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AI-BASED INTERACTIVE POWERPOINT ON PHOTOSYNTHESIS AND CHEMICAL REACTIONS

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Abstract

Photosynthesis and chemical reactions are essential concepts in biology and chemistry learning; however, students often experience difficulties in understanding these topics due to their abstract characteristics and complex processes. The integration of artificial intelligence (AI) in interactive learning media is considered capable of improving students' conceptual understanding and engagement in science learning. This study aimed to develop and evaluate an AI-Based Interactive PowerPoint on photosynthesis and chemical reactions for biology and chemistry education. This research employed a Research and Development (R&D) approach using the 4D model, consisting of Define, Design, Develop, and Disseminate stages. The developed media integrated AI-assisted explanations, animations, interactive quizzes, and visual simulations. The research participants were students from biology and chemistry education programs. Data were collected through expert validation sheets, practicality questionnaires, and pretest-posttest instruments. The obtained data were analyzed descriptively and quantitatively using percentage analysis and N-gain scores. The findings showed that the AI-Based Interactive PowerPoint achieved a very valid category based on expert assessment and was considered highly practical by students and lecturers. Furthermore, the media effectively improved students' understanding of photosynthesis and chemical reaction concepts, as indicated by the increase in posttest scores and positive student responses toward the learning process. The integration of AI features also encouraged more interactive, visual, and student-centered learning experiences. In conclusion, the AI-Based Interactive PowerPoint is feasible and effective as an innovative learning medium for integrated biology and chemistry education. The developed media can support meaningful science learning and enhance students' engagement and conceptual understanding in the digital learning era.

Keywords: AI-based learning; chemical reactions; interactive PowerPoint; photosynthesis

Abstrak

Fotosintesis dan reaksi kimia merupakan konsep penting dalam pembelajaran biologi dan kimia; namun, siswa sering kali mengalami kesulitan dalam memahami topik-topik ini karena sifatnya yang abstrak dan prosesnya yang kompleks. Integrasi kecerdasan buatan (AI) ke dalam media pembelajaran interaktif dinilai mampu meningkatkan pemahaman konsep dan keterlibatan siswa dalam pembelajaran sains. Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi PowerPoint Interaktif berbasis AI mengenai fotosintesis dan reaksi kimia untuk pendidikan biologi dan kimia. Penelitian ini menggunakan pendekatan Research and Development (R&D) dengan model 4D, yang mencakup tahapan Pendefinisian, Perancangan, Pengembangan, dan Penyebarluasan. Media yang dikembangkan

mengintegrasikan penjelasan berbantuan AI, animasi, kuis interaktif, dan simulasi visual. Partisipan penelitian adalah mahasiswa dari program studi pendidikan biologi dan kimia. Data dikumpulkan melalui lembar validasi ahli, kuesioner kepraktisan, serta instrumen *pretest* dan *posttest.* Data yang diperoleh dianalisis secara deskriptif dan kuantitatif menggunakan analisis persentase dan skor N-gain. Hasil penelitian menunjukkan bahwa *PowerPoint* Interaktif berbasis AI tersebut mencapai kategori sangat valid berdasarkan penilaian ahli dan dinilai sangat praktis oleh mahasiswa maupun dosen. Selain itu, media ini secara efektif meningkatkan pemahaman mahasiswa mengenai konsep fotosintesis dan reaksi kimia, sebagaimana ditunjukkan oleh peningkatan skor *posttest* dan respons positif mahasiswa terhadap proses pembelajaran. Integrasi fitur AI juga mendorong pengalaman belajar yang lebih interaktif, visual, dan berpusat pada mahasiswa. Sebagai kesimpulan, *PowerPoint* Interaktif berbasis AI ini layak dan efektif digunakan sebagai media pembelajaran inovatif untuk pendidikan biologi dan kimia terintegrasi. Media yang dikembangkan ini dapat mendukung pembelajaran sains yang bermakna serta meningkatkan keterlibatan dan pemahaman konsep mahasiswa di era pembelajaran digital.
Kata kunci: pembelajaran berbasis AI; reaksi kimia; PowerPoint interaktif; fotosintesis

