based educational game. This criterion is a direct tool for identifying self-reported intrinsic motivation. The next criterion evaluates the perceived value or usefulness of the activity. This criterion aims to understand whether participants find the activity meaningful or beneficial in some way. Lastly, the third criterion explores the participants' sense of autonomy and control over the activity. This criterion assesses whether individuals feel that they have a choice in participating and if they perceive the activity as voluntary or imposed.

Data Collection

The development of the web-based educational game on PTE followed the ADDIE (Analysis, Design, Develop, Implement, and Evaluate) instructional design model, as presented in Figure 1.

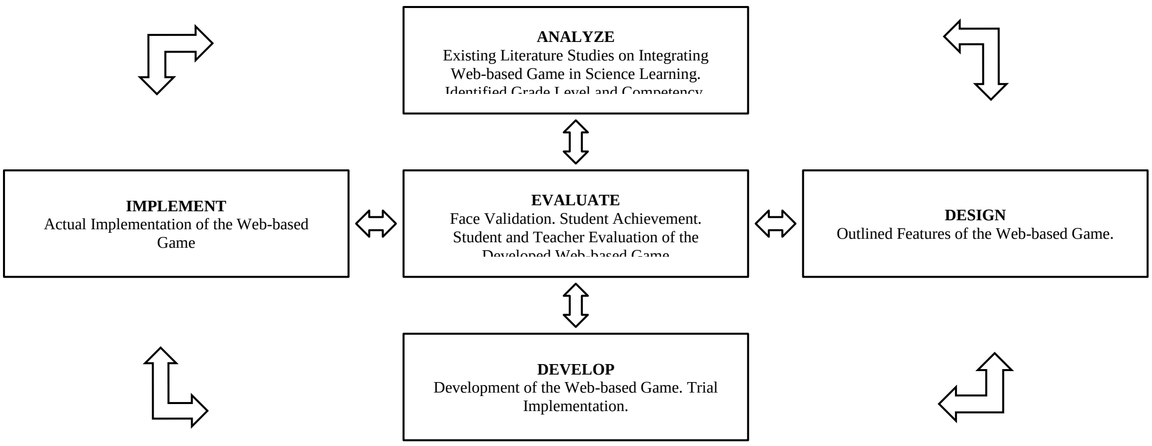

Figure 1: Development of the Web-based Educational Game on the Periodic Table of Elements using the ADDIE Model

The first phase involves the analysis of the existing literature and studies on the integration of web-based games in science learning and PTE. Afterwards, the intended grade level and learning competency are specified, ensuring alignment with curricular standards and learner needs. This phase provided the conceptual and pedagogical basis for the succeeding stages of development. In the design phase, the essential features and structure of the web-based educational game were outlined based on the results of the analysis. Instructional objectives, game mechanics, content sequencing, and assessment strategies were carefully planned to support meaningful learning experiences and student engagement.

The development phase involved the actual creation of the web-based educational game using various programming languages, followed by a trial implementation. This trial phase aimed to identify potential technical and pedagogical issues prior to full deployment and pilot testing of the test questionnaire. At this stage, a separate Grade 8 section from the same school, with the same number of students as the main research participants, was selected. Feedback gathered during this phase was carefully considered to refine and improve the game.

In the implementation phase, the finalized version of the web-based educational game was utilized in an actual learning environment as a stand-alone instructional material. Each student was asked to bring devices such as smartphones, tablets, and laptops to access the game. A total of three science class periods were allotted for the conduct of the study. The first session was used for the orientation and administration of the pre-test, the second for the gameplay, and the third for the administration of the post-test. Finally, the evaluation phase assessed the effectiveness of the developed web-based educational game through face validation by several computer and instructional experts, analysis of student achievement, and student and teacher evaluations. Face validation and teacher evaluation were conducted before the actual implementation of the developed game. Meanwhile, the post-test, and students' activity perception questionnaire was administered after the implementation of the game.

