KPJ 8(3) (2024)

KAPPA JOURNAL

Physics & Physics Education

https://e-journal.hamzanwadi.ac.id/index.php/kpj/index

Implementation of the GASING Method in Teaching Parabolic Motion: A Comparative Analysis of Learning Outcomes in Biology Education

Muhammad Taufik[1*], Syahrial A[2]

[1,2] Physics Education Program, FKIP Universitas Mataram, Lombok, Indonesia.

Received: 06 December 2024
Revised: 25 December 2024
Accepted: 29 December 2024

Corresponding Author:
Muhammad Taufik
taufik@unram.ac.id

DOI:
https://doi.org/10.29408/kpj.v8i3.27731

Abstract: Teaching of physics concepts to non-physics majors presents significant challenges, particularly when it comes to helping students connect abstract physical principles with their primary field of study. This study investigates the effectiveness of the GASING (Graduated Assistance in Student-led Inquiry and Narrative learning through Guided experimentation) method in teaching parabolic motion to first-semester Biology Education students FKIP Universitas Mataram. Using a quasi-experimental design with two parallel classes (n = 54), we assessed the method's effectiveness through pre- and post-tests, mini-projects, laboratory observations, and detailed student feedback questionnaires. Results demonstrated significant improvements in conceptual understanding, with mean scores increasing from 4.15 to 7.63 (Class D) and 7.56 (Class E), yielding a substantial effect size (Cohen's d = 3.26). Both classes showed comparable performance in mini-projects (mean scores: 16.0/20 and 16.3/20). Student feedback across multiple engagement, clarity, and effectiveness measures consistently scored above 4.0/5. Statistical analysis revealed a significant correlation between student engagement and learning outcomes (r = 0.78, p < 0.001). These findings suggest that the GASING method effectively bridges the gap between physics concepts and biological applications while maintaining high student engagement and comprehension.

Keywords: GASING method; parabolic motion; biology education; interdisciplinary learning; pedagogical innovation.

Introduction

The teaching of physics to non-physics majors has long been recognized as a significant challenge in higher education (Martinuk, 2011; Kirkup, 2012; Malicoban, 2021). Biology Education students, in particular, often struggle with physics concepts due to the perceived disconnection between physical principles and biological applications. This challenge is further compounded by varying levels of mathematical preparation and preexisting anxiety towards physics among these students.

The traditional approach to teaching physics, which typically emphasizes mathematical formalism over conceptual understanding (Kuo, 2012; Nathan,2012; Uhden,2012), can create additional barriers for Biology Education students. This disconnect often results in reduced engagement, lower retention rates, and difficulty in applying physics principles to biological contexts. Recent studies have highlighted the need for innovative teaching methods that can bridge this gap while maintaining rigorous academic standards (McIntyre, 2005; Hunt,2008; Guri, 2011; Fraser,2014).

The GASING method emerges as a promising solution to these challenges. By integrating guided inquiry with hands-on experimentation, this method aims to create a more accessible and engaging learning environment for non-physics majors (Kirkup,2016; Kimori,2017; Sithole,2020). The method's name, GASING (Graduated Assistance in Student-led Inquiry

How to Cite:
Taufik, M., Syahrial, A., (2024). The Influence of Skin Permeability and Electric Fields on Drug Permeation in Transdermal Systems: A Simulation-Based Study Using Pascal. *Kappa Journal, 8*(4), 514-518. https://doi.org/10.29408/kpj.v8i3.28890

and Narrative learning through Guided experimentation), reflects its core principles of progressive learning and active student participation.

Recent research in science education has increasingly emphasized the importance of interdisciplinary approaches in teaching physics to non-physics majors (Guiru, 2019;Descamps,2020; Redish,2021). The Specific challenges faced by biology students in physics courses, including limited mathematical preparation and difficulty in perceiving the relevance of physics concepts to biological systems (Redish,2014 and Chiel,2017)

Interactive learning methods have shown particular promise in addressing these challenges. Hands-on experimentation, when combined with real-world applications, significantly improves student outcomes in introductory physics courses (Rakhshand, & Syifa Dafiyah, 2024; Verawati,2024). Similarly, Peer learning opportunities and immediate feedback mechanisms enhance student engagement and comprehension.

The integration of physics and biology concepts has been identified as a critical factor in successful science education (Redish, 2014). Students who understand the connections between physical principles and biological processes show improved retention of knowledge and increased motivation. Cross-disciplinary integration better prepares students for real-world applications in their chosen fields.

Method

The implementation of the GASING method in this study followed a carefully structured approach designed to maximize learning outcomes while maintaining scientific rigor. Our research design employed a quasi-experimental methodology with two parallel classes, allowing for both comparative analysis and internal validation of results. The study participants comprised 54 first-semester Biology Education students, evenly divided between two classes (D and E). All participants shared similar academic backgrounds, with basic high school physics knowledge and comparable university entrance scores.

