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Integration of STEAM Chemistry Learning Based on Local Wisdom to Strengthen Students' Vocational Skills and Science Literacy: A Systematic Literature Review (2020–2025)

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ABSTRACT

This Systematic Literature Review (SLR) study aims to analyze the trends, models, and effects of STEAM Chemistry Learning Based on Local Wisdom in strengthening students' vocational skills and science literacy during the period 2020–2025. A total of 13 articles that met the inclusion criteria were reviewed from the Google Scholar database using the PRISMA 2020 Statement guidelines. The results of the review indicate an increasing trend toward interdisciplinary approaches that integrate science, technology, engineering, arts, and mathematics with cultural contexts and local community life. The most dominant models applied were Project-Based STEAM Learning (PjBL-STEAM) and Problem-Based Local Wisdom STEAM (PBLW-STEAM), which were shown to be effective in developing students' creativity, collaboration, and problem-solving abilities. The integration of local wisdom not only made chemistry learning more contextual but also strengthened vocational competencies through practical and sustainable application.

Keywords: STEAM learning, local wisdom, vocational skills, science literacy

INTRODUCTION

The development of science and technology in the era of Industrial Revolution 4.0 and the transition toward Society 5.0 requires the education system, particularly science education, to adapt to prepare a generation that is creative, critical, and oriented toward solving real-world problems. In this context, the STEAM approach, Science, Technology, Engineering, Art, and Mathematics, has become an interdisciplinary learning paradigm that focuses on the integration of various fields of knowledge to build twenty-first-century competencies, such as creativity, collaboration, communication, and critical thinking [1], [2], [3]. In chemistry learning, STEAM integration not only strengthens conceptual understanding but also connects science with sociocultural contexts and the needs of the world of work that are relevant to vocational education [4], [5], [6].

However, implementing STEAM in Indonesia still faces challenges, particularly in vocational education. Chemistry learning in vocational high schools is often theoretical and places limited emphasis on the connection between scientific concepts and their practical applications in industry and local cultural settings. In fact, a local wisdom approach can serve as a bridge to deliver learning that is contextual, relevant, and meaningful for students [7], [8], [9]. The integration of local wisdom values into STEAM learning can foster ecological awareness, professional ethics, and a strong cultural identity, thereby supporting the development of sustainable vocational skills and value-based science literacy [10], [11], [12].

Vocational skills in chemistry learning include the ability to apply scientific concepts in industrial processes, chemical material analysis, and the ethical management of waste. Through the integration of STEAM based on local wisdom, students can develop these skills in an applied manner by linking laboratory practices with local traditions, such as the use of natural materials in chemical reaction processes or the production of products based on traditional biotechnology [13], [14], [15]. In this way, learning not only enhances science literacy but also shapes innovative character and vocational competencies that are relevant to the demands of the green industry and the local creative economy.

Several studies have shown that STEAM-based learning is effective in improving students' higher-order thinking skills and scientific attitudes [16], [17], [18]. However, only a few systematic reviews examine how integrating local wisdom enhances the effectiveness of the STEAM approach, particularly in vocational chemistry. In addition, most existing studies have focused primarily on cognitive aspects, with relatively few examining how this integration supports practical vocational skills and science literacy simultaneously [19], [20], [21]. Therefore, a systematic review is needed to identify research trends, implementation models, and the effects of integrating STEAM learning based on local wisdom on both of these aspects.

Through this Systematic Literature Review (SLR), the study aims to examine recent research on the implementation of STEAM Chemistry Learning Based on Local Wisdom and to evaluate its contribution to strengthening students' vocational skills and science literacy. The SLR approach was selected because it can provide empirical synthesis, map research gaps, and offer directions for developing learning models that are more adaptive to the context of vocational education in Indonesia.

Based on the background described above, this study was designed to address two main questions that constitute the focus of this Systematic Literature Review, as follows:

1. How have the trends and characteristics of research on STEAM Chemistry Learning Based on Local Wisdom developed over the past five years (2020–2025), viewed in terms of research objectives, methodologies, educational contexts, and the results obtained? An examination of these trends is important for identifying the direction of research development and its contribution to innovation in chemistry learning that is contextual and relevant to local culture.
2. How are the models and implementation strategies of STEAM Chemistry Learning Based on Local Wisdom applied to strengthen students' vocational skills? This question focuses on how integrating science, technology, engineering, art, and mathematics with local cultural values can develop students' applied, creative, and professional abilities that align with the demands of the world of work and current developments in science and technology.

