

The Effectiveness of Using Instructional Materials in Biology Teaching and Learning: Human Immunity Battle (HIB) Boardgame

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Abstract

The traditional technique to teaching human immunity in Biology in Malaysian secondary schools has run into difficulties, with students struggling to understand. This is due to an insufficient utilization of instructional materials with high complexity and abstractness of the topic. As a result, a board game called Human Immunity Battle (HIB) is designed to assist secondary school pupils in mastering the topic while enhancing teaching and learning engagement. The major objective of this study is to improve students' understanding and boost their enthusiasm in learning biology, specifically on the topic of human immunity. N=101 of secondary school students from Putrajaya, Selangor Malaysia with 52 form 4 students and 49 form 5 students in science stream were successfully recruited for the study. IBM Statistical Package for the Social Sciences (SPSS) version 23.0 was used to analyse the data using descriptive statistics, Pearson correlation tests Analysis of Variances (ANOVA) and T-Test. The results of Pearson correlation showed statistically significant correlation between students' perception of teaching aids and its benefits with $r = 0.809$, $p < 0.001$. Besides, there was no significant difference found between the perceptions of teaching aids and overall student performance. Overall, the success of instructional materials in teaching and learning is determined by how students perceive their benefits as well as their perception of the teaching aid employed. However, students' performance is determined by more than just their engagement in learning or the efficiency of instructional resources; it is also influenced by demographic, social, and attitude aspects. Furthermore, it is impossible to deny that instructional strategies can assist biology students enhance their performance and engagement in challenging topics like human immunity.

Keywords: Biology, Board Game, Human Immunity System, Instructional materials

Introduction

Background of Study

The topic human immunity is one of toughest topic for students due to its intricate mechanisms and abstract concepts. Given its complexity, students frequently find it difficult to completely understand the human immune system. Such complex subjects may not be efficiently taught using traditional approaches, which may also not improve student comprehension. The Cognitive Load Theory, which contends that complicated subjects like human immunity impose a high inherent cognitive load, a theory to support the argument that human immunity is a difficult topic for secondary school students (Sweller, 2020). This complexity results from the subject matter's abstract and intricate nature, which calls on students to comprehend a variety of interdependent elements, including pathogens, different immune cells, and immune response processes. Research has indicated that subjects that necessitate students to connect newly learned material to prior knowledge frequently lead to cognitive overload, which can impair learning in the absence of appropriate instructional support (Evans et al., 2024).

Statement of Problem

The human immune system is a complex network of different cells, tissues, and organs that cooperate to protect the body from infections. According to Stranford et al., (2020), studying immunity in human is similar as studying a foreign language. Students frequently struggle with the specific terminology of immunology thus, discouraging them to quickly pick up new vocabulary and apply it to gain knowledge and solve challenging problems. Students can overcome these obstacles with the use of a flexible approach and innovative learning techniques such as board game. However, according to Bennour et al. (2021), students are most likely to misunderstand the concepts of pathogens and diseases, while immune barriers are the least frequently misinterpreted. Innovative pedagogical approaches are required to solve these issues. Almasri (2022) in his study, examined the views and experiences of 1,034 university students utilizing simulations for physics, chemistry, and biology courses to investigate the relationships between learners' engagement and satisfaction with these tools and their preferred learning styles. The study conclusively indicate that educators worldwide are increasingly accepting of the use of computer simulations as well as other interactive tools to teach scientific topics because of the growing integration of technology in education.

The Human Immunity Battle (HIB) board game addresses an important issue in biology education which is a lack of gamification teaching resources for complicated concepts such as immune. Traditional teaching approaches frequently disengage students and make it difficult for them to grasp complex topics, resulting in knowledge gaps (Johnson & Coulter-Kern, 2019). A lack of interactive tools could affect students' capacity to comprehend and relate to biological processes, which is critical for understanding subjects such as human immunology. The HIB board game is a unique solution that gamifies the learning process, making it more approachable and entertaining. By adding adaptive gameplay that progresses from fundamental to sophisticated concepts, the game promotes deeper knowledge and active engagement, thereby overcoming the constraints of traditional teaching approaches. Gamification of education, like games, can increase student engagement, improve specific abilities, and optimize learning as a model for building instructional software, which can boost motivation across diverse academic subjects (Smiderle et al., 2023). Teachers also can modify

the game's rules to teach various subjects, making it a useful instructional tool in a variety of educational contexts.

