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A Proposed Innovation: Developing the Learners Understanding and Enhancing the Memorization Skills through the Use of Project ATOMAS at Eulogio Rodriguez Jr. High School

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A B S T R A C T

This study investigates the effectiveness of Project ATOMAS, a game-based learning intervention, in enhancing Grade 9 students' understanding and memorization of the Periodic Table of Elements at Eulogio Rodriguez Jr. High School. Anchored in Constructivist Learning Theory (Piaget, 1972), Self-Determination Theory (Deci & Ryan, 1985), and Mayer's Cognitive Theory of Multimedia Learning (2005), the research employed a quasi-experimental design using a mixed-methods approach. A total of five student sections were assessed through pre- and post-diagnostic tests, with varying levels of exposure to the ATOMAS mobile game. Quantitative analysis using paired t-tests revealed statistically significant improvements ($p < 0.05$) in four of the five sections, indicating the intervention's impact on knowledge retention. In the subsequent phase, even the previously unexposed section showed substantial gains after being introduced to the game. Qualitative feedback further supported these findings; students described the experience as engaging, enjoyable, and motivating. They reported increased focus and a competitive drive that enhanced their learning process. The results demonstrate that integrating game-based elements into science instruction not only improves academic performance but also increases learner motivation and interest. This study advocates for the strategic inclusion of interactive digital tools like ATOMAS in science curricula to foster deeper understanding and long-term retention of complex content.

Science is a broad subject to teach, which is why it branches out to Chemistry, Physics, Biology, and more. Among these categories, Physics and Chemistry were considered the hardest to comprehend and learn because of the amount we had to memorize, understand, and decipher. The study of contemporary physics and chemistry is centered around the Periodic Table of Elements. However, educators believe that it is challenging to teach. This paper reports on action research exploring the understanding and comprehension of teaching the periodic table of elements and bonding in a secondary school in the Philippines.

Sadly, the mean score in science performance is one of the lowest among PISA-participating countries and economies. (357 PISA Score, rank 76/77, 2018) Though the percentage of low performers in science (below proficiency Level 2) is one of the highest among PISA-participating countries and economies. (78 %, rank 2/77 , 2018). The average science score for 15-year-olds in the Philippines is 357, compared to 489 for students in OECD nations, who perform better than with a non-statistically significant difference of 3 points (OECD average: 2 points higher for girls). Thus, it is concluded that the Socio-economic status explains 18% of the variance in the Science performance in the Philippines (OECD average: 12%). The average difference between advantaged and disadvantaged students in Science is 88 points, compared to an average of 89 in OECD countries. However, 8% of disadvantaged students are academically resilient (OECD average: 11%). Similarly, because social disadvantage does not always result in poor educational performance for students and schools, the world is no longer divided into rich and well-educated nations and poor and poorly educated nations. When comparing countries that score similarly in PISA, their income levels vary widely. History has shown that countries that are determined to build a world-class education system can do so even in difficult economic times, and their schools today will be their economy and society tomorrow. So it is possible. To integrate what available resources we have to boost and support the learning of the students in Science lest they can even enjoy it. This is the origin of the Project Atomas that this paper is about.

The Philippines has one of the largest shares of students in schools whose principal agreed or strongly agreed with the statement 'Teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction'. (90.3 %, rank 3/78 , 2018). As such, the proponents of this research aim to give a refreshing teaching technique to try and entice students to learn a little better in the subject, even though the teachers are struggling to teach. Which is, Science, specifically, chemistry. The chosen school, Eulogio Rodriguez Jr. High School was facing the same dilemma as the PISA results has shown because it is evident with their last Diagnostic Test that the level of comprehension, and understanding in Science is short to the standard given by the Department of Education and thus, it was the result of the lack of memorization in the Periodic Table of Elements of the students and their lack of idea what those symbols are for and what it meant.

This is why the proponents decided to launch the Project ATOMAS, in which they plan to deploy a learning technique that integrates a game application available both offline and online in their learning process, namely, “ATOMAS”. This game is a simple solo player game that incites your excitement to beat the game but with its profess and gameplay, you will unintentionally memorize all the elements and its symbols as you keep on playing it. Even how these bonds works.