Data Analysis

The improvement in students' scores from pre-test to post-test was measured using the normalized gain (g). The g value was calculated as the ratio of the difference between the average post-test and pre-test scores to the difference between the maximum possible score and the average pre-test score (Hake, 1998, as cited by McKagan et al., 2022). Descriptive statistics (mean and standard deviation) were used to present the data obtained from the teacher evaluation and student perception questionnaires. A paired-samples t-test was employed to identify the significant difference that existed between the pretest and posttest scores of the students. The confidence level used for hypothesis testing is set at 95%. All descriptive and inferential statistical analyses were performed using Jamovi statistical software.

Ethical Considerations

This study was subjected to several ethical considerations. Initially, the paper was presented to the school administrators and the university's Research Ethics Committee so that the study could be conducted. Upon approval, the researchers informed the teacher and student respondents about the objectives and purpose of the study and asked for their participation in the research through a signed consent and assent form. The respondents were assured that the results of the administered questionnaire are kept confidential and used only for research purposes exclusive to this study, as provided by the Data Privacy Act of 2012.

RESULTS AND DISCUSSION

Development of the Web-based Educational Game on the Periodic Table of Elements

The development of the web-based educational game was guided not only by technical and visual design considerations but also by established instructional and learning theories to ensure its pedagogical effectiveness. The game design was anchored on a combination of behaviorist, cognitive, constructivist, and motivational learning frameworks. From a behaviorist perspective, the incorporation of rewards, scoring systems, and immediate feedback reinforces correct responses and strengthens memory retention. Cognitively, the game employs scaffolding through progressively challenging levels, allowing learners to build on prior knowledge while minimizing cognitive overload. From a constructivist standpoint, the interactive nature of the game promotes active engagement, enabling learners to construct understanding through repeated interaction with element names, symbols, and properties. Furthermore, motivational principles, particularly those related to intrinsic motivation and self-efficacy, are embedded through goal-oriented tasks, autonomy in level selection, and visible progress indicators, which sustain learner engagement throughout the activity.

The web-based educational game underwent multiple redesigns to fully encapsulate the game mechanics, which is to create a game that captures the element properties. The web game was created using three programming languages: GDscript; HyperTest Markup Language (HTML); and Cascading Style Sheet (CSS).

GDscript is a hybrid programming language that uses Python-inspired code made for game development from the game engine Godot, enabling the game to be completely open-sourced, which allows the web game to be uploaded to web browsers for free without any charges. On the other hand, HTML was used for the structure of the open menu interface, and CSS was optimized for design and adjustments of the website of the game. The game's coding utilized JSON files to ensure that its features are properly organized and not intermingled. Lastly, the game is programmed to get progressively harder, where the properties get faster and harder to catch, encouraging active thinking and sustained cognitive engagement.

A key component of the game's instructional design is its feedback mechanism, which extends beyond simple score reporting. While immediate feedback is provided at the end of each level through the display of correct and incorrect responses, the system is also designed to identify student misconceptions based on recurring errors. For instance, when a learner repeatedly selects incorrect element-symbol pairings or mismatches atomic numbers with element names, the system flags these patterns and presents targeted corrective feedback. This feedback includes not only the correct answer but also brief explanatory statements that clarify the relationship between the concept and the correct response (e.g., explaining why a specific symbol corresponds to a given element or how atomic numbers are uniquely assigned).

Figure 1 illustrates the open menu user interface of the web-based educational game. Meanwhile, Figure 2 presents the open-menu user interface of the developed web-based educational game. Upon launching the game, users are directed to the open menu, which provides a description of the game along with detailed instructions and the DepEd's learning competencies the game that the game is designed to address.

