Proceeding International Conference on Religion, Science and Education (2026) **5**, 1113-1119

The Effectiveness of Developing Interactive PowerPoint Based on Problem Based Learning (PBL) on Genetics Material to Improve Students' High Order Thinking Skills

Adi Hartono*
Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Samudra
Jalan Prof. Dr. Syarief Thayeb, Meurandeh, Kecamatan Langsa Lama, Kota Langsa, Aceh 24416, Indonesia.

Corresponding author*
adihartono@unsam.ac.id

Abstract: The urgency of this research stems from the need for innovative learning media that integrates technology with pedagogical strategies to foster students' higher-order thinking skills in Genetics courses. Genetics material is often considered complex, requiring a learning approach that is not only theoretical but also contextual and interactive. Therefore, the development of interactive PowerPoint media based on Problem-Based Learning (PBL) is crucial to address the limitations of conventional learning. This study aims to test the effectiveness of using PBL-based interactive Power Point in improving students' higher-order thinking skills, especially in the analysis, synthesis, and evaluation of genetic concepts. The method used was an experimental study with a pretest-posttest control group design. The subjects were biology education students divided into two groups: an experimental group using interactive PowerPoint based on PBL and a control group using conventional presentation media. The research instruments were a high-level thinking ability test and a questionnaire assessing students' responses to the learning media. Data were analyzed using a t-test to determine differences in ability improvement between groups. The results showed that the experimental group experienced significant improvements in higher-order thinking skills compared to the control group. Furthermore, student responses to the PBL-based interactive PowerPoint were very positive, with the majority stating that the medium was engaging, easy to use, and helpful in understanding abstract genetic concepts. The conclusion of this study confirms that the development of PBL-based interactive Power Point is effective in improving students' high-level thinking skills in genetics material. The implication of this research is the need to implement interactive media based on innovative learning models in biology lectures to support 21st century learning, as well as as a reference for teachers in developing similar media in other biology materials.

Keywords: Interactive PowerPoint, Problem Based Learning, Genetics, Higher Order Thinking Skills, Learning Media.

Introduction

The development of 21st-century education demands that students not only master conceptual knowledge but also possess higher-order thinking skills (HOTS), which include the abilities of analysis, evaluation, and creation. In the context of biology education, this ability becomes highly crucial as students are required to comprehend complex, abstract, and integrated concepts such as genetics (Abdulah et al., 2021; Ketaren & Nasution, 2025). However, the reality in the field shows that the process of genetics learning often remains conventional, focusing on the lecturer, and does not fully encourage students to think critically and solve problems. As a result, students' understanding of the concept of genetics tends to be more rote and less applicable (Ulfa et al., 2021; Primahesa et al., 2023).

The limitations of conventional learning demand the need for innovative learning media that can provide interactive, contextual, and challenging learning experiences. PowerPoint is frequently employed as a presentation medium in academic settings, yet it is often utilized passively for the purpose of displaying static textual content and images (Handayani & Anam, 2024). However, with the support of interactive features such as

ISSN 2829-3355 | EISSN 2828-8467

hyperlinks, animations, triggers, and quizzes, Power Point can be developed into an engaging and stimulating interactive learning media that is capable of stimulating the students' thought process. As such, the development of interactive Power Point presentations needs to be integrated with a learning model that can facilitate active student engagement in the learning process (Isna & Affifah, 2023; Walangitan et al., 2025).

The Model Problem Based Learning (PBL) is considered to be an effective approach to developing higher-order thinking skills in students. PBL places students at the center of learning by presenting authentic problems that must be analyzed and solved collaboratively (Ramdiah et al., 2018; Fatmawati et al., 2023). This process encourages students to integrate conceptual knowledge with the ability to think critically, reflectively, and creatively (Hujjatusnaini et al., 2022; Hasan et al., 2024). Several previous studies have indicated that the implementation of PBL in biology education is capable of enhancing students' understanding of concepts, scientific thinking skills, and motivation to learn. Nevertheless, the implementation of PBL still faces constraints in terms of the availability of attractive and easily implementable supporting media in lectures (Orozco & Yangco, 2016; Sabu, 2020).

