



## Equibrilliant Gameboard Assessment to Increase Students' Conceptual on Chemical Equilibrium

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### ABSTRACT .

Equibrilliant is a gameboard assessment designed to improve students' conceptual understanding of Chemical equilibrium. This game-based learning teaching material aims to overcome prolonged misunderstandings by providing teachers with quick feedback and enhancing students' motivation through the enjoyment of play-based learning. This approach applies the formative assessment to replace conventional assessment which limits the evaluation of students' progress, contributes to prolonged misconceptions, creates stressful situations, and diminishes motivation. An analysis of pre- and post-test results reveals that Equibrilliant gameboard assessment has improved the conceptual achievement of 50% of students' and has provided a high impact assessment with a high mean score of 4.64. Utilizing Equibrilliant is a better way of assessing students' concepts to prepare matriculation graduates to be knowledgeable, innovative, and competitive in the STEM field in the future.

**Keywords:** Game-based learning; Formative assessment; Chemical Equilibrium; Matriculation; Chemistry education

## INTRODUCTION

Chemical equilibrium encompasses intricate sub-microscopic concepts that are connected to each other. Prolonged misconceptions limit the students' overall comprehension of the topic at hand. One of the reasons for this situation is that students are not provided with immediate feedback on their misconceptions [1]. Furthermore, traditional assessment expects students to furnish the correct answers expected of them. Consequently, lacking a firm understanding of the required concept, students often resort to memorising the terms to achieve a good score. This tradition creates a stressful situation for students, especially for those who are low achievers [2].

From an open-ended question survey with Matriculation college lecturers, they understand the importance of giving quick feedback, as students can use it immediately to improve their learning. However, time constraints have limited the implementation of giving direct feedback [3]. The ideas for improvement from lecturers are often delayed until a certain point, by which time students have forgotten about their mistakes. An open-ended question survey with matriculation college lecturers shows some problems in the implementation of formative assessment in the Chemical Equilibrium topic.

Consequently, students lack a platform to attract teachers' attention when they misunderstand the concepts. Therefore, it becomes impossible for teachers to identify who

is struggling for the teacher's attention and which aspects the students really need help with during the class [4]. Moreover, lecturers continue to advance to deeper concepts which necessitate a more complex understanding until the syllabus concludes, without realizing that students are grappling with previous difficult concepts. Hence, a lack of on-going assessment occurs because assessments are conducted at the end of the topics. This results in no quick feedback, but rather a gap between students' misconceptions and interactions between both parties. So, teachers cannot monitor the learner's progress during the course [3].

In conclusion, the implementation of formative assessment during the teaching and learning process is the most concerning issue to be solved. As a solution, assessment tools that can be easily implemented in the class must be developed to assist lecturers in addressing the stated problems and helping students achieve better results in the Chemical Equilibrium topic.

## MATERIAL AND METHODS

The ADDIE model, which encompasses the Analysis, Design, Development, Implementation and Evaluation stages, has been adapted and utilized as a product design method in this innovation process.

In the Analysis stage, the problem is identified through the conduct of a needs analysis based on students' work, by means of open-ended question surveys with matriculation college lecturers and a systematic literature review. The identified problems are the lack of formative assessment implementation during the teaching and learning process and the lack of students' motivation. The current solution available is analyzed, and a chemical equilibrium-themed gameboard which incorporates constructivist learning theory is proposed as a potential solution.

In the Design stage, the product structure, and the way to implement learning and formative assessment into the gameboard are determined. The colours, components, and materials such as binding board, paper and plastic in the product are also determined. The design of the Equibrilliant Gameboard Assessment components is included in Appendix 2.

