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Mind Map-Assisted STEM Integration to Enhance Students' Science Skills in the 21st Century: A Literature Review

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Abstract: Creative thinking skills help students develop new ideas and concepts, imagine, find interrelated relationships, and have multiple perspectives on something. If their creative thinking skills are lacking, students will face difficulties in solving problems or learning questions. Mind Mapping helps organize numbers, letters, words, ideas, concepts, and other items so that they are not lost shortly. This helps students understand and develop creative thinking in science learning in the 21st century. Where the purpose of the study is to examine the Integration of Mind MAP in STEM to Improve Students' Science Skills in the 21st Century: Literature Review. This review was conducted based on state-of-the-art methods using the guidelines for preferred reporting items for reviews and meta-analyses (PRISMA). The results of this study explain the Description of STEM Content (Science, Technology, Engineering, Mathematics); Benefits of the STEM Learning Method, namely (Improving Skills, Motivating Children, Self-Evaluation, Fun Learning, Important Pillars); Advantages of the Mind Mapping Learning Model (Can express opinions freely; Notes are more concise and clear; Easier to find notes if needed; Notes are more focused on the core material; Easy to see the overall picture; Disadvantages of the Mind Mapping Learning Model (It takes longer to "see" the relationship between one idea and another. Often, material that is just a repetition of what was previously overlooked).

Keywords: Mind map; Science; STEM

Introduction

In the modern era, the focus of learning is no longer on teachers; instead, students must be more involved in the learning process. Students must be able to learn with digital technology. This can improve the quality of student learning in the classroom. In addition, students will be more active and effective in absorbing lessons from teachers. To encourage the success of the learning process, student activity is very important. In the twenty-first century, Indonesia faces problems such as poor education services, poor quality of education, low standards of higher education, and less literate students. One of the government's efforts to overcome this problem is to improve the quality of learning (Tanta et al., 2023). Quality learning is very important for the progress of the country (Metekohy et al., 2022). Science learning is one of the subjects that must be studied in the twenty-first century (Osborne & Allchin, 2024). As a result, schools and educators can meet all students' needs to support students' science learning process (Darling-Hammond et al., 2020).

According to Montag-Smit et al. (2017), creative thinking can help solve problems by generating new ideas and solutions. According to Juliana et al. (2021) and Khessina et al. (2018), creativity is not only the ability to abstract and realize ideas into reality, but is also expected to be able to solve problems in creative

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ways. By abstracting their ideas and imaginations, they can think creatively and create thought patterns that they will apply in real life. Creative thinking skills have not been used well at this time (Busyairi et al., 2022; Forte-Celaya et al., 2021). This has an impact on the way creative teachers choose learning models. A lack of creative thinking skills can cause difficulties for students in solving problems. In addition, the lack of understanding and knowledge of educators on how to apply learning can lead to a lack of creative skills in students. There are no teaching materials specifically designed to encourage students to improve their creative skills. Learning models that allow students to solve problems, find new ideas, and think creatively can improve their creative thinking skills (Luthfia, 2024; Kholid et al., 2024).

Students will use their thinking skills to search, find, and use knowledge to understand concepts from the information learned during the learning process, which will result in changes in their personal development. Everyone who wants to be successful in their life must have the ability to think creatively. By thinking creatively, a person can develop or find original, aesthetic, and constructive ideas that are related to the perspective of the concept and emphasize aspects of intuitive and rational thinking. In addition, the use of technology-based learning media by teachers has limitations. Therefore, the Science, Technology, Engineering, and Mathematics (STEM) approach helps mind maps because it is the latest approach that can solve problems in the education process (Safitri, 2023; (Indriyani et al., 2022). The STEM approach also combines science, technology, engineering, and mathematics in learning activities so that it can solve problems. STEM learning helps improve the quality of student education with the help of mind maps that can be used to address students' cognitive levels.

Mind mapping is a visual method for mapping information that helps students recall lessons (Feng et al., 2023). As expressed by Buzzan, mind mapping is a learning model that aims to improve students' creative thinking skills by pouring out ideas or ideas that increase creativity in the brain. It is used to organize numbers, letters, words, ideas, concepts, and so on so that they are not lost soon. By using mind mapping, students can improve their ability to think creatively. One of the learning models called Mind Mapping asks students to create images or diagrams of key concepts that are interconnected with each other, which are indicated by curved lines connecting the parts. The purpose of this model is to help students improve their ability to think creatively when creating mind maps (Sun et al., 2022). To help students remember and understand various concepts or materials that are so broad, mind mapping is considered an ideal learning model. One way to train students in organizing information in learning is to train their ability to think creatively.