Objective of the Study and Research Questions

This main aim of this study is to evaluate the effectiveness of interactive educational tools, HIB Boardgame in immunity education. The research objectives of this study are:

- To determine the relationship between students' perceptions of teaching and learning utilizing teaching aids and their perceptions of the benefits of the Human Immunity Battle Board Game.
- To determine Difference of student's perceptions towards the use of teaching aids according to performances in biology.

Literature Review

Students' interest in learning Immunity in Human topics

Studies show that several factors, like instructional strategies, the subject's perceived worth, and its applicability to real-world situations, will influence students' motivation in studying human immunity. Siani et al. (2024) state that immunology's complexity, interdisciplinary nature, and ongoing developments make it particularly difficult to teach and learn. Students find it challenging to understand the complex relationships that exist between cells, organs, and signalling pathways in the immune system. Added complexity is the requirement for mastery across different biological domains. Furthermore, the field's quick advancements in vaccines and immunotherapy necessitate ongoing updates to curricula, which presents more challenges for teachers in terms of inspiring and involving students.

Development Processes of Human Immunity Board Game

The Human Immunity Battle (HIB) board game was created as an innovative way to improve biology education, focusing on the immune system. The human immunity battle board game involves the scientific concepts of human immunology, recognizing the different levels of competencies among students to make complicated biological concepts easier to understand. This was addressed by the development of the Human Immunity Battle (HIB) Board Game, as an interactive teaching tool which highlight gamification theme and actively involves students to streamline the learning process. Inspired by the practicum observations of student involvement in learning the topic in the classroom, this interactive board game was created to imitate the immune responses mechanism in fighting pathogens. A vibrant colour of palette was chosen to create engaging components, including a game board, dice, and detailed cards as shown in Figure 2.0. The board game was modified based on student and supervisor comments, ensuring it was informative and engaging to be used as one of the teaching materials for the subject. When used in the classroom, the HIB board game effectively promoted teamwork and critical thinking, transforming biology learning into an interactive and enjoyable experience even with the complex topic like human immunity.

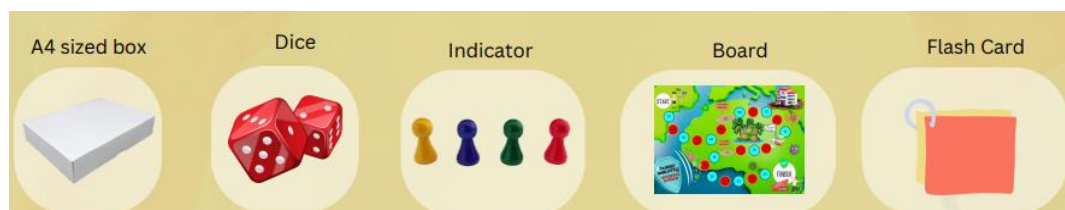


Figure 2.0: HIB board game Interface

The innovative instructional immunity in human board games embraces the principles of gamification by infusing fun and challenge into learning. An adaptive gameplay is included in the game ranging from basic to complex concepts, hence, promoting engagement and deeper understanding among players. The concept aims to boost students' engagement and understanding through gamification whereby its interactive nature encourages active participation, fostering greater interest in the subject and addressing limitations of traditional teaching. This approach extends beyond the board game itself. The game's framework can inspire educational software to enhance motivation across various academic fields. Teachers can adapt its rules for versatile subject teaching, making it a valuable pedagogical tool. By making immunity education more approachable, this tool hopes to increase students' comprehension of the subject by assisting them in visualizing and understanding important concepts.

