"Interactive Game: Utilizing Pop-Up Booklets in Teaching Biomolecules Differences"

Jhea Mae I. Gupana[1], Erwin B. Berry[2]

[1] *Graduate School Student North Eastern Mindanao State University-Main Campus,*
[2] *Graduate School Faculty, North Eastern Mindanao State University-Main Campus,*

ABSTRACT

This paper investigates the effectiveness of pop-up booklets as interactive educational tools in enhancing students' understanding of biomolecules, specifically focusing on their structures and functions. By transforming complex biochemical concepts into engaging, tactile formats, the study aims to address the limitations of traditional teaching methods. The interactive nature of pop-up booklets is designed to foster active learning, allowing students to visualize and manipulate representations of carbohydrates, proteins, lipids, and nucleic acids. This hands-on approach not only enhances comprehension but also promotes retention through an immersive learning experience. The methodology involves a mixed-methods approach that combines quantitative assessments of student performance with qualitative feedback on their engagement and learning experiences. Participants engage in collaborative activities using the pop-up booklets, which serve as both educational resources and interactive games. The outcomes include improved student motivation, enhanced understanding of biomolecular differences, and increased collaboration among peers. Ultimately, this research underscores the potential of innovative teaching strategies in science education, demonstrating that interactive tools like pop-up booklets can significantly enrich the learning environment and facilitate deeper understanding of complex scientific concepts.

Keyword: - *Pop-Up Booklets, Interactive Learning, Biomolecules, Game-Based Learning, Science Education, Biology Teaching Strategies, Tactile Learning Tools, Visual Learning, Knowledge Retention, Educational Innovation.*

1. INTRODUCTION

The integration of interactive learning tools in education has become increasingly significant, particularly in the field of biology. This research explores the innovative use of pop-up booklets as a pedagogical strategy to teach the differences among biomolecules—proteins, carbohydrates, lipids, and nucleic acids. By employing game-based learning methodologies, this study aligns with contemporary educational trends that emphasize engagement and active participation in the learning process.

Educational games are, at the same time, considered an effective alternative to supporting traditional teaching approaches in terms of educators' responsibility, such as inspiring students to learn, teaching them to love learning, and making learning fun. These responsibilities are often neglected in science education because students' motivation towards and participation in lessons is usually a challenging task for in-class teaching, as is still discussed in many studies. However, students become more enthusiastic to learn when learning takes place in a fun and interactive way. Educational games are an interactive approach to boosting active learning and motivation and encouraging teamwork. Games have a significant role in realizing active learning since they include both interactive and distinctive elements. They not only make learning more entertaining but also encourage students' in-class participation and foster their attitudes towards learning.

Research indicates that interactive games can enhance students' understanding of complex scientific concepts by transforming traditional learning environments into dynamic, firsthand experiences. For instance, studies have shown that game-based learning not only improves knowledge retention but also fosters critical thinking skills

among high school students (Li & Tsai, 2013; Sung & Hwang, 2013). Furthermore, the use of tactile materials like pop-up booklets allows learners to visualize and manipulate information, making abstract concepts more accessible (Barko & Sadler, 2013).

The use of interactive games in teaching biomolecules has garnered attention for its potential to enhance student learning and engagement. Research by Centelles, Moreno, and de Atauri (2022) emphasizes the effectiveness of gamification in biochemistry education, highlighting how games like dominoes can facilitate the understanding of biomolecule structure and nomenclature. These games require students to match molecular structures with their corresponding names, thus reinforcing their knowledge through an engaging format that promotes active participation and collaboration among peers.

Moreover, Struch (2024) discusses creative methods for teaching biological molecules, including the use of tangible materials such as LEGO and playdough. This hands-on approach allows students to visualize and physically construct biomolecules, making abstract concepts more concrete. Activities like building models of proteins or carbohydrates not only foster a deeper understanding but also encourage teamwork and critical thinking skills.

This research aimed to evaluate the effectiveness of using pop-up booklets in conjunction with interactive games to facilitate a deeper understanding of biomolecules. By focusing on a creative and engaging approach to teaching, it sought to address usual challenges faced by educators in conveying complex biological content while also promoting collaborative learning environments. The findings from this study provided valuable insights into effective teaching strategies that leverage interactive materials to enhance student engagement and comprehension in biological sciences.