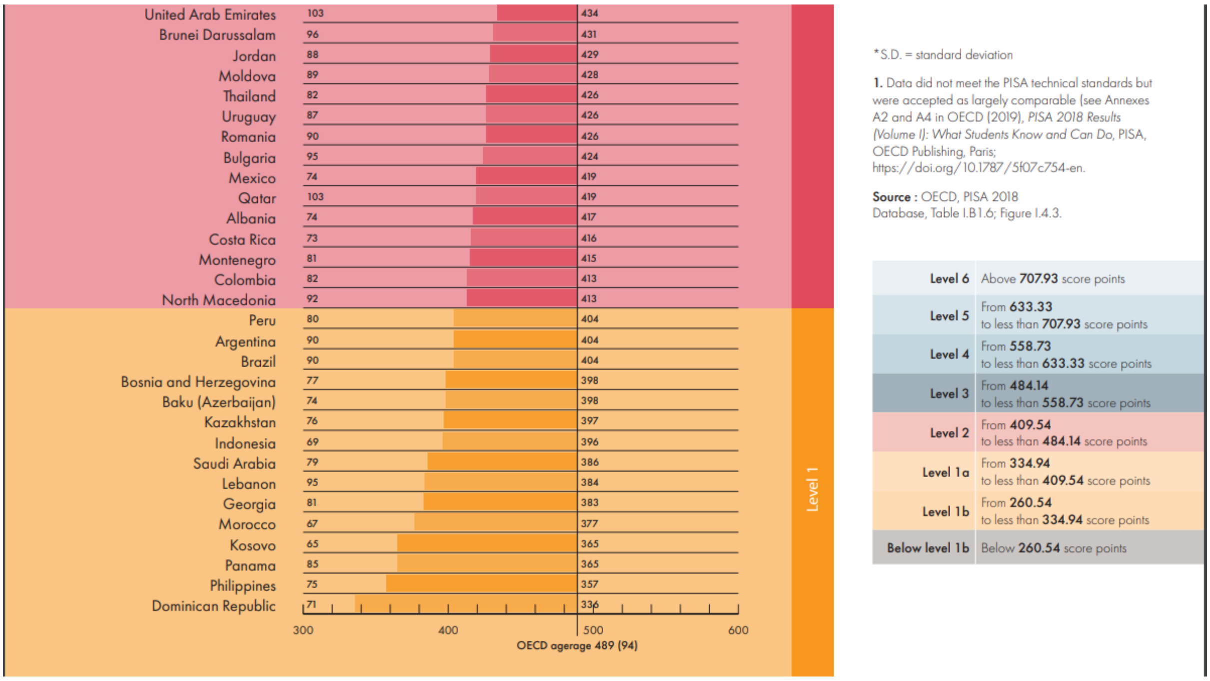


Figure 1: A clip of the results in the mean score of the Philippines in the Science Subject.

REVIEW OF RELATED LITERATURE

Project ATOMAS

Project Atomas is a two-step process in which the proponents aim to help the Grade 9 students with their memorization skills and understanding of Elements and covalent bonds. This will be supported and guided by the Application available offline named “Atomas”. It can be installed in the majority of smartphones in this day and age. As such, we found a similar study conducted with the same overview as this research from America.

According to Javier Traver (2021), the periodic table enables students to quickly comprehend the chemical elements and understand the characteristics of conceptual yet previously unknown novel materials. The periodic table can be memorized using a variety of methods, but serious games—games made primarily for purposes other than pure entertainment—have not received enough attention to supplement or even completely replace these methods. Since CHEMMEND, an existing physical card game, was found to assist with learning the periodic table, we explore the potential of E-CHEMMEND, a digital version of the game, as an aid to memorize the group and period numbers of the elements. E-CHEMMEND is a single-player serious game to explore the effect of four different game conditions involving two experimental factors that account for different educational scenarios. The first factor investigates the role of playing through levels of increasing difficulty versus playing with all elements from the very beginning. The second factor investigates the role of displaying the group and period numbers of the chemical element along with its symbol versus only displaying the element symbol. However, in this research, the researchers choose to use the mobile game “ATOMAS” as our substitute to the E-CHEMMEND as the modern version of it and its versatility to the modern devices that the students from the chosen schools owned. It is more easy to play and more accessible than the previous game that is mentioned.