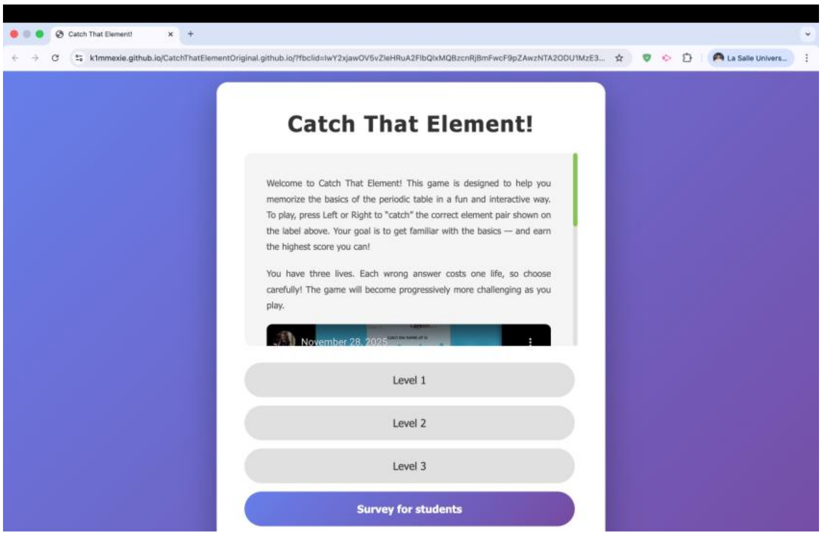

Figure 2: Open Menu User Interface of the Developed Web-Based Educational Game

The interface allows users to freely navigate among the three game levels, enabling them to select and interact with specific content. Moreover, each level is supported by narration of the instructions and mechanics to guide students through the game. Sound effects and background audio are also incorporated to enhance engagement, sustain attention, and create an immersive learning experience. Lastly, at the end of each level, students are provided with feedback showing their correct and incorrect responses, accompanied by explanations that aim to reinforce understanding and support learning.

Figure 3 displays the interface of the first level of the developed web-based educational game.

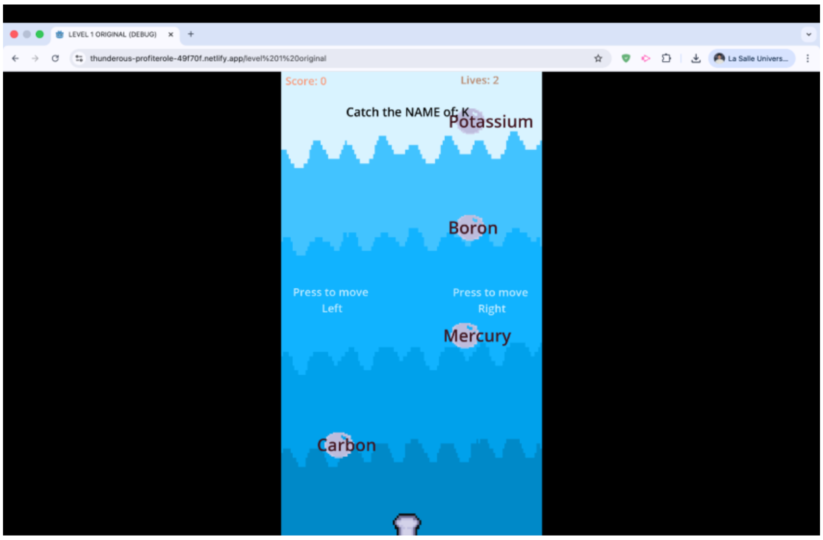

Figure 3: Interface of the First Level of the Developed Web-Based Educational Game

The primary objective of Level One is to facilitate the identification of chemical element symbols and their corresponding names. At this stage, gameplay centers on a dynamic "target label" positioned at the top of the interface, which serves as the main instructional directive. This label provides real-time prompts indicating the specific element name or symbol that the player must identify and "catch" from the items appearing on the screen. Through repeated and interactive gameplay, this level familiarizes players with element nomenclature and symbol recognition. At the end of each level, immediate feedback is given by displaying the scores and the correct answer given.

At this stage, gameplay centers on a dynamic "target label" positioned at the top of the interface, which serves as the main instructional directive. This label provides real-time prompts indicating the specific element name or symbol that the player must identify and "catch" from the items appearing on the screen. Through repeated and interactive gameplay, this level familiarizes players with element nomenclature and symbol recognition. At the end of each level, immediate feedback is given by displaying the scores and the correct answer given.