INTRODUCTION

The rapid development of educational technology in the era of Society 5.0 has transformed traditional learning paradigms into dynamic, digital-based experiences. In science education, abstract and complex topics often present significant pedagogical challenges. Photosynthesis and chemical reactions are prime examples of concepts requiring high conceptualization, as they involve sub-microscopic processes and biochemical pathways that are invisible to the naked eye. In practice, conventional teaching methods frequently fail to bridge the gap between abstract chemical equations and students' visual understanding, leading to persistent misconceptions (Widarti et al., 2024). Consequently, there is an urgent need for innovative learning media that can present these complex concepts in a more interactive, adaptive, and engaging format to foster 21st-century skills such as critical thinking and digital literacy (Aliya & Sulisworo, 2025).

Numerous studies have explored the development of interactive learning media to improve students' comprehension of abstract science topics. Previous literature indicates that the use of standard multimedia platforms, such as Microsoft PowerPoint equipped with animations and hyperlinks, can enhance student engagement, collaborative skills, and academic performance (Sitompul et al., 2026). Furthermore, recent research has successfully integrated Artificial Intelligence (AI) into elementary and secondary science education, particularly through platforms like Canva AI or ChatGPT to design multi-representation learning objects (Estuhono & Safitri, 2025; Alfiani & Sulisworo, 2023). However, most existing literature treats AI tools and presentation software as separate entities; studies on embedding generative and adaptive AI directly into presentation media to create real-time simulations for specific biochemical topics remain scarce. Most interactive PowerPoints used in schools today are static, pre-designed templates that lack the ability to dynamically respond to diverse student learning paces (Estuhono & Safitri, 2025).

This study addresses this gap by establishing its scientific novelty: the development and integration of an AI-driven Interactive PowerPoint specifically tailored for teaching photosynthesis and chemical reactions. Unlike conventional multimedia, this media utilizes embedded AI algorithms to provide real-time adaptations, automated scaffolding, and interactive visual simulations of biochemical processes (such as the light-dependent reactions and the Calvin cycle). This integration transforms PowerPoint from a passive slide-showing tool into an intelligent, responsive learning environment that supports differentiated instruction as highlighted in recent adaptive learning paradigms (Ghazal et al., 2024).

Despite the potential of AI in education, a critical problem remains: how can AI-powered interactive presentation media be effectively designed and implemented to reduce cognitive load and minimize misconceptions in complex biochemical topics? It is hypothesized that the utilization of an AI-based Interactive PowerPoint on photosynthesis and chemical reaction topics will significantly enhance students' conceptual understanding and learning motivation compared to traditional interactive media.

The purpose of this article is to evaluate the design, feasibility, and pedagogical effectiveness of the AI-based Interactive PowerPoint in clarifying the mechanisms of photosynthesis and chemical reactions, thereby providing a robust framework for educators seeking to implement intelligent digital media in the modern science classroom.

METHOD

This study employed a Research and Development (R&D) approach using the 4D instructional design model developed by Thiagarajan, Semmel, and Semmel (1974). The 4D model was selected because it provides a systematic and effective framework for developing and validating educational media. The research consisted of four stages: Define, Design, Develop, and Disseminate.

The define stage aimed to identify and analyze the learning needs related to photosynthesis and chemical reactions. This phase included needs analysis, student analysis, concept analysis, and task analysis. Observations and interviews with teachers revealed that students often experience difficulties in understanding the abstract concepts and processes involved in photosynthesis and chemical reactions. Based on these findings, the learning objectives were determined according to the current curriculum requirements.

At this stage, the initial design of the AI-Based Interactive PowerPoint was developed. The activities included selecting the learning media format, designing presentation layouts, preparing storyboards, and organizing instructional content. Interactive components such as animations, visual simulations, quizzes, and AI-assisted explanations were integrated into the media to support students' conceptual understanding and engagement in learning. The result of this stage was the initial prototype (Prototype I).

