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# Literature Review: The Effect of Science, Technology Engineering, Arts, and Mathematics (STEAM)-Based Worksheet to Improve Learners Creativity in Physics Learning

**Indri Maya Ariana[1*], Binar Kurnia Prahani[1], Dwikoranto[1], Muhammed Akif Kurtuluş[2]**

[1]State University of Surabaya, Surabaya, Indonesia
[2]Alanya Alaaddin Keykubat Üniversitesi, Alanya, Turkey

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**ABSTRACT**

***Objective:*** *So far, students are limited by the use of teaching materials such as package books or textbooks as one of the available learning resources. The main problem that arises is the lack of availability of STEAM-oriented Learner Worksheet teaching materials that can arouse students' creativity. This research aims to conduct a literature review related to the effect of science, technology, engineering, arts, and mathematics (STEAM)-based Worksheet to improve students' creativity in physics learning.* ***Method:*** *The research method used is literature review or literature study. The secondary data used in this study came from national and international articles indexed by Google Scholar, DOAJ, and Scopus totaling 21 articles with a time span of 2019 to 2024.* ***Results:*** *From this research, it is concluded that, showing that the Science, Technology, Engineering, Arts, and Mathematics (STEAM)-based Learner Worksheet has a significant effect on increasing student creativity in physics learning. STEAM-based Worksheet is considered valid, practical, and effective in supporting 21st century learning that involves critical thinking, creativity, problem solving, and collaboration.* ***Novelty:*** *Thus, the use of STEAM methods in education, especially through the development of STEAM-oriented Learner Worksheets in Indonesia, continues to show a positive impact in improving students' critical thinking and creative thinking skills, as well as strengthening science and technology literacy.*

## INTRODUCTION

Education today increasingly emphasizes the importance of developing learners' creativity in learning, especially in science fields such as physics as an effort for learners to face the challenges of the 21st century (Novitra, 2021). According to the Organization for Economic Co-operation and Development (OECD), creativity and creative thinking are considered the most important skills for learners in 2030 (Vincent-Lancrin et al., 2019). Learning tools such as Learner Worksheets can play a supporting role in the learning process with the aim of increasing the interactive relationship between teachers and students which will ultimately have an impact on increasing student creativity (Tukan, 2020). The use of Science, Technology, Engineering, Arts, and Mathematics (STEAM) oriented Learner Worksheets is expected to be an effective learning media to stimulate learner creativity. Arsy & Syamsulrizal's research (2021) shows that the STEAM approach improves students' knowledge competence and creativity.

An innovative learning approach called STEAM (Science, Technology, Engineering, Arts, and Mathematics) combines the fields of science, technology, engineering, arts, and mathematics, this learning approach allows learners to gain meaningful learning experiences (Haifaturrahmah et al., 2020). This approach can also encourage learners to use creativity in solving problems (Estriyanto, 2020). However, STEAM-based learning

is rarely applied in schools, this is due to the lack of training and introduction to STEAM learning. The results of the analysis show that 66.67% of teachers do not know STEAM-based learning and how to implement it (Haifaturrahmah et al., 2020). Teachers still apply a learning approach that emphasizes understanding concepts, principles, and theories, but does not equip students with creative thinking skills, thus reducing students' creativity (Darling-Hammond, 2019; Rahmawati, 2019). The low level of creative thinking skills is due to the use of lecture learning models that make students as listeners without involving students in active participation (Primadoniati, 2020). In addition, learning strategies usually focus on developing analytical thinking with ordinary problems, so creative thinking is rarely emphasized in the learning process (Prafitasari, 2021; Suhirman, 2021).

To create good learning, teaching materials must be in accordance with the material taught so that students' thinking skills develop (Haifaturrahmah et al., 2020). So far, students are limited by the use of teaching materials such as package books or textbooks as one of the available learning resources. Books tend to be informative and subject matter is given broadly and generally, so that learning in the classroom is teacher centered, students also lack varied learning resources (Puspita, 2019). In addition, the use of Worksheets teaching materials in some schools has not been fully structured (Ramli, 2020). Learner Worksheets ideally include clarity of material division, clear numbering, title, learning guidelines, competencies, supporting information, tasks and procedures, and evaluation (Umar, 2022). The main problem that arises is the lack of availability of STEAM-oriented Learner Worksheets teaching materials that can arouse students' creativity, while the Learner Worksheets is still STEM-oriented (Lock, 2019).

Previous research states that 6C skills are the skills needed in the 21st century. The term 6C includes the ability of Critical Thinking, Creativity, Collaboration, Communication, Character, and Citizenship. These 6C skills are important competencies that need to be developed in the learning process of students to prepare them for the challenges of life in the future (Rochmah, 2023). So that STEAM-based teaching materials are needed to help learners achieve this ability, along with the findings that the STEAM approach also has a positive effect on increasing creative thinking (Prameswari, 2020; Bassachs, 2020). In line with that, Herlina, Ramlawati, and Hasri (2022) developed a STEAM-based E-LKPD saying that the E-LKPD is valid and can be used to increase students' creativity. Therefore, it is hoped that there will be further studies on STEAM-based Learner Worksheets to generate student creativity in physics learning (Yuntiaji, 2020).

Based on the information mentioned above, the purpose of this research is to analyze from literature studies the effect of Science, Technology, Engineering, Arts, and Mathematics (STEAM)-oriented Learner Worksheets to increase students' creativity in physics learning so as to create more meaningful and memorable learning. The use of STEAM-oriented student worksheets provides additional value compared to STEM-oriented student worksheets, because in addition to integrating science, technology,

engineering, and mathematics, it also includes elements of art to encourage students to develop creativity through innovative learning experiences.