Meanwhile, Figure 4 presents the interface of the second level of the developed web-based educational game. Level Two introduces a higher degree of complexity by building upon the fundamental identification skills developed in the preceding stage.

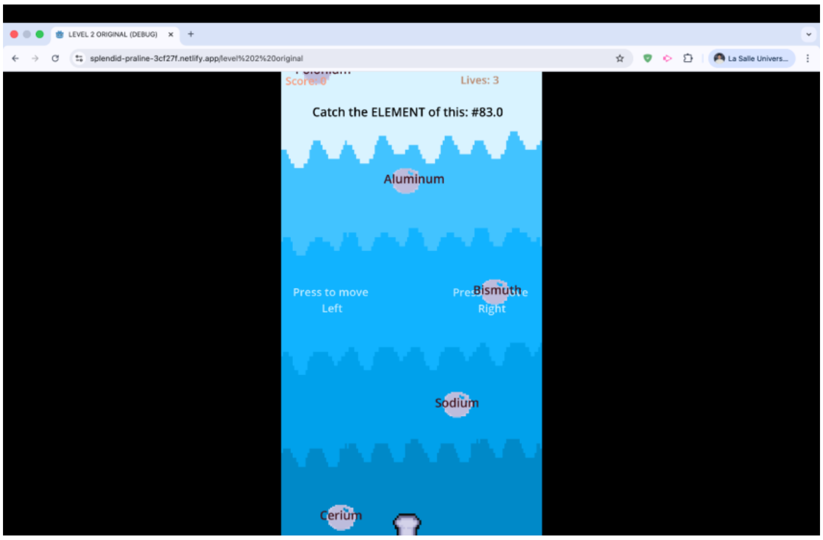

Figure 4: Interface of the Second Level of the Developed Web-Based Educational Game

Unlike Level One, which emphasized the relationship between element names and symbols, this level utilizes the same gameplay mechanics but shifts the focus to atomic numbers and element names. This level was designed to familiarize users with the atomic numbers associated with each element. While the gameplay remains centered on the dynamic "target label," the instructional prompts now assess numerical recall. Specifically, the target label may display a given atomic number, requiring the player to identify and "catch" the corresponding element name or symbol as it appears on the screen.

Lastly, Figure 5 exhibits the interface of the third level of the developed web-based educational game. The final stage of the web-game, level three, focuses on element name and atomic mass identification.

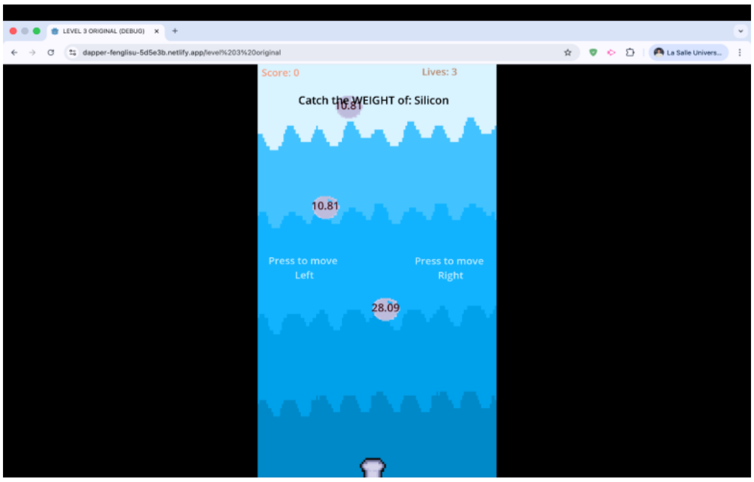

Figure 5: Interface of the Third Level of the Developed Web-Based Educational Game

By the time students reach this level, players have already seen the names and symbols many times in the first and second levels. This makes it easier for users to handle the new, harder information about atomic mass. By combining the "target label" with a timer and a scoring system, the game turns a difficult memorization task into a fast-paced challenge. Playing this level will allow the player to have an understanding of the element's basic details.