The develop stage aimed to produce a valid, practical, and effective learning

medium. The initial prototype was evaluated through expert validation involving subject matter experts and media experts. The material experts assessed the accuracy and suitability of the photosynthesis and chemical reaction content, while media experts evaluated the design, interactivity, and integration of AI features. After revisions based on expert suggestions, the product was tested on students of Biology and Chemistry Education programs. The trial was conducted to evaluate the practicality and effectiveness of the media in improving students' understanding of the concepts presented.

In the dissemination stage, the validated AI-Based Interactive PowerPoint was introduced for broader educational use. The final product was shared with lecturers and students and documented in scientific publications to support wider implementation in biology and chemistry learning. Data were collected using validation sheets, response questionnaires, and cognitive learning tests. Validation sheets were used to determine the feasibility of the developed media, while questionnaires measured students' and lecturers' responses toward the practicality of the product. The effectiveness of the media was evaluated through pre-test and post-test results related to photosynthesis and chemical reactions. The collected data were analyzed descriptively and quantitatively. Validation and practicality data were converted into percentage categories, while the improvement of students' conceptual understanding was analyzed using the normalized gain score (N-gain) based on the comparison between pre-test and post-test results.

RESULTS AND DISCUSSION

Results

The results of this study describe the development, validation, practicality, and effectiveness of the AI-Based Interactive PowerPoint on photosynthesis and chemical reactions developed using the 4D model.

1. Define Stage Results

The needs analysis showed that students experienced difficulties in understanding abstract concepts related to photosynthesis and chemical reactions. Based on interviews and classroom observations, most students stated that conventional teaching methods were less effective in explaining molecular processes, biochemical pathways, and chemical interactions occurring in living systems.

The analysis also revealed that students required more visual, interactive, and technology-based learning media to improve conceptual understanding. Lecturers similarly reported that integrating digital media and AI-assisted explanations could support more active and student-centered learning. Therefore, the development of an AI-Based Interactive PowerPoint was considered necessary to address these learning challenges.

2. Design Stage Results

At the design stage, the initial product (Prototype I) was successfully developed. The media consisted of: 1) interactive presentation slides, 2) animated photosynthesis pathways, 3) simulations of chemical reactions, 4) AI-assisted explanations, 5) interactive quizzes, and 5)

visual learning components. The media interface was designed using attractive colors, clear navigation buttons, and contextual illustrations to increase student engagement during learning activities.

3. Develop Stage Results

The developed media was validated by two material experts and two media experts. The assessment focused on content accuracy, language clarity, visual design, interactivity, and AI integration. The validation results are presented in Table 1.

Table 1. Expert Validation Results

Assessment Aspect	Percentage (%)	Category
Content Feasibility	92	Very Valid
Language Feasibility	90	Very Valid
Visual Design	94	Very Valid
Media Interactivity	93	Very Valid
AI Feature Integration	91	Very Valid
Average Score	**92**	**Very Valid**

The results indicate that the AI-Based Interactive PowerPoint met the criteria of a highly feasible learning medium. Validators suggested minor revisions related to font consistency, animation timing, and simplification of several scientific explanations. These suggestions were implemented before conducting the product trial.

The practicality test was conducted involving students and lecturers after the implementation of the developed media. The assessment included ease of use, attractiveness, clarity of material, and usefulness in learning activities. The results of the practicality test are shown in Table 2.

Table 2. Practicality Test Results

Respondent	Percentage (%)	Category
Lecturer Responses	95	Very Valid
Student Responses	93	Very Valid
Average Score	94	Very Valid

Students reported that the media was interesting, interactive, and easy to operate. The AI-assisted explanations and animations helped them understand the processes of photosynthesis and chemical reactions more clearly. Lecturers also stated that the media supported interactive and student-centered learning activities.

