



Innovative teaching: How pre-service teachers use artificial intelligence to teach science to fourth graders

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ABSTRACT

This study aims to uncover the prompts most frequently repeated by pre-service teachers when using the Copilot technique, as well as their reflections on its use in preparing and planning science lessons for fourth graders. The qualitative research methodology with an exploratory case-study design was conducted on a purposeful sample of 20 pre-service teachers. The sample was divided into four focus groups. Data was collected through document analysis of the outcomes from the pre-service teachers' artificial intelligence creations, their reflective journal entries, and the discussion that occurred during the four focus groups' interviews. The study's results revealed that the applications mostly used by pre-service teachers include lesson plans, instructional media, authentic assessment, tables, pictures, drawings, and instructional strategies. Six themes emerged from the reflective Journal and focus groups' interview analysis connected to the use of the Copilot method in teaching. These themes were the following: developing cognition of new ideas, attracting attention to things that never crossed their minds, saving time and effort, compatibility with students' needs, less human interaction, and dependency.

Keywords: artificial intelligence, Copilot, pre-service teachers, science

INTRODUCTION

Artificial intelligence (AI) plays a vital role in the constant increase of societal digitization. Thus, major countries all over the world put a lot of effort into providing high-quality teaching in the field of AI by using AI and technology in teaching (Touretzky et al., 2019). AI-supported technology has become increasingly crucial in our daily lives; as it changes our way of thinking, behaviors, and interactions with one another (Chen et al., 2020a). Moreover, it was noticed that there is a rapid increase in the use of AI technologies in the educational field where it works towards radically changing the nature of teaching in the classroom (Zhang & Aslan, 2021).

Teachers' understanding and awareness levels about AI significantly affect the future of the students who are being prepared for the AI era (Ryu & Han, 2018). Teachers also play a crucial role in preventing the misuse of AI technologies, as well as broadening the academic knowledge base. Despite the numerous calls to raise awareness, many teachers refuse to use programs that collect student data. Further, they distrust the companies that utilize technology as a fix to all educational issues (Stockman & Nottingham, 2022). Keep in mind, AI cannot replace the role of teacher; however, it can provide opportunities for students to use AI-based learning tools when appropriate (Halaweh, 2023; Utami et al., 2023).

One of the methods researchers used to study generative AI in lesson planning was asking the AI to create virtual lesson plans then analyzing the outcomes (van den Berg & du Plessis, 2023; Cooper, 2023).

Researchers found that generative AI was useful for teachers in generating course materials, evaluations, offering recommendations, translating information into other languages (Chen et al., 2020a), and easing students' work evaluation (Lo, 2023).

BACKGROUND

Copilot AI is an AI assistant developed by Microsoft that's designed to enable individuals, employees, IT professionals, and developers to improve their productivity. The emergence of generative AI such as Copilot, a virtual assistant developed by Open AI, and ChatGPT, generated a great interest and an intense debate on the matter in the teaching field. Generative AI and other forms of AI technologies have the potential to impact significantly the education sector by offering customized educational experiences for students and automating teachers' administrative tasks. However, using generative AI should be a starting point and not the final product, which is why teachers must analyze and adjust AI-generated lessons (van den Berg & du Plessis, 2023, p. 10). A similar study by Cooper (2023) explored how ChatGPT can affect science teaching and can be of great help for teachers in planning their lessons. Using AI tools such as Copilot or ChatGPT can enhance students' research skills by providing relevant information and resources, suggesting new perspectives, and introducing unfamiliar research topics. This equips students to better understand and assess their research subjects.

It is considered challenging to train pre-service teachers in instructional strategies that rely on AI (Pedró et al., 2019). Therefore, there is a strong demand for research on the acceptance of AI in teacher education and the factors that influence its use; however, such research is currently limited. The current available research on the topic of accepting technology in the educational context depend on the technology acceptance model (Scherer & Teo, 2019; Tarraga-Minguez et al., 2021).

Moreover, experimental research on accepting AI in teacher education focused mostly on teachers who are in service, with a limited number of studies that shed light on pre-service teachers.

Several studies indicate that teachers spend a lot of time planning and preparing educational tools (Walker, 2023). Therefore, it is important to propose a method that makes this task more efficient without compromising the quality of the outcome. To achieve this, the study explored how generative AI can support pre-service teachers by generating information upon demand. It is also essential to consider pre-service teachers' perspectives on using AI in teaching and learning, as well as the key factors that influence their intention to adopt this technology and easily blend AI technology in the future.

Artificial Intelligence in Education

The integration of AI into education holds considerable promise, but the existing literature also identifies several limitations and challenges that educators, policymakers, and technologists need to consider. Balancing the optimistic view of AI in education requires addressing these concerns, which can be broadly categorized into the following areas.

AI contributions to education are of high importance. This field lies at the intersection between AI sciences and educational technology. It aims to deepen the understanding of both teachers and learners on how to learn effectively. It also enhances the clarity and inclusivity of external influences through AI techniques, making teaching, learning, and management much smarter (Mu, 2019). There has been a rapid growth in the use of AI techniques in the field of education (Talanquer, 2023), which is radically changing the nature of teaching in school lessons (Zhang & Aslan, 2021). Therefore, the role of AI in teaching is to create learning environments that are more targeted, efficient, and effective (Gocen & Aydemir, 2020; Haseski, 2019).

