www.ijres.net

Enhancing Students' Conceptual Understanding on Bioenergetics through BEEP Cards

Camille Lozano Espino
Bulacan State University, Philippines

To cite this article:

Espino, C.L. (2024). Enhancing students' conceptual understanding on bioenergetics through BEEP cards. *International Journal of Research in Education and Science (IJRES), 10*(3), 543-560. https://doi.org/10.46328/ijres.3471

IJRES International Journal of Research in Education and Science
2024, Vol. 10, No. 3, 543-560 https://doi.org/10.46328/ijres.3471

Enhancing Students' Conceptual Understanding on Bioenergetics through BEEP Cards

Camille Lozano Espino

Article Info

Article History

Received:
14 February 2024
Accepted:
26 June 2024

Keywords

Game-based learning
Conceptual understanding
Life science teaching

Abstract

The study examined the effectiveness of BEEP Cards (BioEnergetics Enhancement Play Cards) on students' conceptual understanding of bioenergetics. The study involved one group of grade 11 students (n=29) from a public secondary school in the Philippines. The study employed a mixed-method research design, utilizing both quantitative and qualitative data to answer the research questions. Specifically, a one-group pretest-posttest action research design was used in this study. The study used a six-week exposure to the use of BEEP Cards. The quantitative data were obtained from a researcher-made and expert-validated 25-item pre- and post-test questionnaire while the qualitative data were secured from focus-group discussions. Dependent samples t-test was used to determine significant differences in students' conceptual understanding of the topic Bioenergetics. Findings revealed a significant difference in the students' conceptual understanding before and after six-week exposure to BEEP Cards. Additionally, responses from focus group discussions imply the effectiveness of BEEP Cards in enhancing students' conceptual understanding. Hence, the utilization of BEEP Cards was found to help enhance students' conceptual understanding and performance in Bioenergetics among the Grade 11 students in a public senior high school in Valenzuela City.

Introduction

The world today has been described as VUCA which stands for volatile, uncertain, complex, and ambiguous (Akinoso, 2015). In this regard, education is one of the fields always affected by the ever-changing world. Changes and developments in the educational landscape require educators to keep abreast of the demands of 21st-century learners. Teaching in the 21st century is becoming more and more challenging, especially as information becomes easily accessible and available (Jan, 2017). The development of competencies known as 21st-century skills is garnering increasing attention as a means of improving teacher instructional quality (Kim, Raza & Seidman, 2019). 21st-century skills are a collection of abilities, and competencies that students need to develop to succeed in work, and life in the 21st century (Sümen & Çalişici, 2017). According to Lai and Viering (2012), 21st-century skills include learning and innovation skills (critical thinking, problem-solving, creativity, innovation, communication, and collaboration), information, media and technology literary skills, and life and career skills.

Critical thinking, being one of the 21st-century skills, needs to be developed among the students. According to Wulandari (2018), conceptual understanding is needed as a foundation for acquiring problem-solving skills, and critical and creative thinking.

Conceptual understanding allows students to transform knowledge into multiple representations and apply it in daily life (Ratnasari, Sukarmin & Suparmi, 2017). Indicators of conceptual understanding include memorizing the concept, integrating the concept with related concepts, transferring and applying the concept to solve problems, reasoning analogically, and reasoning locally and globally (Schönborn & Anderson, 2008). The development of conceptual understanding in science education is important for students in today's world if they are to become citizens who can make informed decisions about themselves and the world in which they live (Martin et al., 2015).

Conceptual understanding is an important goal in learning in general but is particularly relevant in science education because such understanding is required to make sense of phenomena (Phanphech et al., 2019). According to Widiyatmoko and Shimizu (2018), conceptual understanding is one of the basic competencies in science learning. Therefore, designing effective strategies that promote the enhancement of conceptual understanding must be one of the priorities of science educators. According to Setyaningrum (2018), game-based learning is one of the teaching approaches quite popular presently. Game-based learning (GBL) can allow learners to acquire and construct knowledge in a fun and focused learning atmosphere (Pan et al., 2021). Klisch et al. (2012) found that games in science education were effective in increasing learners' conceptual understanding of science content presented in the game.

During the second quarter of the school year 2020-2021, the mean percentage score (MPS) in the grade 11 Earth and Life Science subject dropped to 35.10 as compared to 68.30 during the first quarter. Moreover, it is also revealed that out of 131 grade 11 students, 92 have a performance of below standards and 11 have poor performance. The data revealed that the competencies on the topics in "bioenergetics" are among the least learned competencies. Additionally, during the interview conducted among the students, it was revealed that the common factor that caused the decline in the MPS was their difficulty in understanding the concepts of the lessons. The students mentioned that they find it difficult to make connections among the concepts and they find it hard to relate one term to another. This prompted the researcher to explore the effectiveness of BEEP Cards on the students' conceptual understanding of bioenergetics.