According to the findings of the observation and interviews with the lecturer of the genetics course, it is evident that a majority of students are facing difficulties in comprehending the process of heredity and genetic mechanisms due to the abstract nature and lack of interactivity in the material delivery. Furthermore, there is a lack of specific research on the development of interactive Power Point media based on PBL for genetics materials in higher education. This gap forms the basis for the present study to develop and evaluate the effectiveness of interactive Power Point based on PBL as an innovative instructional medium expected to enhance students' higher-order thinking skills.

The purpose of this study is to examine the effectiveness of interactive Power Point based on PBL in enhancing students' higher order thinking skills in the area of genetics. Specifically, this research is expected to contribute to the development of innovative digital learning media that align with the demands of 21st-century learning, while also enriching empirical references on the integration of technology and problem-based learning models in biology education. The findings of this research are expected to serve as a reference for educators and curriculum developers in designing more effective, engaging, and high-level thinking skill-oriented learning strategies.

MATERIALS AND METHODS

This study employed a quasi-experimental approach with a pretest-posttest control group design (Sugiyono, 2019). This design was chosen to evaluate the effectiveness of interactive Power Point as a learning media based on Problem Based Learning (PBL) in improving students' higher-order thinking skills. Two groups of students were involved in the study: the experimental group, which learned using interactive PBL-based Power Point, and the control group, which used conventional Power Point media. Both groups were administered a pretest and a posttest to gauge the improvement in high-level thinking skills.

The research subjects are fourth semester students of the Biology Education program at the Faculty of Teacher Training and Education, Universitas Samudra, who are currently taking the Genetics course. The research sample was determined using the purposive sampling technique based on criteria of initial academic ability equivalence and willingness to participate in the research. Each class is comprised of 30 students, resulting in a total of 60 participants. The random assignment of experimental and control groups is carried out to minimize research bias (Creswell & Guetterman, 2021).

The development of interactive Power Point is carried out through the Research and Development (R&D) model that adapts the steps outlined by Borg & Gall (2003), namely: (1) analysis of the needs and characteristics of students, (2) media design, (3) development of interactive Power Point prototype, (4) validation by media and subject matter experts, (5) limited trial, and (6) product revision. The media was developed by utilizing

features such as hyperlinks, triggers, animation paths, and interactive quizzes based on problem scenarios that support the syntax model of PBL (Arends, 2012). Two expert professors in instructional media and two expert professors in genetics carried out the validation of the media using Likert-scale validation sheets.

The implementation phase of the research will be carried out over four meetings in the Genetics course. The experimental group engaged in a learning session utilizing interactive, Problem Based Learning (PBL) based Power Point, whereas the control group utilized conventional Power Point without interactive elements and problem scenarios. The learning process in the experimental group follows five stages of PBL syntax, namely: (1) student orientation to the problem, (2) organization of learning tasks and group distribution, (3) guidance in independent and collaborative investigation, (4) presentation of investigation results, and (5) reflection on the problem-solving process (Hmelo-Silver, 2004). Each stage of the learning process is supported by an interactive Power Point designed with features such as hyperlink, trigger, animation path, and reflective quizzes to guide students to think analytically, evaluatively, and creatively about the given genetic cases.

The research instrument is comprised of three main components. Firstly, the test of high-level thinking abilities consists of essay questions that are structured based on the revised Bloom's taxonomy indicators by Anderson and Krathwohl (2001). This includes the ability to analyze (C4), evaluate (C5), and create (C6). This test is utilized during the pretest and posttest stages to measure the improvement of students' higher-order thinking abilities. Secondly, the student response questionnaire is utilized to uncover students' perceptions of the effectiveness, attractiveness, and usability of interactive Power Point media based on Problem-Based Learning (PBL). Thirdly, the observation sheet for the implementation of learning is prepared to assess the extent to which the stages of PBL are consistently carried out during the lecture. All instruments were validated by three experts, composed of two biology learning experts and one education evaluation expert, to ensure the appropriateness of the content and reliability of the instruments used in the research.