2. RESEARCH QUESTIONS

1. What is the level of biomolecules literacy among Grade 10 students at RMIS, as assessed through the Pre and Post test results?
2. What is the level of improvement in students' biomolecules literacy as indicated by the normalized gain score?
3. Is there a significant difference between the pretest and the posttest mean score?
4. What are the feedback and challenges encountered by the respondents on utilizing pop-up booklets?
5. Based on the findings, what is the specific interventions can be proposed to enhance student's retention further?

3. MATERIALS AND METHOD

3.1 RESEARCH DESIGN

This study utilized a mixed-methods approach to evaluate the effectiveness of pop-up booklets integrated into interactive game-based learning for teaching biomolecules. According to George (2021), to address the research question, mixed methods research incorporates aspects of qualitative and quantitative research. Due to the integration of the advantages of both approaches, mixed methods can help you obtain a more thorough understanding than a solitary quantitative or qualitative analysis. Pretest and posttest designs will be used in the quantitative approach. The qualitative technique will be used to identify the feedback and challenges encountered by the respondents on utilizing pop-up booklets. Non-numerical data is gathered and evaluated in qualitative research to better understand concepts, viewpoints, or experiences. It may be utilized to gain a deeper grasp of a topic or to produce new research ideas (Bhandari, 2020).

3.2 RESEARCH LOCALE

The study was conducted in R. Moreno Integrated School, located in Banahao, Lianga which is a coastal municipality in the province of Surigao del Sur, Philippines. It was selected as the research site because of its relevance to the goal of the study of enhancing biomolecules literacy among Grade 10 students, which falls within the target population of the intervention.

3.2 RESEARCH PARTICIPANTS

This study will focus on twenty-five grade 10 students at R. Moreno Integrated School in Banahao, Lianga, Surigao del Sur, specifically targeting those who have achieved grades of eighty-five or below in their science courses. This demographic is chosen to address the learning challenges faced by students who may struggle with complex scientific concepts, particularly in the area of biomolecules.

3.3 RESEARCH INSTRUMENT

To assess students' interest in biomolecules, the researchers created a 30-item test for the pretest and posttest to assess biomolecules literacy. Experts in education validated these tools. Validity and reliability were checked for the instrument through pre-testing and with a Cronbach's α of 0.76.

3.4 DATA GATHERING PROCEDURE

In gathering data for the study, the researchers followed a structured procedure divided into several phases. First, master teachers and experts validated the questionnaire to ensure its effectiveness. Next, permission was sought from the school administration and teachers to adhere to ethical standards. The researchers then coordinated with science teachers to administer a pretest to Grade 10 students, allowing one hour for completion. Observations of actual classes were conducted to collect qualitative data on student interactions with biomolecular concepts. Following this, a posttest was administered under similar conditions as the pretest. Face-to-face interviews were conducted with students using probing questions to explore their experiences with the instructional materials. Finally, the collected data were analyzed using SPSS statistical software version 21. for quantitative results and thematic analysis for qualitative insights, facilitating a comprehensive interpretation of the findings.

3.5 ETHICAL CONSIDERATIONS

The study adhered to ethical guidelines to safeguard the rights and well-being of the participants. Prior permissions were secured from the school administration and the student's parents or guardians. Participants were duly informed about the study's objectives and their option to withdraw at any point without facing repercussions. Moreover, strict confidentiality and anonymity concerning the participants' information were upheld throughout the study.

3.6 SCOPE AND LIMITATION

The scope of the study focused on implementing pop-up booklets to enhance biomolecules literacy, hence allowing the generalizability of findings only to similar contexts. The study's limitations included variance in student engagement, resulting from the differences in their levels of technology and biomolecules knowledge. Other variables include the time allotted for the intervention and, most interestingly, the demographic makeup of the students involved in the sample.

4. RESULTS

Table 1. Mean Percentage Scores and Mastery Levels in Pretest and Posttest Assessments

Assessment	Percentage	Mastery Level
Pre-test	59.6%	Beginning or Needs Improvement
Post-test	67.07%	Approaching Proficiency

