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INNOVATION IN ACTION: TURNING IDEAS INTO REALITY

Chapter 7
DAPoEff: The Ultimate Chemistry Board Game

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ABSTRACT
Understanding chemical equilibrium and Le Chatelier's Principle can be challenging for students due to the abstract nature of these concepts. Conventional teaching methods often fail to engage learners, hindering their ability to achieve desired learning outcomes. To address this challenge, DAPoEff: The Ultimate Chemistry Board Game integrated with custom AI chatbot was developed as an innovative solution. The project adopts the ADDIE Model to ensure a structured development process, incorporating gamification to transform the delivery of chemical concepts into an interactive and effective learning experience. With a sample size of 70, the results indicated a significant improvement in students' understanding and application of chemical equilibrium concepts. The triangulation of data shows students' active participation and positive experience in learning the concept. We aspire for DAPoEff to be adopted by educational institutions worldwide, making an interactive approach to learning chemistry accessible to all.

Key Words: DAPoEff, board game, chatbot, chemical equilibrium, Le Chateliers' principle

1. INTRODUCTION

DAPoEff board game is an educational tool designed to simplify complex concepts such as chemical equilibrium and Le Chatelier's Principle in a fun, engaging, and interactive manner. The name DAPoEff represents key concepts: (D) Disturbance, (A) Action to reduce the effect of the disturbance, (PoE) Position of Equilibrium, and (Eff) Effect on reactants and products as equilibrium is re-established. These principles are seamlessly integrated into the design of the board game to ensure a comprehensive and cohesive learning experience. Through interactive gameplay mechanics, players engage strategically to solve challenges presented on task cards, exploring the effects of disturbances on equilibrium systems. Players are encouraged to apply theoretical knowledge and devise strategies to win the game. Movement cards allow players to collect tokens, while power cards can be used to accelerate task completion or hinder opponents. Adding a dynamic twist, a disturbance occurs at the end of

each round, where all players must exchange their movement cards with the player next to them, mimicking real-life external changes that disrupt chemical equilibrium. This innovative project aims to bridge the gap between theoretical knowledge and experiential learning by reimagining the delivery of chemical concepts through DAPoEff, an interactive chemistry board game.

2. PROBLEM STATEMENT

Understanding chemical equilibrium and Le Chatelier's Principle is challenging for many students due to the abstract nature of these concepts (Riddle et al., 2023). Traditional teaching methods, such as lectures and textbook exercises, often fail to engage students effectively or provide interactive, hands-on learning experiences. As a result, students struggle to predict how a system at equilibrium responds to changes in concentration, temperature, or pressure (Liu et al., 2024). Chemical equilibrium is widely regarded as a difficult concept for students to grasp. Its complexity arises from its abstract nature, the need for mathematical calculations, and the interpretation of graphs to fully comprehend the material (Andriani et al., 2021). According to the Matriculation Examination Report for Chemistry (SK015) for the academic year 2022/23, students often fail to internalize the concept and struggle to apply it when answering questions. Specifically, 35% of candidates were unable to state the effect of temperature on the concentration of HCl in a given chemical equation. Furthermore, 60% of students were unable to predict the position of equilibrium or use the correct terminology to accurately explain the argument for the context of endothermic reaction (BMKPM, 2023). Students find it difficult to visualise equilibrium shifts because lecture notes and textbooks alone do not provide a dynamic representation of the process. Even with the inclusion of technological tools such as PowerPoint slides and videos, the delivery often remains one-directional and does little to enrich students' understanding. This limitation arises from the passive nature of the available teaching resources, which do not encourage active participation or effective engagement with the concept.

3. OBJECTIVES:

i. To enhance students' understanding of Le Chatelier's Principle via the improvement of test score in answering question related to problem-solving
ii. To provide engaging and effective learning sessions through the interactive DAPoEff board game.

4. METHODS & MATERIAL

ADDIE Model was adopted to develop the innovation project.

Analysis (A)
In this phase, the focus is on understanding the learning objectives, target audience, and educational challenges. From the survey and worksheet, students struggle with concept of chemical equilibrium and Le Chatelier's' principle. Thus, innovation project was aligned to the learning objectives of applying Le Chatelier's Principle to predict shifts in equilibrium in response to changes in several factors like concentration, temperature, and pressure. The

targeted audience is for pre-universities and college-level students studying chemistry. The educational challenges involved the lack of students' active participation in the conventional teaching methods, thus there is a need for interactive learning methods that promotes students' centred learning.

