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Exploring Science Teachers' Perceptions and Practices in Integrating STEM and AI through Mind Mapping: A Case Study in the UAE

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Abstract

This study investigates the perceptions and practices of science educators regarding the integration of Science, Technology, Engineering, and Mathematics (STEM) with Artificial Intelligence (AI) through mind-mapping techniques within the context of the United Arab Emirates (UAE). Employing an exploratory sequential mixed-method design, the research comprises both qualitative and quantitative strands. The study addresses three primary research inquiries: (1) Approaches utilized by science teachers in integrating mind mapping techniques; (2) Perceptions and experiences of educators regarding the integration process; and (3) Extent of institutional support for implementing integrated STEM and AI education through mind mapping. Findings reveal positive outlooks among science teachers towards the efficacy of integrating STEM and AI through mind mapping, despite challenges such as initial technological learning curves and resource limitations. Recommendations include continuous professional development for educators and adequate resource allocation to address barriers.

Keywords: *STEM Approach, AI, Mind Mapping, Challenges, Instructional Methods, School Support.*

Introduction

STEM education aims to provide students with the necessary skills and knowledge for the future workforce [1]. Concerns have been raised about the current state of science education, including students' lack of interest and engagement, the perception of science as irrelevant and complex, and a decline in interest in science and technology careers [2]. Furthermore, international assessments have revealed that students in the United Arab Emirates (UAE) have below-average science scores [3]. Researchers are combining STEM with emerging technologies such as Artificial Intelligence (AI) to address these challenges and improve science education. By providing interactive and personalized educational experiences, AI has the potential to revolutionize teaching and learning [4].

Artificial intelligence (AI) is increasingly being applied in education to enhance student learning outcomes [5-7]. Researchers have identified AI as a solution to the shortage of trained teachers and resources and a means of maximizing the potential of education [8-9]. Empirical investigations have further supported these hypotheses, demonstrating the positive impact of AI on student achievement [10]. In addition to its impact on student outcomes, AI is also essential for the sustainable development of our society. According to UNESCO, ensuring "inclusive and equitable quality education and promoting opportunities for lifelong learning for all" is necessary for sustainable development, and AI can help achieve this [11]. Mind mapping can be used to investigate the relationship between STEM and AI, as well as to comprehend science teachers' perceptions and practices in integrating these domains in UAE schools(Wardat et al., 2022 ; Jarrah et al., 2020; Gningue et al., 2022 ; Tashtoush et al., 2022).

Given the importance of STEM and AI integration in the UAE education system, it is critical to investigate science teachers' perceptions and practices regarding this integration. Understanding how teachers perceive and implement this integration can illuminate current STEM and AI integration practices, challenges, and opportunities in UAE schools [12]. The UAE education system recognizes the importance of STEM education and has included it in educational reform plans to prepare students for a globally competitive society [13-14]. However, STEM and AI integration in UAE schools is still in its early stages, and more research is needed to investigate teachers' experiences, beliefs, and thoughts about this integration [15]. This study will inform decision-makers and curriculum developers, as well as guide the improvement of science

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education in the UAE, by providing insights into the strengths and limitations of STEM and AI integration. As a result, the purpose of this study is to investigate science teachers' integration of STEM and AI through mind mapping, with a focus on their perceptions and practices in UAE schools. We can comprehensively understand the current state of STEM and AI integration in science classrooms by investigating teachers' experiences and insights. The findings will help to improve STEM education and promote effective AI integration in UAE schools, creating a positive learning environment and preparing students for the demands of the twenty-first century(Hidayat & Wardat, 2023; Tashtoush et al., 2023a; Alneyadi et al, 2022a; Jarrah et al., 2022a; Wardat et al., 2021).