In the Development stage, the Equibrilliant Gameboard Assessment product is developed according to the previously designed physical and online forms. In the physical version, the gameboard measures 16 inches by 16 inches. Questions related to the chemical equilibrium topic, classified according to Bloom's Taxonomy levels C1 to C4, are presented in the form of cards. Fact cards are also included. The answers to these question are provided on the reverse side of the cards. A user instruction guide is accessible through a QR code, offering students an overview of how to play the game. The validity of the gameboard is assessed by several experts, and modifications are made based on their feedback. In the online version, the Equibrilliant Gameboard Assessment, consisting of the same components, is designed using PowerPoint.

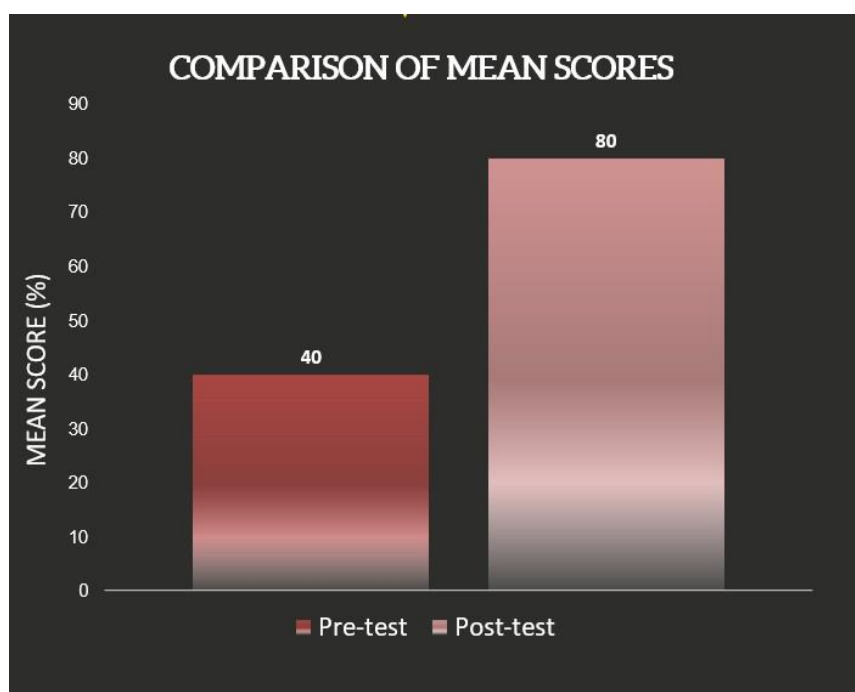
For the Implementation stage, the Equibrilliant Gameboard Assessment is tested on 25 matriculation college students via physical learning through hands-on activity and online through Google Meet. The online version through Google Meet is an alternative due to pandemic constraints. Both implementations follow the same rules for gameplay. A briefing about the game is given by the facilitator before it begins. Discussions among peers about the selected questions and feedback from facilitators are incorporated during the game to

achieve the objectives of the innovation. The discussions in group take place face to face and in breakout rooms for physical and online learning, respectively. The total points obtained by each group are calculated, and the winner is determined. The related documents used during physical and online implementation are included in Appendix 3.

Evaluation was conducted on the usability of the media and the effectiveness of learning materials. Pre-test, post-test and a student feedback survey were conducted after the intervention with the sample, and the collected data were analyzed descriptively. The data obtained were then analyzed to determine the usability of the gameboard and the effectiveness of assessment-based game learning. The feedback obtained was used to make improvements to the gameboard.

## RESULTS AND DISCUSSION

Pre-test and post-test results show a 50% increase in mean scores in the post-test compared to the pre-test, as shown in **Figure 1**. The pre-test mean score is 40%, but it increases to 80% after the intervention using Equilibrium Gameboard. This proves students' improvement in the Chemical Equilibrium concept, successfully achieving the first objective of the product.