The effectiveness of the media was measured using pre-test and post-test scores to determine the improvement in students' conceptual understanding. The average pre-test and post-test scores are presented in Table 3.

Table 3. Pre-test and Post-test Results

Test	Mean Score
Pre-test	58.4
Post-test	84.7

The increase in learning outcomes indicates that students' understanding improved after using the AI-Based Interactive PowerPoint. Furthermore, the normalized gain (N-gain) analysis showed an average score of 0.63, which falls into the moderate-to-high improvement category. These findings demonstrate that the developed media effectively improved students' understanding of photosynthesis and chemical reaction concepts. The integration of AI-assisted features,

animations, and visual simulations contributed positively to students' learning experiences and conceptual comprehension.

Prototype II of the developed PowerPoint media is shown in the following figure.

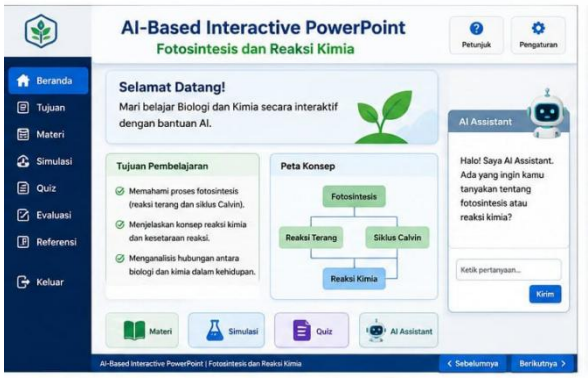


Figure 1. AI-powered interactive PowerPoint main interface

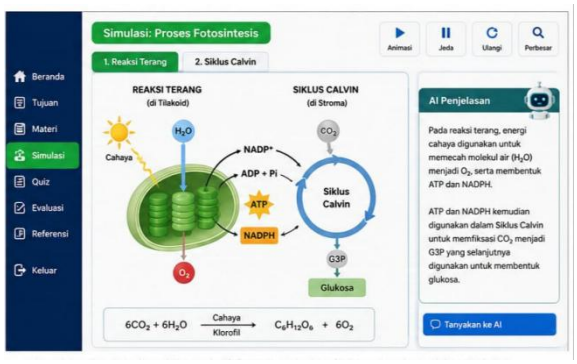


Figure 2. Interactive visualization of photosynthesis (light-dependent reactions and the Calvin cycle) with AI-based explanations

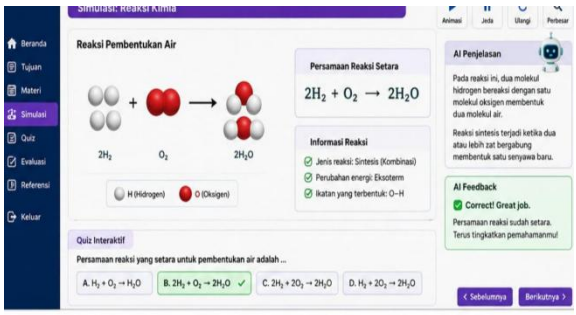


Figure 3. Chemical reaction simulations and interactive quizzes with AI-based feedback

4. Disseminate Stage Results

In the dissemination stage, the final product (Prototype II) was introduced to lecturers and students for broader implementation in biology and chemistry learning. The developed media was also documented as part of scientific publication outputs to support the integration of AI-based digital learning in science education. Overall, the results indicate that the AI-Based Interactive PowerPoint is valid, practical, and effective as an innovative learning medium for integrated biology and chemistry education.

Discussion

The results of this study indicate that the AI-Based Interactive PowerPoint on photosynthesis and chemical reactions is valid, practical, and effective for supporting integrated biology and chemistry learning. The findings demonstrate that the integration of AI-assisted explanations, interactive animations, and multimedia components can improve students' conceptual understanding, engagement, and learning motivation. These results are consistent with recent developments in digital science education, which emphasize the importance of interactive and AI-supported learning environments.