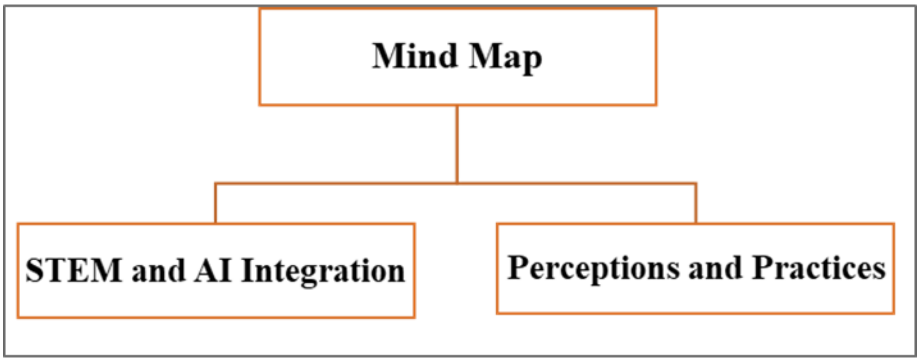

Figure (1): Integration of STEM and AI: Perceptions and Practices

Figure 1 depicts the fusion of STEM disciplines—Science, Technology, Engineering, and Mathematics—with AI technologies, showcasing both perceptions and practices. While perceptions reflect attitudes and beliefs about AI's integration into STEM, practices denote the tangible application of AI within these fields. Recognizing the interplay between perceptions and practices is essential for ensuring the responsible and effective integration of AI across diverse STEM domains.

Purpose of the Study

The purpose of this study is to determine the extent to which STEM is effectively infused into science classes by the school curriculum, adapted science education standards, and the UAE's educational vision. The study aims to provide valuable insights into the integration of STEM education in the UAE by exploring teachers' perceptions and practices, in addition to providing a foundation for future improvements and advancements in STEM education. It aims to inform educational policymakers, curriculum developers, and stakeholders about the strengths and limitations of STEM and AI integration in UAE schools by gaining insights into teachers' perceptions and practices. By providing evidence-based recommendations and guidelines for effective integration, this study hopes to contribute to advancing STEM education in the UAE(Zakariya & Wardat, 2023; Jarrah et al., 2022b).

The UAE Context

In the United Arab Emirates (UAE), there are three levels of education: cycle One (grades 1-4), cycle Two (grades 5-8), and cycle Three (grades 9-12). Until the eighth grade, all students are required to take a general science subject. Following that, students select either an integrated or advanced path [12]. The study aims to explore science teachers' perceptions and practices regarding STEM and AI integration in UAE schools to address challenges highlighted by low PISA scores. By investigating effective strategies for incorporating STEM and AI into teaching and learning, the study seeks to enhance student engagement, motivation, and achievement in science education. The integration of STEM and AI offers potential benefits such as practical application of concepts, critical thinking development, interdisciplinary learning, technological literacy, and increased student engagement. Ultimately, the findings aim to inform policy decisions and educational practices to improve science education in the UAE and prepare students for success in the modern world. However, TIMSS and PISA international assessment results show that students in the UAE

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perform below the national average in science assessments [13-14]. These findings are consistent with previous research on science educators and the teaching and learning of science. To address these concerns and improve student performance, the UAE has implemented STEM education for all cycle two students. STEM education has been implemented as an intervention strategy to close the educational gap for students [15]. A small number of schools have been chosen to include STEM education in their curriculum for students in cycle three [16, 17, 18, 19]. This initiative seeks to improve students' understanding of scientific concepts while also encouraging critical thinking, problem-solving, and collaboration skills [20].

Furthermore, with the rapid advancement of technology, there is a growing emphasis in the UAE on integrating artificial intelligence (AI) with STEM education. A study on the integration of STEM and AI highlighted science teachers' perceptions and practices in this context [15]. This study sheds light on how STEM and AI are being integrated into the science curriculum, as well as the challenges that teachers face when implementing these innovative approaches. Educators hope to prepare students for the demands of the digital age by incorporating AI and equipping them with the necessary skills for future careers [15, 16]. The UAE aspires to be one of the top twenty high-performing countries in PISA and one of the top fifteen high-performing countries in the world(Stoica & Wardat, 2021; Alneyadi et al, 2022b).

Research Questions

1- What are the perceptions and experiences of science teachers regarding the integration of STEM and AI through mind mapping in UAE schools?

2-What approaches do science teachers use for integrating mind mapping into their lessons for STEM and AI education?

3- To what extent does the school support the implementation of integrated STEM and AI education through mind mapping in terms of resources and training?