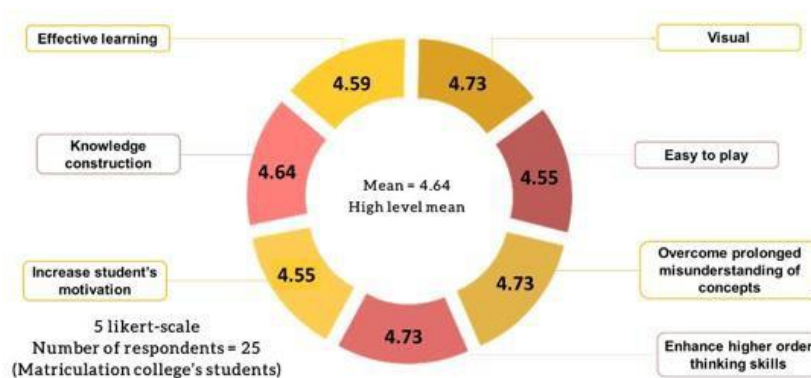
**Figure 1:** Comparison of pre-test and post-test mean scores

Students' feedback survey, using a 5-point Likert scale questionnaire, shows a high mean score of 4.64, as shown in **Figure 2**. **Table 1** displays the mean score for each item in the survey. This proves that the Equibrilliant Gameboard Assessment has a substantial impact on student's concepts, knowledge, thinking skills, and motivation. The survey also

indicates that this gameboard provides effective learning, is engaging partly due to its attractiveness, and is easy to play.

**Table 1:** Mean score of students' feedback survey using a 5-Point Likert scale questionnaire

No	Item	Mean Score
1	Overcome prolonged misunderstanding of concepts	4.73
2	Effective learning	4.59
3	Knowledge construction	4.64
4	Enhance higher order thinking skills	4.73
5	Increase student's motivation	4.56
6	Easy to play	4.55
7	Visual	4.73



**Figure 2:** Average mean score of students' feedback survey

## Product Testing and Fine Tuning

The product is tested and run before it is implemented on the Matriculation students. Complications and difficulties encountered during the testing that hinder the smooth progress of the learning process are identified. These include issues such as the time allocated for answering questions and giving feedback, determining the turns, and the way in which students present their answers. Improvements are made following discussion among team members on how to tackle these issues. Reviews from experts are also taken into consideration for improving the Equibrilliant Gameboard Assessment.






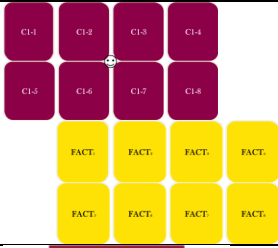
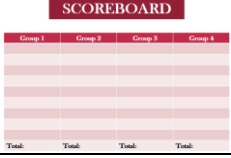
## Product Specification

Equibrilliant Gameboard Assessment, as shown in **Figure 3**, provides a fun and meaningful approach to learning chemical equilibrium. It consists of assessments based on Bloom's Taxonomy levels, offering students interactive exercises with questions and facts in an enjoyable environment. When using the physical board, students can play within the group cooperatively and actively compete with other groups to win the game [5]. **Table 2** displays the final product of the Equibrilliant Gameboard Assessment after fine-tuning.



Figure 3: Equibrilliant Gameboard Assessment

Table 2: Final product of Equibrilliant Gameboard components

Component	Material (Physical)	Final Product	
		Physical	Online
Board	Binding board (6-inch x 6-inch)		
Toggle	Plastic		
C1-C4 Q&A Cards Flash Cards	Glossy paper (2.5-inch x 3.3-inch)		
Scoreboard	-		
<b>Total Cost</b>		RM 50 per set	RM 0

There are rules that must be followed for this gameboard to achieve its objective. The instructor will act as the facilitator, and each group will take turns to pick a card between C1, C2, C3 or C4 cards from the board, which represents the number of steps they will take: one, two, three, or four respectively. The students then need to answer the question within the time limit. If the students answer the questions correctly, points will be given to the group based on the level of questions they select: C1 earns 1 point, C2 earns 2 points, C3 earns 3 points, and C4 earns 4 points. Each space on the board consists of benefits or drawbacks. Benefits and drawbacks are

applied for correct and wrong answers respectively. The answers will then be discussed in front of the whole class. With this quick feedback and formative assessment, students can enhance their understanding of chemical equilibrium.

