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Faculty of Administrative  
Science and Policy Studies

# i-SPIKE 2021

*Leading An Artificial Innovation In Knowledge, Education And Design*

## **i-SPIKE 2021 INTERNATIONAL EXHIBITION & SYMPOSIUM E-PROCEEDINGS**

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## ONLINE GAMES FOR LEARNING LEWIS STRUCTURE

Wan Elina Faradilla Wan Khalid  
Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Negeri Sembilan,  
Kampus Kuala Pilah  
wan\_elina@uitm.edu.my

Tuan Sarifah Aini Syed Ahmad  
Akademi Pengajian Bahasa, Universiti Teknologi MARA Cawangan Negeri Sembilan,  
Kampus Seremban  
tsyaini@uitm.edu.my

Nor Akmalazura Jani  
Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Negeri Sembilan,  
Kampus Kuala Pilah  
NorAkmalazura@uitm.edu.my

Rohaiza Saat  
Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Negeri Sembilan,  
Kampus Kuala Pilah  
rohaizas@uitm.edu.my

Nurazira Mohd Nor  
Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Negeri Sembilan,  
Kampus Kuala Pilah  
nurazira@uitm.edu.my

### ABSTRACT

The application of online games has become prevalent in learning various courses including Chemistry. There are various online games for learning Chemistry which are available ubiquitously on many free online platforms. However, most of the games are developed by using applications which provide specific templates. The applications also only allow limited modifications in terms of game design which involves multimedia and gamification elements. Therefore, the Chemistry online game called Play Chemistry: Lewis Structure is developed by using the application called Scratch which allows unlimited game design based on the creativity of the developers. The topic, Lewis Structure, is selected due to the reason that the topic is challenging to be learnt by the students at the tertiary level. This paper aims to describe the development of a series of Chemistry online games called Play Chemistry: Lewis Structure. The series contains three games for three molecules namely tetrachloromethane ( $\text{CCl}_4$ ), methane ( $\text{CH}_4$ ) and water ( $\text{H}_2\text{O}$ ). The games are developed for tertiary students at the diploma/degree level. The instructional design model applied for the design and development of the games is the ADDIE Model. The game adopts structural gamification by applying selected gamification elements such as score, praise feedback, explanatory feedback, verification feedback, and lives. The games are embedded on Google Site (<https://sites.google.com/view/lewis-structure/home>) for the students' easy access. The three molecules are considered easy molecules. Therefore, future work will focus on more difficult molecules.

**Keywords:** Games-based learning, online game, chemistry, Scratch

## INTRODUCTION

Online games are widely used in educational institutions, schools, and homes as one of the platforms to attract students' interests and encourage them to be actively involved in the learning process. Nowadays, games are popular among students no matter at the school level or higher education. The use of games in learning aims to help students understand what they have learned in an interesting way. Digital game-based learning approaches have proven to be a more effective method and can increase motivation among students to study the subject matter (Hamari et al., 2016; Marina, 2008; Reynolds et al., 2020). Games for learning or known as educational games incorporate gamification approaches. Gamification is defined as applying game elements in non-game settings with the intention to engage and motivate the students through the learning process (Legaki et al. 2021). A new "race style" game called Fastest Fingers was proposed by Michael (2013) to solve an organic chemistry problem and then build the correct molecule as quickly as possible. The developed game required the students to work in teams of three or four to build the molecules themselves. Through this process, students gain a better understanding of the three-dimensional shape of these molecules. In chemistry, Lewis structures can be considered a very important and fundamental topic. Usually, the tertiary level students can have the knowledge on Lewis structure in General Chemistry (Cooper et al., 2009; Nassiff and Czerwinski, 2015; See 2009). Despite this, drawing a simple molecule is considered very simple for the students, however, as they progress and arrive at more complex molecules, the students feel that it is a challenging task and some students consider the Lewis structure topic to be very difficult to visualise and apply (Cooper et al., 2010). In addition, the concept of electron octet is not very clear to some of the students. Hence, it is important to develop a different approach where the students are able to know the number of electron valence and remember all the steps (rules) in a more entertaining way. This paper describes the development of Lewis structure games especially for chemistry students in terms of selecting the game content, development of the storyboard and games development.

