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DEVELOPMENT OF AN EDUCATIONAL TOOL FOR LEARNING PERIODIC TABLE

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ABSTRACT

Learning the periodic table is essential in chemistry, yet many students struggle with understanding and memorizing it. With advancements in technology, education has become more accessible, making e-books a more convenient alternative to traditional textbooks. To support and enhance the learning process, the flipped e-book Beyond the Basics: An Exploration of the Periodic Table has been developed for primary, secondary, pre-diploma, and diploma students as an instructional tool. Designed using Canva, a user-friendly platform for creating professional educational materials, the e-book integrates engaging visuals and interactive content. Additionally, learning games are created using Wordwall, a game-based learning platform, to reinforce key concepts. The e-book is easily accessible via a shared link and Google Sites, ensuring convenience for students. This e-book introduces learners to the names, symbols, atomic numbers, and mass numbers of key elements from Group 1A(1) to 8A(18) and transition metals in a simplified manner. To emphasize the significance of these elements, real-world applications are included, helping students understand their relevance in daily life. The ADDIE Model is applied as the instructional design framework to ensure effective content delivery. In conclusion, integrating a flipped e-book approach with traditional learning methods enhances student engagement and understanding of the periodic table. Future developments will focus on creating more interactive e-books and educational games to further promote interest in Science, Technology, Engineering, and Mathematics (STEM) education.

Keywords: *Educational tool, Flipped book, Periodic table*

INTRODUCTION

Understanding and learning fundamental science concepts and principles, particularly in chemistry, can be challenging. Numerous research studies have highlighted significant learning difficulties and identified the main factors contributing to these challenges. Chemistry is challenging to teach and learn at both secondary and tertiary levels as its concepts often contradict with student's everyday experiences and intuitive understanding (Treagust et al., 2018). Elementary school students tend to engage more effectively with teaching materials that integrate diverse media formats, including images, audio, and video, combined with vibrant colours and an attractive visual design (Martatiyana et al., 2023). The study of chemical elements, which are systematically organized in the periodic table, is fundamental to the field of chemistry. This provides the basis for understanding atomic structure, electron configurations, periodic trends, and the resulting chemical behaviour and properties of matter (Galizia 2025; Ullah et al., 2025). Previous studies have indicated that students frequently encounter difficulties in understanding the periodic table, while educators face challenges in delivering the topic effectively (Narod and Narrainsawmy, 2022). The rise of educational technology has paved the way for innovative learning tools, with e-books emerging as a compelling alternative to traditional textbooks because of their portability, interactivity, and multimedia capabilities (Paristiowati et al., 2019). To address these challenges, a flipped e-book entitled "Beyond the Basics: An Exploration of the Periodic Table" has been developed as an instructional tool for primary, secondary, pre-diploma, and diploma students. This resource aims to provide a simplified and engaging approach to understand the periodic table, catering to a wide range of learners. The e-book covers the names, symbols, atomic numbers, and mass numbers of elements from Groups 1A(1) to 8A(18), along with selected transition metals. To emphasize their significance, real-world applications are included to help students relate these elements to everyday life. The flipped e-book is designed using Canva and incorporates engaging visuals and interactive content to enhance the learning experience. Furthermore, the integration of learning games created with Wordwall further enhances the learning experience by providing opportunities to strengthen key concepts through interactive gameplay (Ohn-Sabatello, 2020).

METHODS

This research focused on the development process of a flipped e-book instructional tool for learning the periodic table, utilizing the ADDIE (Analysis, Design, Development, Implementation and Evaluation) model as the guiding framework. The study aimed to systematically design and develop the flipped e-book to enhance student engagement and conceptual understanding through interactive and multimedia elements. The ADDIE model is a widely used framework for developing products, including digital teaching materials. Utilizing the ADDIE process to create such materials is considered one of the most effective approaches today. The following steps outline how to design digital teaching materials based on the ADDIE model.

Analysis

In the Analysis phase of the ADDIE instructional design model, preliminary classroom observations and informal assessments indicated that students exhibited limited conceptual understanding of the periodic table when taught through conventional lecture-based approaches. This problem underscored the need for a more interactive and learner-centered instructional strategy, prompting the development of a flipped e-book as a digital learning tool aimed at enhancing student engagement and comprehension of periodic table concepts.

Design

During the Design phase of the ADDIE model, the flipped e-book was carefully planned with interactive elements such as audio narration for each chemical element and vivid colour illustrations all strategically incorporated to capture students' attention of learning periodic table to facilitate active learning and reinforce students' understanding of the periodic table.

Development

In the Development phase of the ADDIE model, the flipped e-book was created by integrating multimedia elements such as YouTube video links, interactive games, simplified explanatory notes with colour illustrations to ensure the content was both engaging and accessible for students learning the periodic table. All elements were intentionally selected to attract and engage with the target participants, aiming to align with their learning preferences and enhance their understanding.

Implementation

In the Implementation phase of the ADDIE model, the developed flipped e-book was introduced to the target participants as part of the instructional process, providing students with structured access to multimedia learning materials aimed at improving their understanding of the subject content.