The emergence of generative AI such as Copilot generated a great interest and an intense debate on the matter in the teaching field. In particular, the Copilot technique and other similar AI techniques have the potential to impact significantly the education sector by offering customized educational experiences for students and automating teachers' administrative tasks. Naturally, the expansion of generative AI in the education industry has led to the creation of targeted educational experiences and the development of content better suited to students' needs and individual capabilities (Chassignol et al., 2018; Crompton & Burke, 2023).

AI tools used in primary education provide aspiring pre-service teachers, with resources for tailored learning experiences and lesson preparation with interactive elements included. Luckin et al. (2020) argue that AI is flexible in catering to student requirements by facilitating teaching methods and Dieker et al. (2019) demonstrate how virtual reality simulations assist future teachers in honing classroom management skills

and enhancing self-assurance. Furthermore Zhang et al. (2021) delve into the significance of AI in creating lesson plans that cater to the learning abilities of students. Game oriented education methods (as discussed by Sung & Hwang, 2021), along with inquiry based instruments (explored by Chen & Liu, 2022) enhance participation and teamwork in the field of science education. Moreover, Mehta and Aguilera (2020) emphasize the importance of issues related to the use of AI highlighting the significance of AI implementation. These research findings collectively illustrate the influence of intelligence on contemporary teaching approaches and the training of educators.

AI has been applied to teaching, administrative procedures, curriculum development, and students' learning processes (Igbokwe, 2023; Nah et al., 2023). The literature shows that AI can support special education needs, accommodate diverse teaching styles, serve as an educational guide, and help students enhance their career plans (Catlin & Blamires, 2019; Mu, 2019). Generative AI tools, such as Copilot, should be viewed as resources that can enhance the quality of teaching in schools, rather than as threats to teacher training, education, or schools. Researchers found that generative AI could be useful for teachers in generating course materials, evaluations, offering recommendations, translating information into other languages and easing students' work evaluation (Lo, 2023).

Regarding lesson planning, researchers were successful in testing generative AI's ability to create teaching plans and additional resources. AI has become embedded in educational practice and assessment, and its influence continues to grow (Clark, 2023). Additionally, there is an urgent need to create teaching environments that enhance critical thinking, motivate individual thought, and actively engage students in the learning process (Hooks, 2022). Generative AI also has an impact on teaching science (Alasadi & Baiz, 2023), especially in assisting teachers in lesson planning (Cooper, 2023). Researchers also found that generative AI can be a valuable starting point for middle school lessons. The primary challenge is selecting a program or educational activity that serves as a suitable main educational strategy for integrating AI, or that can develop AI models appropriate for students' levels (van den Berg & du Plessis, 2023).

Challenges of AI in Education

Like any new technology, AI tools such as Copilot and ChatGPT come with user concerns, particularly regarding their use in assessing students' knowledge and skills. For instance, teachers are concerned that students might directly copy and paste the generated text without sufficient contrast of what is selected, without evaluating the content, critically analyzing the selections, or properly attributing the original sources, making the final text unfit for academic writing (García-Peñalvo, 2023). Further, concerns about plagiarism detection have been raised with ChatGPT-generated articles, making it more challenging than ever to distinguish between authentic student writing and AI-generated text (Chatterjee & Dethlefs, 2023; Khalil & Er, 2023). Teachers are increasingly concerned that students might use AI to complete, illicitly, their written tasks, as some AI tools have been proven to instantly generate articles that evade plagiarism detectors. Khalil and Er (2023) conducted an experiment to determine whether plagiarism detectors can identify AI-generated articles. Of the 50 essays they inspected, the plagiarism-detection software considered 40 of them with a high level of originality, as evidenced by a similarity score of 20% or less. Similarly, Susnjak (2022) experimented with ChatGPT to evaluate its ability to perform cognitive tasks and found that it is capable of exhibiting critical thinking skills and generating logically coherent, realistic text.

While AI can offer innovative methods to enhance educational experiences and support independent learning, concerns persist about accessibility and inequality, which may widen existing educational gaps. Additionally, it's important to emphasize the adaptable nature of the teacher's role inside the classroom, as AI could shift some responsibilities away from traditional teaching towards less demanding tasks.

Moreover, the use of AI in education raises ethical concerns related to data privacy, student supervision, and human interaction in educational settings. Thus, Selwyn (2019) stresses the importance of balancing AI integration in education by carefully considering its potential benefits and drawbacks.

Williamson et al. (2020) explored the political and educational implications of the recent rapid transition to online learning, highlighting challenges such as digital equity, technology access, and the preparedness of teachers and educational institutions for this digital shift. Their research underscores the need for critical thinking about the integration of digital technologies in education.

Research Questions

1. What are the prompts that pre-service teachers frequently use when employing the Copilot technique in teaching science to fourth graders?

This question aims to explore how pre-service teachers use Copilot, emphasizing the areas where AI is most beneficial for lesson planning.

2. What are pre-service teachers' reflections on using Copilot as a pedagogy tool in science for fourth graders?

This question explores teachers' experiences and their attitudes towards using AI tools in teaching, offering insights into the tools' effectiveness and ease of use.

Relation to study objectives: Both questions align with the study's objective to evaluate Copilot's effectiveness in lesson planning and teaching. By examining teacher's usage patterns and reflections, the study aims to assess the practical impacts of AI in education, inform future training, and guide the development of educational tools.

METHODOLOGY

The Qualitative Approach

The study used the qualitative method, as it allows for an in-depth examination of pre-service teachers' experiences, reflections, and attitudes toward using Copilot in lesson planning. The qualitative method is particularly effective in capturing detailed insight, individual reflections, and contextual factors that the quantitative method may not adequately address. The main advantage of this method is that it provides rich, detailed data that helps in understanding the complexities of integrating AI into teaching. However, a drawback is that qualitative results, unlike quantitative ones, are often difficult to generalize to larger populations.