## GAMES DEVELOPMENT

Play Chemistry: Lewis Structure is designed by using the ADDIE Model which consists of five phases namely (1) Analysis, (2) Design, (3) Development, (4) Implementation and (5) Evaluation. The model is selected due to its systematic and easy approach in creating an effective, creative, and efficient product. Apart from that, the ADDIE Model is chosen as it involves a teaching and learning environment which fits the objective to enhance the student's understanding in constructing chemical structure of molecules using Lewis diagrammes (Hidayanto et. al., 2017; Sahrir and Alias, 2012). The game is mainly designed for the first-year students at diploma or degree levels who have basic knowledge in general chemistry. At the first stage, the game is limited to simple and common covalent molecules including  $\text{CCl}_4$ ,  $\text{CH}_4$  and  $\text{H}_2\text{O}$  which have single bonds and follow the octet rule (no expanded octet). The game starts with the simple molecules to familiarise the students with common patterns of Lewis structure and bonding. Structural gamification is chosen for the game design in the storyboard development. Structural gamification is basically the use of game elements to increase the students' participation by keeping the content unchanged (Lamprinou and Paraskeva, 2015). Several gamification elements such as praise feedback, explanatory feedback, verification feedback, and lives were deliberately selected. This is because the objective of the game is to help the teaching and learning process either in the virtual or physical class. The purpose of applying the selected gamification elements are as follows:

a. Explanatory feedback

To construct understanding based on the mistakes done in performing the tasks in the game so that students' knowledge and skills can be improved.

b. Praise feedback

To make students feel good so that it can increase their motivation to perform the tasks in the game.

c. Verification feedback

To inform students' performance so that they can gauge their learning progress.

d. Score

To reward students' achievement so that it can positively reinforce them to engage in the game.

e. Life

To allow freedom to fail so that students have several opportunities to perform the tasks in the game.

The game tasks in the game are arranged according to cognitive difficulty levels based on the revised Bloom's Taxonomy (Krathwohl, 2002). The taxonomy has six cognitive levels which are (1) Remember, (2) Understand, (3) Apply, (4) Analyse, (5) Evaluate, and (6) Create. The following gamification elements are provided when students give the correct or wrong response to the task in the game.

a. When students answer the task correctly

One point (score) is awarded to inform their achievement. Verification feedback is provided in the form of a pleasant sound to notify that their answer is correct. Praise feedback is provided in the form of onscreen text such as "Well done!". Then, they will proceed to the next task.

b. When students answer the task incorrectly

No point is awarded to notify that there is no achievement. Verification feedback is provided in the form of an unpleasant sound to notify that their answer is incorrect. Praise feedback is provided in the form of onscreen text such as "Try again!" to increase their motivation to proceed with the next attempt. Explanatory feedback is provided to improve their understanding so that it will facilitate them to answer correctly in the next attempt. Another opportunity (life) to perform the task is provided.

The game was developed using Scratch, an online application for developing interactive games, stories, and animations. Scratch can be accessed at <https://scratch.mit.edu/>. Projects can be downloaded and accessed offline or shared on the website. The shared projects can be embedded on any social media such as Facebook, Telegram, and Whatsapp, or online platforms such as learning management systems, Google Sites, blogs, and websites. Scratch was chosen to develop the game as it is not costly as no subscription fee is required. Furthermore, it is easy to use since users do not need to learn any programming language. Besides, there are many supports to learn using Scratch such Scratch Wiki, YouTube tutorial video channels and Facebook support groups.

## CONCLUSION

An online game for Lewis structure that uses structural gamification has been developed. This online game was developed as an alternative for online teaching and learning that is suitable particularly for the current COVID-19 pandemic situation where all the teaching and learning processes are carried out through online and distance learning (ODL). The developed game is expected to create an exciting and fun way of teaching and learning Chemistry as well as assist students to personalise their learning. In the future, the project will be continued by creating more games in learning Lewis structure of more difficult molecules which consist of multiple bonds (double and triple bonds), and molecules which deviate from the octet rule as well as charged molecular ions.

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