## RESEARCH METHOD

The research method used is literature review or literature study (Dawana et al., 2022). Literature review is a type of research that uses existing resources in libraries, such as documents, magazines, books, and historical records to obtain data (Sugiyono, 2019). The secondary data used in this study came from national and international articles indexed by Google Scholar, DOAJ, and Scopus totaling 21 articles with a time span of 2019 to 2024. Researchers collected data related to the effect of science, technology, engineering, arts, and mathematics (STEAM)-oriented Learner Worksheets to improve student creativity in physics learning. The data analysis method consists of planning, implementation, and synthesis stages which are the three main stages of the literature review. In the first stage, the planning stage, involves determining the research protocol including research motivation, research questions that must be answered. In this case, the researcher aims to obtain findings that are the focus of the research. Second, the implementation stage involves the collection of all data items which are then identified important data or information in the literature that is considered necessary to achieve quality research results. Third, the synthesis stage involves the extracted data being analyzed and interpreted to answer the research questions, and to gain useful insights from the research (Quin, 2023). General background of research, general background of research, general background of research, general background of research, general background of research, general background of research, general background of research, general background of research, general background of research, general background of research, general background of research.

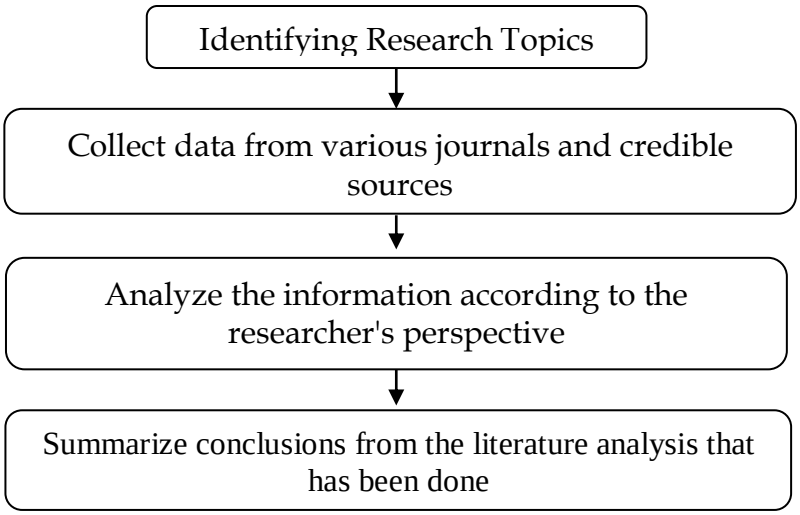


**Figure 1.** Systematic literature review diagram.

## RESULTS AND DISCUSSION

### *Results*

The articles used as a literature review are articles published from the range of 2019 - 2024. The articles analyzed discuss the application of Science, Technology, Engineering, Arts, and Mathematics (STEAM)-oriented approaches and Learner Worksheets in education. In addition, the article emphasizes how the STEAM approach can enhance learners' creativity by enabling them to acquire cross-disciplinary skills and be able to solve problems innovatively. Based on the results of the article analysis, the following data were obtained. Analysis of 20 articles explaining the Effect of Science, Technology, Engineering, Arts, and Mathematics (STEAM) Based LKPD to Improve Learners' Creativity in Physics Learning Table 1.

**Table 1.** Synthesis analysis of literature search

| No. | Author's Name | Journal Name | Article Tittle | Result |
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| 1 | Cathérine Conradt y dan Franz Xaver Bogner | Smart Learning Environments (2020) | STEAM teaching professional development works: effects on students' creativity and motivation | Appropriate teaching materials provided to teachers in the STEAM-oriented learning process show successful influence on learners' creativity and self-efficacy. Creativity in education promises to develop schools that fulfill modern ideas about learning and success (National Research Council) [NRC]. |
| 2 | José-Antonio Marín Marín, Antonio-José Moreno-Guerrero, Pablo Dúo-Terrón dan Jesús López Belmonte | International Journal of STEM Education (2021) | STEAM in education: a bibliometric analysis of performance and co-words in Web of Science | STEAM studies have an established and strong line of research over time. In addition, the study topics on STEAM include points related to gender differences, the influence of STEAM on people of different races, the skills developed by students, and training teachers to implement the teaching and learning process with the STEAM approach. |
| 3 | Kinanti Andartiani Sri Sulistyor Yuli Kurniawat S Pranoto | International Journal of Research and Review Vol. 9; Issue: 1; January (2022) | Electronic Development of Student Worksheets Based on Science, Technology, Engineering, Art, and Mathematics to Improve Creative Thinking Ability of Class V | The results of this study indicate that the development of STEAM-based student worksheets (Science, Technology, Engineering, Art, and Mathematics) can improve the creative thinking skills of grade V elementary school students in science learning. The results of this study also show that the STEAM student worksheets developed have high validity, effectiveness, and practicality in improving students' creative thinking skills. The results of this study also show that STEAM student worksheets can be used as an effective learning tool in |