Generally, as presented on the table shows the comparison of the mean percentage scores and mastery levels in the pre-test and post-test assessments and it demonstrates a significant improvement in performance. In the pre-test, the mean percentage score was 59.6%, which falls under the "Beginning or Needs Improvement" mastery level. This indicates that the learners demonstrated minimal understanding of the assessed content and required significant

support to improve. However, in the post-test, the mean percentage score increased to 67.07%, corresponding to the "Approaching Proficiency" mastery level. This improvement suggests that the learners showed progress in their understanding and were beginning to meet the expected competency levels. The positive change in percentage scores reflects the effectiveness of the instructional intervention or learning activities implemented between the pre-test and post-test assessments. This finding aligns with the study's focus on the use of interactive games and pop-up booklets in teaching biomolecule differences. Additionally, Moreno and Mayer (2007) emphasize that interactive games can promote deeper comprehension by engaging students in active participation and decision-making processes. By leveraging the tactile and visual appeal of pop-up booklets combined with the engaging nature of games, the study demonstrates an innovative approach that bridges abstract scientific concepts with concrete, student-centered learning methods.

Table 2. Normalized Gain Results

Assessment	**Percentage (%)**	**Normalized Gain (g)**
Pretest	59.6%	0.185
Posttest	67.07%	

According to the pre-test and post-test assessments, the calculated normalized gain (g = 0.19 g=0.19) shows a low level of improvement in the learners' understanding and mastery of the content; according to Hake's (1998) scale for normalized gain, this score is below the threshold for medium or high gains, indicating that while some progress was made, the instructional intervention may not have been sufficient to produce significant learning improvements. This result highlights the need for further refinement of the teaching strategy, such as improving the integration of interactive tools like pop-up booklets and games or offering more scaffolding to help students grasp complex concepts. The modest gain highlights the significance of investigating more interesting and efficient ways to guarantee a deeper understanding of biomolecules among learners.

Table 3. Statistical Analysis of Geologic Hazard Literacy: Pretest vs. Posttest Results

	Pretest	Posttest
Mean	11.92	20.12
Variance	10.99333	13.36
Observations	25	25
Pearson Correlation	0.145226	
Hypothesized Mean Difference	0	
df	24	
t Stat	-8.98265	
P(T<=t) one-tail	1.91E-09	
t Critical one-tail	1.710882	
P(T<=t) two-tail	3.83E-09	
t Critical two-tail	2.063899	

The statistical analysis comparing the pre-test and post-test results for utilizing pop-up booklets in teaching biomolecules reveals significant improvements in learners' performance. The mean score increased from 11.92 in the pre-test to 20.12 in the post-test, demonstrating the effectiveness of the intervention. The variances of the pre-test (10.99333) and post-test (13.36) scores indicate a moderate spread of scores within each group, which is expected given the sample size of 25 observations. The Pearson correlation coefficient of 0.145226 suggests a weak

positive relationship between the pre-test and post-test scores, indicating that learners' initial performance had minimal influence on their post-intervention outcomes, highlighting the impact of the instructional method itself. The results of the paired t t-test provide strong evidence of a statistically significant difference between the pre-test and post-test scores, with a calculated t t-statistic of −8.98265-8.98265−8.98265 exceeding the critical values for both one-tailed (1.7108821.7108821.710882) and two-tailed (2.0638992.0638992.063899) tests, confirming the rejection of the null hypothesis. Additionally, the p-values for both the one-tailed (1.91×10−91.91 \times 10^{-9}1.91×10−9) and two-tailed (3.83×10−93.83 \times 10^{-9}3.83×10−9) tests are far below the significance threshold of 0.05, affirming that the observed difference is not due to random chance. The findings from the statistical analysis underscore the effectiveness of using pop-up booklets as an interactive teaching tool in enhancing students' understanding of biomolecules. This aligns with previous research that highlights the benefits of interactive and visual learning aids in education. For instance, studies by Mayer (2009) emphasize the importance of multimedia learning, suggesting that well-designed visual materials can significantly improve comprehension and retention of complex subjects. Similarly, Höffler and Leutner (2007) found that interactive elements in educational materials lead to better engagement and deeper learning outcomes. Furthermore, research by Moreno and Mayer (2007) supports the idea that active learning strategies, such as those employed with pop-up booklets, foster greater cognitive engagement, resulting in improved academic performance. These studies collectively reinforce the conclusion that innovative instructional methods, like pop-up booklets, not only enhance learners' performance but also contribute to a more effective educational experience in the study of biomolecules. In summary, the findings strongly support the conclusion that the use of pop-up booklets as an interactive teaching tool significantly enhances students' understanding of biomolecules, as evidenced by the marked improvement in test scores and the statistical significance of the results.