Previous research has been conducted (Razak et al., 2024), The Influence of the Science Technology Engineering and Mathematics Approach with Mind Maps on the Higher Order Thinking Skills (HOTS) of Students in Biology Learning Class X SMA N 4 Kerinci, (Sari & Murdiono, 2021) The Effect of the Implementation of Mind Mapping Method on Critical Thinking Skills in Civic Education Learning, but there has been no research that examines Mind Map Assisted STEM Integration to Improve Students' Science Skills in the 21st Century; literature review. Based on the literature review above, this study aims to examine Mind Map Assisted STEM Integration to Improve Students' Science Skills in the 21st Century; literature review.

Method

We conducted this study as a systematic review following the PRISMA guidelines. The PRISMA guidelines provide several things to consider in preparing a systematic review. In this study, we will focus on several key things: focus on 21st-century learning; Augmented Reality has several advantages and disadvantages in utilization of Augmented Reality. This helps to form the basis of our assessment. Initially, we collected the latest studies on Mind Map Assisted STEM Integration to Improve Students' Science Skills in the 21st Century, based on several selected keywords. Then, we applied eligibility criteria to the collection. We only selected literature published in 2015 or later to provide an overview of current trends. In addition, we limited the type of literature to literature in the form of journals and proceedings.

Result and Discussion

Preferred Reporting Items for Systematic Reviews (PRISMA) is the reporting technique used in this study. The study was conducted methodically during the required research stages. The information provided is comprehensive and unbiased and aims to combine relevant research results. The steps of a systematic literature review include developing a research question, searching the literature, screening and selecting relevant articles, screening and selecting the best research results, analyzing, synthesizing qualitative results, and preparing a research report. Writing the background and objectives of the study, collecting research questions, searching the literature, selecting articles, extracting articles, assessing the quality of basic studies, and summarizing the material are the steps in the systematic literature review research process.

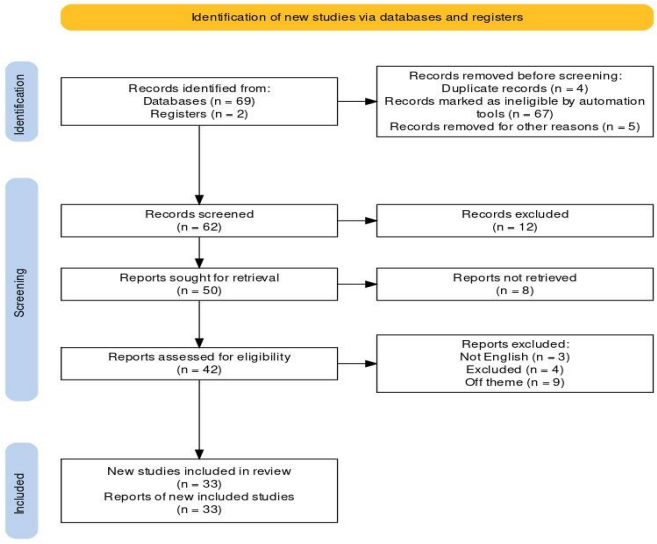

Figure 1. Literature search process flow based on PRISMA guidelines

Full article published in international journal 2015-2023, indexed in database, and themed Mind Map Assisted STEM Integration to Improve Students' Science Skills in the 21st Century; literature review.

One of the new learning approaches that emerged in the Industrial Revolution 4.0 Era is the STEM approach, which stands for Science, Technology, Engineering, and Mathematics. This approach is defined as learning that combines four disciplines, namely Science, Technology, Engineering, and Mathematics, with a focus on the learning process that explores two or more fields that actively involve students. In addition, Roberts and Bybee argue that the four fields of science integrated in STEM must function as a holistic whole. Students' ability to read, write, observe, and do science and the ability to apply these abilities in solving everyday problems related to the STEM fields are the learning objectives of the STEM approach. In the context of elementary and secondary education, STEM Education aims to develop students who understand STEM and who have: Knowledge, attitudes, and skills in solving real-world problems, designing, explaining natural phenomena, and concluding based on existing evidence regarding STEM; Understanding the characteristics of STEM as investigation, knowledge, and design that are put forward; The material, intellectual and cultural environment is shaped by awareness of STEM disciplines; Engaging in STEM studies, constructive and reflective using ideas from science, technology, engineering and mathematics.