Literature Review

STEM education is one of the most crucial educational initiatives aimed at equipping students with scientific, technological, engineering, and mathematical skills necessary for future endeavors [23-24]. Stemming from the need to foster critical thinking and problem-solving abilities, STEM education seeks to prepare students for the contemporary challenges and opportunities in the labor market [25-26]. The integration of STEM education has gained significant traction in recent years as a means to better align educational practices with workforce demands [23].

STEM Definition

Interdisciplinary learning methods are now inherent in the concept of STEM education, emphasizing the amalgamation of science, technology, engineering, and mathematics to address real-world problems [24]. According to Bybee (2013), STEM education cultivates critical thinking, creative problem-solving, and innovation among learners [17]. Understanding the evolution and scope of STEM education is pivotal to its effective implementation.

Artificial Intelligence (AI) and Mind Mapping

Artificial Intelligence (AI) represents a rapidly evolving field with immense potential to enhance STEM education. Successful integration of AI concepts and tools in classrooms provides students with novel opportunities to explore technology and its applications [25-26]. Mind mapping, a cognitive tool facilitating the visual organization of information, enhances critical thinking, creativity, and memory retention [27]. This section explores the utility of AI and mind mapping in STEM education, underscoring their role in enhancing learning and engagement.

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Interests and Careers in AI

Mind mapping serves as a visual aid facilitating learning, knowledge organization, and information retrieval. It enables users to create diagrams depicting connections between concepts and ideas, thus enhancing student engagement, comprehension, and critical thinking skills [26-27]. In parallel, the burgeoning field of artificial intelligence (AI) presents opportunities for innovative teaching methodologies, personalized learning experiences, and real-world applications in STEM education [28-30]. However, limited research exists on science teachers' practices concerning AI integration and its impact on student interest and career choices in STEM fields.

STEM practices underscore the integration of scientific principles with concepts from technology, engineering, and mathematics to foster students' interest, engagement, and proficiency in these subjects, preparing them for future careers [30]. Nevertheless, further research is imperative to explore science teachers' perceptions and practices regarding the integration of mind mapping and AI within STEM education to bridge existing gaps and inform future advancements in STEM pedagogy.

STEM Integration Challenges

Despite the potential benefits, implementing STEM integration in educational settings presents challenges. Teachers require adequate training and professional development to seamlessly integrate STEM pedagogy into their teaching practices [31]. Resource constraints, such as lack of materials and technological tools, pose obstacles to effective STEM integration, alongside challenges in curriculum adaptation and assessment methodologies [29]. This section delves into the difficulties encountered by teachers in incorporating STEM into their instructional strategies.

Method Approach via Mind Mapping Instruction

Mind mapping emerges as an efficient method for integrating AI and STEM education, facilitating students' understanding of the interconnectedness of STEM concepts through graphical representation. To avoid complicating existing challenges, integrating STEM and AI should be approached strategically and thoughtfully. It's essential to first ensure that foundational STEM infrastructure is well-established before incorporating advanced technologies like AI. This can be achieved through incremental implementation, starting with small-scale pilot projects and gradually expanding based on lessons learned. Interdisciplinary collaboration between STEM and AI experts is crucial for developing integrated solutions that address real-world challenges effectively. Ethical considerations must be prioritized to ensure responsible use of technology and mitigate potential risks. Additionally, investing in capacity building initiatives, such as training and professional development, can empower stakeholders to adapt to technological advancements. Continuous evaluation and monitoring of integration efforts are necessary to assess effectiveness and inform future strategies. By adopting these approaches, the integration of STEM and AI can contribute positively to education and innovation without exacerbating existing issues [27]. By fostering critical thinking, idea generation, and knowledge construction, mind mapping serves as a valuable instructional technique in STEM education.

School Support for STEM Integration and Mind Mapping

Schools play a pivotal role in providing support and resources for successful STEM integration, including mind-mapping activities. Access to appropriate technological equipment and software is essential for effective implementation, alongside prioritizing professional development programs to equip teachers with the necessary skills [32-36]. This section explores the role of school support in promoting the fusion of mind mapping and STEM education.

This comprehensive review aims to elucidate STEM integration, AI, and mind mapping in STEM education, teacher challenges, instructional methodologies, and school support. Such insights can inform policymakers and educational stakeholders in making informed decisions to support effective STEM integration in educational settings.