Quantitative data was analyzed using the parametric statistical test of Independent Sample t-test to examine the difference in average score improvement between the experimental and control groups (Santoso, 2021). The enhancement of high-level thinking skills is also measured using N-gain score (Hake, 1998). Meanwhile, qualitative data from student response surveys is analyzed descriptively using percentages and categorization of responses. The validity of the instrument was analyzed using the content validity test by experts, reliability was calculated using the Cronbach's Alpha coefficient, while normality and homogeneity tests were conducted prior to inferential analysis.

RESULTS AND DISCUSSION

The research results indicate a significant increase in students' Higher Order Thinking Skills (HOTS) after participating in interactive Power Point-based Problem Based Learning (PBL) instruction. Based on the results of the pretest and posttest, the average score of the experimental group increased from 56.7 to 84.2, while the control group increased from 55.9 to 72.1. The calculation of N-gain indicates an increase of 0.67 in the experimental group (medium-high category) and 0.38 in the control group (medium category) based on Hake's classification (1998).

The inferential analysis utilized the Independent Sample t-test, which indicated a significant value (p-value) of 0.001 ($p < 0.05$). This suggests that there is a significant difference in the improvement of higher-order thinking abilities between the experimental and control groups. This result indicates that the use of interactive, PBL-based Power Point is more effective than conventional presentation media in enhancing students' analytical, evaluative, and creative abilities in the subject of Genetics.

Additionally, the survey results indicate that students are highly satisfied with the instructional media. A total of 92% of the students expressed that interactive PowerPoint aids in their

understanding of abstract genetic concepts, while 88% feel more motivated to learn. Furthermore, 90% found the visual presentation and media navigation to be highly engaging and user-friendly. The observation of the implementation of the learning process also indicates that the stages of PBL can be effectively applied, with an average implementation rate of 93.5%, indicating that students actively participate in problem-solving processes and group discussions.

The considerable improvement in the high-level thinking abilities of the experimental group demonstrates that the integration of interactive Power Point and Problem Based Learning model is capable of creating meaningful and stimulating learning that enhances the complex thinking processes of students. This is consistent with the view of Hmelo-Silver (2004) who asserts that PBL is effective in developing analytical and reflective skills through the solving of authentic problems. In the context of Genetics material, the use of interactive media enables students to visualize abstract processes such as the mechanisms of trait inheritance and protein synthesis dynamically, thereby enhancing their ability to connect theoretical concepts with real biological phenomena.

This finding is also in line with the study by Ketaren & Nasution (2025), which reported that interactive PBL-based media in Chemistry material can significantly improve N-gain in higher-order thinking skills by 0.69 (moderate to high category). Similarly, the research conducted by Hasan et al. The results of the 2024 Genetika course indicate that the PBLRQA strategy significantly enhances the metacognitive abilities and higher-order thinking of biology students. Therefore, the effectiveness of interactive Power Point media based on PBL in this study strengthens the empirical evidence that the combination of technology and problem-based learning is a superior strategy in the context of science education in higher education.

In addition to influencing the enhancement of cognitive abilities, the survey results indicate that interactive Power Point media also has a positive impact on student motivation and engagement in learning. The visual aspect, interactivity, and ease of navigation provide a more engaging and personalized learning experience. This is supported by the findings of Isna & Affifah (2024) who discovered that the use of interactive PowerPoint quizzes can enhance students' generic science skills and learning enthusiasm. As a result, interactive media-based learning not only enhances learning outcomes, but also fosters a collaborative learning environment and stimulates curiosity.

The successful implementation of this media is also influenced by the syntax of problem-based learning (PBL), which positions students at the center of the learning process. In the problem orientation stage, students are presented with real cases related to inheritance of traits, gene mutation, or chromosomal abnormalities, which require analysis and data-based problem solving. The final reflection stage provides an opportunity for students to evaluate problem-solving strategies and draw conceptual conclusions. This type of learning systematically builds higher-order thinking skills in accordance with the critical thinking model proposed by Anderson & Krathwohl (2001).

