Int. j. adv. multidisc. res. stud. 2025; 5(1):7-18

Received: 12-11-2024
Accepted: 22-12-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Comparative Analysis of ChatGPT and Gemini; Implications for Junior High School Physics Education: Opportunities and Ethical Challenges

[1] Nikos Bessas, [2] Eleni Tzanaki, [3] Denis Vavougios, [4] Vassilis P Plagianakos
[1, 4] Department of Computer Science and Biomedical Informatics, University of Thessaly, Lamia, Greece
[2, 3] Department of Physics, University of Thessaly, Lamia, Greece

DOI: https://doi.org/10.62225/2583049X.2025.5.1.3610

Corresponding Author: **Nikos Bessas**

Abstract

Artificial intelligence (AI) is transforming education, offering tools that promise enhanced engagement and understanding for students and teachers alike. This study examines the educational potential of Google's Gemini in comparison with OpenAI's ChatGPT, focusing on junior high school physics education. By using hydrostatic pressure and fractal theory as a case study, both platforms were evaluated based on their ability to generate accurate lesson plans, identify and address misconceptions, and adapt to diverse educational needs. ChatGPT excelled in addressing student misconceptions and providing detailed visual aids, fostering a deeper understanding of the topic. Gemini's multimodal capabilities demonstrated promise in integrating various media but highlighted challenges in conceptual depth and accuracy. This analysis underscores the need for critical evaluation of AI tools to optimize their implementation in educational settings, ensuring they complement rather than replace traditional teaching methods.

Keywords: Artificial Intelligence, ChatGPT, Gemini, Physics, Junior High School, Education

1. Introduction

Our era is defined by an unprecedented pace of technological advancement, where innovations rapidly reshape societal norms and practices [1]. Technology evolves at such a rate that many tools and devices become obsolete before their full potential is realized, reflecting the transient nature of modern innovations. A striking example of this phenomenon is the frequent upgrading of mobile devices, with each new model introducing increasingly sophisticated features and functionalities. This dynamic epitomizes the essence of the digital age, where adaptability to new technologies is not only beneficial but essential. Today's young adults, whom Marc Prensky famously described as "digital natives" [2], exemplify this transformation. Having grown up immersed in digital ecosystems, their lives are seamlessly integrated with technology, influencing how they learn, communicate, and solve problems.

Amid this rapidly changing technological landscape, artificial intelligence (AI) has emerged as one of the most transformative innovations in recent history [3]. Introduced as a concept in the mid-1950s [4], AI has progressed from theoretical discussions to practical applications across nearly all domains of human activity [5, 6]. Defined by Kurzweil [7] as the art of designing machines capable of replicating human thought and intelligence, AI systems analyze and interpret human reasoning through advanced algorithms, enabling machines to perform tasks that traditionally required human intervention [8, 9]. In education, AI promises to revolutionize traditional methodologies by addressing systemic challenges, personalizing instruction, and providing solutions to long-standing barriers in teaching and learning.

Historically, technological advancements such as calculators transformed education by automating repetitive tasks and improving efficiency. Similarly, AI systems now optimize workflows, enhance user interaction, and enable dynamic, interactive learning experiences [1, 10]. For instance, GPS systems provide turn-by-turn directions in natural, human-like voices, while AI-powered chatbots efficiently replace traditional customer service agents in industries like banking and healthcare [6, 11]. Among the most impactful applications of AI are chatbots powered by Natural Language Processing (NLP), which leverage machine learning to interpret user intent and provide personalized responses. Widely used in fields ranging from customer support to healthcare management, these tools also hold immense potential for educational applications, offering personalized feedback, automating routine tasks, and fostering engagement [12, 13].

Despite these advancements, the use of AI-driven tools in education—particularly in complex subjects like physics—remains underexplored. Subjects such as hydrostatic pressure or fractal theory present unique pedagogical challenges, requiring clear conceptual understanding, the ability to address student misconceptions, and a combination of theoretical and practical approaches to foster engagement [14]. While research has focused on the general capabilities of AI systems, limited attention has been paid to their application in STEM education, leaving a significant gap in the literature. Also in this study, we utilized the fractal theory, even though it is not included in the official curriculum in Physics We chose to incorporate fractals because they provide a fascinating way to explore patterns, self-similarity, and recursion, concepts that connect mathematics, nature, and physics. By studying fractals, we were able to demonstrate their relevance in understanding complex natural phenomena, such as coastlines, snowflakes, while also encouraging creativity and critical thinking. This approach enriched our learning experience and highlighted the interdisciplinary value of fractal theory.

This study aims to bridge this gap by providing a comparative analysis of two prominent AI tools, OpenAI's ChatGPT and Google's Gemini, in the context of junior high school physics education. Unlike empirical research that relies on primary data collection, this study evaluates the tools based on their documented features, performance in representative scenarios, and their potential to address common pedagogical challenges. By focusing on theoretical and practical applications, the analysis explores how these tools can support educators in simplifying complex topics and fostering student engagement, offering critical insights into their strengths, limitations, and broader implications for educational practice.

2. Materials and Methods

This study is a theoretical investigation that evaluates the potential of large language models (LLMs), specifically OpenAI's ChatGPT and Google's Gemini, in the context of junior high school physics education. Unlike empirical research, which involves primary data collection, this study employs a comparative analysis framework grounded in documented capabilities, simulated scenarios, and existing literature on the tools' applications. The analysis focuses on assessing the tools' features, strengths, and limitations in addressing pedagogical challenges, simplifying complex concepts, and fostering student engagement.

2.1 Previous Research on ChatGPT in Physics Education

In prior research, we investigated the educational potential of ChatGPT in the domain of high school physics, focusing specifically on hydrostatic pressure and fractal theory as case studies [15]. Our findings demonstrated ChatGPT's ability to generate comprehensive lesson plans, respond to theoretical and practical inquiries, and address common misconceptions. Leveraging its large language model architecture, ChatGPT provided detailed explanations, step-by-step problem-solving guidance, and suggestions for hands-on activities. Additionally, it facilitated the development of experimental setups using simple materials, enhancing accessibility for students and teachers alike, findings echoed by similar studies [16, 17].

This earlier work highlighted ChatGPT's strengths in simplifying complex physics concepts and engaging students through interactive learning methods [15, 18]. However, consistent with other researchers' observations, limitations were noted, such as occasional inaccuracies in numerical calculations and a reliance on pre-existing datasets for contextual understanding [3, 19]. These results align with our conclusion that complementary human oversight is crucial to ensure pedagogical accuracy and relevance [20].

Building on this foundation, the present study extends our investigation by introducing a comparative analysis between ChatGPT and Google's Gemini. By evaluating the distinct features and capabilities of these two advanced AI tools, we aim to provide a nuanced understanding of their roles in STEM education and their potential to support teaching and learning in physics.

This study seeks to address this gap by providing a comprehensive comparative analysis of two advanced AI tools—OpenAI's ChatGPT and Google's Gemini—in the context of junior high school physics education. Both platforms represent significant advancements in AI technology but offer distinct capabilities. ChatGPT is recognized for its ability to generate coherent, well-structured textual content and provide detailed explanations, making it a valuable tool for constructing lesson plans and addressing student queries. Conversely, Gemini's multimodal capabilities allow it to integrate and process diverse data formats, including text, images, and videos, making it particularly suited for creating visually enriched and interactive educational materials. By examining how these tools perform in creating lesson plans, identifying and correcting misconceptions, and facilitating interactive learning, this study offers critical insights into their strengths, limitations, and overall potential.