Due to COVID-19 restriction, this game can also be played online using PowerPoint and Google Meet. The rules will be similar to playing the game physically, and students are divided into breakout rooms to discuss how to answer the questions. The first three groups that reach the end will be given additional points, and the points will be added to determine the winner of the game.

The Equibrilliant Gameboard Assessment can be used in the Matriculation College as this topic is taught during matriculation and is considered a difficult topic. **Table 3** shows the lesson plan for the class which uses game-based learning and can be implemented during class. In this lesson plan, the Equibrilliant Gameboard Assessment is used as a learning material.

**Table 3:** Lesson plan of Chemical Equilibrium topic



<b>Subject</b>	Chemistry		
<b>Topic</b>	Chemical Equilibrium		
<b>Level</b>	Matriculation Studies		
<b>Model of learning</b>	Game-based learning		
<b>Related material/Settings</b>	Equibrilliant Game Board Assessment		
<b>Learning Objectives</b>			
The aim of this session is to overcome the student's misconceptions in the topic of chemical equilibrium. The students will be able to:			
a- Explain reversible reaction, dynamic equilibrium, and law of mass action terms			
b- State the characteristics of a system in equilibrium			
c- Interpret concentration reactants and products against time curve (reversible reaction)			
d- Define homogeneous and heterogeneous equilibria			
e- Write expressions for equilibrium constants for homogeneous and heterogeneous systems			
f- State Le Chatelier's principle and apply Le Chatelier's principle			
<b>Activities of Learning</b>			
<b>Activities</b>	<b>Description</b>	<b>Time allocation</b>	<b>Remarks</b>
<b>Introduction</b>	The instructor conditions students to be ready to learn. The instructor briefs the activity and rules of the game to the students.	5 minutes	User manual instruction video  <a href="https://drive.google.com/file/d/1FSucwdA3BOyOz97uegRh2YiuvOv3Ipbjv/view">https://drive.google.com/file/d/1FSucwdA3BOyOz97uegRh2YiuvOv3Ipbjv/view</a>
	Students will listen and understand the rules and roles of the game.		

### Commercialization Potential



Based on the interview that we conducted regarding the commercialization potential of Equibrilliant Gameboard Assessment, our target customers and users gave positive feedback regarding the product. This indicates high potential for commercialization in the market. This innovation has received evaluation and recognition from several important and accredited individuals.

This innovation has been disseminated to educational institutions through competitions, face-to-face and online presentations, visits, and face-to-face partnerships. Among the partnerships to disseminate this innovation are Malacca Matriculation College and Johor Matriculation College. This innovation project has a great potential to be extended and used in others Matriculation Colleges, Form Six Colleges, pre-university centres, and secondary schools throughout Malaysia because of its uniqueness. The use of this innovation is not limited

### Achievement and Recognition





	
<p>Platinum Award in 14th SOE Innovation Day, FesKiK, UTM, Johor</p>	<p>Gold Award in 14th SOE Innovation Day, FesKiK, UTM, Johor</p>

### Recognition from the Validators

Experts/ Validator		Comments
<p>Nor Azian Idris, KIK coordinator, panel of International Innovation</p>		<p>"This product is beneficial and can aid students to understand the topic deeper".</p>
<p>Dalina Daud, R&amp;D coordinator, Subject Matter Expert of Chemistry</p>		<p>"This game is the best and can be adopted into other chemistry topics or even into the curriculum".</p>





Rahmah Wasimin, Subject Matter Expert Lecturer.		"Equibrilliant Gameboard is one of the best teaching aids because it will attract students' attention to learn this topic effectively. And one of the impressive elements in this game board is the way formative assessment is heavily implemented during the game".
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### Comments from Matriculation Students

Target Users		Comments
Student 1		"This game board is very exciting and helps me increase my confidence when answering questions and can enhance collaboration among group. I recommend this game board to be used in other matriculation colleges too".
Student 2		"From my experience, based on this activity, I learned about my mistakes and how careless I am in my work. This activity is very fun and gives me new knowledge and makes me happy. Get to play with my friends makes me happy too".
Student 3		"This game challenges my quickness and intelligence. I felt challenged when people can answer the question, but I can't, that is when I can look back at my work and check for any mistake".
Student 4		"This game helps me to think quicker and can enhance my skills in Chemical Equilibrium topic".