Research Problem

The main purpose of this study is to determine the effectiveness of BEEP Cards on the conceptual understanding of Grade 11 students. Specifically, this study aimed at answering the following questions:

1. Is there a significant difference between the pretest and posttest mean results of the students because of the utilization of BEEP Cards?
2. How do the students evaluate the effectiveness of BEEP Cards in consideration of goals and objectives, design, components and organization, playability/playfulness, and knowledge acquisition?

Research Hypothesis

There is no difference in the pretest and posttest mean results of the students as a result of the utilization of BEEP Cards.

Literature Review

Game-Based Learning in Science

Game-based learning has been shown to have a positive impact on various learning levels, including logical-mathematical, naturalistic, and linguistic abilities (Pérez, Duque & Garcia, 2018). Game-based learning in science is effective in enhancing student motivation and engagement (Makalintal & Malaluan, 2019; Wang & Zheng, 2020). It has been shown to help students achieve learning competencies in biology, physics, and earth science (Makalintal, 2019). Moreover, research has consistently shown a positive impact of educational card games on science learning. Studies by Liu and Chen (2013) found that students' scientific knowledge and interest in learning were improved through the use of educational card games. Similarly, Haris, Talip and Hasan (2019) reported that engineering students demonstrated enhanced understanding and positive attitudes towards the use of educational card games in engineering science. Rajashekar and Bellad (2016) further supported these findings, showing that educational card games improved academic performance in nerve-muscle physiology for 1st MBBS students. Laçin-Şimşek, Öztuna-Kaplan and Sever (2022) highlighted the role of educational games, including card games, in facilitating the understanding of science concepts in science education. This literature collectively highlights the effectiveness of game-based learning in enhancing science learning.

Conceptual Understanding

Conceptual understanding is one of the skills that students must have to effectively learn science. This understanding is crucial for students to make complex inferences and engage in scientific work (Mi, Lu & Bi, 2020). Educational card games have been shown to enhance conceptual understanding of science. Haris, Talip and Hasan (2019) found that engineering students' understanding was improved through the use of immersive card games. This research is similar to the purpose of the current study since the focus is to determine if there will be an improvement in students' conceptual understanding following the utilization of BEEP Cards. Similarly, Liu and Chen (2013) reported that elementary school students' scientific knowledge of transport and energy was enhanced by participating in a card game. Faria (2016) also found that the use of educational games in the classroom positively impacted the learning of geology concepts. Kordaki and Gousiou (2016) further emphasized the potential of educational computer card games to improve learners' understanding and skills in complex subjects. Thus, these studies sufficiently highlight the effectiveness of educational card games in promoting conceptual understanding of science.

Theoretical Framework

The roots of the use of BEEP Cards can be traced from the social constructivist theory of learning. According to

the social constructivist theory of learning, learners construct knowledge rather than just passively take in information. Lev Vygotsky, the main proponent of social constructivism, effective learning happens when there is an interaction among and between students (Vygotsky, 1978). This theory specifically proposes that learning involves both personal and social processes. The personal process of learning involves the active construction of knowledge and understanding while the social process of learning involves social interactions.

The utilization of games in education is influenced by the social constructivist theory of learning. Kordaki (2014) argues that this theory emphasizes the role of engaging learners in meaningful and enjoyable learning activities to improve the process of learning. Moreover, games have been found to provide students with strong motivation to become active participants in the learning process. Additionally, Piyawattanaviroj (2019) found that a game environment helps enhance students' positive attitude toward learning as it is believed to improve students' cognition and collaboration as well as challenge them to study with enjoyment and excitement.

Methodology

Research Design

The study utilized a mixed-method approach to research (Cresswell & Plano Clark, 2017), utilizing both quantitative and qualitative data to answer the research questions. Specifically, a one-group pretest-posttest action research design. Using this type of design, the difference between the pretest and posttest scores was measured. The advantage of this design is that the researcher can compare scores after treatment to scores on the same measure in the same participants before the treatment. This study aimed to gain a better understanding of the teaching practice and how it could enhance students' conceptual understanding of the lesson. The research was conducted over six weeks to examine the effectiveness of BEEP Cards in enhancing students' conceptual understanding of the lessons in Bioenergetics.

Research Locale and Participants

The study involved selected students in 11-GAS class enrolled under the General Academic Strand (GAS) in one of the senior high schools in Valenzuela City, Metro Manila, Philippines. The students who were selected are the ones with grades that range from 75-79 from their science subject in Grade 10. As per DepEd Order No. 25, s. 2022, students who obtained a grade of 75-79 in any learning area are the ones to attend enrichment classes. There were altogether 29 grade 11 students in the class who were selected to become participants with a frequency of 16 (55.17%) males and 13 (44.83%) females. These students are taking Earth and Life Science subject during the first semester of the academic year 2021-2022. The students varied in proficiency level in science as manifested in their general weighted average in science subject in grade 10.