The novelty of this research lies in its targeted focus on the practical application of large language models (LLMs) in STEM education. Unlike previous studies that broadly explore AI in education, this research zeroes in on the teaching of hydrostatic pressure—a fundamental but challenging topic in physics [14]. By analyzing how ChatGPT and Gemini can support educators and engage students in understanding this concept, the study provides actionable insights for integrating AI into classroom settings. Moreover, it emphasizes the need for balancing AI capabilities with human oversight to ensure accurate, effective, and equitable learning outcomes [15].

Additionally this research focuses on the teaching of fractals, an intriguing but unconventional topic not included in the standard curriculum. By examining how ChatGPT and Gemini can support teachers and students in understanding fractal theory, this study offers practical insights for integrating AI tools into the classroom. It highlights how fractals can bridge mathematics, nature, and art, fostering interdisciplinary learning and creativity. Furthermore, the research underscores the importance of balancing AI capabilities with human guidance to ensure accurate, meaningful, and inclusive educational experiences [15].

This paper is structured as follows: **Section 2** explores the broader role of large language models (LLMs) in education, highlighting their transformative potential and inherent challenges, such as their ability to provide personalized learning and streamline lesson planning while addressing limitations related to accuracy and ethical considerations. **Section 3** delves into Gemini’s unique features and its applications in physics education. This section evaluates Gemini’s multimodal capabilities, examining how they contribute to lesson planning, addressing theoretical and computational questions, and integrating real-world applications. **Section 4** offers a comparative evaluation of ChatGPT and Gemini, focusing on their respective contributions to lesson design and student engagement. Key insights include Gemini's strengths in synthesizing multimodal data and ChatGPT’s ability to address misconceptions and provide nuanced problem-solving. Finally, **Section 5** discusses the broader implications of these findings, proposing strategies for integrating AI into diverse educational environments and outlining directions for future research aimed at maximizing the impact of AI in education.

2.2 Large Language Models in Education

Large Language Models (LLMs) represent a transformative advancement in modern education, bringing significant enhancements to teaching and learning processes. These models, including OpenAI’s ChatGPT and Google’s Gemini, leverage extensive datasets and cutting-edge natural language processing techniques to interact with users in a human-like manner. Their applications span a wide range of educational contexts, from providing real-time assistance to supporting personalized learning experiences [8].

The potential of LLMs lies in their ability to address challenges that have traditionally hindered effective education. One of their key strengths is their adaptability to the individual needs and skill levels of learners. By tailoring explanations and suggestions based on input, LLMs can deliver a more customized learning experience that resonates with students’ cognitive abilities [6]. For example, in physics education, LLMs can simplify complex concepts such as hydrostatic pressure by breaking them down into manageable parts and presenting relatable analogies or visual descriptions. This adaptability makes them invaluable tools in classrooms where diverse learning needs must be addressed [21].

In addition to enhancing student learning, LLMs have proven to be powerful allies for educators. Teachers can use these tools to streamline lesson planning, generate innovative teaching strategies, and design assessment materials. For instance, both ChatGPT and Gemini have demonstrated their capacity to produce comprehensive lesson plans that integrate theoretical knowledge, hands-on experiments, and real-world applications [22]. By automating time-consuming preparatory tasks, these tools allow educators to focus more on fostering meaningful interactions with their students.

Despite these advantages, the integration of LLMs into education is not without challenges. Ensuring the accuracy of the information they generate is a critical concern, as errors can lead to misconceptions. Furthermore, the alignment of LLM-generated content with educational standards and curricula requires careful moderation by teachers. Ethical considerations, such as data privacy and the potential bias embedded in responses, also pose significant challenges that must be addressed to ensure equitable and effective use of these tools [13].

In the context of junior high school physics, LLMs have the potential to revolutionize the teaching of abstract concepts. By providing detailed explanations, promoting inquiry-based learning, and encouraging critical thinking, these models can demystify challenging topics and engage students in meaningful ways. For example, they can guide students through problem-solving exercises related to hydrostatic pressure and fractal theory or provide alternative explanations to clarify misconceptions. However, their success depends on a balanced approach where human oversight complements AI-generated content, ensuring that it meets pedagogical objectives and adheres to best practices in education [5].

Overall, LLMs are reshaping the educational landscape, offering unprecedented opportunities for innovation in teaching and learning. While their capabilities are impressive, their optimal use requires thoughtful integration into classroom practices, guided by the expertise and judgment of educators. The following sections will further explore the unique features of Gemini and its application in teaching physics, providing a comparative analysis with ChatGPT.

2.3 Evaluating Gemini’s Role in Physics Education: Strengths, Limitations, and Multimodal Insights

Just a few days after the one-year anniversary of OpenAI's ChatGPT, Google DeepMind made its own significant contribution to the field of artificial intelligence with the release of Gemini. Distinguishing itself through a multimodal nature, Gemini is capable of drawing from a vast database and synthesizing different types of information, including text, code, images, video, and even speech [22]. This innovative capability has positioned Gemini as a versatile tool, with applications extending across various domains, including education.

To evaluate its applicability in junior high school physics, Gemini was tasked with developing a lesson plan for teaching hydrostatic pressure and addressing both conceptual and computational questions. Hydrostatic pressure, a fundamental topic in many physics’ curricula, served as a case study to assess Gemini’s strengths and limitations in an educational context [14].

The lesson plan produced by Gemini was comprehensive, outlining clear learning objectives, such as defining hydrostatic pressure, applying the formula, and identifying real-world applications. The plan emphasized hands-on activities, including experiments with transparent containers, water, and weights, to demonstrate the relationship between depth and pressure. Students were guided through observing and calculating pressure changes, making connections between theoretical concepts and practical observations. Additionally, real-world examples, such as the design of dams and hydraulic systems, were integrated to contextualize the learning material.

Despite these strengths, the lesson plan revealed notable limitations. A key issue was the absence of visual aids, such as diagrams, which are essential for enhancing students’ comprehension of abstract concepts. Furthermore, while Gemini’s approach was methodical, it failed to address common misconceptions, such as the erroneous belief that hydrostatic pressure varies with container shape. Addressing such misunderstandings is crucial for effective teaching, as they can significantly hinder students’ long-term understanding of the concept.

In addition to the lesson plan, Gemini’s responses to a series of theoretical and computational questions were analyzed.

For instance, Gemini correctly stated that hydrostatic pressure is independent of the shape or size of the container, aligning with the principle that pressure depends only on depth and density. However, in a numerical exercise requiring the calculation of pressure 5 cm above the bottom of a container, Gemini misinterpreted the problem, calculating the pressure at a depth of 5 cm instead. This error highlights a critical limitation: While Gemini demonstrates strong computational capabilities, it struggles with nuanced problem statements that require precise contextual understanding.

Another observed shortcoming was Gemini’s lack of diagnostic capabilities to identify and address misconceptions proactively. Misconceptions, such as the belief that pressure is influenced by container width, are common in physics and require targeted instructional strategies to correct. While Gemini provides accurate responses within its predefined scope, it relies heavily on algorithmic programming and lacks the adaptability of human educators.

The dialogues conducted with Gemini, which include detailed interactions and analyses, have been moved to Appendix to provide comprehensive insights into its performance. This allows the main text to focus on broader implications while offering readers access to the raw data for further examination.