Methodology

Study Design

This study is cross-sectional study which focuses on the advancement of gamification to learn the immunology-related subjects. This study ethically approved by REC Committee of Education Faculty UiTM with approval number ED/REC/F/10918.

Instruments Development

The questionnaire titled "Teacher Expectations Regarding the Integration of Interactive Multimedia with STEM in Physics Education: A Preliminary Study on Geometry Optics Learning Materials" by Pricillia et.al (2020) was utilised and modified to address objective number 1. Beside the study also utilised a questionnaire titled "Student Perception on Teaching Materials Development to Increase Students' Knowledge of Aceh's Maritime Potential" by (Ridhwan et al., 2019), which is modified to investigate students' perception regarding the utilisation of teaching aids in the biology classroom. In addition, the selected items from the questionnaire "Impact of Instructional Materials in Teaching and Learning of Biology in Senior Secondary Schools In Yakurr LG A" by Igiri et al., (2015) and "Problems Faced by Preschool Teachers When Using Teaching Aids in the Teaching Learning Process" by Rajapaksha and Chathurika (2015) were also utilised to address the research question regarding the advantages of teaching aids in the Biology learning process for Form 4 Biology students. The students' questionnaire comprises four sections: Part A, Part B, Part C, and Part D. Part A comprises the demographic information of the participants, encompassing their gender, age, class, and Biology grade. Part B consists of 7 items that which discovered the benefits of using teaching aids in learning Biology to the students while Part C consists of a list of 5 items that which analyse perception of students towards the use of teaching aids in Biology classroom. Part D of the questionnaire consists of 6 items which look into the types of teaching aids used in Biology classroom. All item was constructed into 4 Likert-Type scale.

Validity and Reliability

The Cronbach's Alpha values for all 3 constructs are more than 0.7, indicating high internal consistency. The constructs of Benefits of teaching aids(0.97 for 7 items); Types of teaching aids(0.79 for 6 items) and Perceptions towards teaching aids(0.85 for 5 items.)

Sampling Methods and Sample Calculations

The sampling method used was stratified sampling, which researcher divides the population into discrete subgroups, or strata, and then selects individuals at random from each stratum. A total of 101 of Form 4 and Form 5 biology students from SMK Tengku Ampuan Rahimah in Klang, Selangor. Each form will be divided into two strata. The number of samples that will be selected from each form will be calculated using the formula of stratified sampling. The result of the calculation shows that the researcher will randomly select 55 Form 4 Biology students and 58 Form 5 Biology students to answer the survey. N=101 respondents among upper secondary school students from had been chosen in the study. The desired number of samples from the population is then determined by referring to the Krejcie and Morgan Table. The result of the calculation shows that the researcher will randomly select 55 Form 4 Biology students and 58 Form 5 Biology students to answer the survey.

Statistical Analysis

All of the score from the survey were analysed using IBM SPSS version 23.0 software. The student's answer was analyses using descriptive statistics, Pearson correlation tests, independent sample t-tests, and ANOVA. The findings indicate that teaching aids have a positive impact on students' learning experiences in Biology.

Findings

The Mean score comparison of student's perceives benefits and perception towards the use of teaching aids in learning Biology.

As reported in Table 5.1, the highest means on benefits perceives on teaching aid were with mean scores of $M=3.54$, $SD=0.71$ and $M=3.54$, $SD=0.69$, respectively. These were found on the second and fifth items in the Table 5.1. "Teaching aids make learning Biology more real and permanent." and "Teaching aids attract my attention to learn Biology." Most respondents appear to agree on those issues, based on the higher mean. Similar mean scores, $M=3.52$, $SD=0.69$ and $M=3.52$, $SD=0.67$, are found for the first and third items, both of which are rather high. In comparison to the other questions, the sixth survey question, "Teaching aids increase my motivation to learn Biology," had the lowest mean score ($M=3.45$, $SD=0.73$). Nonetheless, the standard deviation score for this item is the greatest. A high standard deviation value denotes a greater diversity of opinions among respondents about the ways in which instructional tools might encourage motivation for studying biology.