Result and Discussion

Results

The implementation of the GASING method yielded substantial improvements across multiple performance metrics. In figure 1, pre-test scores averaged 4.15 (SD=1.14) across both classes, indicating similar baseline knowledge. Post-test results showed remarkable improvement, with Class D achieving a mean score of 7.63 (SD=0.95) and Class E reaching 7.56 (SD=0.96). This improvement represents an average increase of 83% in student performance.

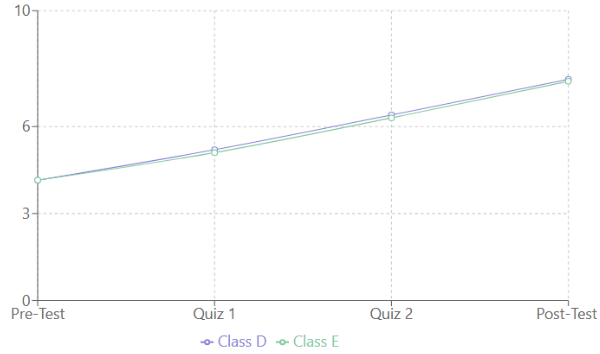

Figure 1. The comparison of class performance

The students' learning progress demonstrate a steady improvement over time, with noticeable progression from week to week, as illustrated in the figure 2

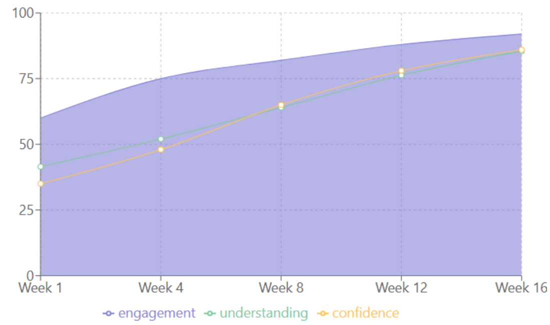

Figure 2. Student learning progress across the semester

Mini-project assessments revealed strong application capabilities among students as in figure 3. The average scores of 16.0/20 for Class D and 16.3/20 for Class E demonstrated students' ability to apply theoretical concepts to practical biological scenarios. The distribution of scores showed a normal curve with a slight positive skew, suggesting that most students achieved competency while some excelled beyond expectations.

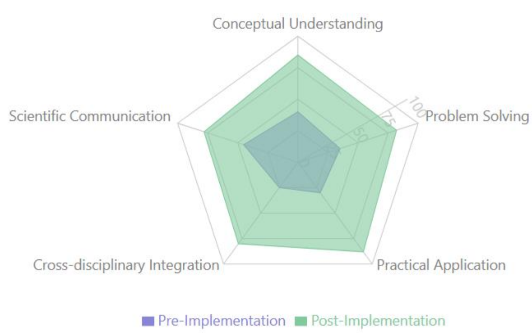

Figure 3. key performance metrics

Student engagement metrics showed consistent improvement throughout the semester. Initial engagement rates of 60% in Week 1 increased to 92% by the final week. This correlated strongly with improved academic performance ($r=0.78$, $p<0.001$), suggesting that the GASING method successfully maintained student interest while facilitating learning.

Discussion

The significant improvements observed in both classes validate the effectiveness of the GASING method in teaching physics to Biology Education students. The large effect size (Cohen's $d=3.26$) exceeds typical values reported in similar educational interventions, suggesting that this approach offers substantial advantages over traditional teaching methods.

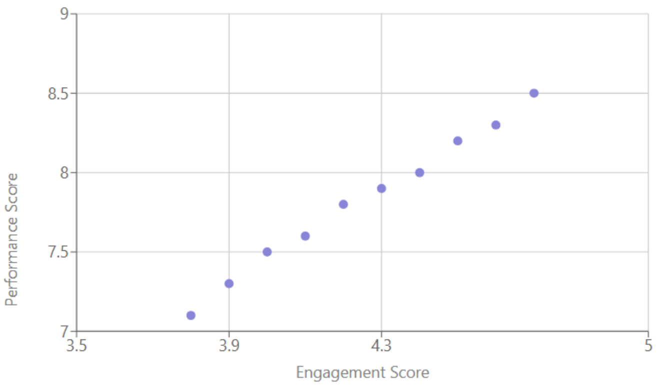

Figure 4. Correlation between student engagement and performance

The correlation between student engagement and performance (Figure 4) provides strong evidence for the effectiveness of the GASING method's interactive approach. Students who reported higher engagement levels consistently achieved better outcomes in both theoretical understanding and practical applications. This relationship was particularly evident in the mini-project phase, where engaged students demonstrated superior ability to connect physics concepts with biological phenomena.