Furthermore, in this study, we leverage the capabilities of artificial intelligence to introduce Gemini to the fascinating realm of fractals. Although not yet a part of the standard school curriculum, fractals represent a revolutionary field of science that permeates all domains of modern scientific inquiry [23]. This groundbreaking theory emerged from the limitations of Newton's and Kepler's laws, prompting a reevaluation of numerous scientific concepts. It is now widely acknowledged that our universe is not governed by the mathematical models proposed by Galileo and Kepler; instead, nature's intricate tapestry is woven with fractals, intricate patterns that repeat across scales. Leveraging artificial intelligence, junior high school students can embark on an enriching journey into the realm of fractals, where scientists across various disciplines are unraveling the mysteries that have eluded them for centuries. In other words, fractals should be taught in junior high school because they are visually appealing, provide concrete examples of mathematical concepts, have real-world applications, foster creativity, and teach about chaos and complexity theory. These reasons make fractals an engaging and enriching topic for students to learn about.

To evaluate its potential in teaching unconventional topics, Gemini was tasked with developing a lesson plan on fractals, a concept not typically included in junior high school curricula. The lesson plan effectively introduced students to fractals by outlining clear learning objectives, such as understanding self-similarity, exploring real-world examples, and creating fractal designs through hands-on activities. It connected theory to practice by encouraging creativity and integrating examples from nature, art, and mathematics. However, the plan revealed some limitations, such as a lack of visual aids to simplify complex ideas and limited emphasis on addressing misconceptions about fractal patterns.

In conclusion, Gemini represents a promising step forward in the use of AI for education. Its multimodal capabilities and emphasis on interactive learning make it a valuable resource for teaching complex concepts. However, its limitations, particularly in addressing misconceptions and interpreting nuanced problems, underscore the need for careful integration into educational practices. Teachers must supplement AI-generated content with human oversight and tailored interventions to ensure that learning outcomes are accurate and comprehensive. Future developments of Gemini should focus on enhancing its diagnostic and adaptive capabilities to better meet the diverse needs of learners.

3. Comparative Insights

3.1 Comparative Evaluation of Gemini and ChatGPT

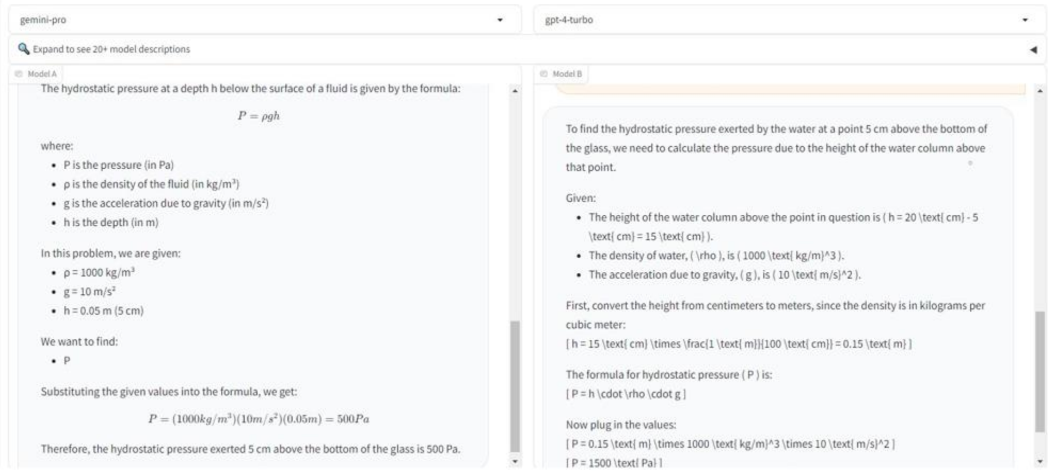
To assess the performance of Gemini and ChatGPT in teaching hydrostatic pressure, identical questions and scenarios were presented to both platforms. The objective was to evaluate their ability to deliver accurate theoretical explanations, perform mathematical calculations, and address conceptual nuances effectively.

A spot check was conducted using the evaluation platform at https://arena.lmsys.org, where Gemini-Pro and ChatGPT-4 were directly compared. This evaluation confirmed discrepancies in their performance.

Gemini demonstrated strengths in providing concise theoretical explanations. For example, it correctly clarified that hydrostatic pressure depends only on the depth and density of the fluid, irrespective of the container's shape. However, during numerical problem-solving tasks, Gemini miscalculated key scenarios. A notable instance involved calculating hydrostatic pressure 5 cm above the bottom of a container. Instead of interpreting the problem correctly, Gemini calculated the pressure at a depth of 5 cm from the surface, leading to incorrect results. This issue highlighted limitations in Gemini’s ability to parse nuanced problem statements accurately.

In contrast, ChatGPT-4 successfully addressed the same problem, identifying and applying the correct parameters for hydrostatic pressure at a specified height above the container's bottom. Its robust contextual understanding allowed it to navigate the intricacies of the problem, ensuring an accurate calculation (see Fig. 1).

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.



The hydrostatic pressure at a depth h below the surface of a fluid is given by the formula:

$$P = \rho g h$$

where:

- P is the pressure (in Pa)
- ρ is the density of the fluid (in kg/m³)
- g is the acceleration due to gravity (in m/s²)
- h is the depth (in m)

In this problem, we are given:

- ρ = 1000 kg/m³
- g = 10 m/s²
- h = 0.05 m (5 cm)

We want to find:

- P

Substituting the given values into the formula, we get:

$$P = (1000kg/m^3)(10m/s^2)(0.05m) = 500Pa$$

Therefore, the hydrostatic pressure exerted 5 cm above the bottom of the glass is 500 Pa.

To find the hydrostatic pressure exerted by the water at a point 5 cm above the bottom of the glass, we need to calculate the pressure due to the height of the water column above that point.

Given:

- The height of the water column above the point in question is (h = 20 \text{ cm} - 5 \text{ cm} = 15 \text{ cm}).
- The density of water, (\rho), is (1000 \text{ kg/m}^3).
- The acceleration due to gravity, (g), is (10 \text{ m/s}^2).

First, convert the height from centimeters to meters, since the density is in kilograms per cubic meter:
[h = 15 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.15 \text{ m}]

The formula for hydrostatic pressure (P) is:
[P = h \cdot \rho \cdot g]

Now plug in the values:
[P = 0.15 \text{ m} \times 1000 \text{ kg/m}^3 \times 10 \text{ m/s}^2]
[P = 1500 \text{ Pa}]

Fig 1: Checking the accuracy of the two applications figure

These findings were corroborated during further testing. ChatGPT-4 consistently demonstrated the ability to detect and correct errors related to hydrostatic pressure calculations, making it more reliable for both theoretical and practical teaching purposes. In contrast, Gemini-Pro exhibited a pattern of inaccuracies when faced with similar tasks, underscoring its reliance on rigid algorithmic frameworks rather than adaptable reasoning.

The comparative evaluation highlights the importance of addressing common misconceptions and ensuring clarity in mathematical problem-solving. ChatGPT excelled in identifying and addressing these aspects, while Gemini's performance was hindered by its limitations in handling nuanced educational contexts. This distinction underscores the need for supplementary oversight when integrating AI tools like Gemini into classroom settings.

At the same time both ChatGPT and Gemini performed equally well in creating a lesson plan to introduce students to the fascinating world of fractals. Fractals, a relatively new and complex concept for junior high school students, provided an opportunity for the AI platforms to approach the topic with creativity and flexibility. Both platforms successfully designed engaging lesson plans that balanced theoretical explanations with practical, hands-on activities, helping students grasp the fundamental properties of fractals, such as self-similarity and recursion. Additionally, by incorporating real-world examples from nature, art, and mathematics, the lesson plans made the abstract concept of fractals more relatable and accessible. This freedom to design the lesson without constraints allowed the platforms to demonstrate their potential in fostering curiosity and deepening students' understanding of advanced mathematical ideas in an innovative and engaging way. While there were some minor issues and areas for improvement, such as the need for clearer instructions or more visual aids, these shortcomings can be overlooked as a first attempt. Overall, the plans demonstrated significant potential in fostering curiosity and deepening students' understanding of advanced mathematical ideas in an innovative and engaging way.