Research Instruments

The research made use of teacher-made pre-test/ posttest, evaluation instrument for the BEEP Cards, fieldnote, audio record of focus group discussions.

Teacher-made Pre-test/ Post-test

The teacher-made test is a 25-item multiple choice type of test that served as the pretest/posttest in the study. The pretest/posttest is intended to be used to determine the effectiveness of the BEEP Cards on the students' conceptual understanding. The test questions were lifted and based on the Science Curriculum Guide and the resource textbooks. The constructed test items were validated by two Master Teachers in Science.

Evaluation Instrument for BEEP Cards

The instrument used to evaluate the BEEP Cards developed by Gutierrez (2014) was adopted in this study to determine students' evaluation of the BEEP Cards. This five-point rating scale consisted of twenty-five (25) statements that evaluate the BEEP Cards into five (5) criteria namely: Goals and Objectives; Design; Components and Organization; Playability and Playfulness; and Knowledge Acquisition. The extent of students' ratings determined the degree values and was interpreted as follows: Outstanding (4.51 – 5.00); Very Satisfactory (3.51 – 4.50); Satisfactory (2.51 – 3.00); Fair (1.51 – 2.50); and Needs Improvement (1.00 – 1.50). Meanwhile, the reliability of the instrument in each criterion was established by acceptable Cronbach alpha values of 0.632, 0.657, 0.678, and 0.659, respectively.

Table 1 shows the number of items in each criterion and the sample statements in the evaluation instrument.

Table 1. Number of Items and Sample Statement for the Evaluation Instrument

Criteria	**Number of Items**	**Sample Statement**
Goals and Objectives	6	The purpose and rationale for the games are fully explained.
Design	5	The terms printed on the two sides of the card are a helpful feature for the player's handling of the cards.
Components and Organization	5	The directions were clear, concise, and easily understood.
Playability/ Playfulness	4	The rules of the games provide players with equal conditions for a fair play.
Knowledge Acquisition	5	Playing the games help me establish better understanding of the concepts of the lesson.

Students' Reflections and Focus Group Discussion

Students' reflections after each use of BEEP Cards were analyzed qualitatively using thematic analysis to substantiate the quantitative findings obtained. Further, qualitative data were also obtained through focus group discussions after the conduct of the study. Semi-structured interview guide questions were used to elicit responses from the students.

Research Procedures

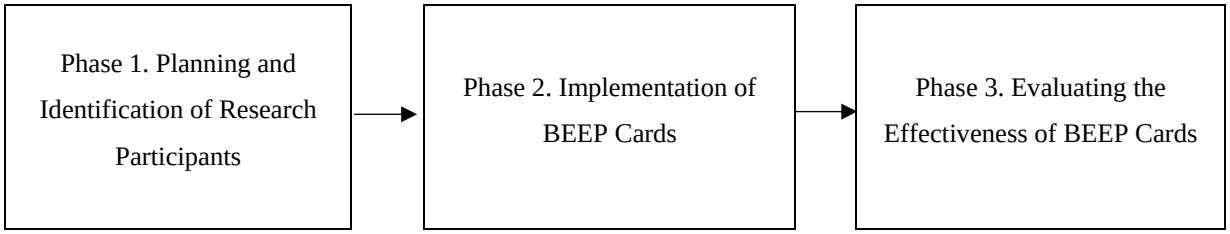


Figure 1. Research Phases

The following is a detailed description of the phases undertaken in this research:

Phase 1: Planning and Identification of Research Participants

In this phase, one section that comprises twenty-nine (29) students of grade 11 from a senior high school in Valenzuela City was selected to serve as the study's participants. These students are taking Earth and Life Science subject during the first semester of the academic year 2021-2022. As regards their frequency level in science, they vary as manifested in their general weighted average in science subject in grade 10. After the selection of the participants, standard operating procedures in conducting research were conducted and the participants were asked to take the validated pretest.

Phase 2: Implementation of BEEP Cards

Following the selection of participants, the study proceeded with the implementation of BEEP Cards as an instructional tool. This phase extended over six (6) weeks, during which BEEP Cards were integrated into each lecture session.

Phase 3: Evaluating the Effectiveness of BEEP Cards

The validated posttest was administered to the participants. A t-test for dependent samples was utilized to show whether there was a significant difference in the pretest and posttest scores of the participants. Additionally, the participants were asked to answer the validated evaluation instrument to evaluate the effectiveness of the BEEP Cards as a teaching strategy in learning the concepts of bioenergetics. The effectiveness of the BEEP Cards was evaluated based on the following: (1) Goals and Objectives, (2) Design, (3) Components and Organization, (4) Playability/Playfulness, and (5) Knowledge Acquisition. Moreover, to ensure the validity of the results, the participants were interviewed using a set of semi-structured questions.