Sampling

The study sample consists of 20 pre-service teachers. This sample size was selected to ensure an in-depth analysis of the data while keeping the study manageable and focused. Participants were selected after completing a course that trained teachers to use innovative teaching tools like Copilot. Although the sample is relatively small, it was not intended to statistically represent all pre-service teachers but to provide an in-depth exploration of this specific group's experiences. The sample includes a cross-section of pre-service teachers from various schools within the region, allowing for an understanding of diverse perspectives.

Fourth Grade Science

The study focused on fourth grade science classes because this age group is at a critical stage for developing foundational scientific understanding and curiosity. Science as a subject is well-suited to interactive and engaging teaching methods, making science classes an ideal setting to explore the effectiveness of AI tools like Copilot in education. Moreover, focusing on fourth graders allows for the assessment of how these teaching methods affect younger students who are still developing their scientific thinking skills.

Design and Data Collection

Using AI in teaching is considered as a relatively new concept for teachers. The qualitative research methodology with an exploratory case-study design was used to examine pre-service teachers' experiences and perspectives on using the Copilot technique in teaching. The goal is to document these experiences and assess the potential impact of the Copilot technique on teaching science to fourth graders (Flynn & Korcuska, 2018). The study collected data from a purposeful sample of 20 pre-service teachers who met the criteria of AI literacy, had over 120 hours of school-based training, and were eager to participate in the study while continuing their training. These teachers were then divided into four focus groups, each group consisting of 5 members. Between 10 March 2024 and 4 May 2024, the pre-service teachers employed the Copilot technique in preparing and planning their science lessons for fourth graders. This period included weekly

meetings held both in-person at the university and via Zoom, accommodating members who were unable to attend in person due to their circumstances. Pre-service teachers were asked to identify the prompts necessary to teach science to fourth graders. Each group elected their own, specific prompts which were compatible with the local curriculum, under the supervision of the researcher, who authored of the local science book for the fourth grade, before using the generative AI technique, Copilot. The Copilot technique was repeatedly employed within each group to ensure compatibility with the students' developmental levels and the curriculum, all under the supervision and auditing of the researcher. The prompts were then collected from the four groups for an in-depth analysis of how pre-service teachers used and applied Copilot. The prompts were directly copied and sent to the researcher. Subsequently, the reflective journal questions were answered and focus group discussions were conducted with all four groups, with the discussions recorded both verbally and in writing.

Study Limitations

The study faced some biases and limitations that could have affected the analysis.

- **Small sample:** The study collected data from a relatively small sample, which may limit the generalizability of the findings to a broader population. Caution is advised when applying these results to other groups or contexts. Further research with larger samples is encouraged to validate and enhance the generalizability of the findings.
- **The researcher is the author of the local science book:** The researcher being the author of the local fourth grade science book could introduce biases into the study, potentially influencing its design, interpretation, or presentation and leading to unintended assumptions. Therefore, it is crucial to acknowledge the potential bias when evaluating the study's authenticity and objectivity. Efforts have been made to moderate these biases; however, further research is required to validate the findings and properly address the limitations.

By acknowledging these limitations, we aim to provide a transparent description of the study's scope and encourage further research to expand upon these findings.

Data Analysis Method

Document analysis was conducted on the results produced by the pre-service teachers to clarify, better understand, and develop cognitive insights from the data generated by Copilot. Bowen (2009) defined document analysis as a systematic procedure for reviewing or evaluating printed or electronic documents. It involved the following steps:

1. **Collecting and categorizing data:** All data received from Copilot was electronic and sent directly to the researcher by the groups. The collected data was then categorized into five themes based on frequency of use by pre-service teachers.
2. **Identifying themes:** Bowen (2009) emphasizes that identifying themes is a crucial step in data analysis. By reviewing the collected data and recognizing common ideas and patterns, five main themes frequently used by pre-service teachers emerged.
 - 2.1. **Lesson plans:** The documents related to planning and preparing the lesson.
 - 2.2. **Educational media:** The tools used in enhancing the educational process.
 - 2.3. **Authentic assessment:** The methods used to accurately and genuinely assess students' performance.
 - 2.4. **Tables, pictures, and drawings:** Documents that include visual elements to clarify concepts and organize information.
 - 2.5. **Engaging teaching methods:** Strategies designed to actively involve all students in the learning process.
3. **Data coding:** Coding follows theme identification, as it involves categorizing the collected data according to the identified themes, with each of the five themes assigned an acronym or symbol. For instance, 'lesson plan' can be represented by the acronym 'LP', and 'educational media' by 'EM', and so forth.

To ensure consistency, coders participated in pre-training sessions focused on the coding framework and themes. Inter-rater reliability was assessed using metrics like agreement ratio and Cohen's kappa, where a value above 0.7 indicated substantial agreement. This step strengthens the study's methodological rigor, ensuring coding accuracy and enhancing transparency in the qualitative analysis.

4. **Data analysis:** After categorizing and coding the data, further analysis is conducted to identify patterns and trends. This analysis provides the researcher with a deeper understanding of the prompts generated by pre-service teachers and insights into their application in an educational context.
5. **Drawing conclusions:** Finally, conclusions are drawn from the analysis, contributing to the understanding of how pre-service teachers use various educational methods and approach lesson planning (Creswell & Plano Clark, 2017).