Performance Level of the Students on the Periodic Table of Elements when Exposed to the Developed Web-based Educational Game as a Stand-alone Material

Table 1 presents the performance level of Grade 8 students on the Periodic Table of Elements in the pretest and posttest after exposure to the developed web-based educational game as a stand-alone instructional material.

Table 1: Performance Level of the Students on the Periodic Table of Elements in the Pretest and Posttest when Exposed to the Developed Web-based Educational Game as a Stand-alone Material

Section	Pretest		Posttest		Normalized Gain (g)
	Average	SD	Average	SD	
Grade 8	8.79	0.82	14.37	0.81	0.90

Note. $g < 0.30$: low gain; $0.30 \leq g < 0.70$: medium gain; $g \geq 0.70$: high gain

The pretest results show a mean score of 8.79 with a standard deviation of 0.82. After the intervention, the posttest mean score increased to 14.37 with a standard deviation of 0.81. Moreover, the normalized gain of 0.90 indicates a high level of learning gain, suggesting that the web-based educational game was highly effective in enhancing students' academic performance.

In the other hand, Table 2 presents the statistical comparison between the pretest and posttest scores of students following their exposure to the developed web-based educational game. The results report that the majority of the item tests, 11 out of 15, show a statistically significant difference and improvement between the pre-test and post-test scores.

Analysis of student responses revealed that learners performed particularly well on items related to element name to symbol recognition and basic identification tasks. This improvement can be attributed to the design of the first level of the game, which repeatedly exposed students to matching tasks involving element names and symbols through fast-paced and interactive gameplay. However, relatively lower performance was observed in items that required higher-level understanding, particularly those involving atomic mass and more complex associations between multiple element properties. The observed misconceptions may stem from cognitive overload during the later stages of the game, where time pressure and increased difficulty require simultaneous processing of multiple attributes.

Table 2: Parametric t-Test Results on Students' Achievement when Exposed to the Developed Web-based Educational Game as a Stand-alone Material

Item	Statistic	df	p Value	Verbal Interpretation
1	-1.98	49.0	0.057	Not Statistically Significant
2	-1.00	49.0	0.326	Not Statistically Significant
3	-2.77	49.0	0.010	Statistically Significant
4	-2.12	49.0	0.043	Statistically Significant
5	-8.57	49.0	<0.001	Statistically Significant
6	-1.68	49.0	0.103	Not Statistically Significant
7	-2.98	49.0	0.006	Statistically Significant
8	-1.36	49.0	0.184	Not Statistically Significant
9	-3.92	49.0	<0.001	Statistically Significant
10	-4.14	49.0	<0.001	Statistically Significant
11	-2.82	49.0	0.009	Statistically Significant
12	-6.30	49.0	<0.001	Statistically Significant
13	-7.29	49.0	<0.001	Statistically Significant
14	-8.57	49.0	<0.001	Statistically Significant
15	-9.38	49.0	<0.001	Statistically Significant

To address these challenges, enhancements to the game design may be considered. Incorporating more explicit and detailed explanatory feedback, particularly for complex items, could help clarify relationships among atomic mass, atomic number, and element identity. Additionally, integrating reinforcement activities or mini-review segments before advancing to higher levels may support the consolidation of prior knowledge. Slowing down the progression or providing optional practice modes for more difficult concepts may also help reduce cognitive load and improve conceptual understanding.

These findings are consistent with the results reported by Hassan and Shafiq (2023), who emphasized that game-based learning environments significantly enhance students' conceptual understanding of scientific concepts by encouraging active participation and reinforcing learning through repetition and problem-solving. Similarly, Angub et al. (2025) reported that digital games in science education promote improved academic performance and deeper academic engagement by shifting learners from passive information reception to active knowledge construction. In the game, the interactive and repetitive gameplay mechanics enhanced retention through active engagement that allows students to quickly identify and select correct answers, fostering sustained attention and repeated exposure to key concepts. Moreover, the integration of audio narration, sound effects, and visual cues contributed to the multisensory experience of the students. Covaci et al. (2018) detailed that multisensory enhancements in games-based learning improve learning experiences by facilitating knowledge acquisition and content understanding.