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| | | | Elementary School Students in Science Learning | improving students' creative thinking skills, and can assist teachers in activating the student learning process and improving student learning outcomes. |
| 4 | Farida Nursyahidah & Eko Retno Mulyaningrum | Kalamatika: Jurnal Pendidikan Matematika Volume 7, No. 2, (2022) | The Impacts Of Stem On Mathematics And Science Through Lesson Study: A Systematic Literature Review | The results of this study indicate that the use of the STEM approach through lesson study has a positive impact on teachers and students. Positive impacts for teachers include improving lesson quality and professional competence, as well as improving critical and creative thinking skills, information technology skills, life and career skills, problem solving skills, basic questioning skills, learning achievement, science literacy skills, concept understanding, and motivation. As for students, positive impacts include improving critical thinking skills, creative thinking skills, information technology skills, life and career skills, problem solving skills, basic questioning skills, learning achievement, science literacy skills, concept understanding, and motivation. |
| 5 | Arina Zaida Ilma, Insih Wilujeng, Asri Widowati Muhammad Nurtanto Nur Kholifah | Pegem Journal of Education and Instruction, Vol. 13, No. 2, (2023) | A Systematic Literature Review of STEM Education in Indonesia (2016-2021): Contribution to Improving Skills in 21st Century Learning | The results of this study show that the implementation of STEM or STEAM education in Indonesia helps students in solving problems, drawing conclusions, and applying their knowledge. In addition, this study also showed that STEM or STEAM education can improve students' critical thinking and logical thinking skills, as well as improve science and technology literacy. |
| 6 | Y S Sari, M Selisne and R Ramli | Journal of Physics: Conference Series (2019) | Role of students worksheet in STEM approach to achieve competence of physics learning | The results of this study contain authors who show that the use of student worksheets with a STEM approach can improve student motivation, learning activities, creative thinking skills, concept mastery, and overall learning competence in physics. The application of STEM in education has shown positive effects on students' critical thinking ability, curiosity, problem-solving skills, and interest in STEM subjects. |
| 7 | Adelia Dwinta Pramashela Hadi Suwono Sulisetijono | Bioedukasi Jurnal Biologi dan Pembelajarannya (Vol.21 | The Influence of Project-based Learning Integrated STEAM on the Creative | This study shows that project-based learning integrated with the STEAM approach can improve students' creative thinking skills, particularly in the context of ecosystems. Students created pop-up books on biogeochemical cycles and |

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| | Ucik Agusti Wulanningsih | No2, June 2023, pp 138-143) | Thinking Skills | showed improvement in their knowledge and creativity. The PBL-STEAM approach is more effective in improving creative thinking skills compared to conventional teaching methods. This study highlights the importance of developing thinking strategies and problem-solving skills in students through collaborative, hands-on projects. |
| 8 | Pradnya Parameswari Suyatno Sutoyo Utiya Azizah | Indonesian Journal Of Educational Research and Review, VOL. 6 NO. 2: JULY (2023) | Scoping Literature Review of STEM Research in Indonesia in Improving Critical Thinking Skills and Concepts Mastery | A literature review of STEM research in Indonesia revealed a focus on improving critical thinking skills and concept mastery in subjects such as chemistry, physics, biology and science. The research methods used predominantly used experimental approaches and STEM integration with project-based learning (PBL) and problem-based learning (PjBL) models. Future research recommendations include exploring alternative methods and models for STEM integration to further improve learning outcomes. Overall, this review underscores the importance of incorporating STEM principles in education to improve students' critical thinking skills and overall learning achievement. |
| 9 | A Solihin, F C Wibowo and I M Astra | Journal of Physics: Conference Series, Volume 2019, The 10th National Physics Seminar (SNF 2021) | Review of Trends Project Based Learning (PjBL) Integrated STEM in Physics Learning | This study highlights the growing use of STEM-integrated Project-Based Learning (PjBL) in physics education, focusing on its effectiveness and impact on student outcomes. Analyzing 80 journal articles with VOSviewer, the research identified trends such as the emphasis on project design, environment, implementation, and learning outcomes. The integration of diverse learning media, especially online platforms and worksheets, has become increasingly popular to enhance STEM-integrated PjBL. Further research is recommended to optimize its effectiveness and improve learning outcomes in physics education. |
| 10 | Irdalisa Zulherman Mega Elvianasti Sri Adi Widodo Erlia Hanum | International Journal of Educational Methodology Volume 10, Issue 1, 923 – 935 | Effectiveness of Project-Based Learning on STEAM-Based student's worksheet analysis With | The results of this study indicate that the use of STEAM-based Student Worksheets with ecoprint techniques increases students' learning motivation and creativity compared to conventional Student Worksheets. The integration of PBL with STEAM-based Student |

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| | | (2024) | Ecoprint Technique | Worksheets helps students engage in project planning, independent learning, active exploration, and collaborative work, leading to higher levels of motivation and creativity. This study recommends further research with a larger sample size and qualitative approach to explore the impact of PBL on STEAM based Student Worksheets with ecoprint technique. Teachers are encouraged to use innovative worksheets to enhance student engagement and learning in biology education. |
| 11 | Siti Suryaningsih Riska Nurlita | Vol. 2 No. 07 (2021): Jurnal Pendidikan Indonesia (Japendi) | The Importance of Innovative Electronic Learner Worksheets (E-LKPD) in the 21st Century Learning Process | The article contains several concepts of the importance of developing innovative Electronic Learner Worksheets (E-LKPD) in the 21st century learning process. Innovative E-LKPD is needed to meet the demands of 21st century learning, such as the need for teaching materials, practicum, reasons for boredom, technological developments, and the impact of the pandemic. The use of appropriate learning methods also affects student learning outcomes and skills in science. In the context of the industrial revolution 4.0, technology is key in education, especially in dealing with online learning during the pandemic. Therefore, the development of innovative E-LKPD based on ICT, STEM, PBL, and STEAM Project is needed to improve students' critical and creative thinking skills and strengthen education in this digital era. |
| 12 | Fitria Lafifa Dadan Rosana Suyanta Suyanta Sabar Nurohman Sri Rejeki Dwi Astuti | International Journal of STEM Education for Sustainability, Vol 3, No.2, (2023) | Integrated STEM Approach to Improve 21st Century Skills in Indonesia: A Systematic Review | Research results show that the STEM approach in science learning in Indonesia has had a significant positive impact in improving 21st century skills in students. By using the STEM approach, learning becomes more effective, with a 35% higher success rate compared to other approaches. Learning models such as problem1based learning (PBL) and project-based learning (PjBL) integrated with STEM have proven successful in improving students' problem-solving skills, collaboration, learning motivation, critical thinking and creativity. In addition, the use of STEM-integrated learning media also contributes to improving students' understanding and |