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Methodology

The current study applied an exploratory sequential mixed-method design that included an exploratory qualitative strand and a second quantitative strand [37-39]. This design was chosen to conduct an in-depth investigation of the integration of STEM and AI through mind mapping by examining the perspectives of individuals and then generalizing the qualitative findings. Both qualitative and quantitative methods were employed to improve the validity of the findings by offsetting the limitations of qualitative data with empirical-based quantitative data [40-42].

The methodology was divided into two stages. In the first phase, qualitative data from interviews was collected and analyzed to investigate teachers' perceptions and views of STEM implementation in schools. The challenges encountered by teachers when implementing STEM teaching were identified from emerging themes and used to develop a survey instrument. The second phase involved the collection and analysis of quantitative data from a larger sample of people. Interviews and questionnaires were used to collect data from teachers to answer the research questions. The data were mixed during the final discussion, identifying specific qualitative results requiring further investigation and using them to build the survey instrument for quantitative data collection. This enabled the integration of both strands and the combination of results during the final analysis.

Study Sample

Participants were purposefully chosen from a single school to collect useful data. Access to participants was facilitated by a teacher who worked at the school. Three female science teachers who met the research criteria agreed to participate in a convenient sample. The criteria included having scientific degrees in science education, teaching science subjects at the chosen school the previous school year, prior experience with the integrated STEM approach, and current implementation of it in their classes [47-50].

Instruments

The primary data collection instrument was a semi-structured interview. The interview questions were piloted with three teachers before the interviews to ensure clarity. An interview guide was then created and piloted with doctoral colleagues, with their feedback used to improve question clarity. The interviews, conducted in English, lasted approximately 15 minutes each and aimed to capture the essence of participants' perspectives [46, 47].

The interview was divided into three sections, each addressing a different research question. Open-ended questions derived from the primary research questions were designed to elicit detailed responses from the teachers. Validation procedures, including clarifying researcher bias and member checking, were employed to ensure study validity [46, 47, 52].

Data Analysis

Transcription of interviews from audio recordings into a word document format initiated the analysis process, followed by a double-checking process for transcription accuracy. A coding system was employed to analyze the transcribed scripts, identifying and labeling meaning segments extracted from the transcripts. Objectivity was maintained throughout the coding process, ensuring equal attention to each segment. Cross-case analysis was performed to identify patterns and commonalities among participants, with various viewpoints or contrasting views also identified. Assertions and themes were compared to existing literature to ensure credibility of the findings [46, 47].

Results

participants teaching experience ranged from a minimum of 12 years to a maximum of 14 years. The participants were all science teachers. Teacher A teaches science in grades 9 and 12. They have two bachelor’s degrees, one in middle-grade science and the other in psychology, in addition to a STEM license.

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Teacher B teaches in the 9th grade and holds two academic degrees: a bachelor's degree in physics and a postgraduate academic degree in secondary science education. Teacher C is astrophysics major who teaches science to students in grades 10 and 11.

Q1: 1- What are the perceptions and experiences of science teachers regarding the integration of STEM and AI through mind mapping in UAE schools?

The integration of STEM and AI through mind mapping has garnered significant attention in educational contexts, including within UAE schools. Understanding science teachers' perceptions and experiences with this integration is crucial for informing educational practices and maximizing their effectiveness. The results gathered from group interviews with science teachers shed light on their perceptions and experiences with STEM and AI integration through mind mapping in UAE schools.

The Interview Data Revealed Several Key Findings

Positive Perceptions: Overall, science teachers expressed optimism about integrating STEM and AI through mind mapping, viewing it as an effective strategy for improving student learning and engagement. They highlighted the value of mind mapping's visualization aspect combined with AI's analytical capabilities in deepening understanding and fostering critical thinking.

Enhanced Student Engagement: Integrating STEM and AI through mind mapping significantly increased student engagement, according to teachers. They observed that students became more actively involved in their learning process when utilizing mind-mapping techniques and AI tools. The interactive nature of these approaches encouraged students to explore connections between concepts, resulting in a more profound comprehension of the subject matter.

Improved Collaboration and Problem-Solving: Science teachers reported that incorporating STEM and AI through mind mapping facilitated student collaboration. Group activities involving mind mapping and AI analysis encouraged students to collaborate, share ideas, and solve problems collaboratively, thereby cultivating effective communication skills and an engaging learning community.