Also, Coello et al. (2025) suggested that interactive games fostered autonomy and intrinsic motivation and moderately improved performance. The game's self-paced navigation and learner control may promote autonomy and intrinsic motivation. Allowing students to select levels and progress at their own pace supports self-directed learning and fosters a sense of ownership over the learning process. Yang and Choi (2023) also demonstrated that digital educational games effectively support learners' understanding by providing immediate feedback, progressive structure, and contextualized learning experiences. The developed web-based educational game incorporates immediate feedback at the end of each level, which played a crucial role in reinforcing learning. By displaying correct and incorrect responses along with explanations, the game allowed students to correct misconceptions in real time. Moreover, the progressive level structure of the game enabled scaffolded learning. The sequencing from element name–symbol recognition to atomic number and atomic mass identification allowed students to build foundational knowledge before engaging with more complex associations.

Furthermore, Ballesteros et al. (2025) emphasized that intervention materials intentionally structured around the Periodic Table significantly improve comprehension among Grade 8 students. Their findings support the notion that learning tools explicitly aligned with curriculum standards and cognitive progression are more effective than generalized instructional approaches. The high and evenly distributed learning gains observed in this study suggest that the structured design of the web-based educational game, progressing from basic identification to more complex associations, successfully scaffolded student learning.

This finding suggests that the web-based educational game effectively enhanced students' understanding, as evidenced by the increase in student achievement across most of the assessed competencies related to the PTE. Overall, the results indicate that the developed web-based educational game can serve as an effective instructional material for enhancing students' understanding of the Periodic Table of Elements. The integration of structured content, interactive gameplay, and immediate feedback appears to mitigate common learning difficulties associated with memorization-heavy topics, thereby supporting both engagement and conceptual mastery. These findings underscore the potential of web-based educational games as viable stand-alone tools in secondary science instruction.

Teachers' Evaluation of the Developed Web-based Educational Game on the Periodic Table of Elements

Table 3 shows the teachers' evaluation of the developed web-based educational game on the Periodic Table of Elements.

Table 3: Teachers' Evaluation of the Developed Web-based Educational Game on the Periodic Table of Elements

Criterion	Mean	SD	Verbal Interpretation
Content Quality	3.65	0.48	Very Satisfactory
Instructional Quality	3.73	0.45	Very Satisfactory
Technical Quality	3.78	0.43	Very Satisfactory
Overall	**3.72**	**0.45**	**Very Satisfactory**

Note. 1.00-1.75: Very Low, 1.76-2.50: Low, 2.51-3.25: High, 3.26-4.00: Very High

The teacher evaluators affirmed that the game is aligned with DepEd learning competencies, conceptually accurate, logically organized, and appropriate for the learners' level. This positive evaluation can be attributed to the deliberate alignment of game content with curriculum standards and learning objectives during the design phase. Ensuring curricular alignment is essential because it guarantees that the instructional material supports mandated learning outcomes and reinforces classroom instruction rather than functioning as an isolated activity.

The logical sequencing of concepts and clarity of language further support comprehension, particularly for Grade 8 learners encountering abstract chemical concepts for the first time. Although the rating for real-life relevance was slightly lower, this highlights an opportunity to incorporate contextual applications of elements to strengthen meaningful learning and real-world connections, an important component in promoting scientific literacy.

Moreover, the results also indicate that the game clearly defines learning objectives, achieves its intended purpose, and maintains an appropriate level of difficulty for the target users as perceived by the teacher evaluators. Moreover, feedback mechanisms and learner control features rated highly, confirming that the game supports self-paced and learner-centered instruction. The strong rating for engagement reflects the effectiveness of interactive gameplay in sustaining attention and motivation. However, the relatively lower mean for creativity stimulation suggests opportunities to incorporate open-ended tasks or exploratory challenges to further enhance higher-order thinking skills.