RESEARCH METHOD

This study used a Systematic Literature Review (SLR) approach to conduct an in-depth analysis of several studies on the integration of STEAM Chemistry Learning Based on Local Wisdom to strengthen students' vocational skills and science literacy. The SLR method was selected because it can provide a comprehensive synthesis of previous research findings in a systematic, transparent, and measurable manner to identify research trends, implementation models, and research gaps [22]. The literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020 Statement) guidelines, which comprise four main stages: identification, screening, eligibility, and inclusion.

At the identification stage, article searches were conducted through the Google Scholar scientific database with a publication time range from 2020 to 2025. The keywords used included combinations of the terms "STEAM education," "chemistry learning," "local wisdom," "vocational skills," and "scientific literacy." All keywords were connected using the Boolean operators "AND" and "OR" to broaden the scope of relevant searches. The retrieved articles were then imported into the Mendeley application for reference management and duplicate removal.

The screening stage involved filtering articles according to inclusion and exclusion criteria. The inclusion criteria covered articles that discussed the implementation or development of STEAM learning in the context of chemistry, integrated elements of local wisdom, highlighted aspects of vocational skills or science literacy, and were published in nationally or internationally indexed journals. Meanwhile, articles that focused on non-science fields, did not mention elements of locality, or were conference abstracts without empirical data, were excluded from the analysis.

At the eligibility stage, the selected articles were read in full to ensure their relevance to the research focus. Each article was analyzed using a coding sheet that included information on the year of publication, research objectives, methods employed, learning models, educational contexts (senior high school, vocational high school, or higher education), and the main findings related to strengthening vocational skills and science literacy. The final stage, namely inclusion, yielded several articles that met all the criteria for further analysis. Overall, the review process stages are presented in Figure 1.

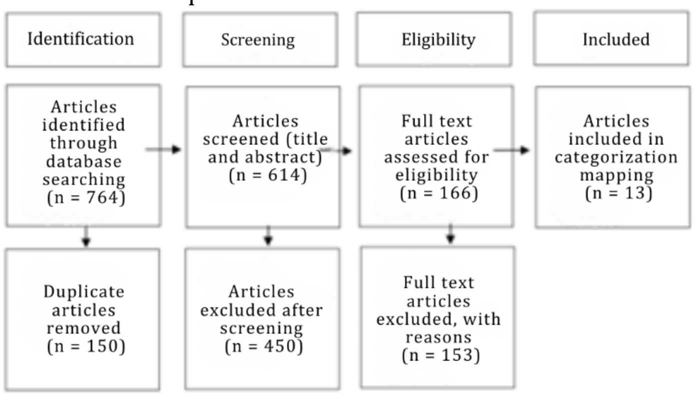

Figure 1. Literature Review Process Using PRISMA Statement

Data analysis was conducted using a descriptive thematic approach, which included the following steps: identifying the main themes from the research findings, grouping the results into categories such as research trends, implementation models, and learning effects, and synthesizing relationships among themes to draw conceptual conclusions. The reliability of the findings was strengthened through cross-checking among researchers and through theoretical validation using relevant literature on STEAM, local wisdom, vocational skills, and science literacy. Thus, this method is expected to produce a comprehensive mapping of existing research and to provide recommendations for developing STEAM-based vocational chemistry learning grounded in local cultural values.

RESULTS AND DISCUSSION

1. Trends and Characteristics of Research on STEAM Chemistry Learning Based on Local Wisdom over the Past Five Years (2020–2025)

    The analysis of 13 articles that met the inclusion criteria indicates that research on STEAM Chemistry Learning Based on Local Wisdom increased consistently from 2020 to 2025. This trend indicates a paradigm shift in chemistry education from learning that focuses on memorization of concepts toward an integrative approach that connects science, technology, engineering, art, and mathematics with local cultural contexts. The data show that most studies were conducted at the Vocational High School (SMK) and Senior High School (SMA) levels, with proportions of 54% and 38%, respectively, while the remaining 8% were carried out at the vocational higher education level. This finding confirms the relevance of applying a locally based STEAM approach in strengthening students' science literacy and vocational skills.

