

# A JOURNEY INTO THE THRILLING DEPTHS OF CHEMISTRY THROUGH GAMIFICATION

OTHMAN, M. I.<sup>1</sup> – HUSIN, N. I.<sup>2</sup> – ABDULLAH, A. R.<sup>2</sup> – BAKHARI, N. A.<sup>2</sup> – ZIN, A. M.<sup>2</sup> – MOKHTAR, M.<sup>2\*</sup>

<sup>1</sup> *Faculty of Pharmacy, Universiti Teknologi MARA Cawangan Pulau Pinang Kampus Bertam, Pulau Pinang, Malaysia.*

<sup>2</sup> *Department of Applied Sciences, Universiti Teknologi MARA Cawangan Pulau Pinang Kampus Permatang Pauh, Pulau Pinang, Malaysia.*

*\*Corresponding author  
e-mail: mmarina[at]uitm.edu.my*

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**Abstract.** In the realm of Pre-Diploma in Science education, cultivating an engaging and interactive learning environment stands as a pivotal factor for student success. Acknowledging the centrality of science as a core subject, this study investigates the potential of gamification to enrich the learning experience and enhance scientific thinking skills among students. The primary objectives involve assessing the impact of CHEM-XPLORACE, a gamified science activity, on students' motivation and learning in the Chemistry subject. Specifically, the study aims to explore students' responses to the integration of gamification in science education. Data were collected from 70 Pre-Diploma in Science students at a branch of Universiti Teknologi MARA, employing a combination of observation and questionnaire survey. Through their participation in CHEM-XPLORACE activities, students' experiences, perceptions, and learning outcomes were systematically gathered and analyzed. The findings uncovered a positive correlation between the implementation of CHEM-XPLORACE and heightened student enjoyment and motivation in learning science, particularly Chemistry. Moreover, students reported an enhancement in their ability to retain scientific facts and knowledge, attributed to their engagement in the gamified activities. The observed increase in motivation and learning outcomes underscores the effectiveness of gamification in Chemistry teaching and learning. The incorporation of interactive and enjoyable elements in learning environments can contribute to a more positive attitude towards science, fostering a deeper understanding of the subject matter. The study recommends educators consider integrating gamification strategies to enhance science education in Pre-Diploma programs.

**Keywords:** *chemistry, gamification, interactive learning, student motivation, scientific exploration*

## Introduction

The waning interest in science subjects has emerged as a significant contributor to the diminishing enrolment of students in chemistry courses at both high schools and universities. Numerous studies have identified the formidable challenges associated with learning chemistry, with perceptions of the subject being labelled as 'difficult' and 'boring.' This perception often stems from a misalignment between instructional methods and the real-world application of chemistry outside the confines of the classroom (Cardellini, 2012). Chemistry instruction, predominantly occurring at the abstract symbolic level, creates barriers for students who grapple with fundamental concepts (Gabel, 1999). Research indicates a prevalent lack of correct understanding among high school and university students regarding these fundamental chemistry principles (Kamisah and Nur, 2013). However, chemistry stands as the cornerstone for innovation, scientific literacy, and problem-solving, especially concerning sustainable development (Lay and Osman, 2018). Despite its pivotal role, the apprehension and

anxiety experienced by science students when dealing with complex chemistry problems pose a considerable obstacle (Purwanto et al., 2022; Saritas et al., 2021). Notably, students' interest, real-life application, and skill development are crucial indicators influencing the future intention to pursue a chemistry course in higher education (Ong, 2022). Recognizing students' preference for playful, motivating, and exciting learning approaches (Álvarez-Herrero and Valls-Bautista, 2021) presents an opportunity for innovative interventions.