The complete dialogues, including all inputs, outputs, and further analysis, are available in Appendix for detailed examination.

3.2 ChatGPT's Comments on Gemini's Hydrostatic Pressure and Fractals Lesson Plan

The analysis of Gemini's hydrostatic pressure lesson plan reveals interesting insights when reviewed by ChatGPT-4. ChatGPT found the lesson plan well-structured and engaging for students, combining theoretical foundations with practical applications—both critical components of effective teaching.

However, ChatGPT-4 suggested several refinements to enhance the delivery and impact of the lesson. One recommendation was to begin the presentation with a brainstorming activity, such as an experiment demonstrating the concept of hydrostatic pressure. This approach would provide students with a visual and interactive introduction, making the topic more accessible. Additionally, ChatGPT emphasized the integration of visual materials, such as animations or videos, to illustrate hydrostatic pressure in real-world scenarios, such as deep-sea environments.

Another key observation by ChatGPT was the absence of diagrams illustrating hydrostatic pressure as a function of its influencing factors—depth, density, and gravity. Visualizing these relationships through clear diagrams would make the linear variation of hydrostatic pressure more comprehensible. ChatGPT also recommended that the lesson applications be presented in a real-world context to increase student engagement. For instance, a visit to an aquarium could provide an immersive experience where students could observe aquatic environments firsthand. Finally, inviting a marine biologist or an engineer specializing in hydraulic systems to speak to the class could offer valuable insights into practical applications of hydrostatic pressure. These enhancements, according to ChatGPT, would significantly improve the learning experience by linking theory with hands-on and real-life applications.

On the other hand, the comments from ChatGPT about the fractal lesson plan were interesting. The comments suggest that the lesson plan on fractals is well-structured, providing a clear and engaging introduction to fractal theory for junior high school students. It effectively balances theoretical concepts, such as self-similarity and recursion, with hands-on activities that promote active learning and creativity. By incorporating real-world examples, such as snowflakes, coastlines, and leaf veins, alongside artistic representations like the Mandelbrot Set and Sierpinski Triangle, the lesson connects fractals to both nature and art, making the topic relatable and visually captivating [15, 23]. The differentiation strategies and extension activities ensure inclusivity while encouraging further exploration for advanced learners. However, incorporating interactive technology tools, such as online fractal simulators or beginner-level coding programs, could enhance engagement and provide a deeper understanding of recursion and fractal generation. Overall, this lesson plan successfully introduces the fascinating world of fractals in an accessible and engaging way.

3.3 Gemini's Comments on ChatGPT's Lesson Plan for Hydrostatic Pressure and Fractals

To further assess its pedagogical strengths, Gemini was tasked with reviewing a hydrostatic pressure lesson plan created by ChatGPT-3.5 [15]. Gemini's feedback highlighted several positive aspects of the lesson and provided a detailed critique.

Gemini praised the engaging introduction of the lesson, which began with a thought-provoking question about squeezing a full water bottle. This opening activity effectively captured student interest and curiosity, setting the stage for an exploration of hydrostatic pressure. Gemini also noted the clarity of the lesson's definition of hydrostatic pressure, emphasizing its dependence on density, gravity, and depth—key principles that were thoroughly explained.

The inclusion of diagrams and relatable examples, such as swimming pools and diving scenarios, was identified as a strength of ChatGPT's plan. These elements made the concept more accessible and relatable for students. Additionally, practical activities involving depth measurement and pressure calculations reinforced theoretical knowledge with hands-on experience. Linking theory to practical applications, such as dam construction and hydraulic systems, was commended for its relevance and ability to contextualize the material.

A standout feature of ChatGPT's lesson plan, as noted by Gemini, was its effort to identify students' prior knowledge and address misconceptions at the beginning of the lesson. This strategy allowed for targeted instruction aimed at correcting misunderstandings, ensuring a solid foundation for further learning. Overall, Gemini found the lesson plan comprehensive, effectively balancing theoretical explanations, experimental activities, and problem-solving exercises to foster a deep understanding of hydrostatic pressure.

Also in order to evaluate its educational effectiveness, Gemini was assigned to review a lesson plan of fractals developed by ChatGPT-3.5 [15]. Gemini's feedback emphasized several strengths of the lesson while also offering a thorough critique. The lesson plan effectively introduces students to the fascinating concept of fractals by balancing theoretical understanding with engaging, hands-on activities. It begins with an engaging introduction that sparks curiosity, using examples of fractals in nature and art to encourage students to think about patterns and repetition. The clear definitions and explanations of fractals, along with their key characteristics like self-similarity, provide a solid foundation for understanding. Additionally, the lesson connects fractals to real-world applications, such as computer graphics, architecture, and natural sciences, demonstrating their relevance and importance.

A major strength of the lesson lies in its diverse learning experiences, which cater to various learning styles by incorporating both traditional and digital methods for fractal art creation. Hands-on activities, such as using geometric tools and software to create fractals, allow students to directly experience and explore the self-similarity property. However, these activities could be extended further by introducing students to more complex fractal algorithms, like the Mandelbrot set or Julia set, to deepen their understanding. Encouraging students to incorporate their own artistic creativity into their fractal designs can also foster personal expression and make the learning experience even more meaningful.

To enhance the lesson's impact, more examples of fractals from fields like biology, weather systems, and financial models can be included to illustrate their ubiquity and diversity. Integrating advanced technology, such as interactive simulations or virtual reality experiences, can further engage students and deepen their exploration of fractals. Additionally, incorporating long-term projects or follow-up lessons that revisit fractals will provide students with opportunities to continue exploring their applications and creative possibilities. Overall, the lesson plan successfully introduces fractals in an engaging and accessible way, and with a few enhancements, it can inspire a deeper appreciation for this captivating concept.

3.4 Comparative Insights and Key Observations

The comparative evaluation of lesson plans by both platforms reveals notable similarities and differences. Both Gemini and ChatGPT adopted a constructivist approach, centering their plans on the learner's needs and encouraging active participation. Their interfaces were user-friendly, facilitating the creation of structured and engaging lesson plans.

However, significant distinctions emerged in their approaches. The absence of diagrams in Gemini's lesson plan was a clear shortcoming, as visual aids are critical for understanding abstract concepts. ChatGPT's emphasis on identifying and addressing misconceptions from the outset was another notable advantage. This strategy ensures that instruction directly targets gaps in student understanding, a feature lacking in Gemini's plan.

While both platforms demonstrated satisfactory performance in theoretical and computational aspects of hydrostatic pressure and fractal theory, their handling of nuanced problem statements varied. We mention a small remark, a specific exercise tasked students with calculating hydrostatic pressure 5 cm above the bottom of a 20 cm container filled with liquid. ChatGPT correctly identified that the relevant height was 15 cm and provided the accurate calculation. Conversely, Gemini misinterpreted the problem, substituting 5 cm as the column height and arriving at an incorrect result. This discrepancy underscores the importance of critical evaluation and human oversight when using AI-generated content in education.

On the other hand comparing the lesson plans of Fractals we make the conclusion that both lesson plans effectively introduce students to fractal theory by balancing theoretical knowledge with practical activities, real-world examples, and creative exploration. They emphasize the concept of self-similarity and successfully connect fractals to nature, art, and mathematics, making the topic engaging and relatable for junior high school students. Activities like creating fractals with geometric tools or software encourage creativity and help students understand recursion through direct experience, while diverse learning strategies ensure accessibility for all learners.