### List of Reviewers/Target customer

Name	Position	Images
En Mohamad Zairul Md Razali	PPC KMM Coordinator Top ranking Chemistry Lecturer of Malacca Matriculation College	
Puan Adzliena Ab. Rahim	Chemistry Senior Lecturer DG54(KUP) Student Innovation Coordinator of Malacca Matriculation College	
Puan Sharifah Nurliyana Syed Nasir	Pensyarah PPC KMM Top ranking Chemistry Lecturer of Malacca Matriculation College	
En. Rajakumar A/L Ramachandran	Prospective Outstanding Chemistry Lecturer DG52 (KUP) in Malacca Matriculation College	

### CONCLUSION

Equibrilliant Gameboard Assessment is the most sought-after innovation product in the current market for the targeted teachers, lecturers and students due to its uniqueness. It is new, and the first of its kind in Malaysia, offering a fully designed finished product. It provides a fun and interactive learning platform based on the Taxonomy Bloom Hierarchy, which includes Higher Order Thinking skills (HOTS) items. This gameboard is user-friendly and interactive, featuring quick-fire Q&A and providing a platform for full teacher's attention with quick feedback. It is visually impressive, and the main advantage is zero cost for online teaching and learning, as well as its affordable cost for

teachers and B40 students (RM50 per set) for hands-on activities in physical classes or at home. This game offers maximum benefits to students, lecturers, and institutions.

Improvement in student's conceptual understanding of Chemical Equilibrium is proven by data analysis of the pre-test and post-test comparison. A high mean score of 4.64 on a 5point Likert scale from student's feedback survey strongly demonstrates an increase in their interest and motivation to learn more about this difficult topic. It overcomes students' prolonged misunderstanding of concepts through visual, effective learning, easy-to-play games, and enhances knowledge construction. All objectives of this innovation development have been 100% achieved.

Furthermore, Equibrilliant Gameboard Assessment provides the best alternative way for teachers or lecturers to implement formative assessment in their classrooms within a short and effective time, solving their previous time constraint problems. Another unique feature is the widely implemented constructivism learning theory, known for its effective learning in educating students in the 21st century. This product promotes cooperative and active learning.

Equibrilliant Gameboard Assessment has high market value and the potential to be commercialised, indirectly benefitting the Matriculation Institution with excellent student achievement in the Chemical Equilibrium topic. It can also be recommended for widespread use in other topics and related subjects across the curriculum. This product has received evaluation and recognition from several important and accredited individuals, such as experts (coordinator of R&D, PLC, Innovation, and subject Matter Expert lecturers) and Chemistry Lecturers in Matriculation Colleges. High-achieving students in STEM-related subjects will have a positive impact on the Matriculation community as it prepares students to the higher-level education, whether inside or outside the country. In conclusion, Equibrilliant Gameboard Assessment contributes significantly to the organisation and Science Education in Malaysia.

For further study, there are a few recommendations for the improvement of Equibrilliant Gameboard Assessment. This game can be adapted for use into other topics and integrate into the curriculum. Additionally, the gameboard assessment should include peer assessment with a reliable rubric for assessing their group members to encourage active participation in discussions through cooperative learning. Furthermore, Microsoft PowerPoint software can be upgraded using high-impact technology applications to ensure effective and smooth implementation of online teaching and learning. In addition, it is suggested to use gloss paperboard or an erasable board for the scoreboard during physical implementation.

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