Table 5.1

Descriptive analysis of the benefits of teaching aids in learning Biology to the students(N=101).

	Benefits Of Teaching Aids in Learning Biology	Mean	Std. Deviation
1	Teaching aids make learning Biology lesson more interesting	3.52	0.69
2	Teaching aids make learning Biology more real and permanent.	3.54	0.71
3	Teaching aids make learning and understanding Biology faster and easier.	3.52	0.67
4	Teaching aids make me remember what has been taught better.	3.48	0.78
5	Teaching aids attract my attention to learn Biology.	3.54	0.69
6	Teaching aids increase my motivation in learning Biology.	3.45	0.76
7	Teaching aids make me participate actively in the classroom.	3.47	0.73
	Overall mean	3.50	0.72

In summary, the overall mean indicates that there are positive benefits for students using instructional aids to study biology. Teaching aids are essential for maintaining students' interest and encouraging more communication between them and their biology instructor in the classroom. When instructional aids are employed effectively, they have the potential to improve student learning outcomes by increasing their effectiveness and enjoyment. The findings of this investigation are consistent with those of a prior study, Nghitoolwa et al. in 2024. The researcher indicated that the data were subjected to a thorough thematic analysis, which revealed several key subthemes that highlight the substantial positive effects of various teaching aids on students' learning outcomes. According to the findings, the use of teaching aids enhances students' comprehension of complex concepts, making the learning process more tangible and easier to grasp. Moreover, these aids were found to increase student engagement by making lessons more interactive and dynamic, capturing their interest and keeping them motivated throughout the learning process. In addition to boosting academic performance, these tools also promote the development of critical thinking skills by encouraging students to analyze and apply the information in a more hands-on manner. Furthermore, in the research, Nghitoolwa et al. 2024 highlights that teaching aids were shown to foster a collaborative learning environment, where students work together more effectively, sharing ideas and learning from one another. Teaching aid is frequently considered to be quite helpful in fostering an engaged teaching-learning environment. It provides students with an important educational experience by relating what they learn in class to real-world situations (Bawa, 2020). In his research, he also found that instructional aids encourage teachers and students to actively engage in the teaching and learning process.

Table 5.2

Descriptive analysis of the perception towards the use of teaching aids (N=101).

	Perception of students towards teaching aids	Mean	Std. Deviation
1	I really need teaching aids during lectures.	3.45	0.79
2	Teaching aids expand my creativity and increase my enthusiasm for learning Biology.	3.60	0.62
3	Teaching aids make learning Biology more interesting.	3.61	0.66
4	I understand better when my teachers use teaching aids while teaching Biology.	3.61	0.62
5	I love learning Biology using textbooks.	3.26	0.90
	Overall mean	3.51	0.72

Table 5.2 represents the means for the perceptions of students towards teaching aid. The statement, Item 3, "Teaching aids make learning biology more interesting," has the highest mean and item 4, "I understand better when my biology teachers use teaching aids." correspondingly with $M=3.61$, $SD=0.66$ and $M=3.61$, $SD=0.62$. The item with the lowest mean ($M=45$, $SD=0.79$) was item 1, "I really need teaching aids during lectures." The aggregate mean indicates that students have a favourable opinion of instructional tools. This result is aligned with Taghavi et al. (2016), who discovered that students' perceptions clearly demonstrated the usefulness of teaching aids in the study of biology. Students' opinions on using models, diagrams, and lab equipment to improve their comprehension of biological topics were generally good. These tools helped students understand complicated processes more easily by making abstract concepts more concrete and approachable. They also stated that the use of instructional aids increased their memory of the material and made the learning process

more participatory and interesting. Overall, the feedback shows that, irrespective of students' gender or field of study, teaching aids have a major positive impact on the efficacy of biology classes.