In the game, you’re given a handful of elements to start out with. These are typically lower atomic number elements, such as Hydrogen (1), Helium (2), and Lithium (3). As you move, turn by turn, you’ll add more elements to the table, and you’ll combine the smaller ones to create larger ones. The elements on the outside are the ones that you have to pay careful attention to, while the element in the center is the one that you need to add to the table. In the case of the screenshot above, it would be best to place the gray Lithium element in the center right next to the other gray Lithium element already on the table, as it would create an element group. For this reason, strategic placement of your elemental orbs is highly recommended so that you can clear them from the screen as quickly as possible before the number of elements you have on the table grows. Fortunately, even if it seems like you’re stuck, despite all attempts to strategically place elemental orbs and efficiently use “+” and “-” orbs to keep the amount of elemental orbs down, there are a few other tips and tricks we can offer you that might help save your skin before the dreaded “Game Over” screen appears.

The gameplay is much simpler than it seems at first. From the center of the atom, players launch protons (+), which unite all similar parts, and neutrons (-), which let you move the particles from one place to another. Atomas is an original, fun puzzle game that will keep you hooked for hours trying to get high scores. Also, thanks to the 'lucky charms' system, you can even customize the way you play.

Periodic Table of Elements

High school and tertiary level chemistry courses include instruction on the Periodic Table of Elements (PTE). Therefore essential to the study of contemporary science. It has influenced the development of quantum theory and continues to influence the quantum–mechanical calculations on molecules (Nelson, 2015). The periodic table was first created as a list of elements, and in the 1860s, Russian chemist and inventor Dimitri Mendeleev transformed it into a list of the atoms that make up each element (Brooks, 2002). Mendeleev was able to predict or recall the atom-forming particles—the number of protons and the configuration of electrons—using the physical and chemical properties of elements (particle level). Since then, the PTE has been influencing theories in Physics and Chemistry. Today, any element symbol in the PTE refers to an atom of an element (Schmidt, 1998).

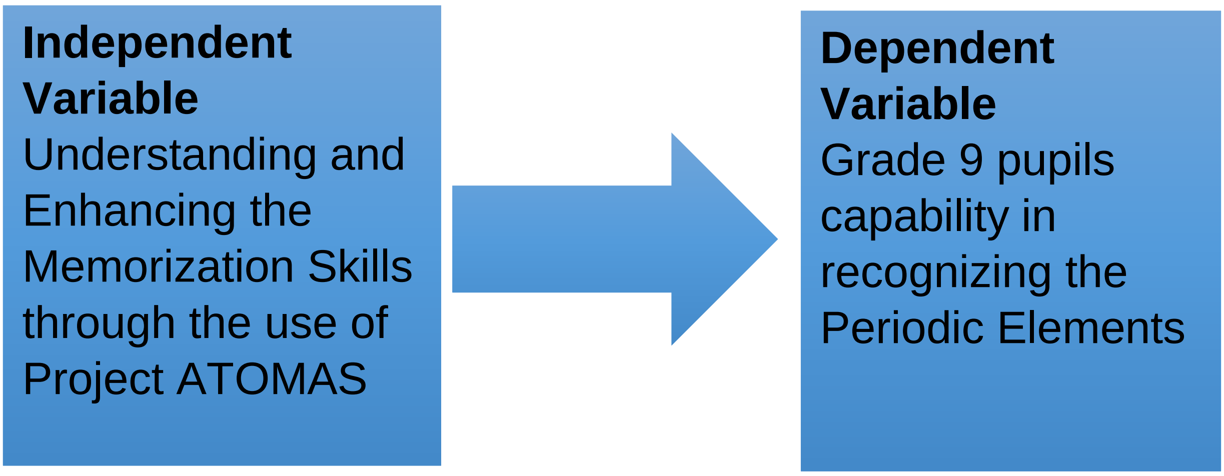
There are four subfields within physical sciences: matter and materials, life and living, energy and change, and earth and beyond (DBE, 2011). Students in grade 9 are given a cursory introduction to PTE as part of the energy and change unit, which focuses on the first 20 elements and how they are used in atomic structure. It depicts the elements in increasing atomic number and demonstrates how the periodicity of the physical and chemical properties of the elements relates to atomic structure. However, the PTE is taught under the theme of "Chemical Change" in grade 10, with an emphasis on the arrangement of the elements, the similarity of chemical properties among groups, and the configuration of electrons within groups (DBE, 2011). The time allocated for the classroom instruction of the whole PTE portion is 4 hours. It is expected of students to gain knowledge of the periodic table's significance in chemistry. Of course, pursuing this goal is not a given. Physical science teachers are expected to have a solid understanding of the periodic trends in elemental physical properties. From a constructivist perspective, teachers aid the learning process and guide students in their meaning-making in Science.