In the 21st century, gamification has emerged as a transformative trend in learning methodologies (Nurtanto et al., 2021). An array of studies underscores the positive impact of gamification on chemistry education. Noteworthy findings by Chans and Castro (2021) indicate that gamification strategies elevate student motivation, engagement, and academic performance, while Lutfi and Hidayah (2021) report heightened student activity, learning outcomes, and motivation through smartphone-based games. The effectiveness of the Kahoot! gamification tool in enhancing overall marks and student performance has been highlighted by Bernal et al. (2018). These collective insights posit gamification as a potent catalyst for improving learning outcomes in chemistry by fostering motivation, engagement, and academic achievement. Gamification, viewed as a versatile learning and assessment tool (Sanmugam et al., 2016), holds the promise of transforming the teaching and learning processes in chemistry. Employing interactive and enjoyable strategies, such as hands-on experiments, role-playing, games, puzzles, visual aids, and real-world applications, can significantly enhance the appeal of chemistry instruction. The CHEM-XPLORACE program, positioned as an exploration activity, has been specifically designed to enhance pre-Diploma in science students' comprehension of fundamental chemistry concepts, foster increased interest and confidence in the subject, and establish a closer rapport between students and instructors. This study aims to achieve two primary objectives: (1) Assessing the impact of gamification on students' motivation of Chemistry subject; and (2) Assessing the impact of gamification on students' learning of Chemistry subject.

Through the comprehensive exploration of these objectives, our study seeks to contribute valuable insights into enhancing the effectiveness of chemistry education through innovative and engaging methodologies.

## Materials and Methods

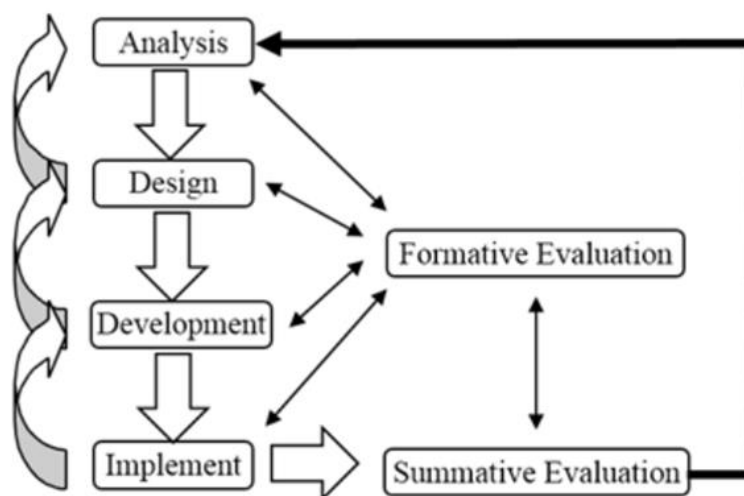
The development of the CHEM-XPLORACE module followed the systematic and widely recognized ADDIE Model (Taufiq et al., 2018) (*Figure 1*). The ADDIE model, encompassing Analysis, Design, Development, Implementation, and Evaluation, provides a structured approach for creating effective instructional materials and courses. The following outlines the phases undertaken during the preparation of the module:

**Analysis:** Conducted interviews with lecturers responsible for teaching pre-diploma science students to ascertain the goals and objectives of the module.

**Design:** Developed a comprehensive blueprint, outlining the module's structure, learning objectives, instructional strategies, assessment methods, and necessary instructional materials.

**Development:** Executed the module in alignment with the designed plan. Three experts validated the module for language, content, and face. A pilot test involving students was conducted to refine the module.

**Implementation and Evaluation:** Carried out during the semester.



**Figure 1.** The ADDIE Model framework.

Source: Taufiq et al. (2018).

The CHEM-XPLORACE module comprises four distinct games, each designed to reinforce different aspects of chemistry:

**Chemelody:** Students are tasked with creating a song and dance incorporating given chemistry terms.

**Chemstick:** In this game, students answer provided questions, with the marks awarded based on the score indicated on the dartboard.