This study employed Qualitative analysis on the reflective Journals and focus group discussions to organize the details shared by pre-service teachers as they prepared and planned lessons using Copilot, aiming to measure Copilot's effectiveness. The analysis steps outlined earlier provided a clear and thorough overview of the data, enabling the development of effective educational strategies based on the findings.

Five Main Questions Guided the Reflective Journal

1. How did you use AI to make your lesson more fun and exciting?
2. Did you have positive experiences enhancing your class with AI? If so, please elaborate.
3. How did you use AI in preparing and planning for teaching?
4. Did you have successful experiences in enhancing the teaching process by using AI? Elaborate.
5. What are the challenges you faced when using AI?

Six Main Questions Guided the Interviews

1. How would you evaluate your experience in using AI to assist with lesson plans, assessment tools, educational strategies, teaching aids, tables, and pictures? What benefits did you gain from this experience?
2. Do you think that AI is significant in the teaching profession? If yes, why?
3. How can generative AI tools enhance students' learning of specific tasks?
4. What advice would you share with students to ensure the productive and responsible use of generative AI tools?
5. What is your opinion regarding the reliability of information provided by AI?
6. What is the potential risk from using AI in teaching?

Thematic Analysis

Thematic analysis was adopted as a suitable method for analyzing the reflective Journals and focus group interview data. This analysis was conducted following a structured process.

1. **Analyzing data:** Analyzing the reflective Journals and focus group discussion data by reading and re-reading the transcripts several times to get more familiar with the participants' statements and opinions. This initial step was crucial for a deeper understanding of the data.
2. **Coding:** The coding was performed line by line, highlighting key phrases and concepts relevant to the research questions. Each code was assigned a label that captured the essence of the corresponding text segment.
3. **Identifying themes:** After coding all the data, the codes were reviewed to identify patterns, which were then compiled into potential themes. The themes were developed based on recurring topics, concepts, and emotions expressed by the participants.
4. **Reviewing themes:** The initial themes were reviewed to ensure they accurately represented the collected data. This process involved cross-checking the themes against the coded data to ensure consistency and interconnectedness, with adjustments made to the themes as necessary.

5. **Defining and naming themes:** The themes were refined by specifying their details and identifying their narratives. This step involved clarifying what each theme represents and how it relates to the research questions.
6. **Writing:** In this final step, the themes were integrated into the research report, with direct quotes from participants used to clarify and reinforce each theme (Creswell & Plano Clark, 2017).

Although no software was used for this analysis, the manual process was rigorous and thorough. Applying the steps outlined above ensured a detailed and accurate interpretation of the data, capturing the complexities of pre-service teachers' experiences with using Copilot in education.

RESULTS

Pre-Service Teachers' Copilot Prompts

Some quotes from the final collected prompts have been attached as appendixes, categorized into the five themes most frequently used by pre-service teachers: lesson plans, educational media, authentic assessments, tables, pictures and drawings, and instructional strategies. The text italicized below was copied directly from Copilot.

When first applying this tool, many of the students' prompts regarding lesson plans were questions which varied somewhat between groups. This was followed by a set of instructions to specify the time for each component of the plan, as many cases lacked defined time allocations. As well as instructions to reduce the time from 100 minutes to 40 minutes to align with the local curriculum. Additionally, some goals required modification, as they appeared unmeasurable or impractical. Multiple instructions were made to change parts of the lesson plan, such as the openings and endings.

What was interesting about the lesson plans created by Copilot was their detail, time specificity, engaging titles, and strong, solid components—but only after being fed multiple instructions. It was also possible to customize and modify the lesson plans to fit the curriculum and students' needs. For instance, one group instructed the AI to create a lesson plan on the elements of weather. When the plan appeared on the screen, it was noted that it lacked specific time allocations for each component. Thus, a request was made to assign a specific time limit to each part of the plan. Indirect methods were then used instead of the direct methods included in the plan. The other groups used Copilot in similar ways to develop plans that aligned with students' needs and the Palestinian curriculum, as demonstrated in the prompts in [Appendix A](#). Each group agreed on their individual prompts, which were then discussed collectively with all the groups.

Instructional media serve as effective and efficient supporting tools in the teaching process, helping to achieve educational goals. Additionally, instructional media can increase students' motivation to learn (e.g., Puspitarini & Hanif, 2019). The students delved deeper into customizing instructional media to enhance its effectiveness in explaining concepts and supporting the educational process. Copilot provided various instructional media, guiding students on how to prepare and utilize them using examples from their surrounding environment. The main focus of the pre-service teachers was on obtaining videos, specific instructional media, and support for the educational process, as shown in the prompts in the appendix. Their requests went beyond just acquiring these aids—they were also interested in understanding how these tools work. This approach helped the participants across the four groups to gather a diverse range of engaging teaching aids that effectively support the achievement of lesson goals. Several of these aids included links, as indicated in [Appendix B](#).