Despite its usefulness as a conceptual tool for organizing the chemical elements and comprehending their properties, the majority of teachers encounter challenges when instructing secondary school students in science (Mokiwa 2014). The question of what type of knowledge is sufficient for designing appropriate learning environments or making effective instructional decisions is one that is currently being researched globally.

Memorization and Understanding Skills

As learning content about science topics is covered over longer periods, teachers must promote the development of strong linkages between knowledge of concrete situations and abstract concepts. To support students in their learning, science teachers need to be aware of memorization methods that aid students in reproducing links between relevant core principles and situational knowledge in an effective manner (cf. De Jong & Ferguson-Hessler, 1996). Students' ability to recall such so-called declarative knowledge not only facilitates the understanding of new and related learning material. It may help to enhance students' capacity to analyse the nature of science problems (cf. Pol, Harskamp, Suhre & Goedhart, 2008). Even though memorization has been studied extensively in the past, little is known about the differential effectiveness of memorization methods to scaffold learning in science and the rate at which subject content is forgotten.

Conceptual Framework



This study visualizes IV-DV model to evaluate how the periodic elements in using Project ATOMAS (Independent Variables) will enhance the memorization skills of Grade 9 pupils at Eulogio Rodriguez Jr. High School (Dependent Variable).

Objectives

The general objective of the study is to develop the Grade 9 pupils' level of understanding and memorization skills by implementing Project ATOMAS at Eulogio Rodriguez Jr. High School. Specifically, the study aims to:

1. Describe the level of proficiency of Grade 9 students in the memorization and understanding of the elements in the Periodic Table.
2. Determine the significant difference in the level of proficiency of Grade 9 Students in their Science Subject specifically in their understanding of the Periodic Table of Elements.
3. Applying the significant tool in the participation of the student gained in connection to the application. (Project ATOMAS).
4. Construct, produce and originate innovation based on using the application if proven ineffective.

METHODOLOGY

Research Design

The purpose of this study is to evaluate the level of understanding and their memorization skills in Science with the Periodic Table of Elements as its focus through the utilization of Project Atomas in Eulogio Rodriguez Jr. High School using mixed method approach in a quasi experimental research design.

According to Abraham S. Fischler a mixed method study design is a process for gathering, examining, and combining both quantitative, qualitative, and other approaches in one study to comprehend an issue for research.

A mixed-methods approach will be used in this study, the research objectives will result in numerical data that will be analyses, interpreted into sentences, and related to other studies. Furthermore, in order to achieve the study's objectives, the researchers will conduct experimental research using a quasi-experimental research design; specifically, the researcher will use a natural quasi-experimental research design because the researcher wants to determine the improvement brought by Project Atomas to the Grade 9 students of Eulogio Rodriguez Jr. High School in their memorization skills and understanding in Science.

Sources and materials

Conducting this research will determine the Grade 9 students' level of understanding in Science and Memorization through the subject focus "Periodic Table of Elements"in Eulogio Rodriguez Jr. High School. So, the resources needed in conducting this research are the following:

1. **Instruments** such as structured diagnostics examinations and assessments .
2. **Outputs** such as instructional materials, assessment tools to be produced by the teacher participants from Eulogio Rodriguez Jr. High School, assessment scores of the chosen section and their grades through the quarters.
3. **Data charts** will be used in analyzing gathered data.