**Chemseeker:** Students solve as many chemistry words as possible within a specified time frame.

**Crosschem:** This challenge involves solving a crossword puzzle related to selected topics within a given time frame.

**Chemscramble:** Students unscramble jumbled letters to form meaningful chemistry terms.

Students were organized into groups of five, and their objective was to navigate through five checkpoints to successfully complete the race. Each group engaged in activities at each checkpoint, including Chemelody, Chemseeker, Chemstick, Crosschem, and Chemscramble, all directly related to topics covered in class. All activities had to be completed within a specified period, and the group achieving success at all five checkpoints first was declared the winner. Likewise, the students were presented with a questionnaire comprising five statements before (pre-score) and after (post-score) their participation in the CHEM-XPLORACE games. The questionnaire aimed to gauge students' perspectives on various aspects related to Chemistry education. The statements included: "I have knowledge of the meaning of the acronym STEM (Science, Technology, Engineering, Mathematics)", "I am interested in studying Chemistry", "I realized that the Chemistry field is very beneficial for the

progress of the country", "I realized that Chemistry fields have a wide range of career opportunities," and "I understand that Chemistry fields are very important in everyday life".

Each statement offered three response options: 'Yes,' 'Not sure,' or 'No' - corresponding to 2, 1, and 0 marks, respectively. The marks assigned were then aggregated to determine the difference between pre-score and post-score, illustrating the change in students' perceptions after engaging in the CHEM-XPLORACE activities. The scoring system allowed for a quantitative assessment of the impact of the gamified learning experience on students' knowledge, interest, and awareness regarding the significance of Chemistry in various contexts. The subsequent analysis of pre-scores and post-scores, as detailed in the results section, provides valuable insights into the effectiveness of the CHEM-XPLORACE games in influencing students' attitudes and understanding of Chemistry-related concepts. This structured approach to assessment facilitates a clearer interpretation of the impact of gamification on students' perspectives, contributing to the broader understanding of gamified learning experiences in the field of Chemistry education.

## Results and Discussion

A total of 70 students participated in both the pre-and post-survey questionnaire, providing insights into their perceptions and attitudes towards various aspects of Chemistry education. The results, presented in *Table 1*, highlight the changes in students' responses before and after engaging in the CHEM-XPLORACE activities. Examining the students' initial understanding of the acronym STEM, a remarkable increase was observed post-engagement with CHEM-XPLORACE. The transition from 31 to 65 students expressing knowledge signifies a substantial 56% improvement, accentuating the positive influence of gamified learning experiences on students' grasp of STEM concepts. These findings align with Lay and Osman (2018) call to enhance STEM education, emphasizing the need for proficiency in both chemistry knowledge and 21st-century skills. Moving to the realm of students' interest in studying Chemistry, the pre-survey indicated 38 students expressing interest, which saw a marginal decrease to 62 in the post-survey. Despite this decrease, the overall change percentage remained stable at 40%. This suggests that CHEM-XPLORACE activities effectively maintained a positive impact on sustaining students' interest in studying Chemistry, echoing the positive outcomes identified by Lutfi et al. (2023) and Chans and Castro (2021).

**Table 1.** Comparative analysis of pre- and post-scores in students' perceptions of Chemistry education.

Statement	Pre-score (1)				Post-score (2)				Difference (1) vs (2)	Change (%)
	Y	NS	N	T	Y	NS	N	T		
I have knowledge of the meaning of the acronym STEM.	31	16	23	78	65	4	1	132	4.08	72
I am interested in studying Chemistry.	38	15	17	91	62	7	1	131	40	44
I realized that the Chemistry field is very beneficial for the progress of the country.	40	14	16	94	67	1	2	135	41	44
I realized that Chemistry fields have a wide range of career opportunities.	41	23	6	105	65	4	1	134	29	28
I understand that Chemistry fields are very important in everyday life.	42	18	10	102	66	4	0	136	34	33

Note: Y=Yes; NS=Not Sure; N=No; T=Total.