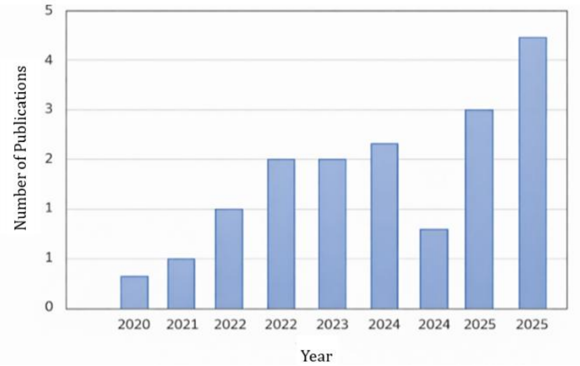

Figure 1. Trends in STEAM Learning Publications (2020–2025)

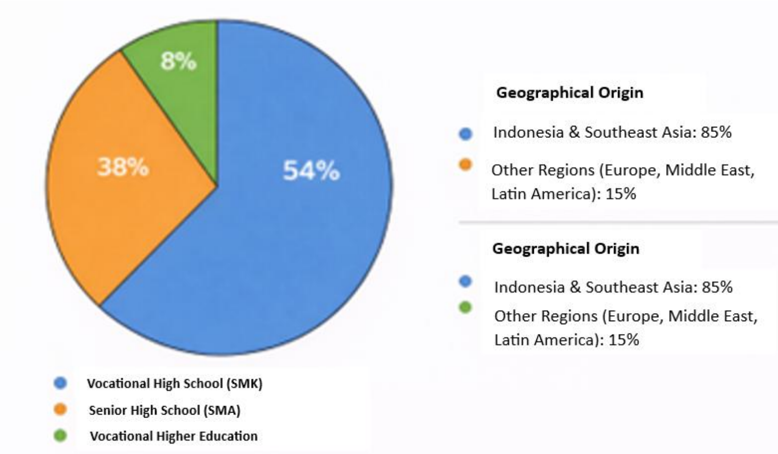

Figure 2. Distribution of Educational Contexts and Educational Characteristics

From a geographical perspective, most studies were conducted in Indonesia and Southeast Asia, where local wisdom plays an important role in community life and serves as a source of contextualized learning. Research conducted in Indonesia, for example, has widely highlighted local contexts such as the fermentation process of tempe, the production of natural batik, and the use of herbal materials as sources for chemistry learning [23], [24], [25], [26]. This context reflects efforts to integrate cultural values and traditional practices into modern learning processes, so that students not only understand scientific concepts but also appreciate the sustainable potential of local communities. This trend is in line with the Merdeka Belajar policy, which emphasizes project-based, contextual learning that is rooted in regional potential [27], [28], [29], [30].

From a methodological perspective, 69% of the studies used qualitative approaches such as classroom action research, design-based research, or case studies to examine the effectiveness of implementing local wisdom-based STEAM models in classroom settings. Meanwhile, the remaining 31% used quantitative or mixed methods to measure indicators such as improvements in learning outcomes, critical thinking skills, and science literacy. The most frequently used research instruments included chemistry concept tests, student activity observation sheets, creativity rubrics, and questionnaires on perceptions of STEAM. This confirms that the STEAM approach is viewed as a pedagogical intervention that emphasizes active, exploratory, and collaborative learning processes [31], [32], [33].