Data Analysis

SPSS version 22 (Statistical Package for the Social Science) was used to analyze quantitative data. A normality test has been done to check the normal distribution of the data to warrant the use of a t-test. T-test for dependent

samples was used to compare the students' scores on the pretest and posttest. In determining the result of the evaluation of the BEEP Cards, the data from the evaluation process were organized, processed, and analyzed statistically using frequency distribution and weighted mean. Frequency distribution was used to determine the participants' response in the evaluation of the BEEP Cards for each indicator in the questionnaire. Weighted mean, on the other hand, was used to analyze the measures of students' evaluation of the BEEP Cards. Meanwhile, thematic analysis was used to analyze the qualitative data obtained from the interview guide questions. The data from the interview were analyzed and coded to reveal the emerging themes.

Results

This section presents the quantitative and qualitative results on the effectiveness of BEEP Cards in enhancing students' conceptual understanding.

Quantitative Findings

Table 2 presents the changes in students' conceptual understanding before and after the exposure to BEEP Cards. As can be seen from the table, the mean pretest score is 9.86 while the mean posttest score is 18.28. The computed t which is equal to 10.37 is greater than the critical t which is 1.699 at 0.05 level of significance. This indicates that the null hypothesis which states that there is no difference in the pretest and posttest mean results of the students because of the utilization of BEEP Cards is rejected. This is also supported by the p-value = 0.0096 which is less than the 0.05 significance level. This implies that the exposure to BEEP Cards enhanced students' conceptual understanding.

Table 2. t-Test for Dependent Samples for the Difference between Pretest and Posttest Scores of Students in the use of BEEP Cards

		Mean Pretest	Mean Posttest	Mean Difference	Std. Deviation	t	df	Sig.
Pair 1	Pretest-Posttest	9.86	18.28	8.42	4.3713	10.37	28	0.0096

As regards the students' evaluation on the effectiveness of BEEP Cards in enhancing students' conceptual understanding, Table 3 provides the summary.

Table 3 shows the summary of students' evaluation of the BEEP Cards. As seen from the table, all of the criteria received a rating of very satisfactory. Item number 5 (Knowledge Acquisition) received the highest weighted mean of 4.064. This means that the participants agreed that the use of the BEEP Cards is an effective means of acquiring knowledge of the lesson. On the other hand, even though it also received a rating of very satisfactory, item number 1 (Goals and Objectives) received the lowest weighted mean of 3.940. This means that the goals and objectives of the game should be explained well to the students to help them understand the relevance and goals of the activity. The overall mean is 4.014 (very satisfactory). This positively denotes that the participants agreed

that the use of BEEP Cards has helped in enhancing their conceptual knowledge of bioenergetics.

Table 3. Summary of Students' Evaluation of the Effectiveness of BEEP Cards

Criteria	Weighted Mean	Verbal Interpretation
Goals and Objectives		
1. The purpose and rationale for the games are fully explained.		
2. The goals and objectives of the games are clearly defined.		
3. The games were thought provoking.	**3.940**	**Satisfactory**
4. The games encourage student interaction.		
5. The games promoted discussion of key topics.		
6. The BEEP Cards help with my recall of concepts/terms.		
Design		
7. Card size is appropriate.		
8. The terms printed on the two sides of the card are a helpful feature for the player's handling of the cards.		
9. The picture printed on the cards is representative of the topic.	**4.032**	**Very Satisfactory**
10. The material used (paper) in the preparation of the cards is durable.		
11. The deck of card is compact and can be easily carried around.		
Components and Organization		
12. The directions were clear, concise, and easily understood.		
13. The games emphasize key points of the topic played.	**3.976**	**Very Satisfactory**
14. The terms used were appropriate to my level of knowledge.		
15. The number of cards was appropriate.		
16. The length of time required to play each game is reasonable.		
Playability/Playfulness		
17. The games provide opportunity for healthy competition and cooperation.		
18. The rules of the games provide players with equal conditions for a fair play.	**4.060**	**Very Satisfactory**
19. The rules of the games provide a set of options for flexibility in making decisions towards playing the games.		
20. Playing the games was fun.		
Knowledge Acquisition		
21. The games were effective in reviewing the concepts of the topics.	**4.064**	**Very Satisfactory**

Criteria	Weighted Mean	Verbal Interpretation
22. The games encouraged the players to dig deeper into the subject matter.		
23. Playing the games is a productive use of time.		
24. Playing the games help me establish better understanding of the concepts of the lesson.		
25. I would recommend the games to my peers.		
OVERALL MEAN	**4.014**	**Very Satisfactory**

Qualitative Findings

The qualitative data from the focus group discussions revealed two emerging themes: (1) increasing students' motivation and (2) active learning. The various responses by the students on each theme are summarized in Table 4.