These findings suggest that the game effectively facilitates learning through clear objectives, appropriate difficulty level, engaging design, and effective feedback mechanisms. Several factors likely contributed to these results. First, the progressive level design scaffolded learning by moving from simple identification tasks to more complex associations, supporting cognitive development and reducing learner overload (Yang & Choi, 2023). Second, the integration of immediate feedback enabled learners to recognize and correct errors, reinforcing accurate understanding and preventing the persistence of misconceptions (Ajogbeje, 2023). Third, the game allowed users to control pacing and sequence, promoting self-directed learning and accommodating differences in learning speed (Coello et al., 2025). These features are critical because effective instructional materials must not only deliver content but also support active engagement, mastery learning, and learner autonomy.

Lastly, the results show high ratings for audio clarity, visual presentation, navigation, and independent usability, indicating that the material provides a seamless user experience. These findings highlight the importance of intuitive interface design and multimodal presentation in maintaining learner engagement. Minor variations in ratings related to user support materials suggest that adding optional tutorials or help features could further assist learners who may require additional guidance.

These results may be attributed to the use of clear screen layouts, synchronized audio narration, intuitive controls, and visually organized elements. Such technical features are essential because poorly designed interfaces can hinder learning by increasing cognitive load and reducing user engagement. The incorporation of narration, sound effects, and visual cues also supports multimodal learning, enabling students to process information through multiple sensory channels (Covaci et al., 2018).

The strong evaluations across content, instructional, and technical domains underscore the importance of holistic instructional design, indicating that the developed web-based educational game is pedagogically sound, technically functional, and highly engaging for learners and that the material meets curriculum standards and supports effective learning delivery. Overall, these findings indicate that the developed web-based educational game possesses the essential qualities of an effective instructional resource and can serve as a reliable stand-alone material for teaching the Periodic Table of Elements.

Students’ Perceptions towards the Developed Web-based Educational Game on the Periodic Table of Elements

Table 4 exhibits the students’ perceptions towards the developed web-based educational game on the Periodic Table of Elements. The results indicate that the game successfully transforms a traditionally memorization-heavy topic into an engaging learning experience. The use of sound effects, scoring systems, timed challenges, and interactive tasks likely contributed to sustained attention and reduced cognitive fatigue. These findings suggest that the game successfully transformed the learning of the Periodic Table of Elements, traditionally viewed as memorization-heavy, into an engaging and enjoyable experience.

Science activities designed to be interesting and enjoyable can foster a more positive learning environment, leading to increased student motivation. Motivated students are then more likely to actively participate in class, persevere through challenges, and retain information effectively. Several design features likely contributed to this outcome. The integration of sound effects, scoring systems, timed challenges, and dynamic visual elements created an immersive environment that sustained attention (Covaci et al., 2018; Ajogbeje, 2023). In addition, the fast-paced gameplay required active participation rather than passive reception of information, promoting sustained cognitive engagement (Sousa et al, 2021). Camacho-Morles et al. (2021) noted that enjoyment in learning is important because it increases attention span, reduces learning anxiety, and enhances willingness to persist in challenging tasks. When students find learning enjoyable, they are more likely to remain focused and retain information more effectively.

Table 4: Students' Perceptions towards the Developed Web-based Educational Game on the Periodic Table of Elements

Criterion	Mean	SD	Verbal Interpretation
Interest and Enjoyment	3.68	0.47	Very High
Value and Usefulness	3.50	0.50	Very High
Perceived Choice	3.51	0.50	Very High
Overall	**3.56**	**0.49**	**Very High**

Note. 1.00-1.75: Very Low, 1.76-2.50: Low, 2.51-3.25: High, 3.26-4.00: Very High

Meanwhile, the results also display the students' perceptions of value and usefulness towards the developed web-based educational game. The results also indicated a very high score, indicating that learners recognized the game's contribution to their academic improvement and study habits. Carril et al. (2021) highlighted the positive impacts of student-perceived value on the learning process, and when students find activities meaningful and beneficial, they are more likely to be intrinsically motivated, actively engaged, and focused on learning goals.