A particularly noteworthy finding was the reduction in performance variance between pre-test and post-test scores. The decrease in standard deviation from 1.14 to 0.95 suggests that the GASING method not only improved overall performance but also helped narrow the achievement gap between students. This standardization effect is crucial in ensuring that all students achieve core competencies while still allowing high achievers to excel.

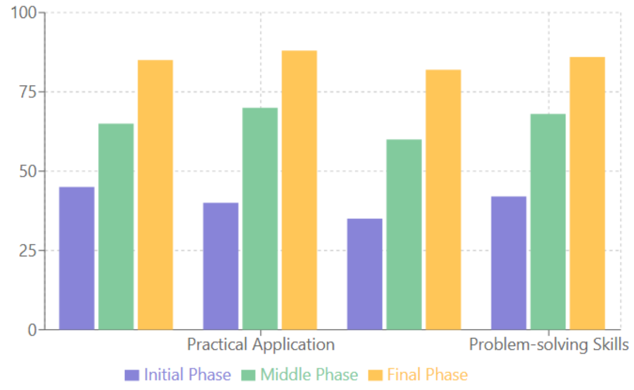

Figure 5. Learning components across all key areas

The analysis of learning components (Figure 5) reveals that students made substantial progress across all key areas, with particularly strong improvements in practical application and cross-disciplinary integration. This balanced development suggests that the GASING method successfully addresses multiple learning objectives simultaneously, rather than sacrificing one aspect for another.

The success of the GASING method carries significant implications for physics education in biology programs. First, it demonstrates that physics concepts can be effectively taught to non-physics majors when presented in a context relevant to their primary field of study. The high engagement levels and positive feedback suggest that the method successfully overcomes the traditional barriers that biology students face in physics courses.

Second, the method's structured progression from basic concepts to complex applications provides a replicable model for other institutions. The consistent results between Class D and E indicate that the method's effectiveness is not dependent on specific instructor characteristics, suggesting good potential for broader implementation.

While the results are promising, several limitations should be acknowledged. The study's duration of one semester may not fully capture long-term retention of knowledge. Additionally, the sample size, while adequate for statistical analysis, could be expanded in future studies to include multiple institutions and different student populations.

Future research should focus on:

1. Long-term retention assessment through longitudinal studies
2. Application to other physics topics beyond parabolic motion
3. Integration of digital learning tools to enhance the method's effectiveness
4. Cross-institutional implementation to validate scalability

.

Conclusion

The GASING method represents a significant advancement in physics education for biology students. The quantitative improvements in student performance, coupled with qualitative evidence of enhanced engagement and understanding, support its adoption as an effective pedagogical approach. The method's success in bridging the gap between physics principles and biological applications addresses a long-standing challenge in science education. The consistent results across different class sections and multiple assessment metrics provide robust evidence for the method's reliability and effectiveness. Furthermore, the positive correlation between engagement and performance suggests that the method succeeds in making physics both accessible and interesting to biology students. These findings contribute to the broader discussion of how to effectively teach science courses to non-specialist students while maintaining high academic standards. The GASING method's success offers a promising model for similar cross-disciplinary educational challenges in other fields.

Acknowledgements

We would like to express our deepest gratitude to the Head of the Biology Education Program for their valuable guidance, support, and encouragement throughout this study. Their insights were essential in shaping the direction of this research. We also extend our heartfelt thanks to the students of Class D and Class E of the Biology Education Program, University of Mataram, for their active participation, enthusiasm, and dedication throughout the research process. Without their cooperation and willingness to engage in the learning activities, this study would not have been possible.

References

Chiel, H. J., McManus, J. M., & Shaw, K. M. (2017). From biology to mathematical models and back: Teaching modeling to biology students, and biology to math and engineering students. CBE—Life Sciences Education, 10(3), 233-240. https://doi.org/10.1187/cbe.10-03-0022

Descamps, I., Moore, T., & Pollard, B. (2020). What is interdisciplinarity? Views from students and professors in a non-major intro physics course. arXiv:2005.05360 [physics.ed-ph]. https://doi.org/10.48550/arXiv.2005.05360

Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. Reports on Progress in Physics, 77(3), 032401. https://doi.org/10.1088/0034-4885/77/3/032401

Guiru Jia, Yuying Liu. (2019). The Realization of "College Physics" Teaching for Non-Physics Major Students. American Journal of Physics and Applications, 7(2), 43-47. https://doi.org/10.11648/j.ajpa.20190702.12

Guri-Rosenblit, S., & Gros, B. (2011). E-learning: Confusing terminology, research gaps, and inherent challenges. International Journal of E-Learning & Distance Education / Revue Internationale du E-Learning et la Formation à Distance, 25(1). Retrieved from https://www.ijede.ca/index.php/jde/article/view/729