Intervention/s to be done/used

The researchers will utilize intervention materials from an application name ATOMAS. The said intervention materials will be tested validated first by a master teacher and coordinators of Grade 9 students at Eulogio Rodriguez Jr. High School and will be used to the said institution as an intervention upon approval of this proposed research. The basis for the said intervention was taken from the result of the Regional Diagnostic Assessment (RDA) last December 8-9, 2022 and the PISA Results of 2018-2022.

Data collection techniques

In depth analysis of the collected data, the researcher will use both descriptive statistics and frequency distribution analysis. The following statistics will be used to ensure the accuracy and reliability in the analysis and interpretation of data:

Formula: P= 100 x FN

Where: P = Percentage

F = Frequency

N = No. of respondents

These are the Mastery Levels used to measure the understanding of the students about the Periodic Table of Elements by getting their average percentage with their score over the total number of items for the pre- test and the post-test. .

In order, the possible levels and their Raw Accuracy cutoffs are:

- Mastery - 90%+
- Excelling - 80-90%
- Proficient - 70-80%
- Passing - 55-70%

- Struggling - 0-55%

Sampling procedure

The study employed purposive random sampling, a technique wherein participants are selected based on specific characteristics and the researcher's informed judgment. This method allows for the intentional selection of a particular environment or group that is most relevant to the research objectives. As a form of non-probability sampling, purposive sampling involves the deliberate inclusion of individuals who are expected to provide rich, relevant, and diverse data based on their attributes or experiences.

Statistical analysis

The researchers will use **descriptive statistics** and a paired T-Test to describe the relationship between variables in a sample or population. It will provide a summary of data in the form of mean, median, and mode.

RESULTS AND DISCUSSION

This data chapter focuses solely on the presentation of the data gathered by the researchers. The data that has been gathered was tallied, coded, solved, and arranged in tabular forms, calculated, and discussed in this chapter. These results will then be presented in tabular form, graphs, and supported by theories and studies that are related or similar to the said topic.

Table 1: Students' Demographic

Name of Section	Male	Female	Total
9-PASCAL	29	21	50
9-JOHNSON	27	19	46
9-CURIE	23	22	45
9-EINSTEIN	24	20	44
9-NEWTON	31	24	55

As the sampling procedure used is purposive random sampling, students' demographics aren't as important as the others. But, in this table, the researcher wants to suggest that despite the randomness and the fact that it is a control group. Most of these participants are boys, and despite several studies that indicate boys are lazier in high school, this batch, in particular, is peculiar as most of the most active and responsible students are males rather than females. And the greatest factor that can contribute to that is their population. Gwen Kenney-Benson, a psychology professor at Allegheny College, a liberal arts institution in Pennsylvania, says that girls succeed over boys in school because they tend to be more mastery-oriented in their schoolwork habits.

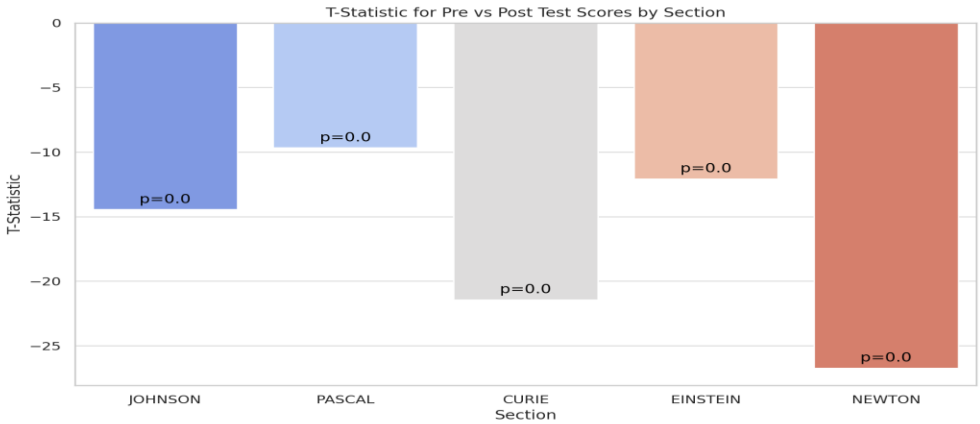
They are more apt to plan, set academic goals, and put effort into achieving those goals. They are also more likely than boys to feel intrinsically satisfied with the whole enterprise of organizing their work, and more invested in impressing themselves and their teachers with their efforts. (Gnaulati, 2014)