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| | | | | their ability to find solutions to problems. However, the success of STEM learning is also influenced by several factors, such as gender, socioeconomic status and the digital divide. Overall, this study shows that the STEM approach has great potential to enhance science learning and develop 21st century skills that are essential for student success in the modern era. |
| 13 | Pardimin Ana Fitrotun Nisa Nurul Hikmah | Jurnal Ilmiah Sekolah DasarVolume 7, Number 2, (2023) | Learning Design Innovation Based on Tri N and STEAM in Developing 21st Century Skills for Elementary School Students | This research produced a learning design innovation consisting of lesson plans, student worksheets, and assessment sheets integrated with the Tri N and STEAM approaches. This development was carried out based on a needs analysis which showed that 39.3% of the learning process had not integrated 21st century skills in the learning process. The results of the needs analysis also show that this happens because 23% of teachers have not mastered how to integrate 21st century skills in the learning process. The needs analysis results also show that teachers have not developed learning tools that can optimize students' 21st century skills and 100% of these teachers need learning tools that can develop students' 21st century skills to the fullest. Based on the needs analysis above, a learning design that can develop 21st century skills is a learning design integrated with Tri N and STEAM. Researchers determined the learning materials, core competencies, and basic competencies based on the 2013 curriculum, as well as formulated appropriate competency achievement indicators. |
| 14 | Merri Sri Hartati Irmaning Rahayu Kashardi Kashardi | Cendikia : Media Jurnal Ilmiah Pendidikan, 14(2) (2023) pp. 75-81 | Critical Thinking Ability Using STEAM-Based PBL Learning at Junior High School Students | The main results of this study show that STEAM based Problem-Based Learning (PBL) is effective in improving students' critical thinking skills compared to conventional learning methods. In the pretest test, the experimental class that applied PBL STEAM had a lower average critical thinking ability than the control class. However, after the treatment, the experimental class showed a significant improvement in their critical thinking skills, while the control class had a lower improvement. The statistical |

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| | | | | test results also showed a significant difference between the experimental and control classes. Therefore, it can be concluded that STEAM based PBL is effective in improving students' critical thinking skills. |
| 15 | Anik Anekawati Jefri Nur Hidayat, Nabila Abdullah, Helliyatul Matlubah | Jurnal Pendidikan Sains Indonesia e-ISSN: 2615-840X p-ISSN: 2338-4379 (2021) | Structural Equation Modeling Multi-Group Of Science Process Skills And Cognitive In Pjbl Integrated Steam Learning | The conclusion of this study is that science process skills affect cognitive learning achievement in the learning process using the Project-based Learning (PjBL) model integrated with STEAM (Science, Technology, Engineering, Arts, Mathematics), and there is a difference in influence between groups of students with right and left brain dominance. |
| 16 | Samsi Nur Hidayati Sunyono Sunyono Lilik Sabdaningtya | Vol. 1 No. 3 (2021): International Journal of Educational Studies in Social Sciences | Inquiry-based E-LKPD in effort to improve the fourth grade students' learning outcome | e-LKPD as one of the teaching materials is needed by students to participate actively and creatively during classroom learning. To use teaching materials in the form of e1LKPD, a learning strategy is needed to support the learning process in the form of an inquiry model. The purpose of cognitive teaching is to prepare students in the process of knowledge transfer. The inquiry learning model is a series of learning activities that emphasize the thinking process to seek and find answers to a problem posed. In addition, the inquiry learning model has also been proven to improve critical thinking and student learning outcomes in science learning in elementary schools. Based on the literature, this inquiry model is suitable to be applied in the learning process to improve student learning outcomes. In conclusion, inquiry-based e1LKPD needs to be developed to improve student learning outcomes in elementary schools. |
| 17 | Edy Suprapto Ika Krisdiana Davi Apriandi Fitria Rizqy Yuanawati | Al-Ishlah: Jurnal Pendidikan Vol.15, 1 (March, 2023), pp. 549-564 | Development of Steam-C Integrated Student Worksheets to Improve Creative Thinking Ability on Flat Side Building Materials | This study concluded that the development of STEAM-C integrated student worksheets using the PjBL approach was effective in enhancing students' creative thinking. The worksheets demonstrated strong validity, with a validity percentage of 81%, meeting the required standards. They were also highly practical, achieving a practicality percentage of 97% in limited trials and 93% in field trials, proving their ease of application in the learning process. Moreover, the |