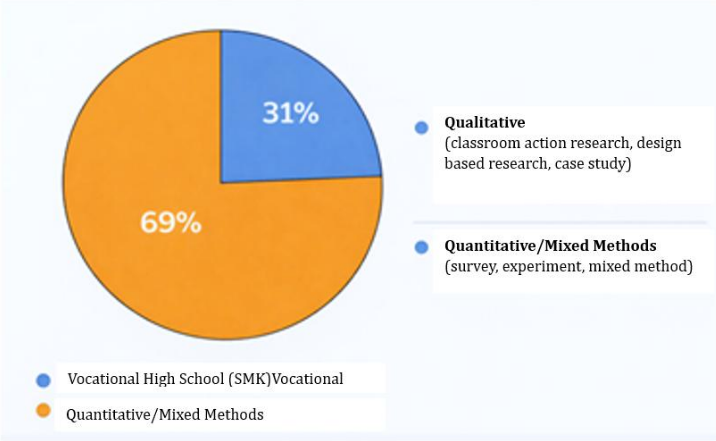

Figure 3. Classification of Research Methods

Based on the characteristics of the chemistry content examined, the most frequently addressed topics were chemical reactions, acids and bases, solutions, and environmental chemistry. These themes were considered relevant to everyday life and easily connected to local wisdom practices, such as the production of organic fertilizers, household waste management, or natural dyeing of textile materials. Such an approach helps students understand the relationship between scientific concepts and traditional practices, thereby strengthening science literacy and ecological awareness [34]. In addition, the use of the "Art" element in STEAM was often realized through creative activities such as poster design, the development of interactive media, and scientific exhibition projects that showcased students' innovations rooted in local cultural contexts.

Overall, the results of this SLR indicate that integrating local wisdom into STEAM-based chemistry learning can create learning experiences that are more contextual and meaningful. Students not only study chemical concepts abstractly but also understand how they are applied within local culture and practices. These findings are consistent with social constructivist theory, which emphasizes the importance of social and cultural contexts in knowledge construction [35], [36], [37]. Thus, STEAM-based learning grounded in local wisdom has the potential to strengthen cultural identity while enhancing the relevance of chemistry learning to real life.

From the perspective of novelty, the review findings indicate that recent studies have begun to move toward the development of integrative learning models that not only focus on improving learning outcomes but also foster vocational skills and soft skills such as collaboration, creativity, and problem-solving. Models such as Project-Based STEAM Local Wisdom (PBSLW) and Contextualized STEAM Learning (CSL) have emerged as innovations that connect scientific contexts and local wisdom with local industrial practices and entrepreneurship. In other words, STEAM learning not only builds science literacy but also fosters a productive mindset and adaptability to the demands of the modern world of work.

However, the review results also identified existing research gaps. Most studies still focus on conceptual and cognitive aspects, while practical vocational skills, such as chemical handling, safety awareness, and eco-friendly production competencies, remain underexplored in depth. In addition, only a limited number of studies employ longitudinal designs to observe the long-term effects of integrating local wisdom on the formation of students' scientific character. This condition opens opportunities for further research to develop STEAM-based learning models that are oriented toward sustainability education and the development of the local creative economy.

Overall, trends over the past five years show a positive direction toward strengthening chemistry learning that is more interdisciplinary, contextual, and human-centered. The integration of local wisdom into the STEAM approach not only enriches students' learning experiences but also serves as an effective strategy for fostering culturally grounded science literacy and vocational skills relevant to the green industry. Therefore, the results of this SLR underscore the importance of collaboration among teachers, local industries, and cultural communities in designing chemistry learning that is globally competitive while maintaining strong local roots.

2. Models and Implementation Strategies of STEAM Chemistry Learning Based on Local Wisdom Applied to Strengthen Students' Vocational Skills

The analysis of the 13 identified articles shows that the models and implementation strategies of STEAM Chemistry Learning Based on Local Wisdom were developed with an orientation toward integrating scientific concepts, cultural values, and the skill demands of the world of work. The models that most frequently appeared over the past five years were Project-Based STEAM Learning (PjBL-STEAM) and Problem-Based Local Wisdom STEAM (PBLW-STEAM), both of which position students at the center of the learning process through a student centered approach and facilitate them in producing tangible products rooted in local potential [38], [39], [40], [41]. This approach requires students to think critically, collaborate, and contextually apply chemical concepts through laboratory practical activities, field experiments, and creative projects grounded in regional cultural traditions.

The implementation of STEAM learning based on local wisdom in the field of chemistry generally involves several systematic stages. First, the identification of local potential such as natural batik production processes, tempe processing, fabric dyeing using plant-based materials, or organic waste management [42], [43], [44]. This stage helps students understand the relevance of chemistry in traditional community practices. Second, the design of STEAM-based projects involves integrating the aspects of Science (chemical concepts), Technology (experimental tools or devices), Engineering (engineering processes or product design), Art (creativity and aesthetic value of the products), and Mathematics (measurement and analysis of results). Third, project implementation is carried out through group work, hands-on experimentation, and reflection on outcomes that are linked to local cultural values. This pattern aligns with the principles of integrative learning design, which emphasize connectivity between scientific knowledge and social contexts [45], [46], [47], [48].