Design (D)
This phase focuses on creating the structure, rules, and components of the game. Players compete to complete the task card based on different equation at equilibrium while navigating the impact of external changes on the system. The game mechanics includes board, movement cards, power cards, and tokens to solve the equilibrium challenges in the task card. This covers the whole complexity of chemical equilibrium from (D)Disturbance, (A) Action to reduce the effect of disturbance, (PoE)Position of Equilibrium and the (Eff) Effect towards reactants and products when the equilibrium is re-established. Thus, the board game of DAPoEff was designed.

Development (D)
The development stage focuses on creating the game materials and testing prototypes. This involves a series of improvement and testing the mechanics for balance and fairness in the game structure. The comprehensive rule book was developed to display the set up instructions, gameplay mechanics, and scoring systems. The game flow was refined based on feedback from alpha and beta-testing which includes both students and teachers' perspective.

Implementation (I)
This phase is where the game is introduced and used in real learning environments. Teachers brief the instruction and provide the demonstration based on the rule book. There are mentors acting as moderators facilitating the game play, clarifying rules and answering related questions on the game structures. The innovators reflect on each implementation session.

Evaluation (E)
The evaluation phase is to assess the effectiveness of the game in meeting learning objectives. A pre-test and post-test were administered to evaluate students' understanding on molecular polarity. Students' feedback was analysed, interviews' transcript and worksheet were examined. Make necessary revisions to enhance the learning experience.

5. FINDINGS

i. Students' understanding

From Figure 1, all the classes selected for intervention showed an improvement in performance by an increase in the overall mean score. For class H37, the mean score improved by 2.50. Meanwhile, the mean score for the class of F17 and H16 improved by 2.34 and 2.47 respectively. The overall mean score for the total respondents of 70 students is 5.58 for pre-test and 8.02 for post-test. This indicates an average improvement of 2.44.

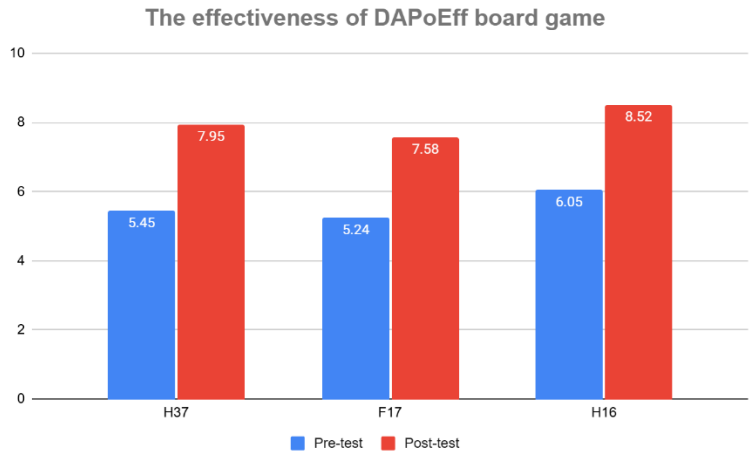

Figure 3: The effectiveness of DAPoEff board game in enhancing students' understanding

ii. Engaging and effective session.

Students' feedback was also taken after the implementation of the DAPoEff board game in the classroom. The following themes emerged from the analysis. In essence, students find that board games effective in enhancing the conceptual understanding. Additionally, they were engaged actively during the session and have a positive experience in learning.

Themes	Description
Effective learning	"Using DAPoEff game help me to understand the Le Chatelier's principle much better." "It is very excellent and well-made game, I hope I can play it again. I think that if I play the game multiple times more, I can understand it better." "The game was fun. I get to understand a bit more about Le Chatelier's Principle especially about the shifting of equilibrium positions."
Active engagement	"I love to have some fun while revising the things that I had learned. Thus, the game really helps me to think the process that happen on paper more realistically". "It's fun to play with friends, learning together about the concept of Le Chatelier's Principle while having fun is the best way to study especially when the topic is confusing." "I am so happy because it makes me want to win the game by recalling all my knowledge about the Le' Chatelier's principle."

6. CONCLUSION

DAPoEff board game has shown to enhance conceptual understanding and create a fun and student-centred learning environment. With a sample size of 70, the results indicated a significant improvement in students' understanding and application of chemical equilibrium concepts. The triangulation of data shows students' active participation and positive experience in learning the concept. We aspire for DAPoEff to be adopted by educational institutions worldwide, making an interactive approach to learning chemistry accessible to all. This is consistent with the fourth aspiration of Sustainable Development Goals (SDG-4) which is to provide quality education.

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