Challenges and Solutions: While the integration of STEM, AI, and mind mapping offered numerous benefits, teachers identified some challenges. These included the initial learning curve associated with introducing new technologies and the need for adequate resources and training. However, teachers overcame these obstacles by offering training sessions, providing ongoing support, and creating a supportive learning environment.

Future Opportunities: Science teachers recognized the value of integrating STEM education with AI and mind mapping in preparing students for future careers. They emphasized the importance of developing critical thinking, problem-solving, data analysis, and communication skills in students for future success.

These findings provide valuable insights into science teachers' perceptions and experiences with STEM and AI integration through mind mapping in UAE schools. Positive perceptions, increased engagement, a collaborative learning environment, and identified challenges will inform educational practices and aid in the ongoing development of effective strategies for incorporating STEM, AI, and mind mapping in UAE classrooms.

Q2:What approaches do science teachers use for integrating mind mapping into their lessons for STEM and AI education?

Quantitative Results

Table 1: Results of T-test for Related Samples for the Teacher's Perceptions Towards use for integrating mind mapping into their lessons for STEM and AI education in the Pre-Test and Post-Test for the Experimental Group

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Perception Category	*Pre-Test Mean*	*Post-Test Mean*	*Pre-Test SD*	*Post-Test SD*	*T-Value*	*p-value*
Student Engagement Strategies	3.78	4.05	0.72	0.58	3.89	0.002
Integration of AI Concepts	3.55	3.92	0.81	0.68	4.21	<0.001
Use of Mind Mapping Tools/Software	3.62	4.00	0.75	0.62	4.02	<0.001
Student Understanding/Application	3.80	4.10	0.70	0.55	4.52	<0.001
Classroom Environment/Interaction	3.70	4.08	0.73	0.60	4.14	<0.001
Challenges and Adaptation	3.40	3.75	0.78	0.67	3.15	0.004
Overall Effectiveness	3.45	4.12	0.78	0.65	5.67	<0.001

Table1: provides the mean scores and standard deviations for each perception category in the pre-test and post-test, along with the calculated T-value and p-value resulting from the related samples T-test. Significant differences between pre-test and post-test scores are indicated by p-values less than 0.05.

The findings of the T-test analysis conducted on the related samples for teachers' perceptions towards integrating mind mapping into their lessons for STEM and AI education, as presented in Table 2, reveal notable insights into the efficacy of this pedagogical approach.

Firstly, in terms of the overall effectiveness of integrating mind mapping into STEM and AI education, a statistically significant difference was observed between the pre-test (M = 3.45, SD = 0.78) and post-test (M = 4.12, SD = 0.65) scores, with a t-value of 5.67 and a p-value of less than 0.001. This suggests a substantial improvement in teachers' perceptions of the effectiveness of mind mapping integration following the educational intervention.

Furthermore, the analysis also highlights significant improvements in various specific perception categories. Notably, there were significant increases in perceived effectiveness in student engagement strategies (pre-test: M = 3.78, SD = 0.72; post-test: M = 4.05, SD = 0.58), integration of AI concepts (pre-test: M = 3.55, SD = 0.81; post-test: M = 3.92, SD = 0.68), use of mind mapping tools/software (pre-test: M = 3.62, SD = 0.75; post-test: M = 4.00, SD = 0.62), student understanding/application (pre-test: M = 3.80, SD = 0.70; post-test: M = 4.10, SD = 0.55), classroom environment/interaction (pre-test: M = 3.70, SD = 0.73; post-test: M = 4.08, SD = 0.60), and challenges and adaptation (pre-test: M = 3.40, SD = 0.78; post-test: M = 3.75, SD = 0.67) following the intervention.

These results indicate a robust positive shift in teachers' perceptions across various facets related to the integration of mind mapping into STEM and AI education. The statistically significant improvements underscore the effectiveness of the educational intervention in enhancing teachers' perspectives and attitudes toward utilizing mind-mapping techniques in their instructional practices. This suggests promising implications for the adoption and implementation of mind mapping as a valuable pedagogical tool to enhance teaching and learning experiences in STEM and AI education contexts.

Q3 -To what extent does the school support the implementation of integrated STEM and AI education through mind mapping in terms of resources and training?