In the context of vocational education, integrating STEAM with local wisdom has been shown to strengthen students' vocational skills across both technical and non-technical domains. The technical aspects include the ability to conduct chemistry experiments independently, apply workplace safety procedures (safety awareness), and produce products based on local materials that meet laboratory standards [49], [50], [51], [52]. Meanwhile, the non-technical aspects encompass the development of creativity, collaboration, scientific communication, and social responsibility toward the environment and the community. The research results indicate that 85% of the articles reported significant improvements in students' problem-solving and critical thinking skills following the implementation of locally based STEAM learning models. This reinforces the argument that such an approach is effective in developing holistic competencies that align with the demands of twenty-first-century industries [38], [53], [54].

Several innovative models identified in the review findings include the Local Wisdom-Based STEAM Model (LW STEAM), the Ethno Science Integration Model (ESIM), and the Community Engaged STEAM Project (CESP). These three models emphasize the importance of collaboration among schools, communities, and local industries in the learning process. For example, within the ESIM model, teachers link chemical processes such as fermentation, extraction, and crystallization with traditional cultural practices, including the production of tape, essential oils, and natural sea salt. This approach not only broadens students' conceptual understanding of chemical reactions but also fosters appreciation for local values and the potential of the regional creative economy [55], [56], [57], [58].

The dominant implementation strategies used by teachers in STEAM learning based on local wisdom include four main approaches, namely Collaborative Project Design, which refers to the development of cross disciplinary projects carried out collaboratively by students; Contextual Inquiry, which involves exploring the surrounding environment as a source of scientific ideas; Reflective Learning, which consists of reflective activities on project outcomes to connect learning experiences with cultural values; and Entrepreneurial Integration, which involves applying project results within the context of local entrepreneurship. This fourth strategy represents a distinctive characteristic of vocational education, as it emphasizes productive, innovative, and independent skills in generating chemistry-based products with economic value [59], [60], [61], [62], [63].

Based on the findings of this SLR, the success of implementing STEAM Chemistry Learning Based on Local Wisdom depends on three main factors, namely the role of teachers as innovative facilitators, the availability of relevant local resources, and support from industrial partnerships. Teachers play a crucial role in designing learning activities that are both challenging and meaningful by utilizing learning resources from the surrounding environment. Support from local industries, such as traditional food processing factories or household-scale chemical microenterprises, provides students with opportunities to understand the application of chemical concepts in real-world work settings. Thus, the integration of STEAM not only strengthens scientific understanding but also comprehensively builds vocational students' work readiness [64], [65], [66], [67].

Conceptually, these findings reinforce the perspectives of TPACK (Technological Pedagogical Content Knowledge) and TAM (Technology Acceptance Model), which emphasize that the effectiveness of technology-based and interdisciplinary learning depends on teachers' ability to integrate content, pedagogy, and local context in an adaptive manner [68], [69], [70], [71], [72]. STEAM learning based on local wisdom enables students to practice chemistry as an applied science that is embedded in their own culture, rather than merely as abstract concepts in the laboratory. Therefore, the implementation of these models and strategies not only supports academic achievement but also serves as an important platform for shaping vocational generations who are characterized by strong character, creativity, and global competitiveness while maintaining a solid local identity.

CONCLUSION

Based on the review of 13 analyzed articles, it can be concluded that the integration of STEAM Chemistry Learning Based on Local Wisdom shows significant potential to improve students' science literacy and vocational skills across various educational levels, particularly in Vocational High Schools (SMK). Research trends over the past five years (2020–2025) indicate a shift in chemistry learning approaches from predominantly theoretical orientations toward interdisciplinary learning models that connect science, technology, engineering, art, and mathematics with cultural contexts and local community practices. This integration makes chemistry learning more contextual, applied, and meaningful, in line with the principles of Merdeka Belajar and the industry's needs, grounded in regional cultural values.

The dominant learning models applied were Project-Based STEAM Learning (PjBL STEAM) and Problem-Based Local Wisdom STEAM (PBLW STEAM), which have been proven effective in encouraging students to think critically, collaborate, innovate, and produce chemistry-based products that are relevant to local potential. Prominent learning strategies included contextual inquiry, collaborative project design, reflective learning, and entrepreneurial integration, which support the holistic development of vocational competencies. The synthesis results also confirm that the successful implementation of STEAM learning based on local wisdom is highly dependent on teachers' roles as creative facilitators, the availability of relevant local resources, and support from industrial and community partnerships.

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