Association between the benefits of employing teaching aids in biology classrooms and how students perceive such aids helps in learning

The correlation between student's perception towards perceive benefits was tested using Pearson Correlation test. Data reported the significantly positive correlation between the advantages of employing teaching aids in biology classrooms and how students perceive such aids to be used with a p-value of less than 0.001, the correlation coefficient of $r = 0.809$. It is necessary to reject the null hypothesis put out for this study issue since the p-value is less than 0.05. The study found a significant positive association ($r = 0.809$, $p < 0.001$) between using teaching aids in biology classes and students' perceptions of their efficacy in enhancing learning. As students realize the value of these tools, their engagement and understanding of the topic improve. The relevance of this link emphasizes the need to include varied teaching aids in curriculum, providing educators with professional development on effective implementation, and using student feedback to better instructional tactics.

The results of this study align with the findings of a previous researcher, Ahmed, in 2018. Ahmed's research indicated that 84% of students acknowledge the significant impact of teaching aids on enhancing their engagement in lessons, while 74% of participants reported that teaching aids contribute to making their lessons more memorable. Furthermore, it was observed that a significant majority of 80% of the participants express agreement, while a little 5% remain neutral, and only 15% disagree with the notion that they comprehend the new language effectively when the teacher uses realia. The utilisation of realia is commonly regarded as highly beneficial in promoting an engaged teaching-learning atmosphere. It offers learners a significant learning experience by linking classroom activities to the actual world (Bawa, 2020). In his study, he also determined that teaching aids facilitate the active participation of both teachers and students in the processes of teaching and learning.

Difference of student's perceptions towards the use of teaching aids according to performances in biology.

The Table 5.3 below represents the difference means according to three groups of student's performance in biology. As showed also in table 5.4, a one-way ANOVA test revealed that there was no statistically significant difference between groups in the way biology students perceived and performed in relation to the usage of teaching aids as test's p-value is more than 0.05.

Table 5.3

The difference in the mean score in the students' perception towards the use of teaching aids with students' performance in biology.

Source of Variation					95% Confidence Interval	
(I) Students' Performance in biology	(J) Students' Performance in biology	Mean Difference (I-J)	Std. Erros	Sig	Lower Bound	Upper Bound
Good	Moderate	.32255	.13924	.068	-.0166	.6617
	Low	.19428	.13282	.440	-.1293	.5178
Moderate	Good	-.32255	.13924	.068	-.6617	.0166
	Low	-.12828	.15351	1.00	-.5022	.2456
Low	Good	-.19428	.13282	.440	-.5178	.1293
	Moderate	.12828	.15351	1.00	-.2456	.5022

Table 5.4

ANOVA test of the difference in the mean score between groups

Source of Variation	Sum of Square	df	Mean Square	F	p-value
Between groups	1.838	2	.919	2.904	.060
Total	32.845	100			

In contrast, previous study by Florence et al., (2023), concluded that biology instructional materials had a significant beneficial effect on students' academic achievement. In the study, students who were educated using these resources did better than those who weren't. The study demonstrated the significant impact of biology instructional materials on academic achievement, underscoring the significance of school type. Their findings were consistent with previous research by Lovina et al., 2024 whereby it stated that the range of experiences that students can have been expanded by instructional materials, which also serve to enhance and complement the teacher's spoken explanations. This enriches the learning experience and piques the interest of teachers in a wide range of learning activities. In the process of imparting knowledge, ideas, skills, and attitude, instructional materials emphasise, clarify, vitalise, and complement teaching and they also improve learning. However, HIB board game does not cover the whole part of the syllabus which lead to the insignificant data. The scoring in biology also measures with few others significant topic which also required the used of instructional material in line.

Conclusion

In summary, the Human Immunity Battle Board Game proved to be a highly effective teaching tool for enhancing student interest and comprehension of difficult biology concepts. A strong association was found between the way biology students felt about the teaching aid and how well they performed academically, suggesting that using these kinds of aids can enhance learning results. This implies that integrating modern and innovative gamified methods to biology instruction can promote a greater comprehension and memorization of scientific ideas.

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