Evaluation

In the Evaluation stage of the ADDIE model, a structured Google Form was utilized to collect data on students' comprehension and perceptions regarding the effectiveness of the flipped e-book approach in enhancing their understanding of the subject matter.

RESULTS AND DISCUSSION

To evaluate the effectiveness of the flipped e-book (Figure 1), a questionnaire was distributed to 64 respondents via Google Form. The main respondents were students from the secondary level, followed by students from diploma, bachelor's degree, pre-diploma, primary, form 6 and post-graduate levels. The questionnaire assessed four main criteria which are student engagement, content organization, usability and gamification element. Based on the results of the questionnaire, majority of the respondents agreed that the e-book is enjoyable to read (89.1%) and its content is well-organized and easy to follow (96.9%).

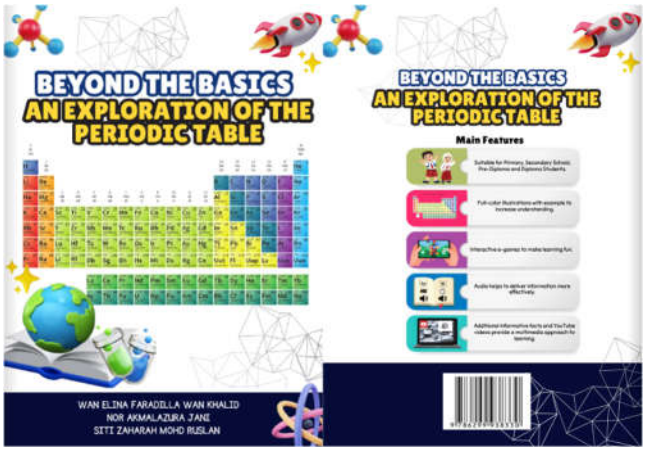

Figure 1.: The flipped e-Book "Beyond the Basics: An Exploration of the Periodic Table" with e-ISBN

In addition, most of the respondents gave positive responses in terms of the e-book usability (Table 1). The results show 93.7% of respondents found that the attractive visual design in the e-book enhanced their learning experience. The clarity of text (95.4%) and audio (87.5%) also contributed to respondents' satisfaction. Accessibility across devices (mobile, tablet, laptop) received a strong response (86.0%), indicating that the flipped e-book format was practical for both classroom and remote learning. These usability outcomes support previous studies emphasizing the role of interactive e-book in increasing student's interest and motivation in learning science (Firdausy and Prasetyo, 2020).

Table 1.: Student feedback on e-book usability

Criteria	Positive response (%)
The visual design (layout, colours, graphics) of the e-book is interesting	93.7
The e-book is easy to navigate	85.9
The audio is clear	87.5
The text is easy to read	95.4
The e-book is easy to use on device	86.0

The integration of gamification in the e-book received positive feedback, indicating its effectiveness in enhancing student engagement and motivation. As shown in Table 2, 92.2% of respondents agreed that the games were relevant to the topic, supporting the alignment of content and learning objectives in understanding the elements in periodic table. Majority of the respondents said that their interest in the topic is increasing after playing the games (90.7%), suggesting that game-based learning can effectively emphasize understanding of chemistry concepts.

Table 2.: Student feedback on gamification element in the e-book

Criteria	Positive response (%)
I enjoy playing the games in the e-book	87.5
The games provided are easy to play	89.1
The games increase my interest on the topic	90.7
The games are relevant to the topic	92.2
I think the games make the e-book more interesting	84.4
I would like more games in the e-book	84.4
I would like to play the games again	86.0
The instructions for the games are easy to understand	85.9

Besides that, most respondents found the games were easy to play (89.1%) and enjoyable (87.5%), reflecting the user-friendliness of the Wordwall platform used. The clarity of game instructions (85.9%) further contributed to a smooth learning experience. Furthermore, 84.4% of respondents agreed that the games made the e-book more interesting and showed interest in having additional games. A positive response of 86.0% for playing the games multiple times highlights the potential for repeated engagement and deeper understanding. These findings are consistent with past studies which highlight gamified learning environments may enhance cognitive engagement and foster positive learning attitudes in STEM education (Byusa et al., 2022; Lee and Hammer, 2021). Overall, the data affirms that gamification is a valuable tool in making chemistry education more interactive, enjoyable, and effective.

CONCLUSION

The implementation of the interactive flipped e-book “Beyond the Basics: An Exploration of the Periodic Table” introduces an innovative approach in chemical education by incorporating interactive elements such as engaging graphics, clear audio, informative videos and game-based learning activities. This e-book is designed to complement traditional teaching methods by enhancing conceptual understanding and increasing student engagement, thereby making the learning process more meaningful and exciting. Future developments will focus on producing additional interactive e-books covering various chemistry topics and integrating additional gamification strategies to further promote interest in STEM education, particularly in the field of chemistry. To support accessibility and ease of use, these educational resources will be consolidated within a centralized web-based platform.

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