Table 4. Results of Thematic Analysis

Themes	Codes	Sample Responses
increasing students' motivation	motivate the students fun and inspiring motivating in learning the lesson	Student 1: "I can say that the BEEP Cards motivate the students to study hard at the same time, enjoy learning." Student 5: "Playing the game is fun and it inspires me to study the lesson so that I will not be defeated by my classmates." Student 18: "…can motivate me to learn the lesson."
active learning	the game is not boring enjoying playing while learning actively involved explore ideas	Student 2: "I love playing the game because it is not boring." Student 7: "I enjoy playing BEEP Cards because I learn a lot of things while playing because I was able to explore new ideas." Student 20: "The game made us actively involved in learning the topic."

Conclusions

This study investigated the effectiveness of the use of BEEP Cards to enhance students' conceptual understanding of Bioenergetics. The results revealed that there is a significant difference between the students' conceptual understanding before and after the utilization of BEEP Cards. This manifestation highlights the effectiveness of the BEEP Cards in improving students' conceptual understanding. Therefore, the study found out that gamification in education can support students' learning. The study's result is similar to the study conducted by Liu and Chen (2013) when they investigated primary school students' performance in learning science concepts using a card game. They found that the card game was effective in improving students' performance. In addition, Selvi and Cosan (2018) conducted a study to investigate the effects of using scientific educational games in teaching Kingdoms of Living Things on students' academic achievement and retention of knowledge. At the end of the study, the students found the games to be informative, entertaining, and reinforcing their learning.

Meanwhile, the evaluation summary of the BEEP Cards indicates that students rated all criteria very satisfactorily. Notably, the highest weighted mean was for Knowledge Acquisition, indicating that students found the BEEP Cards effective in enhancing their understanding of the lesson. However, while Goals and Objectives also received a very satisfactory rating, its weighted mean suggests the importance of clearly explaining these aspects to students for better comprehension. Overall, the mean rating reflects the participants' agreement on the effectiveness of BEEP Cards in improving conceptual knowledge of bioenergetics.

From the themes that emerged from the qualitative data, gaining motivation, and being actively involved in the process of learning appeared to be linked to the enhancement of students' conceptual understanding. This denotes that incorporating games in the teaching and learning process would be valuable tools to promote students' learning. Considering the findings from the analysis of the gathered data, students' exposure to BEEP Cards has a considerable impact on enhancing their conceptual understanding in Bioenergetics. A significant increase in students' conceptual understanding was evident in a higher mean posttest score (18.28) compared to the mean pretest score (9.86). Further, this was supported by the resulting computed t-value of 10.37 versus the critical t of 1.699, making the null hypothesis rejected. Consequently, results also revealed that exposing students to BEEP Cards greatly improved their conceptual understanding in Bioenergetics.

Based on the study's findings, utilization of BEEP Cards as a teaching strategy is found to be effective in enhancing students' conceptual knowledge. School heads may consider formulating a policy for its potential utilization and adoption not only in Science subjects but across all the other curriculum learning areas in order to improve students' learning. Moreover, the researcher highly recommends successive researchers to conduct similar studies involving larger sample size to attain decisive results while limiting errors.

References

Chen, P. K. and Liu, E. F. (2013). The Effect of Game-Based Learning on Students' Learning Performance in Science Learning – A Case of "Conveyance Go". *Procedia – Social and Behavioral Sciences, 103,* 1044-

1051. https://doi.org/10.1016/j.sbspro.2013.10.43

Creswell, J. W., & Clark, V. L. (2017). *Designing and conducting mixed methods research*. SAGE Publications.

DepEd Order No 25, s 2022. Amendment to DepEd Order No. 13, s. 2018 (Implementing Guidelines on the Conduct of Remedial and Advancement Classes During Summer for the K to 12 Basic Education Program)

Gutierrez, A. F. (2014). Development and Effectiveness of an Educational Card Game as Supplementary Material in Understanding Selected Topics in Biology. *Life Sciences Education*, *131*(1), 76-82. https://doi.org/10.1187/cbe.13-05-0093

Haris, N. I., Talip, A., & Hasan, M. Z. (2019). Development and evaluation of immersive card games as booster memory in engineering science. *IOP Conference Series: Materials Science and Engineering*, 551*(1),* 012021.

Jan, H. (2017). Teacher of 21st Century: Characteristics and Development. *Research on Humanities and Social Sciences, 7*(9), 50-54.

Klisch, Y., Miller, L., Wang, S., and Epstein, J. (2012). The Impact of a Science Education Game on Students' Learning and Perception of Inhalants as Body Pollutants. *Journal of Science Education and Technology*, 21*(2),* 295-303.