The prompts in the evaluation area focused on selecting rating criteria and ways for assessing students' products or performances, including tools like participation charts, anecdotal records, rubrics, and rating scale ([Appendix C](#)). This focus stemmed from the difficulties that teachers face, such as the time-consuming and painstaking effort to set the criteria and build these tools (Burden & Byrd, 2018). The use of generative AI has made it easier for pre-service teachers to select suitable assessment criteria and create authentic assessment standards, aligning with findings from Clark's (2023) study. This was evident in the prompts and modifications made to ensure alignment with the lesson and its goals. There is no doubt that, when used effectively, AI can provide teachers with exciting and engaging ideas, particularly when pre-service teachers work in groups to refine these ideas and assess their alignment with curriculum goals and students' developmental needs, as

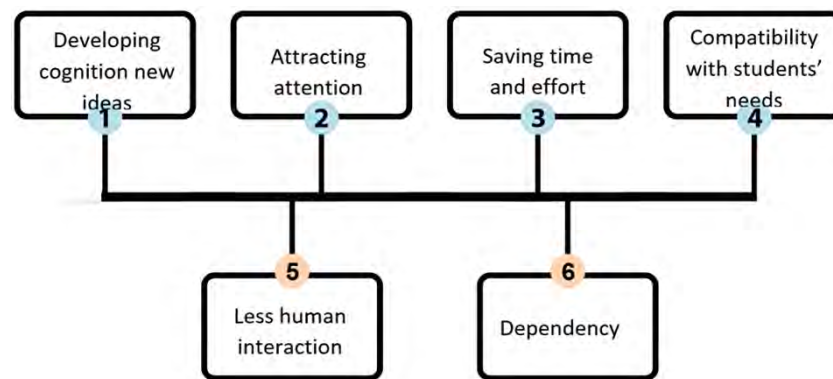


Figure 1. Depiction of themes using an affinity diagram (Source: Author)

demonstrated in the previous prompt. The main focus of all the prompts was on collaborative work in selecting their nature before using Copilot. After employing Copilot, the prompts were discussed between the members within each group to ensure their reliability and suitability with the curricula before presenting them to schools and the other groups. This process allowed for careful consideration, consensus, and retention for application in schools.

To enhance and enrich lessons, the pre-service teachers put a lot of thought into using Copilot to generate tables and pictures as supplementary content. This approach aimed to train students in reading tables, extracting information, and interpreting data from tables and graphs in ways that align with the local curriculum and the international trends in science education. As demonstrated in the prompt in [Appendix D](#), one of the groups tasked Copilot with creating a table showing the average temperatures throughout the year in the students' local area, as well as generating a picture of clouds with their classifications for the same lesson, while the others were encouraged to create tables, drawings, and shapes. It is worth noting that Copilot provided links to websites containing various shapes and drawings, allowing pre-service teachers to select the most suitable ones for their students.

One of the most repeated prompts involved requests for learner-oriented instructional strategies that engage all students in the lesson. To address this, generative AI was used to create instructional strategies that actively engage the students, including prompts focused on generating teaching methods that consist of games, enquiry-based learning, and collaborative approaches. During each meeting, the students discussed these strategies both within their individual groups and collectively across all groups. Through the prompts, participants showed an interest in connecting science with society and technology. They aimed to link science with the local environment and technology to achieve educational goals, engage students, and enhance their motivation (Abualrob & Daniel, 2011). This is evident in the prompt questions addressing local temperatures and biodiversity.

One of the greatest challenges when first using generative AI was crafting the prompts. Fortunately, however, this quickly became standard practice for all the groups. What was astonishing was how pre-service teachers utilized information and skills gained from their university courses. For instance, several prompts reflected knowledge from their studies, such as developing student-centered teaching strategies, including inquiry-based learning, collaborative learning, and learning through games and discussions. The beauty of it lies in the students' ability to integrate and apply knowledge from their previous courses while using AI in learning. This was evident in their questions about evaluation criteria and methods based on performance, as shown in the prompts ([Appendix E](#)).

Pre-Service Teachers' Reflections About Using Copilot as a Pedagogy Tool

The analysis resulted in six themes that highlight the main points emerging from the reflective Journals and focus group discussions. [Figure 1](#) illustrates the similarities among the themes by showing several recurring patterns in the process of developing the codes and themes. Below, each section will be discussed in detail and supported by actual comments from the participants.

Developing cognition of new ideas

Pre-service teachers stressed that using generative AI for preparing and planning lessons expanded their perceptions with new and exciting ideas they hadn't encountered before. It was also highly effective during their training with fourth grade science classes. All participants highlighted the importance of using Copilot in teaching, noting that it provides innovative ideas that go beyond traditional teaching methods.

Group 1: "I used Copilot to evaluate students' performance while seeking a precise criterion for measuring their achievements. Copilot suggested beneficial and comprehensive criteria, some of which were new to me but compatible with the evaluation system."

Group 2: "It helped me create interactive lessons and provided new ideas when selecting the evaluation criteria."

Group 3: "It brought my attention to things that had never even crossed my mind! It helped me expand my ideas to include new and unconventional aspects."

Group 4: "It provided me with plenty of new ideas to enhance evaluation. One of Copilot's suggestions that stood out to me was the use of educational games. I incorporated these games into several classes and topics, and the experience was wonderful. I noticed that all the students were more engaged, as the games captured their attention in a creative and enjoyable way."

Attracting attention to things that never crossed their minds

Pre-service teachers believe that AI highlighted aspects of planning and preparing science lessons that had never even crossed their minds. These include various strategies, indirect instructional methods, evaluation techniques, teaching aids from the local environment, authentic assessment varieties, and evaluation criteria. Although they had acquired this knowledge during their university studies, it was absent from their minds while planning and preparing for teaching.

Group 1: "Copilot brought my attention to ideas that made my class more effective. For example, I used different educational strategies in the same lesson which made it ..."

Group 2: "Copilot has opened new doors for me in evaluation and provided new ideas that I hadn't considered, even though I was already familiar with the concepts."