Overall, the findings of this study indicate that interactive Power Point based on PBL can serve as an effective alternative digital learning media in supporting biology education in the digital era. The implication is that the development of interactive media based on innovative learning models needs to be expanded not only to the subject of Genetics, but also to other abstract topics in biology such as biotechnology, evolution, or molecular ecology. It is hoped that professors and curriculum developers will use these findings as a basis for designing student-centered learning that focuses on the development of higher order thinking skills (HOTS) and science literacy.

The significant improvement in higher-order thinking skills in this research is also attributed to the demanding nature of Genetics material, which requires high levels of abstract and analytical thinking. The concept of inheritance of traits, DNA structure, and transcription-translation mechanisms is often challenging to comprehend solely through lectures or verbal explanations (Reece et al., 2014). The integration of interactive elements in Power Point, such as animated

simulations and reflective case-based questions, assists students in concretely visualizing the concepts. This supports Mayer's (2017) findings in the multimedia learning theory, which explains that dynamic visualization can strengthen the connection between verbal and visual cognitive channels, thus expediting the process of constructing meaning.

In addition to cognitive aspects, the active involvement of students in the learning process significantly contributes to the successful improvement of high-level thinking skills. According to Savery (2015), the PBL model requires students to identify problems, propose hypotheses, seek information, and verify solutions independently or collaboratively. Through the use of interactive Power Point presentations, each stage is effectively facilitated—for example, by including hyperlinks to scholarly references, simulations, or formative quizzes. This approach is consistent with the findings of Zubaidah et al. (2018) study demonstrates that digital media-based PBL significantly enhances critical thinking skills and problem-solving abilities in science students.

On the other hand, this research also demonstrates the existence of variations in the extent of improvement among individuals, particularly influenced by differences in students' motivation and digital literacy. Students with a high level of technological literacy are better able to utilize the interactive features in Power Point to independently explore learning content. This finding is consistent with the study conducted by Pratiwi et al. (2023) emphasizes that the effectiveness of digital media in PBL learning heavily relies on the technological readiness and self-directed learning of students. Therefore, the implementation of interactive media needs to be accompanied by training in basic digital skills so that all students can obtain the full benefits of learning.

From a pedagogical perspective, the success of interactive Power Point media based on PBL also reinforces the relevance of the student-centered learning paradigm in higher education. Students are no longer passive recipients of information, but actively engage as creators of knowledge. This condition aligns with the constructivist views of Piaget and Vygotsky, which emphasize that knowledge is constructed through social interaction and meaningful learning experiences. This outcome is consistent with the research of Wahyuni & Nasir (2022) which reports that the application of interactive multimedia-based PBL is able to enhance the reflective and collaborative thinking abilities of biology students at a state university in Indonesia.

In addition to enhancing higher-order thinking skills, the implementation of PBL-based interactive Power Point media also has implications for the improvement of students' scientific communication skills. During the process of discussion and presentation of research findings, students are trained to formulate arguments based on data, present opinions logically, and provide feedback on their peers' views. This skill is an essential part of 21st-century competencies that are highly needed in the context of modern science learning (Trilling & Fadel, 2009). As a result, interactive media serves not only as a visual aid, but also as an integrative tool that connects cognitive, social, and metacognitive aspects in learning.

Finally, this study provides empirical contribution to the development of technology-based learning strategies in the field of biological education. The use of interactive Power Point based on PBL has been shown to not only enhance learning outcomes but also enrich students' learning experience through challenging problem-based learning that is relevant to real-life contexts. In line with the research of Hidayati et al. (2024), the utilization of digital media designed with strong pedagogical principles can enhance science literacy and the preparedness of students to face the challenges of global higher education. Consequently, the continuous development of similar media is necessary by integrating instructional design principles, interactive technology, and the competency needs of the 21st century.

