

# STEM education and local wisdom for sustainability: A decade of trends and insights from bibliometric analysis

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**Abstract.** Education is an important foundation for advancing the Sustainable Development Goals (SDGs), especially through the integration of STEM-based approaches with indigenous knowledge. This study aims to map trends, thematic developments, and geographical collaborations in relevant literature published between 2014 and 2024, to identify the direction of contextual and sustainable development of science education. This study uses the PRISMA flow to extract data from the Scopus database. Furthermore, the data was analyzed using bibliometric methods using VOSviewer, Datawrapper, and Microsoft Excel. The results of the analysis show a consistent growth in the number of publications over the past decade. The dominant themes are curriculum design, learning media and technology, learning models and approaches, and issues related to the COVID-19 pandemic and sustainability. In terms of keywords, the identification of seven thematic clusters highlights the relationship between the integration of local knowledge, creativity, problem-based learning, and scientific literacy. In terms of geographical contribution, Indonesia represents a strong involvement and focuses on the integration of cultural values into science education. In conclusion, strengthening the integration of local wisdom with STEM has the potential to significantly encourage an inclusive and sustainable learning environment and encourage educational innovation on a global scale.

## 1 Introduction

Education is an important foundation for advancing the Sustainable Development Goals (SDGs) which encourages enhancing the quality of individuals and society in facing global challenges [1,2]. The post-pandemic digital transformation has also changed educational practices such as the increasingly used hybrid learning model [3]. However, to strengthen sustainable development, the development of digital transformation must be balanced by integrating local wisdom into education. This is because the local context is familiar and

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relevant to real life allows students to better understand science concepts [4,5]. As proven in several previous studies, it can be increased by the integration of local wisdom in learning through a STEM-based approach [6,7].

Several studies have been conducted to test the effectiveness of local wisdom-based learning devices to enhance student learning competencies and contextual roles of local wisdom in education [8,9]. In this case, education integrated with local wisdom plays an important role as a counterweight in the global digital transformation to achieve sustainability. STEM education is increasingly recognized for fostering innovation, critical thinking, and problem-solving skills that are essential for sustainable development. This is because STEM has been proven effective in achieving inclusive, quality, and sustainable education goals [11]. Studies over the past decade (2014-2024) have shown a significant increase in the themes of STEM, Local wisdom, sustainability, and science education both in terms of the number of publications and thematic diversity. The purpose of this study is to provide a bibliometric of STEM education and local wisdom in the context of sustainability by mapping trends, developments, and research directions in this field globally.

This study focuses on the analysis of trends, main topics, and geographical collaboration I scientific publication over the past decade (2014-2024). In addition this study also explores that dominant keywords, research clusters, and thematic contributions of the most influential articles in the study of the integration of STME education and local wisdom for sustainable development. Through this study, it is expected to obtain a comprehensive understanding of the current research landscape and potential directions for its future development.

## **2 Methods**

This study used a systematic review aimed at synthesizing current scientific knowledge related to "STEM Education, local wisdom, Sustainability, and Science education". This approach was combined with a bibliometric analysis model to collect data on existing research trends [12]. Data were obtained from Scopus using an institutional account from the State University of Surabaya, Indonesia, in June 2025. Scopus was used because it was proven to be superior to other bases [14-15]. This study used the preferred reporting items for systematic reviews and meta-analysis models (PRISMA) in selecting articles (article inclusion and exclusion). so that appropriate articles are obtained. This model consists of four stages, namely identification, screening, eligibility and inclusion [16].

Based on Fig. 1, the PRISMA flow in this study begins with the identification of articles using primary keywords related to STEM integration, local wisdom, sustainability and scientific education. The screening process is carried out by setting a publication year limit of 2014–2024, selecting documents that are of the article type, in English, and have open access. The final stage includes selecting the most relevant articles to the research topic for bibliometric analysis.