Table 1. Stem Content Description

Source	STEM Content Description
Nursafitri & Anriani (2023), Kelley & Knowles (2016)	Science (In the form of facts, concepts, procedures about science that will be studied)
Oschepkov et al. (2022), Hu et al. (2024)	Technology (In the form of technology used and or developed)
Zulirfan & Yennita (2022), Barak et al. (2024), Chiarello et al. (2021)	Engineering (Engineering activities: what products are designed, tools and materials needed, testing product optimization, evaluating product results, etc.)
Deeken et al. (2020), Ye et al. (2023), Gravemeijer et al. (2017), Lin et al. (2021)	Mathematics (Mathematical activities required in calculations, such as mathematical concepts applied, and theorems required)

STEM education aims to develop students who understand STEM and who have: Knowledge, attitudes, and skills in solving real-world problems, designing, explaining natural phenomena, and concluding based on existing evidence about STEM; Understanding the characteristics of STEM as inquiry, knowledge, and design that is put forward; The material, intellectual and cultural environment is shaped by awareness of STEM disciplines; Engaging in STEM studies as caring, constructive and reflective citizens using ideas from science, technology, engineering and mathematics. STEM is a learning approach that is considered by the spirit of the 2013 Curriculum.

Table 2. Benefits of STEM Learning Methods

Source	Benefits of STEM Learning Methods
Debora & Pramono (2021), Ichsan et al. (2023), Istiana et al. (2023)	Improve Skills
Bayanova et al. (2023), Leung (2023), Caspi et al. (2023)	Motivate Children
Karakaya & Yılmaz (2022), Khoiri (2019), Chen et al. (2024)	Self-Evaluation
Permanasari et al. (2024), Mou (2024), Hsiao & Su (2021)	Fun Learning
Astawan et al. (2023)	Important Pillars

It is hoped that STEM learning will help Indonesian students acquire modern skills, such as critical thinking, innovation, creativity, problem-solving, cooperation, and collaboration. Several elements of STEM should be emphasized when teaching. These include asking questions and providing explanations about problems; developing and using models; designing and conducting research; interpreting and analyzing data;

using mathematical and computational thinking; making explanations and designing solutions; participating in argumentation activities based on existing evidence; and providing information, assess, and conveying.

Benefits of STEM Learning Methods
Improving Skills

STEM methods involve students in problem-solving, analysis, group collaboration, and discussion. This helps improve critical thinking, problem-solving, teamwork, and communication skills which are important in the professional world.

Motivating Children

STEM methods offer interesting and relevant learning experiences for children. By connecting learning to real-world contexts and providing opportunities to create, explore, and find solutions. This method can motivate children to learn and develop their interests in STEM fields.

Self-Evaluation

STEM methods provide benefits for learning and teachers' ability to evaluate student progress. Through project-based or problem-solving tasks, students can directly see their progress, get feedback, and improve their skills and understanding.

Fun Learning

By incorporating aspects of art into STEM methods, such as modeling or creative design, learning becomes more fun and interesting for students. This helps create a positive learning atmosphere, increase student engagement, and encourage creativity in STEM problem-solving.

Important Pillars

The STEM method includes collaboration, character building, communication, critical thinking, and creativity as 5 important pillars of learning. Collaboration in teams strengthens social skills and teamwork, character building involves ethical values and responsibility, communication is important in sharing ideas and solving problems, critical thinking is needed to analyze and evaluate information, and creativity is needed to generate innovative solutions in STEM.