CONCLUSIONS

The research findings demonstrate that the development of interactive Power Point

presentations based on Problem Based Learning (PBL) is effective in enhancing students' higher order thinking skills in the subject of Genetics. The utilization of this media for learning is capable of stimulating students to engage in analytical, evaluative, and creative thinking in solving complex biological problems. Hal ini terbukti dari peningkatan nilai N-gain yang signifikan pada kelompok eksperimen serta hasil uji t-test yang menunjukkan perbedaan nyata dibandingkan kelompok kontrol. In addition to the improvement of learning outcomes, students also demonstrated a positive response towards the interactive media, which is perceived as engaging, user-friendly, and helpful in understanding abstract genetic concepts.

Therefore, the integration of interactive Power Point and PBL syntax can create a meaningful and contextual learning process, while also strengthening the implementation of the student-centered learning paradigm in higher education. This media serves not only as a means of presentation, but also as a tool for facilitating critical, reflective, and collaborative thinking among students. In general, the findings of this research serve to reinforce the empirical evidence that a problem-based approach supported by interactive technology is capable of enhancing the quality of modern biology education, particularly in abstract conceptual topics such as genetics.

Acknowledgements: The authors would like to express their sincere gratitude to the Institute for Research and Community Service (LPPM), Universitas Samudra, for providing research funding and administrative support for this study. Appreciation is also extended to the Department of Biology Education, Faculty of Teacher Training and Education, Universitas Samudra, for facilitating the implementation of this research within the Genetics course. The researchers gratefully acknowledge the cooperation and active participation of all students involved in the study, whose engagement contributed greatly to the success of the research.

Special thanks are also addressed to the expert validators—two specialists in biology education and one specialist in educational evaluation—for their constructive feedback and valuable insights during the validation process of the learning instruments and interactive media. The authors are indebted to their colleagues who provided helpful discussions and technical support during the media development and classroom implementation stages. Their assistance and encouragement have been instrumental in completing this research successfully.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this research article. All procedures and analyses were conducted objectively, without any commercial, financial, or personal relationships that could influence the results or interpretations of the study. The research was carried out solely for academic and scientific purposes to contribute to the development of innovative learning media in biology education.

REFERENCES

Abdulah, A., Mustadi, A., & Fitriani, W. (2021). PBL-based interactive multimedia in improving critical thinking skills. *JPI (Jurnal Pendidikan Indonesia),* 10(1), 136-144. https://doi.org/10.23887/jpi-undiksha.v10i1.25521

Anderson, L. W., & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman.

Arends, R. I. (2012). *Learning to Teach (9th ed.).* New York: McGraw-Hill.

Borg, W. R., & Gall, M. D. (2003). *Educational Research: An Introduction (7th ed.).* Boston: Pearson.

Creswell, J. W., & Guetterman, T. C. (2021). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (6th ed.).* Pearson.

Fatmawati, U., Yuniar, R., & Nurmiyati, N. (2023). Development of Interactive Learning Media with Android-Based Simulative Approach on Genetic Substance and Protein Synthesis. *Bioedusiana: Jurnal Pendidikan Biologi,* 8(2).

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics,* 66(1), 64–74.

Handayani, M., & Anam, R. A. S. (2024). The Use of Problem-Based Learning to Improve Higher Order Thinking Skills of fifth-Grade Students. *Journal for Lesson*

and Learning Studies, 7(3). https://doi.org/10.23887/jlls.v7i3.81563

Hasan, I., Budiarsa, I. M., Bialangi, M. S., & Jamhari, M. (2024). PBLRQA Strategy on Metacognitive Skills and Higher-order Thinking of Students in the Genetics Course. *Jurnal Penelitian dan Pengembangan Pendidikan,* 8(1), 154-165. https://doi.org/10.23887/jppp.v8i1.61962

Hidayati, N., Sari, N. P., & Kurniawati, L. (2024). Integration of digital media and problem-based learning to enhance students' scientific literacy and creative thinking skills. Journal of Biology Education Research, 19(2), 112–123.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn?. *Educational Psychology Review,* 16(3), 235–266.