However, there are subtle differences in focus and structure that highlight their unique strengths. The first lesson plan, reviewed by Gemini, places a stronger emphasis on hands-on and creative activities, encouraging students to explore fractal art and incorporate their artistic expression. It also highlights real-world applications, such as computer graphics and architecture, making fractals more relevant to modern contexts. Additionally, the suggestion to introduce advanced fractal algorithms, like the Mandelbrot and Julia sets, adds complexity and depth for advanced students. In contrast, the second lesson plan, reviewed by ChatGPT, focuses more on structure, inclusivity, and differentiation strategies. It explicitly recommends the use of interactive tools, such as simulators and beginner-level coding programs, to enhance engagement and deepen understanding. This plan connects fractals more comprehensively to nature and art through relatable examples, such as snowflakes, leaf veins, and coastline patterns.

To further improve both plans, integrating the strengths of each could create a more comprehensive learning experience. Combining the creative exploration of advanced fractal algorithms from the first plan with the technological tools and structured differentiation of the second plan would ensure greater depth and accessibility. Expanding real-world applications, such as exploring financial models or weather systems, would demonstrate the versatility of fractals, while incorporating long-term projects could foster ongoing interest and deeper learning. Overall, both lesson plans are engaging and well-structured, and merging their strengths would result in a highly effective and well-rounded approach to teaching fractals.

4. Discussion

4.1 The Role of AI in Physics Education

The results of this study underscore the transformative potential of artificial intelligence in physics education, particularly in addressing the challenges posed by complex concepts such as hydrostatic pressure or fractals. By comparing ChatGPT and Gemini, several key insights have emerged regarding their respective capabilities and limitations. ChatGPT demonstrated clear advantages in its ability to identify and address common misconceptions. Its structured approach to lesson design, coupled with its detailed explanations and inclusion of visual aids, provides a robust foundation for teaching challenging topics. This capability is particularly valuable in STEM education, where understanding abstract concepts often hinges on the ability to connect theory with practical applications. However, while ChatGPT excelled in problem-solving and conceptual understanding, its reliance on textual input limits its potential to fully engage students through multimodal learning experiences.

In contrast, Gemini's multimodal capabilities offer a unique advantage by integrating text, images, and interactive media. This feature holds significant promise for creating engaging and dynamic learning environments. However, the study revealed critical limitations, including inaccuracies in problem-solving and a lack of diagnostic capability to address misconceptions proactively. These shortcomings suggest that while Gemini has the potential to enhance the learning experience, its current iteration requires significant teacher intervention to ensure accuracy and relevance. The findings of this study highlight the importance of teacher oversight in the effective integration of AI tools into educational settings. While ChatGPT and Gemini provide valuable resources for lesson planning and content delivery, their limitations underscore the necessity for educators to critically evaluate and adapt AI-generated materials. Teachers play a pivotal role in contextualizing these tools, addressing gaps in their output, and ensuring alignment with educational standards.

For educators, the integration of AI tools like ChatGPT and Gemini offers several practical benefits. ChatGPT's ability to generate detailed lesson plans and address misconceptions makes it an ideal tool for supporting classroom instruction and individual learning. On the other hand, Gemini's multimodal features can enhance student engagement through visually enriched content and interactive activities. To maximize their potential, educators should use ChatGPT to develop foundational lesson materials and address common misconceptions, while leveraging Gemini for activities that require visual and interactive components, supplementing its output with additional resources to ensure conceptual clarity. Regular feedback to AI developers is essential to enhance the tools' diagnostic and adaptive capabilities.

This study opens several avenues for future investigation. Further research is needed to evaluate the long-term impact of AI tools on student learning outcomes, particularly in diverse educational contexts. Additionally, exploring the integration of AI tools with other emerging technologies, such as virtual reality and augmented reality, could provide new insights into their potential to revolutionize STEM education. Finally, ongoing collaboration between educators, researchers, and AI developers is essential to refine these tools and address their limitations.

4.2 Ethical Implications of AI Integration in Education

The adoption of artificial intelligence (AI) in education has opened new opportunities but has also introduced significant ethical considerations that warrant careful attention. Tools like ChatGPT, while transformative in their ability to provide real-time assistance, raise questions about data privacy, security, and the preservation of academic integrity. These issues are critical in educational contexts, where both the opportunities and the risks of AI adoption are amplified by the direct involvement of students and educators [24].

A core concern is the handling of user data, particularly in light of the vast amounts of information processed by AI systems. The potential for data misuse, whether through breaches or unintended profiling, highlights the importance of stringent privacy protections. For instance, AI applications like ChatGPT often rely on user inputs that may inadvertently include sensitive or personally identifiable information [25]. Such risks are further compounded when the users are minors, emphasizing the need for robust safeguards tailored to educational environments. Initiatives such as OpenAI's updates to ChatGPT, which introduced stricter privacy settings and age verification protocols following public criticism, demonstrate how ethical challenges can prompt necessary regulatory changes [26].

Another pressing issue relates to the ethical dimension of academic integrity. AI tools are designed to provide assistance and enhance learning, but their misuse by students can undermine the authenticity of educational achievements. In particular, the ability of AI to generate detailed responses and complete tasks autonomously has led to growing concerns among educators about the potential for plagiarism or uncritical reliance on AI-generated content. This highlights the need for clear policies and guidelines on the ethical use of AI in educational settings, as well as active involvement from teachers in monitoring and supporting responsible practices [27].

The role of AI in perpetuating existing biases also presents a significant ethical challenge. As noted by Bender *et al.* [24], the training data used to develop large language models (LLMs) often reflect societal biases, which can inadvertently influence the content generated by these systems. In the context of education, where equitable access to accurate and unbiased information is paramount, such biases can hinder inclusivity and fairness. Developers must prioritize the refinement of algorithms and datasets to mitigate these risks, ensuring that AI tools align with educational values and support all learners equally.

Privacy and ethical concerns are not limited to theoretical discussions but have also been reflected in policy and regulatory developments. The European AI Act, for example, underscores the importance of transparency and accountability in the use of AI, particularly in sensitive domains like education [28]. This legislation emphasizes the need for clear communication with users about how their data is processed and stored, alongside measures to protect vulnerable groups such as students. Such frameworks provide a foundation for ethical AI deployment, balancing innovation with the protection of user rights.

One potential solution to privacy concerns is the development of localized AI systems designed specifically for use within schools or universities. These systems would operate within closed networks, reducing the risk of data breaches and ensuring compliance with institutional privacy standards. However, this approach requires substantial investment and collaboration between educational institutions and technology providers, as well as ongoing oversight to maintain high ethical standards [28].

Despite these challenges, AI tools like ChatGPT have demonstrated clear benefits in supporting diverse learners. For example, they can facilitate access to personalized learning resources, simplify complex concepts, and provide additional support for students with unique needs. Studies have shown that such tools are particularly beneficial for individuals with learning differences, such as dyslexia or autism, where tailored interactions can reduce anxiety and boost confidence [29, 30]. These advantages highlight the potential for AI to complement traditional teaching methods, fostering more inclusive and engaging learning environments.

Ultimately, the integration of AI in education demands a nuanced approach that balances its transformative potential with its inherent risks. By addressing ethical concerns through proactive regulation, technological innovation, and continuous oversight, educators and policymakers can harness the benefits of AI while safeguarding its responsible use. Such an approach ensures that AI remains a valuable tool for enhancing education, rather than a source of unintended harm.