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| | | | | worksheets were highly effective, as shown by the N-Gain percentage of 86% in limited trials and 71% in field trials, reflecting significant improvements in students' understanding and skills. Observations further highlighted that the use of these worksheets actively fostered the development of students' creative thinking abilities. |
| 18 | Muhamma d Rizky Pratama, Ulya Fawaida, Rica Mae Guarin | Mudarrisa: Jurnal Kajian Pendidikan Islam, Vol. 15, No. 1, (2023) | Project-Based Learning in Elementary School: Influence on Students' Creative Thinking Ability | The results of this study reveal that the application of the Project-Based Learning (PjBL) model that has been implemented in the experimental class with six stages, starting from determining the project, designing the steps, preparing the project schedule, and completing the project with teacher guidance. Preparation of reports and presentations and evaluating project results. From the findings after "the PjBL model is applied through the making of Herbarium, all students in class IV A, totaling 26 students, can obtain a recapitulation of student scores in the Project-Based Learning assessment rubric as a whole can be seen in graph one as follows: Percentage Results of PjBL Learning. Graph 1 shows that all groups achieved 100% on the criteria of formulating the problem, determining the project, and determining the tools/materials; 83% on designing the experiment and making the project; 72% on cooperation; and 89% on presentation and report. The six-step project-based learning was well organized, and students were enthusiastic about it. |
| 19 | Kamilatul Khoiroh Bea Hana Siswati Kamalia Fikri | Proceeding of Internationa l Conference on Biology Education, Natural Science, and Technology, Vol. 1 (2023) | The Effect of STEM (Science, Technology, Engineering,and Mathematics) based Textbooks in Biotechnology Learning Material on The Critical Thinking Skills and Learning Results of Senior High School Students | The results showed that the use of STEM-based textbooks had a significant impact on various aspects of learning outcomes of grade XII students at SMAN 3 Jember. STEM-based textbooks positively influenced students' critical thinking skills, cognitive learning, affective attitudes and psychomotor skills. The experimental class showed significant improvement in all those dimensions compared to the control class. It was found that the use of STEM-based textbooks promoted substantial improvements in students' critical thinking skills, cognitive knowledge, positive attitude towards learning, and |

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| | | | in The Industrial Agriculture Area | psychomotor skills. These results emphasize the importance of integrating STEM elements in educational materials to improve overall student learning outcomes. |
| 20 | Putri Amelia Solihah Ida Kaniawati Achmad Samsudin R.Riandi | Indonesian Journal of Science & Technology 9(1) (2024) 163-190 | Prototype of Greenhouse Effect for Improving ProblemSolving Skills in Science, Technology, Engineering,and Mathematics (STEM)-Education for Sustainable Development (ESD): Literature Review, Bibliometric, and Experiment | This study used bibliometric analysis to gain insight into contemporary research trends related to the greenhouse effect and approaches to solving it. A total of 200 publications, ranging from 2013 to 2023, have been published on the topic of the greenhouse effect and its mitigation strategies. The evolution of research on the greenhouse effect and its solutions is depicted, showing that the number of studies conducted tends to increase from year to year, with the highest number of articles in 2023. The learning outcomes show a significant improvement in students' problem-solving ability related to the greenhouse effect after being treated using project-based learning. This learning method successfully increased students' interest and deepened their understanding of the subject matter. |
| 21 | I Gede Astawan Dewa Nyoman Sudana Nyoman Kusmariya tni I Gusti Ngurah Japa | Internationa l Journal of Innovation, Creativity and Change. www.ijicc.n et Volume 5, Issue 5, Special Edition: ICET Malang City, (2019) | The STEAM Integrated Panca Pramana Model in Learning Elementary School Science in The Industrial Revolution Era 4.0 | The main results of this study indicate that science education at the primary level needs to integrate the STEM/STEAM approach to prepare students for the challenges of the modern world. The implementation of STEM, which focuses on Science, Technology, Engineering and Mathematics, has been widely carried out in various developed countries to address the challenges of the industrial revolution 4.0. Research shows that implementing STEM in learning can improve students' academic and non academic achievement. STEM emphasizes cross disciplinary learning, integrating science, engineering, technology and mathematics in a real-world context to develop STEM literacy among students. |

### *Discussion*

Based on the results of the analysis of 21 articles related to the title "The Effect of Science, Technology, Engineering, Arts, and Mathematics (STEAM)-Based worksheets to Improve Learners' Creativity in Physics Learning", various studies show that providing appropriate and STEAM-oriented teaching materials can support the development of 21st century skills involving critical thinking, collaboration, and

innovation. By encouraging learners to think creatively and be confident in facing challenges, STEAM is in line with modern learning concepts that not only emphasize content mastery, but also build learners' character and competence to face a changing world (Conradty C, 2020). STEAM has a strong foundation and evolves to cover various dimensions, such as gender inclusiveness, ethnic background, learner skill development, and teacher training. This confirms that STEAM not only serves as a pedagogical approach, but also as a platform for creating inclusive and relevant learning (Marin et al., 2021). Research related to the development of STEAM-based student worksheets shows that this learning media has high validity, effectiveness and practicality in supporting students' creativity in learning (Andartiani K et al., 2022). The learner worksheets developed are not only able to encourage learner creativity, but also provide structured guidance for teachers in managing more meaningful learning (Nursyahidah F et al., 2022). The STEAM approach not only benefits the improvement of creativity and learning quality but also strengthens science literacy skills, technology, and higher order thinking skills (Ilma et al., 2023).

The use of STEM-based student worksheets in physics learning not only increases students' motivation and learning activities, but also boosts students' creative thinking skills, problem solving, and interest in STEM subjects. The application of STEM has been proven effective in encouraging curiosity and strengthening critical thinking skills needed to solve complex problems (Sari et al., 2019). Project-based learning integrated with STEAM can improve students' creative thinking skills, students not only gain knowledge, but also develop higher creativity compared to conventional learning methods (Pramashela et al., 2023). In addition to project-based learning (PjBL), problem-based learning (PBL) with STEM integration can improve learners' critical thinking skills and concept mastery (Parameswari et al., 2023). By utilizing various learning media, the STEM approach is increasingly effective in improving student learning outcomes (Solihin et al., 2021). All these findings underscore the importance of incorporating various innovative STEAM and STEM-based learning approaches, including PBL and PjBL, to increase learner engagement, develop critical and creative thinking skills, and prepare learners with skills relevant to global challenges (Irdalisa et al., 2024).