Hujjatusnaini, N., Corebima, A. D., Prawiro, S. R., & Gofur, A. (2022). The effect of blended project-based learning integrated with 21st-century skills on pre-service biology teachers' higher-order thinking skills. *Jurnal Pendidikan IPA Indonesia,* 11(1), 104-118. https://doi.org/10.15294/jpii.v11i1.27148

Isna, I., & Affifah, J. R. (2023). Powerpoint Intractive Quiz As A Learning Media In Improving Science Generic Ability in Material Classification Topic. *JCER (Journal of Chemistry Education Research),* 7(1), 204-209. https://doi.org/10.26740/jcer.v7n1.p204-209

Ketaren, F. K., & Nasution, H. A. (2025). Development of Interactive E-Module Based on Problem Based Learning to Improve Students' Higher Order Thinking Skills in Acid Base Material. *Jurnal Pendidikan dan Pembelajaran Kimia,* 14(2), 137-148. https://doi.org/10.23960/jpkv2.14214

Mayer, R. E. (2017). Multimedia learning (3rd ed.). New York: Cambridge University Press. https://doi.org/10.1017/9781316941355

Orozco, J. A., & Yangco, R. T. (2016). Problem-based learning: effects on critical and creative thinking skills in biology. *The Asian Journal of Biology Education,* 9, 2-10. https://doi.org/10.57443/ajbe.9.0_2

Pratiwi, N. D., Rahayu, S., & Nurmiyati, S. (2023). The effect of digital literacy and self-directed learning readiness on students' learning outcomes in problem-based learning environments. Journal of Educational Technology and Learning, 12(4), 211–220.

Primahesa, A., Sajidan, S., & Ramli, M. (2023). Improving higher order thinking skills in high school biology: A systematic review. *Biosfer: Jurnal Pendidikan Biologi,* 16(1), 206-219. https://doi.org/10.21009/biosferjpb.26724

Ramdiah, S., Abidinsyah, H., & Mayasari, R. (2018). Problem-based learning: Generates higher-order thinking skills of tenth graders in ecosystem concept. *JPBI (Jurnal Pendidikan Biologi Indonesia),* 4(1), 29-34. https://doi.org/10.22219/jpbi.v4i1.5490

Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2014). Campbell Biology (10th ed.). Boston: Pearson Education.

Sabu, N. (2020). The Moderating Effect of Prior Knowledge on Higher Order Thinking Skills in the Interactive Multimedia Learning Environment. *International Journal of Academic Research in Business and Social Sciences,* 10(3). http://dx.doi.org/10.6007/IJARBSS/v

Santoso, S. (2021). *Menguasai Statistik dengan SPSS 26.* Jakarta: Elex Media Komputindo.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-Based Learning, 9(2), 9–20. https://doi.org/10.7771/1541-5015.1559

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D.* Bandung: Alfabeta.

Trilling, B., & Fadel, C. (2009). 21st century skills: Learning for life in our times. San Francisco, CA: Jossey-Bass.

Ulfa, R., Habiddin, H., & Utomo, Y. (2021). Interactive instructional: theoretical perspective and its potential support in stimulating students' higher order thinking skills (HOTS). *J-PEK (Jurnal Pembelajaran Kimia),* 6(1), 1-8. http://dx.doi.org/10.17977/um026v6i12021p001

Wahyuni, S., & Nasir, M. (2022). Enhancing reflective and collaborative thinking skills through interactive multimedia-based problem-based learning in biology education. Journal of Biology Education Innovation, 8(3), 155–167.

Walangitan, M. N., Sumampouw, H. M., & Tengker, A. C. (2025). Peningkatan Hasil Belajar Biologi melalui Pendekatan Kontekstual Berbantuan PowerPoint Interaktif: Studi pada Materi Sistem Pernapasan Manusia. *Pentagon: Jurnal Matematika dan Ilmu Pengetahuan Alam,* 3(3), 13-26. https://doi.org/10.62383/pentagon.v3i3.708

Zubaidah, S., Corebima, A. D., & Mistianah. (2018). Asesmen kemampuan berpikir kritis siswa melalui pembelajaran berbasis masalah terintegrasi media digital. Jurnal Pendidikan Biologi Indonesia, 4(1), 29–38. https://doi.org/10.22219/jpbi.v4i1.5536

THIS PAGE INTENTIONALLY LEFT BLANK