Group 4: "I had neglected plenty of the strategies I learned during my freshman and sophomore years at university, but thanks to Copilot, I was able to recall and apply them during my training and teaching at schools."

Saving time and effort

The study's participants emphasized the importance of Copilot in saving time and effort in lesson planning and preparation, tasks that previously took several hours to complete.

Group 1: "Copilot suggested new ways to save significant time and effort. For example, I could input all of the students' information—such as their participation, answers, activities, and exams—and Copilot would provide a detailed and descriptive evaluation for each student."

Group 3: "We used to spend over 4 hours preparing lesson plans. The advantage of using Copilot is that, rather than using the generated plans as they were, we benefited from the hints and tips provided for creating our own lessons, which saved us a lot of time and effort."

Group 4: "A lot of time was spent on creating rubrics and setting criteria suitable for the students' products and performances, but thanks to Copilot, it saved us a lot of our time and effort."

Compatibility with students' needs

The participants emphasized that Copilot provides educational materials compatible with students' needs, offering diverse resources that account for individual differences within the classroom.

Group 1: "Through our research for strategies, Copilot provided us with a lot of options, each compatible with a specific level. This allowed us to select the strategy that best matched the mindset and level of our students."

Group 2: "The aids are tailored to each student's needs by providing diverse methods and approaches to explain every point in the lesson, aligning with their needs and personal interests, making the class ..."

Group 3: "One of the most challenging aspects for me was planning lesson content and finding methods that suit my low-achieving students, but Copilot provided me with a lot of support in this area."

Group 4: "Today, I can confidently plan content that is compatible with all of my students' varying levels."

Less human interaction

Pre-service teachers noted that the rise of Copilot might reduce future interactions among teachers, as it provides answers to many questions that they would typically discuss with their colleagues in the field.

Group 1: "While we are currently working in groups, I believe that in the future we may drift apart because Copilot provides us with everything we need."

Group 1: "I don't think so; I believe it will increase the exchange of ideas between colleagues in the same field because Copilot presents a diverse range of perspectives."

Group 2: "Interaction among teachers is decreasing."

Group 4: "There is a lack of communication between individuals. Instead of engaging in discussions with experts from various fields to gather creative ideas, we now turn to Copilot for electronic information."

Dependency

There was extensive discussion centered on concerns about mental lethargy and total reliance on AI, with several participants highlighting these issues. However, the majority of the participants pointed out that Copilot nurtures the mind with hints and tips, and that creativity and innovation arise from employing, adding to, and modifying these ideas. As for pre-service teachers' dependency on Copilot, it varies based on individual nature, societal culture, and upbringing. Such dependency is likely only found among a small group of individuals who do not strive to develop themselves.

Group 1: "I don't think so; in fact, I believe it's the opposite. It encourages more research."

Group 3: "right! I have noticed that some of my colleagues don't give much importance to many topics and would tell me that I shouldn't bother myself since everything is available on Copilot."

Group 4: "It depends on the teacher. There are two types of teachers; those who always strive to develop themselves and those who don't care to."

DISCUSSION

Pre-Service Teachers' Prompts

The integration of several AI based applications in teaching has grown significantly in recent years. Understanding AI's potential has become crucial for pre-service teachers, not only for enhancing future student learning outcomes but also for shaping their career paths (Ayanwale et al., 2024). Pre-service teachers recognize technology's potential to enhance learning outcomes, improve educational effectiveness, and achieve educational goals. If AI proves to be highly beneficial and significantly impacts educational results, it is likely to be adopted, although it would require a lot of effort to learn how to use it (Zhang et al., 2023). The integration of AI-based applications in teaching has shown significant growth in recent years (Talanquer, 2023).

Pre-service teachers primarily used Copilot for preparing lesson plans, assessment tools, student-centered instructional strategies, educational aids, and creating tables and pictures for fourth grade science classes (Alsadi & Baiz, 2023; Cooper, 2023). This aligns with Talanquer's (2023) findings on the use of AI tools in teaching and with Clark's (2023) approaches to AI in evaluation. The implemented prompts on Copilot were agreed upon by consensus within the work groups (van den Berg & du Plessis, 2023). What makes this study unique is that no prompts were approved without consensus within each group, across all groups, and from the researcher.

It often took several attempts and revisions of the prompts on Copilot to reach a final version that aligned with the curriculum and the students' developmental characteristics. Pre-service teachers may depend on AI-based educational technology to do their work more often if it was user-friendly, increasing the tangible benefits of technology in education (Zhang et al., 2023).

Copilot provided pre-service teachers with complete, detailed and time-specific lesson plans, with the option to modify them to suit the curriculum, students' needs, and developmental abilities. These plans were essential for planning and preparing for their training and teaching in schools, as well as assisting in selecting instructional strategies and evaluation methods. The prompts reveal how pre-service teachers were influenced by their university courses, with Copilot serving as a tool to employ strategies that were often overlooked when using traditional teaching methods.

The ability to revise and evaluate prompts was reflected in the teamwork and collaboration with the researcher. Copilot provided evaluation measures, such as rubrics, which typically require a lot of time to prepare (Burden & Byrd, 2018). It is crucial to improve career development for pre-service teachers by implementing policies that make teaching them AI easier (van den Berg & du Plessis, 2023). This is particularly significant in education, where students and teachers must navigate the responsible use of AI and distinguish between appropriate and inappropriate applications (Rodríguez-García et al., 2021).