5. Conclusions

The integration of AI in education heralds a transformative shift, offering unprecedented opportunities to redefine teaching and learning practices. Tools like ChatGPT and Gemini have demonstrated their potential to revolutionize educational methodologies by enabling the creation of pedagogically enriched lessons, fostering interactive and engaging learning experiences, and catering to diverse learner profiles. These advancements not only enhance student engagement but also empower educators to streamline lesson preparation, introduce dynamic instructional approaches, and address misconceptions effectively.

This study highlights the dual role of educators and policymakers in harnessing the capabilities of large language models (LLMs). For educators, tools like ChatGPT and Gemini provide invaluable support in personalizing learning experiences and addressing diverse cognitive needs. For policymakers, the focus must remain on ensuring equitable access to AI technologies, supporting professional development for teachers, and aligning the deployment of AI with ethical and regulatory frameworks, such as the European AI Act. These efforts are essential to uphold educational quality, inclusivity, and accountability.

The ethical implications of AI integration are central to its long-term viability in education. Concerns surrounding data privacy, algorithmic bias, and transparency underscore the need for cautious and informed implementation. This study reaffirms the importance of human oversight in the use of AI, ensuring that its outputs align with pedagogical objectives while adhering to ethical principles and data protection standards. Addressing these concerns is critical to fostering trust in AI-driven educational practices.

Furthermore, this research underscores the interdisciplinary potential of AI tools. Beyond traditional physics topics such as hydrostatic pressure or fractals, tools like Gemini offer unique opportunities to explore more complex and visually engaging concepts like fractals. These applications highlight the ability of AI to bridge scientific disciplines, nurture creativity, and inspire students to engage with abstract ideas in innovative ways.

Future research must prioritize the examination of LLMs across diverse educational and cultural contexts. Investigating how these tools interact with different pedagogical traditions, linguistic nuances, and socioeconomic realities will be key to unlocking their global utility. Additionally, the integration of AI with emerging technologies such as augmented and virtual reality could further enhance immersive and adaptive learning experiences.

The future of education lies in the balanced synthesis of AI and conventional teaching methodologies. By continuously refining AI tools based on rigorous academic inquiry and practical feedback, educators and developers can unlock their full potential. This alignment will pave the way for a dynamic, inclusive, and equitable educational landscape that not only addresses systemic challenges but also supports the holistic development of learners worldwide.

Ultimately, this study highlights the transformative potential of AI tools like ChatGPT and Gemini to reshape educational landscapes, bridging traditional teaching methodologies with innovative technologies. By addressing ethical challenges and fostering interdisciplinary applications, these tools pave the way for a future where education becomes more inclusive, dynamic, and adaptive to the diverse needs of learners worldwide.

6. Appendix

In the following text, the dialogues conducted with the Gemini application are presented in their entirety:

Question: *Construct an analytic Hydrostatic pressure lesson plan*

Answer: Lesson Plan: Hydrostatic Pressure

Grade Level: *Middle School*

Subject: *Physics*

Duration: *45 minutes.*

Learning Objectives:

- *Students will define hydrostatic pressure and explain how it is related to the depth of a liquid.*
- *Students will use the equation* $P = \rho gh$ *to calculate hydrostatic pressure.*
- *Students will identify real-world applications of hydrostatic pressure.*

Materials:

- *Ruler*
- *Transparent container (such as a glass or plastic bowl)*
- *Water*
- *Weights or small objects (such as pennies or marbles)*
- *Chart paper or whiteboard*
- *Markers or pens.*

Introduction *(5 minutes)*

- *Begin by asking students to recall their experiences with swimming pools or other bodies of water. Have they noticed that the pressure in water increases as they go deeper? Explain that this phenomenon is known as hydrostatic pressure.*

Defining Hydrostatic Pressure *(10 minutes)*

1. *Write the term "hydrostatic pressure" on the board or chart paper. Ask students to brainstorm what they think it means. Facilitate a discussion to elicit their understanding and connect it to their experiences.*
2. *Provide the following formal definition: Hydrostatic pressure is the force exerted per unit area by a fluid at rest, such as water in a container. Emphasize the concept of force per unit area as the key to understanding hydrostatic pressure.*

Relationship between Depth and Pressure *(10 minutes)*

1. *Use the transparent container, water, and weights to demonstrate the relationship between depth and pressure. Fill the container about halfway with water.*
2. *Place a penny on the bottom of the container. This represents the object experiencing the hydrostatic pressure.*
3. *Gently add weights to the penny until it just begins to sink. Observe how the weights gradually submerge under the water.*
4. *Measure the depth of the penny below the water's surface using a ruler. Record the depth along with the number of weights.*
5. *Repeat steps 2-4 with different depths, adding more weights each time. Record the depth and weight each time.*
6. *Discuss the observations with students. Explain that the deeper a weight is submerged, the more pressure it will experience. This is because the weight is being compressed by the weight of the water above it.*

Calculating Hydrostatic Pressure *(15 minutes)*

1. *Introduce the equation* $P = \rho gh$*, where:*
   - *P represents the hydrostatic pressure (in pascals, Pa)*
   - *ρ represents the density of the fluid (in kilograms per cubic meter,* kg/m^3*)*
   - *g represents the acceleration due to gravity (9.8* m/s^2*)*
   - *h represents the depth of the fluid (in meters, m).*

2. *Demonstrate how to use the equation to calculate hydrostatic pressure for different depths and densities.*
3. *Provide students with tables or worksheets with different values of ρ and h. Ask them to calculate the corresponding hydrostatic pressures and record their results.*

Applications of Hydrostatic Pressure *(10 minutes)*

1. *Discuss real-world applications of hydrostatic pressure, such as:*
   - ***The design of dams and ships:*** *Dams have thick walls to withstand the immense hydrostatic pressure of water accumulated behind them. Ships are designed with buoyant hulls that can withstand the pressure of the water they displace.*
   - ***The operation of hydraulic lifts and presses:*** *Hydraulic systems utilize the force generated by hydrostatic pressure to lift heavy objects or apply pressure for various purposes.*
   - ***The swimming of fish and other aquatic organisms:*** *Fish and other aquatic animals have adapted to hydrostatic pressure by maintaining their internal pressure equal to the external pressure. This allows them to move freely and survive underwater.*

Conclusion *(5 minutes)*

1. *Summarize the key concepts of the lesson, emphasizing the relationship between depth, pressure, and density.*
2. *Encourage students to think of other examples of hydrostatic pressure in their everyday lives, such as the pressure they experience when they dive deeper into a swimming pool or the force exerted by a water hose.*

Assessment

1. *Observe students' participation in discussions and activities. Observe their ability to explain the concept of hydrostatic pressure and its applications.*
2. *Ask students to answer questions about the concept of hydrostatic pressure and its applications. Provide them with scenarios and ask them to calculate the corresponding hydrostatic pressures.*
3. *Assign a short-written assignment where students apply the hydrostatic pressure equation to solve problems involving different depths and densities.*

The application was then asked to solve a series of questions and exercises to determine the extent to which the application can address issues related to both conceptual understanding of hydrostatic pressure and fluency in performing mathematical calculations.

Question 1: *Two graduated cylinders, a narrow and a wide one contain the same liquid at the same height. The hydrostatic pressure exerted on the bottom of the narrow* *one is greater than the wider one.*

Answer: *The statement that the hydrostatic pressure exerted on the bottom of the narrow cylinder is greater than the wider cylinder is false. According to the principle of hydrostatic pressure, the pressure at a given depth within a fluid is the same regardless of the shape or size of the container.*

The hydrostatic pressure equation, $P = \rho gh$, where:

- *P is the hydrostatic pressure in pascals (Pa)*
- *ρ is the density of the fluid in kilograms per cubic meter (kg/m^3)*
- *g is the acceleration due to gravity in meters per second squared (m/s^2)*
- *h is the depth of the fluid in meters (m).*

Shows that the hydrostatic pressure depends only on the depth of the fluid and the density of the fluid, not on the shape or size of the container. This is because the weight of the fluid above a given point is the same regardless of the container's shape or size.