Kordaki, M. (2014). A constructivist, modeling methodology for the design of educational card games. *Procedia Social and Behavioral Sciences*, 191, 26-30. https://doi.org/10.1016/j.sbspro.2015.04.669

Kordaki, M., & Gousiou, A. (2017). Digital card games in education: A ten year systematic review. *Computers & Education*, 109, 122-161. https://doi.org/10.1016/j.compedu.2017.02.011

Laçin-Şimşek, C., Öztuna-Kaplan, A., & Sever, T. (2022). Educational games in science center: Experiences of pre-service science teachers. *SAGE Open*, 12*(2),* 1-15. http://doi:10.1177/21582440221104779

Makalintal, J. D., & Malaluan, N. E. (2019). Game-based learning activities in teaching grade 7 science. *International Journal of Research-GRANTHAALAYAH*, 7*(5),* 256-277. https://doi.org/10.29121/granthaalayah.v7.i5.2019.845

Mi, S., Lu, S., & Bi, H. (2020). Trends and foundations in research on students' conceptual understanding in science education: A method based on the structural topic model. *Journal of Baltic Science Education*, 19*(4),* 551-568. https://doi.org/10.33225/jbse/20.19.551

Pan, L., Tlili, A., Li, J., Jiang, F., Shi, G., Yu, H., & Yang, J. (2021). How to implement game-based learning in a smart classroom? A model based on a systematic literature review and delphi method. *Frontiers in Psychology,* 12. https://doi.org/10.3389/fpsyg.2021.749837

Pérez, M. D., Duque, A. G., & García, L. F. (2018). Game-based learning: Increasing the logical-mathematical, naturalistic, and linguistic learning levels of primary school students. *Journal of New Approaches in Educational Research,* 7*(1),* 31-39. http://doi:10.7821/naer.2018.1.248

Piyawattanaviroj, P., Maleesut, T., & Yasri, P. (2019). An educational card game for enhancing students' learning of the periodic table. *Proceedings of the 3rd International Conference on Education and Multimedia Technology*, 380-383. https://doi.org/10.1145/3345120.3345165

Rajashekar, R. K., & Bellad, A. (2016). Effectiveness of educational card games as a supplementary educational tool in academic performance. *Indian Journal of Clinical Anatomy and Physiology*, 3*(1),* 4-7.

Selvi, M., & Cosan, A. O. (2018). The Effect of Using Educational Games in Teaching Kingdoms of Living

Things. *Universal Journal of Educational Research*, 6*(9),* 2019-2028.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes Cambridge, Mass.: Harvard University Press

Wang, M., & Zheng, X. (2020). Using game-based learning to support learning science: A study with middle school students. *The Asia-Pacific Education Researcher*, 30*(2),* 167-176. https://doi.org/10.1007/s40299-020-00523-z

Author Information

Camille L. Espino

https://orcid.org/ 0009-0005-7208-5108

Bulacan State University

Guinhawa, City of Malolos, Bulacan

Philippines

Contact e-mail: *camille.espino@bulsu.edu.ph*

Appendix A. Evaluation Instrument for the BioEnergetic Enhancement Play Cards (BEEP Cards)

Direction: The following statements evaluate specific aspects of the BioEnergetics Enrichment Play Cards (*BEEP Cards)* on a scale of 1 to 5. Put a check ( ) on the box that accurately defines the way you feel regarding each statement.

Scale:

5 – Strongly Agree
4 – Agree
3 – Neutral
2 – Disagree
1 – Strongly Disagree

Goals and Objectives		**Scale**				
		5	**4**	**3**	**2**	**1**
1.	The purpose and rationale for the games are fully explained.					
2.	The goals and objectives of the games are clearly defined.					
3.	The games were thought provoking.					
4.	The games encouraged student interaction.					
5.	The games promoted discussion of key topics.					
6.	The BEEP Cards help with my recall of concepts/terms.					

Design		**Scale**				
		5	**4**	**3**	**2**	**1**
7.	Card size is appropriate.					
8.	The terms printed on the two sides of the card are a helpful feature for the player's handling of the cards.					
9.	The picture printed on the cards is representative of the topic.					
10.	The material used (paper) in the preparation of the cards is durable.					
11.	The deck of card is compact and can be easily carried around.					

Components and Organization		**Scale**				
		5	**4**	**3**	**2**	**1**
12.	The directions were clear, concise, and easily understood.					
13.	The games emphasized key points of the topic played.					
14.	The terms used were appropriate to my level of knowledge.					
15.	The number of cards was appropriate.					
16.	The length of time required to play each game is reasonable.					

Playability/Playfulness		**Scale**				
		5	**4**	**3**	**2**	**1**
17.	The games provide opportunity for healthy competition and cooperation.					
18.	The rules of the games provide players with equal conditions for a fair play.					
19.	The rules of the games provide a set of options for flexibility in making decisions towards playing the games.					
20.	Playing the games was fun.					