Pre-Service Teachers' Reflections About Using Copilot as a Pedagogy Tool

The current study highlights the importance of using a generative AI tool, Copilot, in science teaching (Alsadi & Baiz, 2023; Cooper, 2023). Pre-service teachers affirmed that Copilot helps in developing and perceiving new and exciting ideas, noting that its most important role is generating unconventional ideas for the teaching process (Martineau, 2023; Nah et al., 2023). Cooper (2023) pointed out that pre-service teachers might find generative AI especially beneficial for providing teaching resources, as they often lack access to a comprehensive bank of reliable materials. Additionally, AI could draw pre-service teachers' attention to components and elements that enhance the educational learning process, increase student engagement, and achieve lesson objectives. Moreover, the participants stressed the importance of employing Copilot in the teaching-learning process for its time-saving benefits in preparation and planning (Martineau, 2023; van den Berg & du Plessis, 2023; Walker, 2023). The current study agrees with that of Nah et al. (2023) that generative AI is a tool that can be used to help teachers plan lessons effectively.

CONCLUSION

The emergence of Copilot and other free generative AI tools has significant implications for teachers, especially pre-service science teachers. This study sheds light on how pre-service teachers use Copilot to support the teaching-learning process, focusing on preparing lesson plans and teaching aids, developing authentic assessment tools, creating tables and pictures, and determining instructional strategies that engage all students in the lesson. This had a different nuance, with consensus on the nature of commands and orders, distinguished by the repetition of commands to achieve the desired outcome. Copilot's outputs varied: they occasionally provided quick insights, stimulated new thinking, and retrieved previously learned information, with the teachers having to occasionally correct errors and address gaps. Consequently, the outputs were not used as is in many cases but were subject to consensus within and across groups, often involving consultation with the researcher. The study revealed Copilot's effectiveness in generating new ideas beyond the pre-service teachers' existing knowledge, highlighting aspects they had not considered, and saving significant amounts of time and effort. Additionally, it produced engaging educational material suitable for all students. The lack of human interaction is attributed to individual differences, as emphasized by several participants. As for dependency, with participants divided between supporters and opponents, further studies are needed.

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APPENDIX A: COPILOT PROMPT (LESSON PLAN)

Certainly! Let's create a **40-minute lesson plan** specifically focusing on **temperature** for fourth grade students using **indirect instruction**:

Lesson plan: Understanding temperature

Objectives & outcomes:

- Students will be able to **describe temperature** as an element of weather.
- Students will learn how to **read a thermometer**.

Materials needed:

- Thermometers (one per student or group)
- Weather chart template (downloadable or printed)
- Pictures of different weather conditions (sunny, rainy, snowy, etc.)

Warm-up (5 minutes):

1. **Indirect instruction:** Begin by asking students a thought-provoking question related to temperature, such as: "Why do we feel warmer in the sun and cooler in the shade?" Allow students to share their ideas and discuss as a class.

Direct instruction (10 minutes):

1. **Indirect instruction:** Instead of directly defining temperature, engage students in a conversation. Show pictures of different weather conditions (e.g., sunny, rainy, snowy) and ask students to describe how they feel in each type of weather. Guide them to recognize that temperature plays a significant role in our comfort level.

Guided practice (10 minutes):

1. **Indirect instruction:** Distribute thermometers to students or groups. Ask them to observe the current temperature in the classroom without explicitly explaining how to read the thermometer.
2. Provide a weather chart template with spaces for temperature readings. Have students record the temperature they observed.

Independent practice (10 minutes):

1. **Indirect instruction:** Encourage students to choose a location (real or imaginary) and research its current temperature. Ask them to record this temperature on their weather chart.
2. Discuss how temperature might vary throughout the day and across different locations.

Closure (5 minutes):

1. **Indirect Instruction:** Reflect on the warm-up discussion. Ask students to share their observations about temperature and its impact on their daily lives.
2. Discuss how understanding temperature helps us dress appropriately, plan outdoor activities, and even predict weather changes.

Assessment:

Indirect Instruction: Observe students during guided and independent practice. Note their engagement and ability to apply temperature concepts.

Check their completed weather charts for accurate temperature readings.

APPENDIX B: COPILOT PROMPT (INSTRUCTIONAL MEDIA)

Let's explore some engaging instructional resources about the **digestive system** that are suitable for fourth grade students:

1. NG science–The digestive system:

- You can watch the video on NG Science's website: [The digestive system](#).

2. Britannica kids and enchanted learning:

- **Britannica kids** offers student text selections, animations, and instructional slides on both human and animal digestion.
- **Enchanted learning** provides a comprehensive glossary of digestion-related vocabulary.

3. Educational videos:

- **Kids health** has a video titled "How the digestive system works," suitable for grades 2-4. It explains the process in an accessible manner.

APPENDIX C: COPILOT PROMPT (EVALUATION)

Table C1. Biodiversity presentation rubric

Criteria	Excellent (4)	Proficient (3)	Basic (2)	Needs improvement (1)
Content	Accurate and comprehensive information about biodiversity.	Mostly accurate information but missing some key points.	Limited information and lacks depth.	Inaccurate or minimal content.
Visual aids	Creative and relevant visuals (images, diagrams, etc.) enhance understanding.	Visuals are present but not very engaging.	Few visuals and not well-integrated.	No visual aids provided.
Delivery	Clear, confident, and audible presentation. Engages the audience.	Mostly clear and some hesitations. Audience engagement varies.	Unclear or hesitant delivery. Limited audience engagement.	Difficult to understand, lacks confidence.
Organization	Logical flow with clear introduction, body, and conclusion.	Somewhat organized and may lack transitions.	Disorganized and lacks structure.	No clear organization.
Audience interaction	Invites questions, encourages participation.	Responds to questions but doesn't actively engage the audience.	Minimal interaction with the audience.	No audience interaction.