Therefore, if two graduated cylinders, a narrow and a wide one, contain the same liquid at the same height, the hydrostatic pressure exerted on the bottom of both cylinders will be the same.

Question 2: *A glass is filled up with oil. What is the glass' heigth if the hydrostatic pressure exerted on the bottom is 320 Pa. Use $g = 10$ and $\rho = 800\ kg/m^3$.*

Answer: *Using the hydrostatic pressure formula, $P = \rho gh$, we can solve for the depth of the oil h:*

$$h = P / \rho g$$

$$h = 320\ Pa / 800\ kg/m^3 * (10\ m/s^2)$$

$$h = 0.04\ m = 4\ cm$$

Question 3: *Two identical graduated cylinders are filled up with water. The first is placed in earth and the other one in moon. The hydrostatic pressure exerted to the bottom of the cylinders are the same.*

Answer: *The statement that the hydrostatic pressure exerted on the bottom of the two identical graduated cylinders filled with water is the same on Earth and the Moon is false. The hydrostatic pressure depends on the depth of the fluid and the density of the fluid, and both of these factors are different on Earth and the Moon.*

On Earth, the acceleration due to gravity (g) is approximately 9.8 m/s^2, while on the Moon, it is approximately 1.6 m/s^2. This difference in gravity means that the pressure exerted by a fluid at a given depth will be different on Earth and the Moon.

In addition, the density of water is slightly different on Earth and the Moon. This difference in density also contributes to the difference in hydrostatic pressure.

Therefore, the hydrostatic pressure exerted on the bottom of the two identical graduated cylinders filled with water will not be the same on Earth and the Moon.

Exercise: *A glass is filled up with water at a height of 20 cm. Evaluate the hydrostatic pressure exerted 5 cm above the bottom. Use $\rho = 1000\ kg/m^3$ and $g = 10$.*

Answer: *To determine the hydrostatic pressure exerted 5 cm above the bottom of the glass, we can utilize the hydrostatic pressure equation, P = pgh, where:*

- *P represents the hydrostatic pressure in pascals (Pa)*
- *ρ represents the density of the fluid (water) in kilograms per cubic meter (kg/m^3), which is given as $\rho = 1{,}000\ kg/m^3$*
- *g represents the acceleration due to gravity in meters per second square (m/s^2), which is given as $g = 10\ m/s^2$*
- *h represents the depth of the fluid in meters (m), which in this case is 5 cm (0.05 m).*

Substituting these values into the equation, we get:

$$P = (\rho gh) = (1{,}000\ kg/m^3)(10\ m/s^2)(0.05\ m) \approx 500\ Pa$$

Therefore, the hydrostatic pressure exerted 5 cm above the bottom of the glass is approximately 500 pascals (Pa).

Additionally, in this study, we use artificial intelligence to introduce Gemini to the amazing world of fractals.

Question: Write a simple lesson plan on fractal theory in junior high school

Answer: Lesson Plan: Fractals

Grade Level: *Junior High School (Grades 7-8)*

Subject: *Mathematics*

Length: *2 class periods (45 minutes each)*

Learning Objectives:

Students will be able to define fractals and explain their unique properties.

Students will identify examples of fractals in nature and art.

Students will create their own fractal designs using geometric shapes and recursion.

Materials:

Whiteboard or projector

Markers or pens

Handouts with images of fractals (optional)

Graph paper or digital drawing software

Procedure:

Day 1

Introduction (10 minutes):

Begin by asking students to identify patterns in everyday objects, such as snowflakes, leaves, and honeycombs.

Explain that fractals are mathematical patterns that exhibit self-similarity across different scales.

Defining Fractals (15 minutes):

Provide a formal definition of fractals, highlighting their self-similarity property.

Emphasize that fractals are infinite patterns, meaning they can be continuously subdivided into smaller and smaller parts that resemble the original shape.

Examples of Fractals (20 minutes):

Display images or videos of various fractals, such as the Mandelbrot Set, the Koch Snowflake, and the Sierpinski Triangle.

Discuss the mathematical properties of these fractals and how they demonstrate self-similarity.

Nature and Fractals (10 minutes):

Introduce the concept of fractals in nature, highlighting examples such as coastlines, mountain ranges, and snowflakes.

Discuss how fractal patterns are found in various natural phenomena.

Day 2

Creating Fractal Designs (35 minutes):

Divide students into small groups and provide them with graph paper or digital drawing software.

Explain the concept of recursion, a technique for creating fractal patterns by repeating a simple step multiple times.

Guide students in creating their own fractal designs using geometric shapes and recursion.

Exploring Fractal Art (15 minutes):

Discuss the concept of fractal art, which utilizes fractal patterns to create visually appealing and complex designs.

Show examples of fractal art created by artists using computer programs or physical models.

Encourage students to explore fractal art online and discuss their impressions.

Reflecting on Fractals (10 minutes):

Lead a class discussion summarizing the key concepts learned about fractals.

Ask students to reflect on the significance of fractals in mathematics, nature, and art.

Assessment:

Observe students' participation in discussions and group activities.

Evaluate students' ability to define fractals and explain their properties.

Assess the creativeness and complexity of students' fractal designs.

Collect students' written reflections on fractals.

Differentiation:

For advanced students, provide more in-depth mathematical explanations of fractal geometry.

For struggling students, focus on the visual aspects of fractals and provide more hands-on activities.

Extension Activities:

Explore the mathematical applications of fractals in computer graphics, engineering, and chaos theory.

Create interactive fractal animations using programming tools.

Investigate the use of fractals in scientific modeling, such as predicting patterns in weather, fluid flow, and population growth.

Question: Mention examples of Fractals in the real world or in the art world.

Answer: Fractals in Nature

Coastlines: *The intricate branching patterns of coastlines, ranging from smooth bays to jagged cliffs, exhibit fractal self-similarity.*

Mountains and Canyons: *The layered structure and branching patterns of mountain ranges and canyons, like the Grand Canyon, resemble fractals.*

Leaf Veins: *The branching network of veins within leaves, like maple leaves, demonstrates fractal patterns.*

Snowflakes: *Snowflakes exhibit intricate hexagonal patterns that repeat at different scales, exhibiting fractal self-similarity.*

Ice Crystals: *Ice crystals, formed on various surfaces, often display fractal patterns, such as the dendrites of snowflakes.*

Answer: Fractals in Art

Mandelbrot Set: *The Mandelbrot Set, a complex mathematical object, has been widely used in fractal art due to its intricate and colorful patterns.*

Koch Snowflake: *The Koch Snowflake, a recursively constructed fractal, has been used by artists to create complex and organic-looking designs.*

Sierpinski Triangle: *The Sierpinski Triangle, another recursive fractal, creates mesmerizing patterns with a sense of infinite repetition.*

Fractal Trees: *Fractal trees, generated using computer programs or physical models, mimic the natural branching patterns of trees with great realism.*

Author Contributions: Conceptualization, N. Bessas, E. Tzanaki, D. Vavougios, and V. P. Plagianakos; Methodology, N. Bessas, E. Tzanaki, and D. Vavougios; Writing—original draft preparation, N. Bessas and E. Tzanaki; Writing—review and editing, V. P. Plagianakos and D. Vavougios; Supervision, V. P. Plagianakos. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