Knowledge Acquisition		**Scale**				
		5	**4**	**3**	**2**	**1**
21.	The games were effective in reviewing the concepts of the topics.					
22.	The games encouraged the players to dig deeper into the subject matter.					
23.	Playing the games is a productive use of time.					
24.	Playing the games help me establish better understanding of the concepts of the lesson.					
25.	I would recommend the games to my peers.					

Name of Evaluator: _____

Grade and Section: _____ Date: _____

Signature: _____

Appendix B. Interview Guide Questions

1. Did you enjoy playing with the BEEP Cards? (please cite instances)

_____
_____
_____
_____
_____

2. How did the BEEP Cards help you understand the concepts?

_____
_____
_____
_____
_____

3. Do you think the use of BEEP Cards is more effective in learning the concepts than the use of traditional methods such as paper-and-pencil? (please cite instances)

_____
_____
_____
_____
_____

4. What are your suggestions to further improve the BEEP Cards?

_____
_____
_____
_____
_____

Name of Interviewee: _____

Grade and Section: _____ Date: _____

Signature: _____

Appendix C. Rationale of the Game

The game was based on the popular card game Rummy as in the study of Gutierrez (2012). From the game from where it was patterned, the object is to lay down (meld) the five cards in one's hands by combining cards to form pairs, three-of-a-kind, four-of-a-kind or five-of-a-kind.

Its major difference from the original game where it was patterned is that each of the cards that compose the deck of the BEEP Cards includes term lifted from the topics on bioenergetics. Instead of matching the face value of the cards or forming numerical straights, the players must form combinations that will demonstrate the relationship between or among the terms that are written on the cards.

The manner through which the player earn points depends on how well he can justify his card combinations in the order in which he declares them to the other players. This means that the players themselves are the referees of their game, while being facilitated by the teacher. This forces the students to be actively engaged in the task.

Goals and Objectives of the Game

The objective of this game is to promote small group discussion, problem-solving skills, independent thinking and active learning by applying basic concepts on bioenergetics in a fun and interactive setting.

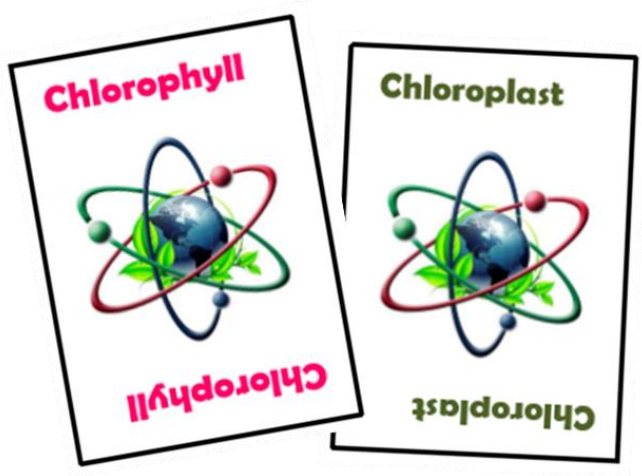
Playing the Game

1. The game can be played by three to five (ideal number of players) players. From the group, one member will be assigned as dealer. The dealer will be the one in-charge of shuffling the deck and dealing each player 5 cards.
2. The dealer will then place the remaining cards in the deck face down at the center of the table, revealing the topmost card, and place it beside the deck. The player at the right of the dealer begins the game. The play continues in a counterclockwise direction.
3. The first player may choose the revealed card beside the deck or he may select the top card on the deck, depending upon potential combinations he may have in his present hand.
4. Upon selecting a card, a player in turn must discard one card, placing it face up beside the deck just like in the start of the play. Note that all discards should remain visible to all players as any one of these cards can be chosen in a player's turn.
5. At this point, this player may pass play to the next player or declare "play" and lay down the cards which form a two- , three-, four- or five-card combination. The player must lay the cards in the exact order according to the relationship which he claims. .
6. Following the player's justification of his organization of cards, the other players will then decide whether or not the combination and justification is valid. Should they unanimously approve of the cards laid down, the hand is scored as follows:

Scoring System

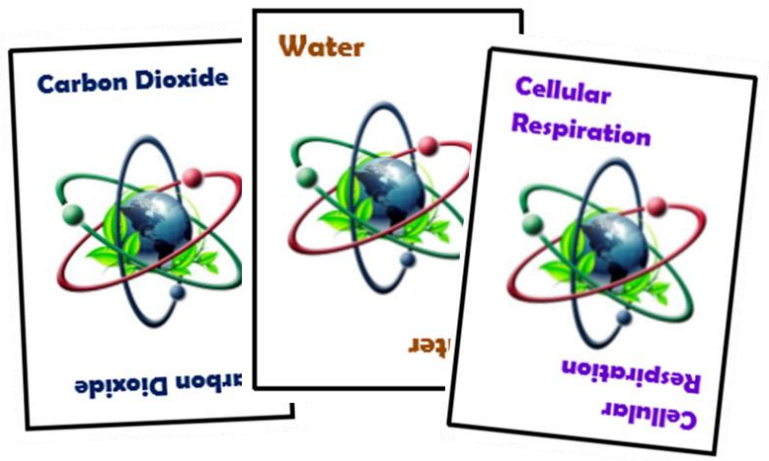
Card Combination	Points
One 2-card combination	2 points
One 3-card combination	3 points
One 4-card combination (two 2-card combination or 4-card combination in a single sequence)	4 points
One 5-card combination (one 2-card combination and one 3-card combination)	5 points
One 5-card combination (5-card combination in a single sequence)	7 points