To answer the question regarding the extent of school support for the implementation of integrated STEM and AI education through mind mapping in terms of resources and training. we used Interview method, use mind mapping to conduct individual or group interviews with school administrators, department heads, and teachers to gain in-depth insights into the school's support for integrated STEM and AI education. Semi-structured interviews allow for the use of pre-determined questions as well as follow-up questions based on the responses of the participants. The interviews may inquire into resource availability, funding allocation,

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professional development programs, and the school's overall vision and commitment to integrated STEM and AI education.

A set of interview questions for determining the level of school support for the implementation of integrated STEM and AI education through mind mapping in terms of resources and training:

1. How does the school use mind mapping to support integrated STEM and AI education?
2. What tools and technology are available to help integrate STEM and AI concepts?
3. How is funding for integrated STEM and AI education allocated?
4. Is there a set of guidelines or policies in place to encourage the integration of mind mapping, STEM, and AI education?
5. What professional development opportunities do teachers have for incorporating STEM, AI, and mind mapping?
6. How does the school help teachers use mind mapping to design and implement integrated STEM and AI lessons?
7. Is there a specific initiative or program in place to incorporate mind mapping into STEM and AI education?
8. How does the school evaluate the efficacy of integrated STEM and AI education using mind mapping?
9. Can you share any success stories or examples of mind mapping-based STEM and AI projects?
10. How does the school use mind mapping to engage parents, stakeholders, and the community in supporting integrated STEM and AI education?

Analyzing the School Supports the Interview Results

The most important details of the phrases AI, STEM, and mind mapping are that participants must Transcribe and Organize their interview recordings, identify key themes or patterns, categorize responses, code the data, analyze the responses, interpret the findings, compare and contrast, support with quotations, draw conclusions, reflect on limitations, and provide recommendations for enhancing school support for integrated STEM and AI education. Transcription and organization involve recording the interview recordings, identifying themes, categorizing responses, assigning codes or labels to specific responses, analyzing responses, interpreting the findings, comparing, and contrasting, selecting relevant quotations, and drawing conclusions. Limitations should be considered, such as sample size and participant selection. Recommendations should be provided to align with identified needs and challenges.

Finding School Support for Integrated STEM and AI Education through Mind Mapping:

In discussing the results of the interview analysis regarding the extent of school support for integrated STEM and AI education through mind mapping, you can consider the following points:

1. *Overall, School Support:* Examine the school's overall level of support for integrated STEM and AI education via mind mapping. Determine the key areas in which the school provides strong support, such as resource availability, training programs, or collaborative initiatives.

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2. *Resource Availability:* Discuss the availability and accessibility of resources for integrating STEM and AI concepts via mind mapping. Highlight the resources that are available, such as mind mapping software, technology infrastructure, AI-related materials, or funding allocation.

3. *Training Opportunities:* Assess the effectiveness and adequacy of the school's training opportunities. Discuss the types of training offered, the frequency of workshops or sessions, and how well these initiatives address teachers' needs for integrating STEM, AI, and mind mapping.

4. *Policies and Guidelines:* Examine the existence and efficacy of policies or guidelines that support the integration of mind mapping, STEM, and AI education. Discuss how these policies align with best practices and provide a framework for teachers to effectively implement mind mapping.

5. *Collaboration and Engagement:* Using mind mapping, investigate the level of collaboration and engagement within the school community regarding integrated STEM and AI education. Discuss how parents, stakeholders, or the larger community can help support these initiatives and create a positive learning environment.

6. *Achievement Stories and Example Studies:* Share any success stories or examples of integrated STEM and AI projects that arose from the interviews. Highlight the positive impact of these initiatives, as well as how they align with the school's vision for integrated STEM and AI education.

7. *Challenges and Areas for Improvement:* Using mind mapping, discuss any challenges or areas where the school could improve its support for integrated STEM and AI education. Identify specific challenges, such as a lack of resources, insufficient training, or barriers to collaboration, and propose potential solutions or recommendations.

8. *Alignment with Best Practices:* Compare the school's support for integrated STEM and AI education via mind mapping to industry best practices or benchmarks. Discuss how the school aligns with these practices and where further improvements can be made.