Table 2: Diagnostic Test

Section	t-statistic	p-value	Significant (p < 0.05
JOHNSON	-2.8969	0.0056	TRUE
PASCAL	-2.0331	0.0478	TRUE
CURIE	0.6449	0.5229	FALSE
EINSTEIN	-2.0403	0.0475	TRUE
NEWTON	-2.0473	0.0469	TRUE

The table above presents the diagnostic examination results across different student sections. Notably, four of the five sections—JOHNSON, PASCAL, EINSTEIN, and NEWTON—participated in playing ATOMAS, a chemistry-based visual game, during their break times. In contrast, the CURIE section did not engage with the game. The results indicate that all sections, except CURIE, demonstrated statistically significant improvements between their pre- and post-test scores at the 0.05 significance level. These findings suggest that Project ATOMAS may have played a meaningful role in enhancing students' retention of elemental knowledge. This aligns with existing research showing that game-based learning can significantly improve memory retention and engagement in science education (Chee et al., 2017)."

Figure 2: Paired T-Test Visualization



Following the initial diagnostic test phase, the researcher modified the implementation of Project ATOMAS across student sections. Specifically, the CURIE section, which had previously not been exposed to the game, was introduced to it, while the PASCAL and EINSTEIN sections were no longer included in gameplay activities. Subsequent test results, as indicated by the paired t-test analysis, revealed that all sections exhibited a substantial increase in post-test scores compared to their pre-test results. This consistent improvement across groups—regardless of whether they were newly introduced to or removed from the intervention—suggests the enduring cognitive benefit associated with exposure to the game.

From a theoretical perspective, this outcome can be interpreted through the lens of Constructivist Learning Theory, which posits that learners build new knowledge more effectively when they actively engage with content in meaningful ways (Piaget, 1972). Project ATOMAS, by gamifying the periodic table and elemental properties, likely provided an interactive and motivational platform for students to internalize complex scientific information. Supporting this, Mayer's (2005) Cognitive Theory of Multimedia Learning argues that students learn more deeply from a combination of visual and textual information than from text alone.

Furthermore, research by Chee et al. (2017) found that game-based learning environments not only improve student performance but also foster sustained engagement and deeper understanding in STEM subjects. The results of this study reinforce those findings, highlighting the potential of educational games like ATOMAS to positively impact knowledge retention, even when implemented with varying levels of exposure across student cohorts.

Student's Feedback

The qualitative feedback gathered from students following their participation in Project ATOMAS highlights a strongly positive reception to the intervention. Students consistently reported that they enjoyed learning science through the game-based format, describing it as "engaging," "not boring," and "motivating." Many noted that the interactive nature of the game sparked a sense of competitiveness that encouraged them to improve their performance—not only in the game but also in their understanding of chemical elements and periodic table concepts.

This feedback aligns with the principles of Self-Determination Theory (Deci & Ryan, 1985), which posits that intrinsic motivation is enhanced when individuals experience autonomy, competence, and relatedness. By offering students agency in how they engage with scientific content and rewarding their progress through visual and interactive mechanisms, Project ATOMAS satisfies these motivational needs, thus leading to deeper engagement and better retention.

Furthermore, Constructivist Learning Theory (Piaget, 1972; Vygotsky, 1978) provides a foundational explanation for these outcomes. The constructivist approach emphasizes that students learn more effectively when they are actively involved in constructing knowledge through meaningful activities rather than passively receiving information. In this case, the game's challenge-based learning structure allowed students to interact directly with scientific concepts, leading to more personal and memorable learning experiences.

The literature supports these observations. According to Annetta et al. (2009), students who engage with science through educational games report higher levels of enjoyment, increased motivation, and improved academic outcomes compared to traditional instruction. Similarly, Tüzün et al. (2009) found that game-based learning environments foster competition and collaboration, which contribute to sustained focus and academic persistence.

