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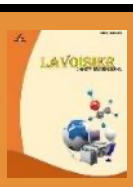

Literature Review: Application of Gamification in Puzzle-Assisted Chemistry Learning on the Periodic System of Elements

Rabiah Afifah Daulay[1], Azli Khairiansyah[2], Abidah Ramadhani[3], Aisya Yurinda[4], Aralia Putri Marsyah[5], Yogi Chandra[6]

[1,2,3,4,5]Faculty Of Mathematics and Natural Sciences, Chemistry Education, Medan State University, Jalan William Iskandar Pasar V Medan Estate, 20221, North Sumatera, Indonesia.
[6]Politeknik Negeri Sriwijaya, Jalan Srijaya Negara Bukit Besar, Palembang, South Sumatera, Indonesia.

*Correspondence: rabiahdaulay@unimed.ac.id

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Abstract
This research explores the use of gamification in chemistry education by incorporating puzzles into the study of the Periodic System of Elements. Gamification, which integrates game-like elements into non-gaming contexts, aims to boost students' motivation and improve their academic performance. In chemistry learning, gamification can transform the educational experience into a more engaging and stimulating one, particularly for challenging subjects like the Periodic System of Elements. Puzzles serve as a gamification tool that can enhance students' interest and facilitate a better understanding of complex chemistry concepts through interactive engagement. The study utilizes a literature review approach to gather and analyze various relevant articles, revealing that puzzle-based learning can enhance student participation, alleviate anxiety, and promote teamwork. The analysis used thematic review to identify patterns in gamification use, puzzle effectiveness, and digital platform support. Results show that puzzle-based learning enhances participation, reduces anxiety, and fosters collaboration. Gamified puzzles are thus recommended as an effective and enjoyable educational approach.

1. Introduction

The use of digital media fosters the development of students' language skills more engagingly and efficiently. By implementing this approach, learners can better prepare themselves to navigate and overcome communication challenges in real-life contexts. The rapid advancement of science, technology, and the arts (IPTEKS) has a direct impact on the increasing accessibility to digital information sources. The rapid and exponential advancement of science and technology can provide significant impacts and control

over all aspects of an individual's life, including education. Therefore, educators must utilise digital technology-based media to support the learning process (Suryanti et al., 2024).

Chemistry is one of the branches of natural sciences (IPA) that holds equal importance to other fields such as physics, biology, geology, and astronomy. It encompasses theoretical concepts as well as mathematical elements. However, even before engaging in chemistry lessons, many students already hold a negative perception, believing that chemistry is difficult, despite not fully understanding the subject. It is often seen as a complicated and confusing subject. This perception affects various aspects of students, including cognitive, emotional, practical, and scientific dimensions. One of the most significant impacts is the decline in students' interest in learning chemistry. This poses a challenge for teachers and schools in fostering students' motivation and enthusiasm toward the subject. In reality, students' interest in studying chemistry is low. Several factors contribute to this, such as the unengaging presentation of chemistry concepts in textbooks, ineffective teaching methods used by teachers, negative information about chemistry circulating in society, and a lack of personal goals or motivation among students to learn the subject. These factors lead to a decreased interest and enthusiasm in studying chemistry. Most students do not view chemistry as an important, engaging, or beneficial subject. On the contrary, they consider it difficult, intimidating, and even risky. These negative perceptions result in a loss of motivation and willingness to study chemistry in depth (Taruklimbong & Murniarti, 2024)

The implementation of gamification in chemistry education plays an important role in enhancing students' learning motivation and can also lead to improved academic performance. This improvement results from students' enthusiasm in engaging with the learning process, which ultimately leads to outputs that align with the intended learning goals. Chemistry learning that incorporates gamification becomes more enjoyable and challenging for students, as they are motivated to complete tasks at various levels. Several chemistry topics have successfully implemented gamification, such as atomic structure, introduction to elements and chemical compounds, chemical nomenclature, reaction rates, redox reactions, and others.

Puzzle-based gamification serves as a tool to engage and encourage students throughout the learning experience. Integrating gamification to boost motivation and involvement represents a significant advancement in the field of education. It involves incorporating game-like elements and strategies into the learning environment to enhance students' motivation, active participation, and academic performance. It is a new learning method that adapts the characteristics of games to boost student motivation during the learning process. Students who feel bored with previously applied learning methods may experience increased motivation through game features integrated into the instructional approach. A game is an interactive program that contains specific rules, levels of difficulty, and provides feedback in the form of scores or standard values achieved after completing a series of challenges. Gamification involves the use of game-like mechanics, visual elements, and game-oriented thinking to boost motivation and engagement, support the learning process, and address various challenges (Susanti, 2021).