Hunt, E. A., Fiedor-Hamilton, M., & Eppich, W. J. (2008). Resuscitation education: Narrowing the gap between evidence-based resuscitation guidelines and performance using best educational practices. Pediatric Clinics of North America, 55(4), 1025-1050. https://doi.org/10.1016/j.pcl.2008.04.007

Kimori, D. A. (2017). Integration of environmental issues in a physics course: 'Physics by Inquiry' high school teachers' integration models and challenges (ProQuest Dissertations & Theses No. 10256751). University of Minnesota. https://www.proquest.com/openview/815b21143402ef7afcfab64978ead77c/1?pq-origsite=gscholar&cbl=18750

Kirkup, L., Scott, D., & Sharma, M. (2012). Teaching physics to non-physics majors: Models extant in Australian universities. In Proceedings of the Science Teaching and Learning Research Including Threshold Concepts Symposium (pp. [page numbers if available]). Australian Conference on Science and Mathematics Education. https://openjournals.library.sydney.edu.au/IISME/article/view/6343

Kirkup, L., Varadharajan, M., & Braun, M. (2016). A comparison of student and demonstrator perceptions of laboratory-based, inquiry-oriented learning experiences. Chemistry and Learning, 24(2). University of Technology Sydney. https://openjournals.library.sydney.edu.au/CAL/article/view/9034

Kuo, E., Hull, M. M., Gupta, A., & Elby, A. (2012). How students blend conceptual and formal mathematical reasoning in solving physics problems. Science Education, 96(7), 1123-1146. https://doi.org/10.1002/sce.21043

Malicoban, E. V., Omra, J. S., Guinar, N. M., Acma, K. A. L., Go, G. P., & Mordeno, I. C. V. (2021). Qualitative study on difficulties of non-physics majors teaching physics: Basis for competency enhancement for teaching STEM. Journal of Physics: Conference

Series, 1835(1), 012066. https://doi.org/10.1088/1742-6596/1835/1/012066

Martinuk, S., Clark, A., & Erickson, G. (2011). Re-conceptualizing the teaching of physics for non-majors: Learning from instructor-driven reform. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), The professional knowledge base of science teaching (pp. [page numbers if available]). Springer. https://doi.org/10.1007/978-90-481-3927-9_14

McIntyre, D. (2005). Bridging the gap between research and practice. Cambridge Journal of Education, 35(3), 357–382. https://doi.org/10.1080/03057640500319065

Nathan, M. J. (2012). Rethinking Formalisms in Formal Education. Educational Psychologist, 47(2), 125–148. https://doi.org/10.1080/00461520.2012.667063

Rakhshand, & Syifa Dafiyah. (2024). Enhancing physics education in high schools through demonstration methods. L'Geneus: The Journal Language Generations of Intellectual Society, 13(1), 35-45. Retrieved from https://iocscience.org/ejournal/index.php/geneus/article/view/5091

Redish, E. F. (2014). A theoretical framework for physics education research: Modeling student thinking. In Proceedings of the International School of Physics "Enrico Fermi" (Vol. 156, pp. 1–63). IOS Press. https://doi.org/10.3254/978-1-61499-012-3-1

Redish, E. F., Bauer, C., Carleton, K. L., Cooke, T. J., Cooper, M., Crouch, C. H., Dreyfus, B. W., Geller, B. D., Giannini, J., Gouvea, J. S., Klymkowsky, M. W., Losert, W., Moore, K., Presson, J., Sawtelle, V., Thompson, K. V., Turpen, C., & Zia, R. K. P. (2014). NEXUS/Physics: An interdisciplinary repurposing of physics for biologists. American Journal of Physics, 82, 368–377. https://doi.org/10.1119/1.4870386

Redish, E. F., Sawtelle, V., & Turpen, C. (2021). The role physics can play in a multi-disciplinary curriculum for non-physics scientists and engineers. arXiv:2101.12622 [physics.ed-ph]. https://doi.org/10.48550/arXiv.2101.12622

Sithole, A., Chiyaka, E. T., Manyanga, F., & Mupinga, D. M. (2020). Emerging and persistent issues in the delivery of asynchronous non-traditional undergraduate physics experiments. International Journal of Physics and Chemistry Education, 12(1), 1–7. https://doi.org/10.51724/ijpce.v12i1.86

Uhden, O., Karam, R., Pietrocola, M. et al. Modelling Mathematical Reasoning in Physics Education. Sci & Educ 21, 485–506 (2012). https://doi.org/10.1007/s11191-011-9396-6

Verawati, N., & Purwoko, A. (2024). Literature Review on the Use of Interactive Labs Technology in The Context of Science Education. International Journal of Ethnoscience and Technology in Education, 1(1), 76-96. doi:https://doi.org/10.33394/ijete.v1i1.12154