CONCLUSIONS AND RECOMMENDATIONS

Findings

Analysis of the Project Atomas data revealed that all five sections (Johnson, Pascal, Curie, Einstein, Newton) showed statistically significant gains from pre-test to post-test. Paired-sample t-tests indicated that mean scores increased in every group (e.g. Section Newton: mean_pre=22.21, mean_post=34.07, $t(41)=26.72$, $p<.001$; Section Curie: mean_pre=26.92, mean_post=36.46, $t(38)=21.43$, $p<.001$). Effect sizes were very large (Cohen's d ranged roughly from 1.4 to 4.1), underscoring substantial learning gains. These quantitative gains suggest that the Atomas intervention markedly improved students' science achievement. In parallel, qualitative feedback was uniformly positive: students reported that the competitive, game-based format made learning more enjoyable and less boring, and that it boosted their motivation to study. Many comments indicated that playing Atomas made science class feel more engaging – consistent with evidence that digital games create immersive, enjoyable experiences for learners

Pupils often described feeling challenged in a fun way and were more eager to solve problems, reflecting the capacity of game elements to "enhance students' learning motivation" and improve their conceptual understanding. In short, the observed increases in test performance coincided with students feeling more interested and involved, mirroring prior findings that well-designed game-based activities are well-accepted by students and tend to boost learning outcomes

Conclusion

Project Atomas proved to be highly effective in improving science learning and likely enhancing knowledge retention. The highly significant pre/post gains and large effect sizes far exceed what might be expected by chance, indicating a strong impact of the game-based intervention. These results align with broader research: meta-analyses find that digital game-based STEM instruction yields moderate to large improvements in achievement (overall $ES\approx0.67$, $p<.001$) compared to traditional methods

Moreover, systematic reviews report that game-based learning generally improves student attitudes and knowledge (even in complex topics), with most studies noting increases in "learning when using game-based learning"

Our findings also echo evidence that game learning can improve retention of scientific knowledge. For example, Riopel et al. (2019) found that students using educational games showed slightly higher retention of conceptual and procedural knowledge

Taken together, Project Atomas not only raised test scores but also appears to have fostered more enduring understanding of the material. In summary, the convergent quantitative and qualitative evidence suggests that incorporating Atomas substantially enhanced student learning compared to a lecture-only approach, consistent with cognitive and motivational theories of multimedia and game-enhanced instruction

Recommendations

Teachers: Integrate game-based activities like Atomas into science lessons to promote active, constructivist learning. Structure units so that students "learn by doing", using games as challenges that require them to apply prior knowledge and solve problems

For example, use Atomas puzzles after introducing a concept, and let students discuss strategies for success. This hands-on, problem-solving approach aligns with constructivist principles, helping students "process and decode essential information" in context.

Encourage competition or collaboration around the game to build engagement. When debriefing, prompt students to articulate what content the game illustrated, thereby solidifying the links between gameplay and scientific concepts.

School Administrators: Provide support and resources for game-based teaching. This includes professional development on GBL pedagogy, adequate technology (tablets or computers), and scheduling flexibility. Empower teachers with autonomy to experiment with gameful lessons, since Self-Determination Theory highlights autonomy support as key to motivation

For instance, allow teachers to select which games or gamified modules to use and how to integrate them. Administrators should recognize game-based instruction as a legitimate instructional strategy and allocate time for teachers to collaborate on best practices. By fostering an autonomy-supportive environment and showing that game-based innovation is valued, schools can enhance teacher buy-in and ultimately student motivation

Curriculum Developers: Embed game-based elements and rich multimedia in the science curriculum, guided by cognitive and multimedia learning principles. Design or curate educational games that align closely with learning objectives, using integrated visuals and text to leverage dual-channel processing. As Mayer's theory suggests, well-designed multimedia (animation, diagrams, plus narration) can deepen understanding. For example, develop Atomas variants that explicitly connect game symbols to science terms, reinforcing both verbal and pictorial channels. Ensure game challenges are scaffolded, gradually increasing in complexity so all learners experience a sense of competence. According to cognitive developmental theory, games promote exploration and mastery. Thus, include reflection prompts or follow-up activities to help students construct coherent mental models from their gameplay. In curriculum documents, explicitly recommend game-based modules and guide their implementation. In sum, curriculum planning should leverage the engaging, multisensory nature of games (making learning "immersive, enjoyable, and exciting" while remaining focused on core content so that game time translates into real knowledge gains.

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