The development of innovative STEM or STEAM-based learner worksheets can meet the needs of learning in the digital era and industrial revolution 4.0. This shows that the development of technology-based teaching materials is an essential step to support 21st century education (Suryaningsih et al., 2021). STEM and STEAM approaches have also proven effective in improving 21st century skills in learners. With learning models such as Project-based Learning (PjBL) and Problem-based Learning (PBL). The success of this approach is inseparable from external factors such as the digital divide and the socioeconomic status of learners, which need further attention to optimize its application (Lafifa et al., 2023). To achieve optimal learning outcomes, it is necessary to analyze the needs that are prioritized in implementing a STEAM-based approach (Pardimin et al., 2023). STEAM-based problem-based learning (PBL) is effective in significantly improving students' critical thinking skills. The difference can be seen in the experimental and control classes, where the STEAM-based approach succeeded in encouraging students to think deeply in solving problems (Hartati et al., 2023). Apart from critical thinking, there are science process skills and cognitive abilities of students that improve after being treated with a STEAM-based approach (Anekawati et al., 2021).

The development of e-worksheets also plays an important role in assisting learning that utilizes modern technology to increase learner involvement in the learning process (Hidayati et al., 2021). The validity, practicality, and effectiveness of e-worksheets provide evidence that the integration of art elements into STEM can enrich students' learning experience, especially in learning (Suprapto et al., 2023). The practicality of the learner worksheet is suitable for use in implementing the PjBL learning model, through this project it can increase students' enthusiasm, collaboration skills, and mastery of material (Pratama et al., 2023). Project-based learning not only improves learners' understanding of global issues, but also increases their interest and involvement in the learning process (Solihah et al., 2024). Khoiroh (2023) revealed the importance of developing STEM-based teaching materials to support holistic learning that is relevant to the needs of the modern era. STEM/STEAM integration prepares learners to face the challenges of the modern era. STEAM shows great potential in creating meaningful learning experiences, fostering science literacy, and developing 21st century skills (Astawan et al., 2021).

Based on the results of the analysis of 21 articles related to the title "The Effect of Science, Technology, Engineering, Arts, and Mathematics (STEAM)-Based worksheets to Improve Learners' Creativity in Physics Learning", research results were obtained which showed that Science, Technology, Engineering, Arts, and Mathematics (STEAM)-based worksheets had an influence on students' creativity in physics learning. Various studies have shown that teaching materials such as worksheets that are appropriately provided to teachers in the STEAM-oriented learning process show their successful influence on student creativity. STEAM-based student worksheets can be used as an effective learning tool in improving students' creative thinking skills, and can assist teachers in activating the learning process of students and improving student learning outcomes. STEAM-integrated Learner Worksheets have high validity, practicality, and effectiveness in improving students' creative thinking skills. These studies contribute to the development of innovative teaching materials such as STEAM-based worksheets that are relevant to the challenges of modern education. Further research can be done by optimizing STEAM-based worksheets in various regions to evaluate its scalability and effectiveness.

## CONCLUSION

**Fundamental Finding:** The results of the analysis of 21 articles on the effect of science, technology, engineering, arts, and mathematics (STEAM)-based worksheets to improve students' creativity in physics learning show that the Science, Technology, Engineering, Arts, and Mathematics (STEAM)-based Learner Worksheet has a significant effect on increasing students' creativity in physics learning. STEAM-based worksheets is considered valid, practical, and effective in supporting 21st century learning that involves critical thinking, creativity, problem solving, and collaboration. In addition, the STEAM approach consistently shows positive results in strengthening science literacy, technology, and higher order thinking skills. **Implication:** The development of STEAM-based teaching materials, such as worksheets, is a relevant strategy in facing the challenges of the modern era, especially in improving 21st century skills in students. **Limitation:** Although this research highlights the advantages of STEAM-based worksheets, there are still limitations in its implementation, especially in the digital

divide and the socioeconomic status of learners. Some studies do not fully explore the application of STEAM in areas with limited access to technology or in different cultural contexts. **Future Research:** Future research needs to focus on optimizing the application of STEAM-based Learner Worksheets by testing their effectiveness in various regions with different socioeconomic backgrounds and technological infrastructure.

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**REFERENCES**

Andartiani K, Sulistyorini S, S Pranoto YK. (2022). Electronic development of student worksheets based on science, technology, engineering, art, and mathematics to improve creative thinking ability of class v elementary school students in science learning. *Int J Res Rev*, *9*(1), 142-150. doi:10.52403/ijrr.20220119

Anekawati A, Hidayat JN, Abdullah N, Matlubah H. (2021). Structural equation modeling multi-group of science process skills and cognitive in PjBL integrated STEAM learning. *J Pendidik Sains Indonesia*, *9*(3), 512-527. doi:10.24815/jpsi.v9i3.20447

Arsy, I., & Syamsulrizal. (2021). Pengaruh pembelajaran STEAM (Science, Technology, Engineering, Arts, and Mathematics) terhadap kreativitas peserta didik. *Biolearning Jurnal*, *8*(1), 24–26. https://doi.org/https://doi.org/10.36232/jurnalbiolearning.v8i1.1019

Astawan IG, Sudana DN, Kusmariyatni N, Japa IGN. (2019). The STEAM integrated panca pramana model in learning elementary school science in the industrial revolution era 4.0. *Int J Innov Creat Chang*, *5*(5), 26-39.

Bassachs, M., Cañabate, D., Nogué, L., Serra, T., Bubnys, R., & Colomer, J. (2020). Fostering critical refection in primary education through STEAM approaches. *Education Sciences*, *10*(12), 384. https://www.mdpi.com/2227-7102/10/12/384

Conradty, C., & Bogner, F. X. (2020). STEAM teaching professional development works: effects on students' creativity and motivation. *Smart Learning Environments*, *7*(1). https://doi.org/10.1186/s40561-020-00132-9

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2019). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 1-44.