2. Materials and Methods

This research utilises the literature review method as the main approach to explore and analyse various scientific sources related to the use of gamification in chemistry learning, particularly those utilising puzzle media and periodic table materials. The article search process was carried out through two main platforms, namely Google Scholar and Scispace, using keywords such as "gamification in chemistry learning", "educational puzzle games in science", "gamification using puzzles", and "periodic table learning with gamification". These keywords were adjusted to filter relevant literature according to the study focus. Inclusion criteria in article selection included: publications released within the last 5 to 10 years (mainly since 2020), relevance to the topic of chemistry learning using gamification or puzzle media, available in both Indonesian and English, and accessible in full. Conversely, articles that do not specifically discuss the use of gamification in the context of chemistry education, that do not contain discussions on the periodic table of elements, or are available only in abstract form, are excluded from the review.

The selection process is conducted in several stages. At the initial stage, 67 articles were found that met the initial search results based on keywords. After filtering through the title and abstract reviews, 38 articles were left that were deemed potentially. These articles were then thoroughly examined to assess their relevance and contribution to the research topic. After undergoing an in-depth analysis stage, 18 articles were selected for the final review as they were most aligned with the study focus and met all the

set criteria. All selected articles were analysed thematically to identify patterns of gamification use, the effectiveness of puzzles as learning media, and their roles. The Android platform supports interactive chemistry learning. This approach aims to strengthen the theoretical and empirical foundations in designing innovative puzzle-based learning media relevant to the needs of today's students.

3. Results and Discussions

A growing body of literature emphasises that gamification through puzzles carries substantial pedagogical value, particularly in science education, such as chemistry. This approach does more than just introduce an element of fun—it has been empirically shown to enhance the overall learning process. Studies conducted by binti Saleh & Ismail (2024), as well as Lobo et al. (2024), affirm that integrating puzzles into learning activities can significantly boost student engagement, especially when dealing with abstract and challenging chemistry concepts that are often difficult to grasp using conventional methods. Moreover, students who participate in gamified learning activities tend to demonstrate improved concentration and sustained attention throughout the lesson. These activities have also been associated with reduced learning anxiety and enhanced retention of the material. This suggests that puzzles serve not only as entertaining elements but also as effective cognitive tools that reinforce understanding and memory.

The formats of educational puzzles vary widely and can be adapted to meet specific learning goals. For instance, puzzles may take the form of completing a periodic table, categorising elements based on shared characteristics, or identifying periodic trends such as atomic radius. Zamhari et al. (2023) emphasise that this flexibility allows educators to tailor puzzle-based tasks to different difficulty levels and instructional objectives, ensuring alignment with desired learning outcomes.

Additionally, the use of Android-based puzzle applications provides students with flexible access to learning materials and supports both individual and collaborative study. Research Lutfi et al. (2023) and Yulian et al. (2023) highlights that digital platforms significantly enhance students' intrinsic motivation and classroom interaction, making them more engaged and responsive to the learning content. Beyond cognitive benefits, puzzle-based learning also supports students' affective development. Collaborative problem-solving tasks foster communication and teamwork skills, as pointed out by Gomes et al. The sense of achievement gained from solving challenges not only builds confidence but also cultivates a more positive attitude toward learning, helping to make subjects like chemistry feel more approachable and enjoyable.

Nevertheless, despite these advantages, the literature also underscores the importance of thoughtful instructional design. Poorly structured or overly complex puzzles can lead to cognitive overload, which may hinder rather than help the learning process. Therefore, it is essential to ensure that puzzle activities are well-aligned with curriculum standards and students' cognitive readiness. Future research could further investigate the long-term impact of puzzle-based gamification on academic performance and explore its scalability across diverse

5. Conclusions

Gamification through puzzle-based learning proves to be a valuable approach in chemistry education, especially for teaching the Periodic System of Elements. Studies reviewed indicate that puzzles can enhance student motivation, deepen understanding of abstract concepts, and promote active participation. Their flexible format also supports varied learning needs and goals. The use of digital platforms further increases accessibility and fosters both individual and collaborative learning. However, effective implementation requires careful design to align with curriculum standards and avoid cognitive overload. Future research is encouraged to examine its long-term educational impact and broader applicability.

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