The identified perception may be attributed to the immediate feedback provided after each level, which allowed students to identify errors and reinforce correct responses. The structured progression of levels also helped students see their improvement over time, reinforcing a sense of competence and achievement. This is supported by Li et al. (2024) stating that systems that show visible progression (levels, progress bars, ranking) help learners track advancement, feel accomplishment, and maintain effort. Moreover, digital educational games that adapt difficulty to students' levels and reward completion improve motivation and satisfaction. Perceived usefulness is important because when learners recognize the relevance and benefits of an activity, they are more likely to invest effort, engage deeply with the material, and transfer learned concepts to academic tasks (Carril et al., 2021). This suggests that the web-based educational game not only enhanced immediate understanding but also supported positive learning behaviors.

Lastly, the results for perceived choice reveal that students felt a sense of autonomy while interacting with the game. Learner autonomy, or the ability of students to take control of their own learning processes, is crucial in science education for several reasons, including fostering student motivation, promoting critical thinking and problem-solving skills, nurturing creativity and innovation, and enhancing metacognitive skills (Uslu & Durak, 2022). The ability to navigate levels freely and progress at their own pace likely contributed to this perception. Autonomy-supportive environments are known to enhance intrinsic motivation, suggesting that the game's design fosters self-directed learning and sustained engagement (Coello et al., 2025).

Overall, the results suggest that the developed web-based educational game, as perceived by students, is engaging, relevant, and promotes autonomous learning. Beyond enhancing cognitive achievement, the game also fosters positive affective and motivational outcomes that are essential for sustained academic success. By integrating interactive challenges, immediate feedback, and learner control, the material cultivates both competence and intrinsic motivation. Incorporating similar motivational and learner-centered elements into science instruction may therefore improve students' attitudes toward complex topics and promote deeper, more meaningful engagement with scientific concepts.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study, the following conclusions are drawn: the developed web-based educational game is well-designed and effectively fulfills its educational objectives., as reflected in the teacher evaluation; it significantly improves students' achievement, as evidenced by the significant higher posttest scores compared to pretest scores, demonstrating its effectiveness in enhancing understanding of element names, symbols, atomic numbers, and classifications; and students' perceived the game as engaging, relevant, and promotes autonomous learning.

Overall, the results demonstrate that the developed web-based educational game is an effective instructional tool for teaching the Periodic Table of Elements for Grade 8 Learners, highlighting the potential of web-based educational games in enhancing both cognitive and affective learning outcomes. These findings highlight the potential of web-based educational technologies as effective instructional strategies for teaching abstract and content-heavy science concepts.

Future research should involve a larger and more diverse sample of students across multiple schools to enhance the generalizability of the findings. Including a control group would allow for stronger comparisons and more robust evidence of the game's effectiveness. Extending the duration of game exposure and incorporating repeated measures could provide insights into long-term retention and learning outcomes. Additionally, the web-based educational game could be improved by adding more interactive features, covering a wider range of chemistry topics, and incorporating adaptive difficulty levels to better accommodate learners with varying abilities. Finally, collecting qualitative data, such as student interviews or focus group discussions, could offer deeper insights into learner experiences and inform further refinement of the game's design and instructional effectiveness.

USE OF ARTIFICIAL INTELLIGENCE TOOLS

This study utilized the following AI tools in the development of the paper: ChatGPT, Grammarly, and Consensus. ChatGPT was used to assist in organizing content structure and improving the clarity of paragraphs. Meanwhile, Grammarly was employed for grammar checking and enhancing the overall language quality. Lastly, Consensus was utilized to identify related studies. The authors ensured that all AI-generated content was critically reviewed and validated to maintain academic integrity and that no statements were directly copied and pasted from these AI tools.

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