Perceptions regarding Chemistry's benefits for societal progress exhibited a positive shift. From 40 students acknowledging this aspect in the pre-survey, the number increased to 67 in the post-survey, indicating a 41% improvement. This underscores the efficacy of CHEM-XPLORACE activities in heightening students' awareness of Chemistry's societal importance, aligning with the emphasis on sustainable development highlighted by Lay and Osman (2018). Exploring awareness of career opportunities within Chemistry fields, the pre-survey recorded 41 students with this acknowledgment, slightly decreasing to 65 in the post-survey. However, the change percentage remained consistent at 29%, indicating that CHEM-XPLORACE activities sustained a positive impact on students' understanding of career prospects. This resonates with the notion that gamification positively influences future intentions to enroll in chemistry-related courses (Ong, 2022). Finally, the category gauging understanding of Chemistry's importance in everyday life demonstrated positive outcomes. The pre-survey had 42 students expressing this understanding, increasing to 66 in the post-survey, indicating a 34% change. This affirms that CHEM-XPLORACE activities effectively enhanced students' appreciation for the significance of Chemistry in their daily lives. These outcomes align with the broader positive impact of gamification on student behaviour and learning outcomes outlined by Nurtanto et al. (2021).

While the current study showcases the positive influence of gamification in Chemistry education, it is crucial to acknowledge certain limitations. The generalizability of gamification across diverse contexts and student populations, as noted by Hürsen and Bas (2019), introduces a layer of complexity into the assessment of its universal effectiveness. External elements influencing students' intentions to enrol in chemistry-related courses further underscore the multifaceted nature of this influence (Ong, 2022). Additionally, the effectiveness of gamification is contingent upon the design of specific gamified elements, learning objectives, and student characteristics, as cautioned by Alomari et al. (2019) and Nurtanto et al. (2021). Therefore, our study's findings with the insights from existing literature reinforces the potential of gamification, exemplified by CHEM-XPLORACE, in positively influencing students' knowledge, interest, and perceptions related to Chemistry education. These outcomes align with the broader positive impacts of gamification (Montenegro-Rueda et al., 2023; Rahman et al., 2018; Wu et al., 2018), but careful consideration of contextual factors and instructional design remains essential for maximizing its effectiveness in diverse educational settings.

However, while this study offers valuable insights into the positive impact of the CHEM-XPLORACE gamification activities on students' perceptions of Chemistry education, certain limitations should be acknowledged. Firstly, the study's generalisability may be constrained, as it focused on a specific group of pre-diploma science students within one university branch. The effectiveness of gamification can vary across diverse student populations and educational contexts. Additionally, the study relied on self-reported data from students, which may introduce response bias. The slight decrease in students' interest in studying Chemistry post-activity prompts further exploration into the factors contributing to this change. Furthermore, the study lacks a control group for comparative analysis, making it challenging to isolate the specific impact of CHEM-XPLORACE activities. These limitations emphasise the importance of considering diverse factors influencing student perceptions in future research.

## Conclusion

In conclusion, CHEM-XPLORACE emerges as a dynamic and interactive educational game, providing a captivating avenue for students to delve into the intricacies of chemistry. Through the strategic infusion of gamification elements, the game not only fosters active participation but also cultivates critical thinking and problem-solving skills among students. Its inherent design sparks curiosity and a sense of adventure, transforming the learning process into an enjoyable journey that significantly enhances knowledge retention. Beyond individual learning, CHEM-XPLORACE promotes teamwork and collaboration, fostering social interaction and honing essential skills such as communication and leadership. The game's versatility in accommodating various learning styles and preferences, incorporating visual, auditory, and kinaesthetic elements, adds another layer to its effectiveness. In essence, CHEM-XPLORACE stands as a commendable and enjoyable approach to chemistry education, contributing to a holistic and engaging learning experience for students.

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## Conflict of interest

The authors confirm that there is no conflict of interest involve with any parties in this research study.

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