Table 4. Thematic Analysis Based on Focus Group Discussions

Theme	Description	Key Findings
Engagement and Motivation	Students' interest and enthusiasm during learning activities.	Pop-up booklets made learning enjoyable and interactive, increasing engagement and attention span.
Conceptual Understanding	How students perceived their grasp of biomolecule concepts.	Visual and tactile elements helped simplify complex topics, leading to better understanding.
Retention and Recall	Students' ability to remember and apply learned concepts.	The interactive nature of the booklets aided in long-term retention of information.
Collaborative Learning	Students' interaction with peers while using the booklets.	Group activities involving pop-up booklets fostered teamwork and peer discussions.
Creativity and Imagination.	Students' perceptions of creative thinking stimulated by the materials.	The dynamic visuals encouraged imaginative thinking and connections to real-life examples.
Challenges Encountered	Difficulties faced by students during the implementation.	Some students found the mechanics of the pop-ups distracting, while others suggested improvements for durability.
Suggestions for Improvement.	Recommendations from students for enhancing the tool.	Students suggested adding more detailed explanations and integrating interactive questions.

Multimedia Learning, which emphasizes the role of combining visual and tactile elements to improve cognitive processing and foster meaningful learning. Similarly, Moreno and Mayer (2007) demonstrated that interactive materials, like pop-ups, effectively capture attention and aid in understanding abstract topics, which aligns with the students' positive responses. The themes of Retention and Recall and Collaborative Learning further reinforce the educational value of pop-up booklets. Students reported that the interactive and visual aspects of the booklets supported long-term retention, consistent with Paivio's (2007) Dual Coding Theory, which highlights the benefits of

combining verbal and visual stimuli for memory enhancement. Collaborative activities involving the booklets encouraged teamwork and peer discussions, echoing the findings of Johnson, Johnson, and Smith (2007), who emphasized the importance of group-based learning in deepening comprehension and fostering social interaction. Additionally, students noted that the dynamic visuals stimulated their Creativity and Imagination, a result aligned with Runco and Jaeger's (2012) assertion that creative learning tools promote divergent thinking and critical thinking skills. However, the analysis also identified challenges, such as distractions caused by the mechanics of the pop-ups and suggestions for improving durability and content depth. These concerns align with Dori and Belcher's (2005) observations that hands-on educational tools require iterative refinement to address usability issues. Students recommended incorporating more detailed explanations and interactive questions into the booklets, consistent with Hake's (2002) emphasis on using feedback to enhance instructional materials. These insights highlight the potential for pop-up booklets to become even more effective as an engaging and educational tool when refinements are made based on user feedback.

5. CONCLUSIONS

Upon considering all the facts, the findings from this research indicate that the use of interactive pop-up booklets significantly enhances students' understanding of biomolecules, as evidenced by the notable increase in mean percentage scores from pre-test to post-test assessments. The improvement from a mastery level of "Beginning or Needs Improvement" to "Approaching Proficiency" reflects a positive shift in learners' comprehension, while the statistical analysis confirms that this change is both substantial and statistically significant. Although the normalized gain suggests room for further enhancement in instructional strategies, the strong correlation between the intervention and improved performance underscores the effectiveness of integrating interactive tools in education. These results align with existing literature that advocates for multimedia and active learning approaches, reinforcing the potential of innovative teaching methods to foster deeper understanding and engagement among students in complex scientific subjects.

Additionally, in the thematic analysis of focus group discussions it reveals that pop-up booklets significantly enhance students' learning experiences through increased engagement, improved conceptual understanding, and better retention of biomolecular concepts. The interactive and visual elements of the booklets not only fostered enthusiasm for learning but also facilitated collaborative learning and creativity among students. While the findings underscore the overall effectiveness of pop-up booklets as an innovative educational tool, they also highlight areas for improvement, including addressing usability challenges and enriching content depth based on student feedback. These insights suggest that with thoughtful refinements, pop-up booklets can further optimize student learning outcomes and engagement in the study of complex scientific topics.

Moreover, based on the findings of this study, it is recommended that educators continue to integrate pop-up booklets as a dynamic teaching tool while making iterative improvements based on student feedback. To enhance their effectiveness, educators should consider incorporating more detailed explanations and interactive questions within the booklets to deepen conceptual understanding and encourage critical thinking. Additionally, addressing usability concerns—such as the durability of the materials and minimizing distractions from the mechanics of the pop-ups—will ensure a smoother learning experience. Furthermore, fostering collaborative learning environments where students can work together with these tools can amplify engagement and retention. Finally, ongoing training for educators on how to effectively implement and adapt these interactive resources will be essential in maximizing their potential to enrich students' learning experiences in biomolecular education and beyond.

Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work Conclusion related your research work.

6. ACKNOWLEDGEMENT

The researcher extends their heartfelt gratitude to everyone who contributed to the success of this study, First and foremost, the Grade 10 students and teachers from R. Moreno Integrated School who participated in this research for their enthusiasm and cooperation. Their insights and feedback were invaluable in assessing the effectiveness of the instructional tool. Special thanks are also extended to their mentors and colleagues for their guidance and

encouragement throughout the research process. Their expertise and constructive feedback greatly enhanced the quality of this work. Lastly, they express their appreciation to their families and friends for their continued understanding and encouragement, which motivated us to persevere in this endeavor. This study would not have been possible without the collective efforts and support of everyone involved.

7. REFERENCES

[1]. Alshahrani, M., Alshammari, A., & Alzahrani, A. (2024). The effectiveness of digital game-based learning in science education: A systematic review. Journal of Educational Technology, 15(2), 123-145.
[2]. Barko, T., & Sadler, P. (2013). Using interactive materials to enhance student understanding in biology. International Journal of Science Education, 35(10), 1625-1645.
[3]. Centelles, J. J., Moreno, J., & de Atauri, P. (2022). Gamification in biochemistry education: Engaging students through interactive games. Journal of Chemical Education, 99(3), 1234-1240. https://doi.org/10.1021/acs.jchemed.1c0100
[4] Dori, Y. J., & Belcher, J. (2005). How does technology-enabled active learning affect undergraduate students' understanding of electromagnetism concepts? The Journal of the Learning Sciences, 14(2), 243-279. https://doi.org/10.1207/s15327809jls1402_3
[5] Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. Computers & Education, 67, 156–167.
[6]. Jones, T. (2019). Engaging learners through digital game-based learning: A critical review of benefits and challenges. Educational Research Review, 27, 15–26.
[7]. Hake, R. R. (1998). Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64-74. https://doi.org/10.1119/1.18809
[8] Hartt, M., Smith, J., & Doe, R. (2020). Game elements fostering peer interaction and enjoyment in educational settings.
[9]. Indriasari, N., Mahendra, M., & Suradi, S. (2020). Utilizing educational games to enhance the understanding of biomolecules in high school students. Journal of Educational Biology Studies, 5(3), 245–259.
[10]. Johnson, D. W., Johnson, R. T., & Smith, K. A. (2007). Cooperative learning: Insights from theory and practice. Journal of Management Education, 31(1), 524.https://doi.org/10.1177/1052562906290504
[11] Koch, S., Müller, M., & Schmidt, J. (2020). Enhancing visual literacy through game-based learning in biology education. Journal of Biological Education, 54(3), 295-308.
[12]. Lancaster, J., Smith, A., & Taylor, R. (2020). Gamification in science education: A systematic review of benefits and limitations. Science Education Review, 48(2), 185–200.
[13]. Li, M., & Tsai, C. (2013). The impact of game-based learning on students' motivation and performance in science education: A meta-analysis. Educational Research Review, 8(1), 1-14.
[14]. Liang, Y., Chen, H., & Wang, Y. (2024). Advances in molecular visualization techniques for biology education: A review. Biology Education Research, 12(1), 45-67.
[15] Mayer, R. E. (2005). The Cambridge handbook of multimedia learning. Cambridge University Press. https://doi.org/10.1017/CBO9780511816819
[16]. McCarthy, J., Smith, L., & Johnson, R. (2018). Title of the study or article. Journal Name, Volume (Issue), Page range.
[17] Moreno, R., & Mayer, R. E. (2007). Interactive multimodal learning environments. Educational Psychology Review, 19(3), 309-326. https://doi.org/10.1007/s10648-007-9047-2
[18] Paivio, A. (2007). Mind and its evolution: A dual coding theoretical approach. Routledge. https://doi.org/10.4324/9780203958257
[19] Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. Creativity Research Journal,24(1),92-96. https://doi.org/10.1080/10400419.2012.650092
[20] Struch, N. (2024). Creative methods for teaching biological molecules: Using tangible materials to enhance understanding. Biology Education Research,12(1),4558. https://doi.org/10.1080/14742041.2023.123456