Below are sample card combinations and justifications:



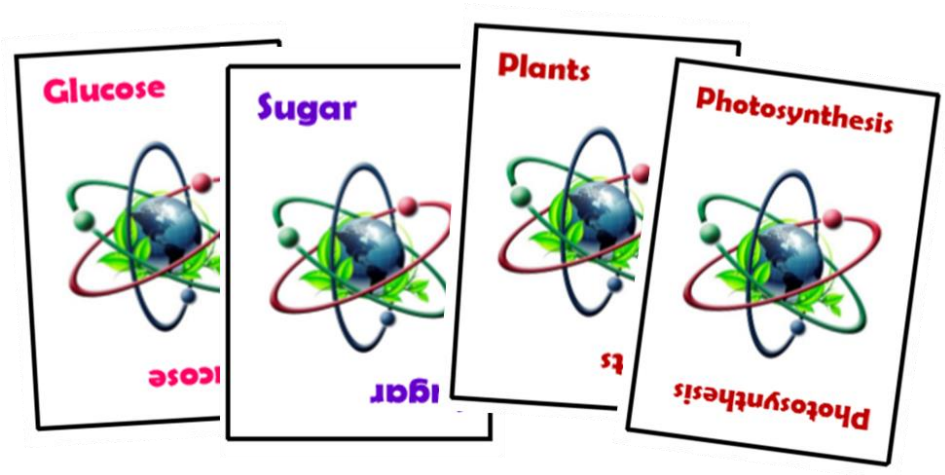
Justification: **Chlorophyll** is a pigment specifically found in the **chloroplast**.

Sample Two-Card Combination



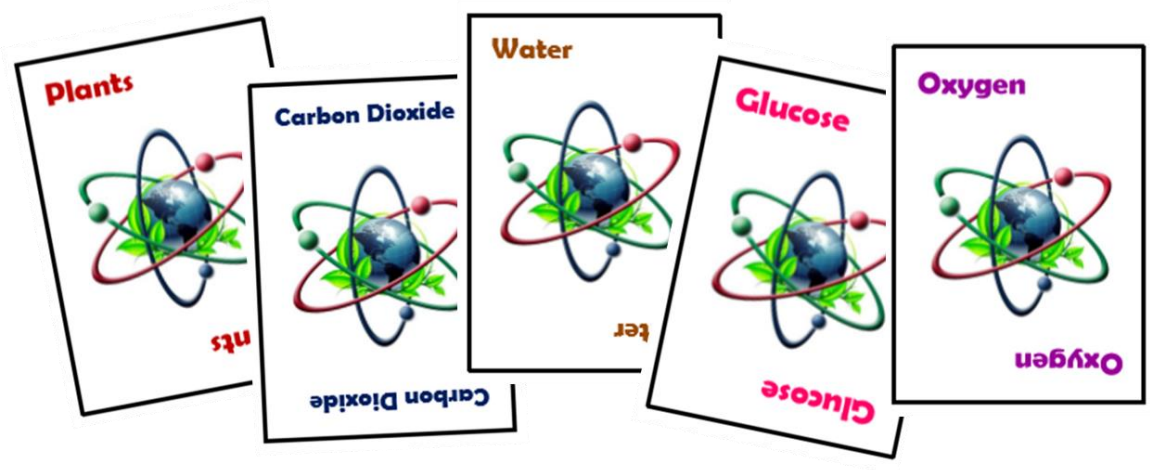
Justification: **Carbon dioxide** and **water** are produced in **cellular respiration**.

Sample Three-Card Combination



Justification: **Glucose** is a form of **sugar** produced by **plants** in the process of **photosynthesis**.

Sample Four-Card Combination



Justification: **Plants** use **carbon dioxide** and **water** to produce **glucose** and **oxygen**.

Sample Five-Card Combination

7. The player then draws the number of cards he played from the deck containing the face-down cards.
8. If the meld is not approved by the other players, each of the others receives one point, the player picks up his cards and play continues.
9. The turn ends when all the cards in the deck are gone, or when the time the players unanimously agreed upon to play the game has already lapsed.
10. The player with the highest point total is the winner.