Table 3. Strengths and Weaknesses of the Mind Mapping Learning Model

Source	Advantages and Disadvantages of Mind Mapping Learning Model
Fadillah (2019), Hanggrasawani et al. (2024), Ayu Maharrany et al. (2022), Sekarini et al. (2020), Lubna & Kumala (2023), Naibaho (2022)	Advantages of Mind Mapping: Can express opinions freely; Notes are more concise and clear; Easier to find notes if needed; Notes are more focused on the core of the material; Easy to see the picture as a whole; Makes the brain organize and remember; Compare and make connections; Facilitates the addition of new information and each map is unique; A new way for students to learn and practice quickly and effectively; How to make notes so that it is not boring for students, teachers must ask students to create a work of art by drawing a mind map to improve the results of the students.
Mashudi & Pristine Adi 2024), Polat & Aydın (2020), Ma et al. (2022)	Disadvantages of Mind Mapping: It takes longer to "see" the relationship between one idea and another. Often, the material that is just a repetition of the previous one escapes attention. As if the new material is in a different section or chapter. This is also experienced by children, especially those who are less diligent and attentive. They may work on the same material without remembering having worked on it before; Time is wasted just to find key reminders or important words, especially if the writing is tight, it cannot make the important words stand out unless they are underlined; Another disadvantage of the general note-taking system is that it is contrary to the way the brain works. Every time an idea is thought of, the idea is put on a page and then forgotten because it continues to the next page, the key reminders are separated from each other so that the relationship is not visible. That way, linear notes will be more "friendly". For people who tend to be left-brained than right-brained; Time is also wasted just to write down words that have nothing to do with memory or reread the same words and are not needed (estimated waste). Moreover, usually only one or two colors are used (usually using pencil, black or blue pen) so that it is not interesting when reread.

The mind mapping model is a diagram used to present words, ideas, tasks, or something else that is linked and arranged around the main idea keyword. In learning activities using mind mapping, this learning is very suitable for reviewing students' initial knowledge using syntax such as competency information, problem presentation, open, students in groups to respond and create various alternative answers, presentation of group discussion results, students make conclusions from the results of each group, evaluation, and reflection. Based on the description above, it can be seen that the mind mapping model is a method designed by

teachers to help students in the learning process, store information in the form of lesson materials received by students during learning, and help students organize the most important cores of the lesson material into maps or graphs so that students understand it more easily.

The application of the mind mapping learning model has advantages, including expressing opinions freely; Notes being denser and clearer; Easier to find notes if needed; Notes being more focused on the core of the material; and Easy see the picture as a whole; Makes the brain organize and remember; Compare and make connections; Facilitates the addition of new information and each map is unique; A new way for students to learn and practice quickly and effectively; How to make notes so that they are not boring for students, teachers must ask students to create a work of art by drawing a mind map to improve the results of these students. Weaknesses of Mind Mapping: It takes longer to "see" the relationship between one idea and another. Even often the material that is just a repetition of the previous one escapes attention.

As if the new material is in a different section or chapter. This is also experienced by children, especially those who are less diligent and attentive. They could be working on the same material without remembering having worked on it before; Time is spent just looking for key reminders or important words, especially if the writing is tight, it cannot make the important words stand out unless they are underlined; Another disadvantage of the general note-taking system is that it is contrary to the way the brain works. Every time an idea is thought of, the idea is put on a page and then forgotten because it continues to the next page, the key reminders are separated from each other so that the relationship is not visible. That way, linear notes will be more "friendly". For people who tend to be left-brained rather than right-brained; Time is also wasted just to write down words that have nothing to do with memory or reread the same words and are not needed (estimated waste). Moreover, usually only one or two colors are used (usually using pencils, black or blue pens) so that it is not interesting when reread.

Conclusion

The use of technology-based learning media by teachers has limitations. Therefore, the Science, Technology, Engineering, and Mathematics (STEM) approach helps mindmap because it is the latest approach that can solve problems in the education process. One of the learning models that can be used as an alternative to improve student learning outcomes is the mind mapping model. The mind-mapping learning model requires students to be responsible for the problems they face and is directed not to depend entirely on the teacher so that active, independent, and creative students will be formed. STEM Integration Assisted by Mind MAP to Improve Students' Science Skills in the 21st Century is urgently needed.

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Author Contributions
Conceptualization, P. N.; methodology, R. M.; validation, S; formal analysis, R. A.; investigation, P. N..; resources, R. M.; data curation, S.: writing—original draft preparation., R. A.; writing—review and editing, P. N.; visualization, R. M. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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