Dawana, I. R., Setyarsih, W., Suprapto, N., & Dwikoranto, D. (2022). The effectiveness of virtual class-based e-learning with video-assisted google classroom as a physics learning media (2016-2020). *Momentum: Physics Education Journal*, *6*(2), 188–198.

Estriyanto, Y. (2020). Menanamkan konsep pembelajaran berbasis STEAM (Science, Technology, Engineering, Art, And Mathematics) pada guru-guru sekolah dasar.

*Jurnal Ilmiah Pendidikan Teknik Kejuruan*, *13*(2), 68–74. https://doi.org/https://dx.doi.org/10.20961/jiptek.v 13i2.45124,

Haifaturrahmah, Hidayatullah, R., Maryani, S., & Nurmiwati. (2020). Pengembangan lembar kerja siswa berbasis STEAM untuk siswa sekolah dasar. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran, Dan Pembelajaran*, *6*(2), 310–318. https://doi.org/https://doi.org/10.33394/jk.v6i2.2604

Hartati MS, Rahayu I, Kashardi K. (2023). Critical thinking ability using STEAM-based PBL learning at junior high school students. *Cendikia Media J Ilm*. *14*(2), 75-81.

Herlina, Ramlawati, & Hasri. (2022). Pengembangan perangkat pembelajaran elektronik berbasis STEAM untuk meningkatkan minat dan hasil belajar. *Chemistry Education Review*, *5*(2), 198–206. https://doi.org/https://doi.org/10.26858/cer.v5i2.13315

Hidayati SN, Sunyono S, Sabdaningtyas L. (2021). Inquiry-based E-LKPD in effort to improve the fourth grade students' learning outcome. *Int J Educ Stud Soc Sci*, *1*(3), 129-132. doi:10.53402/ijesss.v1i3.28

Ilma AZ, Wilujeng I, Widowati A, Nurtanto M, Kholifah N. (2023). A systematic literature review of STEM education in Indonesia (2016-2021): Contribution to improving skills in 21st century learning. *Pegem Egit ve Ogr Derg*, *13*(2), 134-146. doi:10.47750/pegegog.13.02.17

Irdalisa I, Zulherman Z, Elvianasti M, Widodo SA, Hanum E. (2024). Effectiveness of project-based learning on STEAM-based student's worksheet analysis with ecoprint technique. *International Journal of Educational Methodology*, *10*(1), 923-935. doi:10.12973/ijem.10.1.923

Khoiroh, K., Siswati, B. H., & Fikri, K. (2023). The effect of STEM (Science, Technology, Engineering, and Mathematics) based textbooks in biotechnology learning material on the critical thinking skills and learning results of senior high school students in the industrial agriculture area keywords: Biotechnology critical thinking skills learning outcomes STEM-based textbooks. *In Natural Science, and Technology*, *1*(1).

Lafifa F, Rosana D, Suyanta S, Nurohman S, Dwi Astuti SR. (2023). Integrated STEM approach to improve 21st century skills in Indonesia: A systematic review. *Int J STEM Educ Sustain*, *3*(2), 252-267. doi:10.53889/ijses.v3i2.219

Lock, RM, Hazari, Z & Potvin, G. (2019). Impact of out-of-class science and engineering activities on physics identity and career intentions. *Physical Review Physics Education Research, 15*(1), 1-11.

Marín-Marín, J. A., Moreno-Guerrero, A. J., Dúo-Terrón, P., & López-Belmonte, J. (2021). STEAM in education: a bibliometric analysis of performance and co-words in Web of Science. *International Journal of STEM Education, 8*(1). *Springer Science and Business Media Deutschland GmbH*. https://doi.org/10.1186/s40594-021-00296-x

Novitra, F,. Festiyed,. Yohandri & Asrizal. (2021). Development of online-based Inquiry learning model to improve 21st-century skills of physics students in senior high school. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*, 1-20.

Nursyahidah F, Mulyaningrum ER. (2022). The impacts of STEM on mathematics and science through lesson study: A systematic literature review. *Kalamatika J Pendidik Mat*, *7*(2), 125-142. doi:10.22236/kalamatika.vol7no2.2022pp125-142

Parameswari, P., Sutoyo, S., & Azizah, U. (2023). Scoping literature review of STEM research in Indonesia in improving critical thinking skills and concepts mastery.

*Indonesian Journal of Educational Research and Review*, *6*(2), 383–395. https://doi.org/10.23887/ijerr.v6i2.56687

Pardimin, Nisa AF, Hikmah N. (2023). Learning design innovation based on trin and STEAM in developing 21st century skills for elementary school students. *Jurnal Ilmiah Sekolah Dasar, 7*(2), 187-194. doi:10.23887/jisd.v7i2.52903

Prafitasari, F., Sukarno, S., & Muzzazinah, M. (2021). Integration of critical thinking skills in science learning using blended learning system. *International Journal of Elementary Education, 5*(2), 434. https://doi.org/10.23887/ijee.v5i3.35788.

Pramashela AD, Suwono H, Sulisetijono S, Wulanningsih UA. (2023). The influence of project-based learning integrated STEAM on the creative thinking skills. *Bioedukasi*, *21*(2), 138. doi:10.19184/bioedu.v21i2.39737

Prameswari, T. W., & Ningrum, A. L. (2020). STEAM based learning strategies by playing loose parts for the achievement of 4C skills in children 4-5 years. *Efektor*, *7*(1), 24–34. https://doi.org/https://doi.org/10.29407/e.v7i2.14387

Pratama MR, Fawaida U, Guarin RM. (2023). Project-based learning in elementary school: Influence on students' creative thinking ability. *MUDARRISA J Kaji Pendidik Islam, 15*(1), 60-83. doi:10.18326/mdr.v15i1.60-83

Primadoniati, A. (2020). Pengaruh metode pembelajaran problem based learning terhadap peningkatan hasil belajar pendidikan agama islam. *Didaktika: Jurnal Pendidikan*.