The needs analysis conducted during the define stage revealed that students experienced difficulties in understanding abstract scientific concepts, particularly those involving biochemical pathways and molecular interactions. This finding aligns with previous studies reporting that

photosynthesis is considered one of the most difficult topics in science learning because students often struggle to visualize invisible biological and chemical processes (Horálek & Distler, 2026). Similarly, interactive animation-based learning media were found to significantly improve students' understanding of photosynthesis concepts by presenting visual and dynamic representations of scientific processes. Therefore, the use of interactive multimedia in this study addressed the conceptual barriers commonly experienced by students in science education (Sari, 2023).

The expert validation results showed that the developed media achieved a very valid category, particularly in terms of content accuracy, visual design, interactivity, and AI integration. These findings indicate that combining biological and chemical concepts within one digital platform can support interdisciplinary science learning effectively. The positive validation results are in line with previous studies showing that interactive PowerPoint media can improve the quality of science learning when supported by attractive visualizations and well-structured instructional designs (Wijaya et al., 2025). Moreover, recent reviews in chemistry education emphasized that AI and machine learning technologies provide substantial opportunities for improving conceptual learning, adaptive instruction, and student engagement in chemistry classrooms (Iyamuremye et al., 2024).

The practicality test demonstrated that students and lecturers responded positively to the developed media. Students considered the AI-assisted interactive PowerPoint easy to use, visually attractive, and helpful for understanding difficult concepts. These findings suggest that digital learning media integrating AI features can create more student-centered learning environments. Previous research also reported that interactive PowerPoint media significantly improved students' creative thinking and critical thinking skills in science learning contexts. The multimedia elements embedded in the developed media, such as animations, simulations, and quizzes, likely contributed to increased student participation and motivation during learning activities (Putri et al., 2025).

The effectiveness test results revealed a significant improvement in students' conceptual understanding, as indicated by the increase in post-test scores and the moderate-to-high N-gain category. This finding supports the argument that AI-enhanced learning environments can positively influence students' academic achievement in science education. A recent systematic review found that AI-based educational tools improve learning outcomes, motivation, problem-solving skills, and personalized learning experiences in science classrooms (Almasri, 2024). Likewise, studies in chemistry education have shown that AI integration supports adaptive feedback, scientific visualization, and interactive experimentation, which contribute to better student understanding of complex scientific concepts.

The integration of AI-assisted explanations within the PowerPoint media also reflects current trends in digital transformation in education. AI technologies are increasingly utilized to support adaptive learning, personalized instruction, and

interactive science simulations. In this study, the AI-based features enabled students to receive clearer conceptual explanations and contextual visualizations, which helped reduce misconceptions related to photosynthesis and chemical reactions. These findings indicate that AI can function not only as a technological tool but also as a pedagogical support system that enhances meaningful learning experiences.

Furthermore, the interdisciplinary integration of biology and chemistry concepts in the developed media represents an important contribution to science education. Photosynthesis involves both biological processes and chemical reactions, requiring students to connect concepts across scientific disciplines. The developed media facilitated this integration through visual simulations and interactive explanations, enabling students to understand the relationship between biochemical reactions and biological functions more comprehensively. This supports the view that interdisciplinary digital learning environments can strengthen students' scientific literacy and conceptual connections across subjects.

CONCLUSION

This study concludes that the AI-Based Interactive PowerPoint on photosynthesis and chemical reactions is a feasible, practical, and effective learning medium for integrated biology and chemistry education. The developed media successfully addressed students' difficulties in understanding abstract scientific concepts through the integration of AI-assisted explanations, interactive animations, and visual simulations. The implementation of the media contributed positively to improving students' conceptual understanding, learning engagement, and participation in science learning activities. Furthermore, the findings indicate that the integration of AI technology into interactive multimedia can support more student-centered and meaningful learning experiences in the digital education era. Therefore, the developed AI-Based Interactive PowerPoint has strong potential to be utilized as an innovative instructional medium to enhance science learning quality and interdisciplinary understanding in biology and chemistry education.

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