Example of a rubric (**Table C1**) for a presentation on biodiversity for fourth grade students *rating scale* “students will create a mini-poster illustrating one of the weather elements (temperature, precipitation, clouds, or wind) and explain its significance.”

When designing criteria for a performance-based assessment on light sources for fourth grade students, it's important to focus on the key elements that reflect both the understanding and application of knowledge in real-world scenarios. Here are some criteria you might consider:

- 1. Complexity:** The tasks should require students to use multiple skills and knowledge areas, reflecting real-world tasks.
- 2. Problem-solving:** Students should demonstrate critical thinking and analytical reasoning skills.
- 3. Synthesis and application:** The ability to synthesize information and apply evidence to create a coherent understanding of light sources.
- 4. Authenticity:** Tasks should mimic real-life situations and require students to apply their learning in practical ways.
- 5. Process-oriented:** Emphasis on the learning process, where students reflect on their understanding and how they apply it.
- 6. Product-oriented:** The end result should be a tangible product that encapsulates the knowledge gained and demonstrates its application.
- 7. Communication:** Clear and effective presentation of ideas and concepts, both orally and in writing.
- 8. Collaboration:** Ability to work effectively with peers, contributing to group tasks and respecting others' ideas.

Certainly! When designing a **Likert scale** for assessing fourth grade students' understanding of light sources, consider the following sample Likert questions. These questions aim to capture students' opinions, attitudes, or behaviors related to light sources:

- 1. “I believe that understanding how light travels is important.”**
 - o Strongly disagree
 - o Disagree
 - o Neither agree nor disagree
 - o Agree
 - o Strongly agree
- 2. “I can explain how shadows are formed using light sources.”**
 - o Strongly disagree
 - o Disagree
 - o Neither agree nor disagree
 - o Agree
 - o Strongly agree

3. ***"I know the difference between natural light sources (like the sun) and artificial light sources (like lamps)."***
 - Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly agree
4. ***"I can describe how light can be reflected, refracted, or absorbed."***
 - Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly agree
5. ***"I understand why some materials are used for specific light sources (e.g., glass or plastic covers for flashlights)."***
 - Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly agree

APPENDIX D: COPILOT PROMPT (GRAPH, PHOTO, AND TABLES)

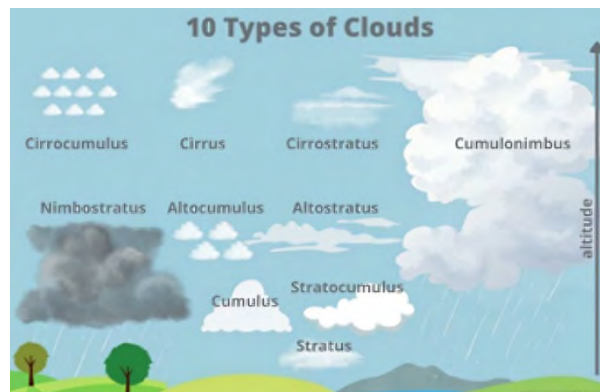


Figure D1. A photo of images of various cloud types (Source: Generated using AI, Copilot)

Table D1. Average temperatures for four Jordanian cities

City	Winter (°C)	Spring (°C)	Summer (°C)	Autumn (°C)
Amman	8.5	18.5	27.0	18.5
Petra	9.0	22.0	37.5	22.0
Aqaba	19.5	29.0	41.0	29.0
Jordan Valley	19.5	29.0	39.0	29.0

Show a photo of images of various cloud types (cumulus, stratus, cirrus) for fourth grade (**Figure D1**).

You create a table showing the average temperatures for four Jordanian cities during the four seasons for fourth grade (**Table D1**).

APPENDIX E: COPILOT PROMPT (INSTRUCTIONAL STRATEGIES)

A teaching method that involves all students in the lesson for ecosystem for fourth grade students.

Certainly! Teaching ecosystems to fourth grade students can be both engaging and educational. Here are some creative methods to involve all students in the lesson:

1. Nonfiction text for teaching ecosystems:

- *Incorporate informational reading by using nonfiction books related to ecosystems. Students can explore examples of producers, consumers, decomposers, herbivores, and carnivores from various ecosystems. Create interactive anchor charts to reinforce learning.*

2. Study jams:

- *Utilize online resources like **study jams**. These short, engaging videos cover ecosystem concepts and are perfect for mini-lessons. Students can take quizzes individually or as a class.*

3. Ecosystem accordion books:

- *Have students create simple ecosystem books. They fold a half sheet of construction paper into fourths and label each section with different ecosystem terms (e.g., producers and consumers). Students draw pictures of examples for each term.*

4. Teaching ecosystems with food chains:

- *Students create their own food chains. Provide them with a sun template and five circles. In each circle, they draw a producer, an organism that gets energy from the producer, and so on. This activity lays the foundation for understanding food webs.*

5. Food web activity:

- *Arrange students in a large circle. Each student receives a card representing an organism. They stand in the middle of the circle with a ball of yarn. As they share interactions (e.g., predator-prey relationships), they pass the yarn to connect the organisms in a food web.*

Remember, hands-on activities, visual aids, and collaborative discussions enhance student engagement and understanding of ecosystems.