Puspita, L. (2019). Pengembangan modul berbasis keterampilan proses sains sebagai bahan ajar dalam pembelajaran biologi. *Jurnal Inovasi Pendidikan IPA*, *5*(1), 79–88. http://journal.uny.ac.id/index.php/jipi

Quin, Federico, Weyns, Danny, Galster, Matthias. (2023). Study systematic literature review on A/B testing. *Journal of Systems and Software.* URL https://people.cs.kuleuven.be/danny.weyns/material/SLR_AB/

Rahmawati, Y., Ridwan, A., & Hadinugrahaningsih, T. (2019). Developing critical and creative thinking skills through STEAM integration in chemistry learning. *In Journal of Physics: Conference Series*, *1156*(1), 012033). IOP Publishing.

Ramli, R., Yohandri, Y., Sari, Y. S., & Selisne, M. (2020). Pengembangan lembar kerja peserta didik fisika berbasis pendekatan science, technology, engineering, and mathematics untuk meningkatkan berpikir kritis peserta didik. *Jurnal Eksakta Pendidikan (JEP)*, *4*(1), 10. https://doi.org/10.24036/jep/vol4-iss1/405

Rochmah, E. N. (2023). Learning environments as STEAM support to sharpen elementary school students' 21st century skills. *DIDAKTIKA: Jurnal Pendidikan Sekolah Dasar*, *6*(1), 61–70.

Sari YS, Selisne M, Ramli R. (2019). Role of students worksheet in STEM approach to achieve competence of physics learning. *J Phys Conf Ser*, *1185*(1). doi:10.1088/1742-6596/1185/1/012096

Solihah PA, Kaniawati I, Samsudin A, Riandi R. (2024). Prototype of greenhouse effect for improving problem-solving skills in Science, Technology, Engineering, and Mathematics (STEM)-Education for Sustainable Development (ESD): Literature review, bibliometric, and experiment. *Indones J Sci Technol*, *9*(1), 163-190. doi:10.17509/ijost.v9i1.66773

Solihin A, Wibowo FC, Astra IM. (2021). Review of trends project based learning (PjBL) integrated STEM in physics learning. *J Phys Conf Ser*. 2019(1). doi:10.1088/1742-6596/2019/1/012031

Sugiyono. (2019). *Quantitative, Qualitative, and R&D Research Methods*. Bandung: Alphabet.

Suhirman, S., Prayogi, S., & Asy'ari, M. (2021). Problem-based learning with character-emphasis and naturalist intelligence: Examining students critical thinking and curiosity. *International Journal of Instruction*, *14*(2), 217–232. https://doi.org/10.29333/iji.2021.14213a.

Suprapto E, Krisdiana I, Apriandi D, Yuanawati FR. (2023). Development of STEAM-c integrated student worksheets to improve creative thinking ability on flat side building materials. *AL-ISHLAH J Pendidik*, *15*(1), 549-564. doi:10.35445/alishlah.v15i1.2480

Suryaningsih, S., & Nurlita, R. (2021). Pentingnya lembar kerja peserta didik elektronik (e-lkpd) inovatif dalam proses pembelajaran abad 21. *Jurnal Pendidikan Indonesia (Japendi), 2*(7).

Tukan, M. B., Komisia, F., Leba, M. A. U., & Amtonis,J. S. (2020). Pengembangan Lembar Kerja Peserta Didik (LKPD) pratikum kimia berbasis lingkungan pada materi laju reaksi. *Jurnal Koulutus*, *3*(1), 108–117. http://www.ejournal.kahuripan.ac.id/index.php/koulutus/article/view/324

Umar, U., Hasratuddin, H., & Surya, E. (2022). Pengembangan LKPD berbasis model think aloud pair problem solving untuk meningkatkan kemampuan pemecahan masalah matematis siswa SD Negeri Medan. *Jurnal Cendekia : Jurnal Pendidikan Matematika.* https://doi.org/10.31004/cendekia.v6i3.1884

Vincent-Lancrin, S., González-Sancho, C., Bouckaert, M., de Luca, F., Fernández-Barrerra, M., Jacotin, G., Urgel, J., & Vidal, Q. (2019). Fostering students' creativity and critical thinking: What it means in school. *Educational Research and Innovation;* OECD. ISBN 978-92-64-94313-1.

Yuntiaji, D. A., Lukman, H. S., & Imswatama, A. (2020). Digital worksheet design based on STEAM to develop students' problem solving skill. *Mathematics Education Journal, 4*(2). http://ejornal.umm.ac.id/index.php/MEJ

**Indri Maya Ariana (Corresponding Author)**
State University of Surabaya
Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya City, East Java 60231
Email: indri.22053@mhs.unesa.ac.id

**Dr. Binar Kurnia Prahani, S.Pd., M.Pd.**
State University of Surabaya
Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya City, East Java 60231
Email: binarprahani@unesa.ac.id

**Dr. Dwikoranto, M.Pd.**
State University of Surabaya
Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya City, East Java 60231
Email: dwikoranto@unesa.ac.id

**Muhammed Akif Kurtuluş**
Alanya Alaaddin Keykubat Üniversitesi

Kestel Neighbourhood University Street No:80 Alanya, Turkey
Email: muhammed.kurtulus@alanya.ac.trk.