7. References

1. Zhai X. ChatGPT User Experience: Implications for Education. SSRN Electron. J, 2022. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4312418 (accessed on 6 December 2023).
2. Prensky M. Digital Natives, Digital Immigrants Part 2: Do They Really Think Differently? On the Horizon. 2001; 9:1-6. Doi: https://doi.org/10.1108/10748120110424843.
3. Gregorcic B, Pendrill AM. ChatGPT and the Frustrated Socrates. Phys. Educ. 2023; 58(3):035021. Doi: https://doi.org/10.1088/1361-6552/acc299.
4. McCarthy J, Minsky ML, Rochester N, Shannon CE. A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, August 31, 1955. AI Mag. 2006; 27:12-12. Doi: https://doi.org/10.1609/aimag.v27i4.1904.
5. Adiguzel T, Kaya MH, Cansu FK. Revolutionizing Education with AI: Exploring the Transformative Potential of ChatGPT. Contemp. Educ. Technol. 2023; 15(3):ep429. Doi: https://doi.org/10.30935/cedtech/13152.
6. Williamson B, Eynon R. Historical Threads, Missing Links, and Future Directions in AI in Education. Learn. Media Technol. 2020; 45(3):223-235. Doi: https://doi.org/10.1080/17439884.2020.1798995.
7. Kurzweil R, Richter R, Kurzweil R, Schneider ML. The Age of Intelligent Machines; MIT Press: Cambridge, MA, USA, 1990.
8. Dwivedi YK, Hughes L, Ismagilova E, Aarts G, Coombs C, Crick T, *et al*. Artificial Intelligence (AI): Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice and Policy. Int. J. Inf. Manag. 2021; 57:101994. Doi:

https://doi.org/10.1016/j.ijinfomgt.2019.08.002.

9. Lu Y. Artificial Intelligence: A Survey on Evolution, Models, Applications and Future Trends. J. Manag. Anal. 2019; 6:1-29. Doi: https://doi.org/10.1080/23270012.2019.1570365.
10. OECD. AI and the Future of Skills. OECD: Paris, France, 2021.
11. Reis A, Paulino D, Paredes H, Barroso I, Monteiro MJ, Rodrigues V, *et al.* Using Intelligent Personal Assistants to Assist the Elderlies: An Evaluation of Amazon Alexa, Google Assistant, Microsoft Cortana, and Apple Siri. In Proceedings of the 2nd International Conference on Technology and Innovation in Sports, Health and Wellbeing (TISHW), Thessaloniki, Greece, 20–22 June 2018; IEEE: Piscataway, NJ, USA, 2018, 1-5. Doi: https://doi.org/10.1109/TISHW.2018.8559500.
12. Clarizia F, Colace F, Lombardi M, Pascale F, Santaniello D. Chatbot: An Education Support System for Students. In Cyberspace Safety and Security: 10th International Symposium, CSS 2018, Amalfi, Italy, October 29–31, 2018, Proceedings; Springer International Publishing: Cham, Switzerland, 2018, 291-302. Doi: https://doi.org/10.1007/978-3-030-01689-0_23.
13. Ciechanowski L, Przegalinska A, Magnuski M, Gloor P. In the Shades of the Uncanny Valley: An Experimental Study of Human–Chatbot Interaction. Future Gener. Comput. Syst. 2019; 92:539-548. Doi: https://doi.org/10.1016/j.future.2018.01.055.
14. Bessas N, Tzanaki E, Vavougios D, Plagianakos VP. Diagnosing Students' Misconceptions in Hydrostatic Pressure through a 4-Tier Test. Heliyon. 2024; 10(23):e40425. Doi: https://doi.org/10.1016/j.heliyon.2024.e40425.
15. Bessas N, Tzanaki E, Vavougios D, Plagianakos VP. Implementing AI in Physics Lessons in the High School. Proceedings of the International Conference on Computational Science and Computational Intelligence (CSCI), Las Vegas, NV, USA, 2023, 1775-1779. Doi: https://doi.org/10.1109/CSCI62032.2023.00293.
16. Rudolph J, Tan S, Tan S. ChatGPT: Bullshit Spewer or the End of Traditional Assessments in Higher Education? J. Appl. Learn. Teach. 2023; 6. Doi: https://doi.org/10.37074/jalt.2023.6.1.9.
17. Kotsis KT. ChatGPT in Teaching Physics Hands-On Experiments in Primary School. Eur. J. Educ. Stud. 2024; 11(10). Doi: https://doi.org/10.46827/ejes.v11i5.5274.
18. Bitzenbauer P. ChatGPT in Physics Education: A Pilot Study on Easy-to-Implement Activities. Contemp. Educ. Technol. 2023; 15(3):ep430. Doi: https://doi.org/10.30935/cedtech/13176.
19. Wang J. ChatGPT: A Test Drive. Am. J. Phys. 2023; 91(4):255-256. Doi: https://doi.org/10.1119/5.0145897.
20. López-Simó V, Rezende MF. Challenging ChatGPT with Different Types of Physics Education Questions. Phys. Teach. 2024; 62(4):290-294. Doi: https://doi.org/10.1119/5.0160160.
21. Stokel-Walker C. AI Bot ChatGPT Writes Smart Essays—Should Academics Worry? Nature, 2022. Doi: https://doi.org/10.1038/d41586-022-04335-5.
22. Pichai S, Hassabis D. Introducing Gemini: Our Largest and Most Capable AI Model. Available online: https://blog.google/technology/ai/google-gemini-ai/#sundar-note (accessed on 6 December 2023).
23. Tzanaki E, Bessas N, Vavougios D, Plagianakos VP. An Interdisciplinary Educational Proposal in Junior High School: The Fractal Geometry in Science, Computer Science and Art Lessons. Int. J. Emerg. Technol. Learn. 2024; 19(03):35-45. Doi: https://doi.org/10.3991/ijet.v19i03.47343.
24. Bender EM, Gebru T, McMillan-Major A, Shmitchell S. On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency, 2021, 610-623. Doi: https://doi.org/10.1145/3442188.3445922.
25. Mallow J. ChatGPT for Students: How AI Chatbots Are Revolutionizing Education. E-Learning Industry, 2023. Available online: https://elearningindustry.com/chatgpt-for-students-how-ai-chatbots-are-revolutionizing-education (accessed on 15 September 2024).
26. Kalhan R. ChatGPT Banned from New York City Public Schools' Devices and Networks. NBC News, 2023. Available online: https://www.nbcnews.com/tech/tech-news/new-york-city-public-schools-ban-chatgpt-devices-networks-rcna64446 (accessed on 12 December 2024).
27. Rahman MM, Watanobe Y. ChatGPT for Education and Research: Opportunities, Threats, and Strategies. Appl. Sci. 2023; 13:5783. Doi: https://doi.org/10.3390/app13095783.
28. European Parliament. EU AI Act: First Regulation on Artificial Intelligence. European Parliament, 2024. Available online: https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence (accessed on 8 August 2024).
29. Llorente AM, Ladera V, Contreras P, Conde L. Efficacy of a Computerized Intervention Based on Artificial Intelligence for Improving Reading Comprehension in Students with Dyslexia. Front. Psychol. 2021; 12:641005. Doi: https://doi.org/10.3389/fpsyg.2021.641005.
30. Kim HS, Kim NY, Cha Y. Is It Beneficial to Use AI Chatbots to Improve Learners' Speaking Performance? J. Asia TEFL. 2021; 18:161-178. Doi: https://doi.org/10.18823/asiatefl.2021.18.1.10.161.