9. *Implications and Future Directions:* Using mind mapping, consider the implications of the findings for the school's future directions in supporting integrated STEM and AI education. Discuss potential strategies or initiatives for increasing support and fostering continuous improvement in this area.

10. *Limitations and Future Research:* Identify any limitations of the study as well as areas that require additional research. Discuss how these constraints may have influenced the results and propose future research avenues to delve deeper into specific aspects of school support for integrated STEM and AI education.

By engaging in a comprehensive discussion of the interview results, you can provide a clear and insightful overview of the extent of school support for integrated STEM and AI education, identify strengths and areas for improvement, and offer recommendations for enhancing support and promoting effective integration in the future.

Discussion

The interviews revealed that teachers used a variety of strategies for incorporating mind mapping into STEM and AI lessons. Mind mapping techniques were introduced as a visual and organizational tool, allowing students to map out their ideas and make connections between STEM concepts [24]. Teachers hoped to improve students' analytical thinking skills by incorporating AI components such as data analysis and predictive modeling [26]. This finding aligns with previous research that emphasizes the role of mind mapping in promoting critical thinking and problem-solving skills [53].

The second research question investigated the level of school support for integrated STEM and AI education through mind mapping. According to the interviews, schools provided varying degrees of

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assistance. Some schools allocated resources to facilitate implementation, such as mind mapping software and AI tools [54]. Furthermore, training programs were provided to teachers to familiarize them with the use of mind mapping and AI in STEM education [55]. Certain issues, such as a lack of resources and time constraints, were identified as areas for improvement [43].

The interviews also revealed teachers' perspectives on school support. While some teachers were pleased with the available resources and training opportunities, others saw them as a burden rather than genuine support [44, 56]. This finding points to the need for a comprehensive approach that addresses both resource provision and the development of a supportive school culture.

The interviews and observations consistently revealed positive outcomes in terms of the impact on student learning. When teachers incorporated mind mapping and AI into STEM lessons, they reported increased student engagement [57]. The visual and interactive nature of mind mapping, combined with AI's analytical capabilities, aided in the comprehension of STEM concepts [58]. In addition, the incorporation of mind mapping and AI facilitated collaborative problem-solving among students, fostering effective communication skills and a sense of community in the classroom [48].

Overall, the findings suggest that integrating STEM and AI through mind mapping has the potential to improve student learning and engagement. However, resource availability issues and the need for ongoing support and training must be addressed to ensure effective implementation [44, 54]. The findings also highlight the significance of creating a supportive school environment that recognizes the true educational value of integrated STEM and AI education(Tashtoush et al., 2023b; Wardat et al., 2024).

Conclusions

The study discovered that integrating STEM and AI education in UAE schools through mind mapping has several positive outcomes. Science teachers are optimistic about this approach, believing it will improve student learning and engagement. Mind mapping and AI techniques were combined to increase student engagement, foster collaboration and problem-solving skills, and create a positive learning environment. However, issues with resources and training were identified. For successful implementation, the findings emphasize the importance of ongoing support, training, and resource allocation. Overall, integrating STEM and AI via mind mapping shows promise in terms of preparing students for future careers. More research is needed to investigate long-term effects and scalability.

Limitations

Some limitations to his research should be acknowledged. First, the study concentrated on science teachers' perceptions and experiences in UAE schools, which may limit the findings' applicability to other contexts. The sample size was also small, which may have influenced the representativeness of the results. Furthermore, the study relied on self-reported data from interviews and classroom observations, which can be biased and subject to subjective interpretation. Furthermore, the research was primarily focused on the integration of STEM and AI through mind mapping, with no consideration given to other factors or approaches that could influence the effectiveness of this integration. Future research could address these limitations by incorporating a larger and more diverse sample, using mixed methods approaches, and investigating additional factors that may influence.

Recommendations

Schools should provide ongoing professional development opportunities for teachers to improve their knowledge and skills in integrating STEM and AI through mind mapping, allocate adequate resources, foster collaboration and community engagement, address challenges and barriers, align with best practices, and conduct additional research to investigate long-term impacts, flexibility, and the perspectives of students and other stakeholders involved in the teaching and learning process. These recommendations can help improve the support for and implementation of integrated STEM and AI education, thereby improving student engagement, critical thinking, and problem-solving skills.

Data Availability: The data used to support the findings of this study are included within the article.

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