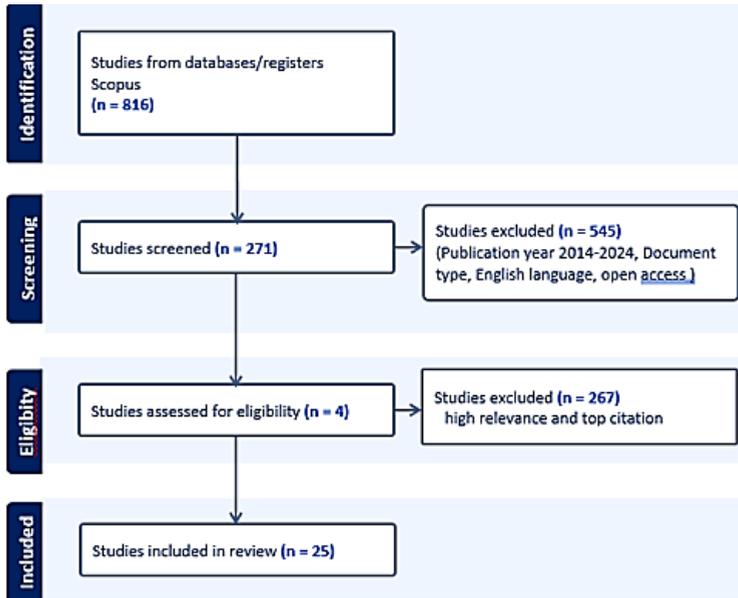


Fig. 1. PRISMA Flow Diagram of Study Selection

### 3 Results and Discussion

#### 3.1 STEM education publication trends, local wisdom, sustainability and science education

Trend analysis shows a consistent increase in the number of publications on STEM Education, Local Wisdom, Sustainability and Science Education over a decade (2014-2024) as shown in Fig.2.

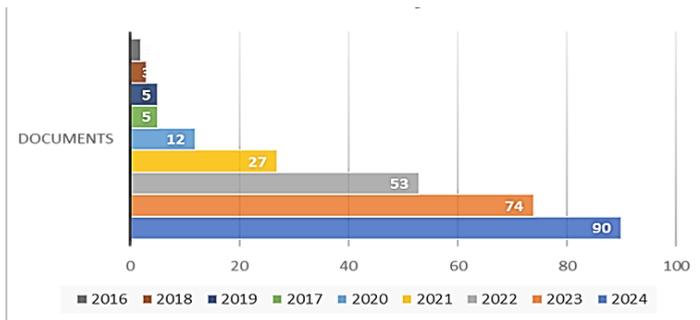
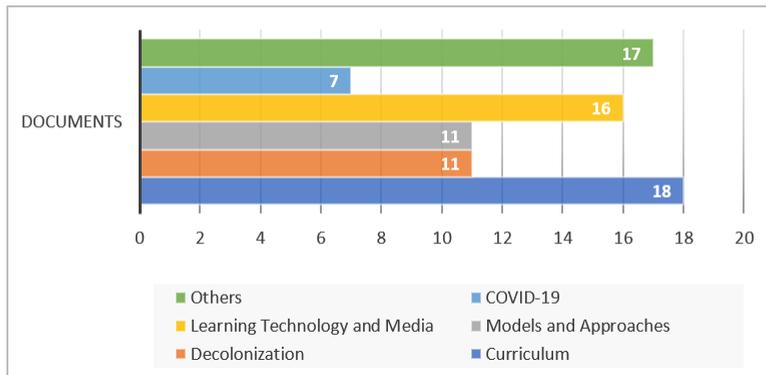


Fig. 2. Research Trends in a Decade Related to STEM Education Publication Trends, Local Wisdom, Sustainability and Science Education

This increase is in line with the approaching deadline set in 2030 [17]. A significant spike occurred in 2021-2022 with 26 documents with a total of 80 articles published in that year. This increase reflects the increasing global attention to contextual, sustainable and inclusive education [17-19].



**Fig. 3.** Dominant Research Themes Identified in the Literature Review

Based on Fig.3, the dominance of curriculum topics in research discourse, followed by technology and learning media, learning models and approaches, and learning issues during the COVID-19 pandemic are the five main themes. These findings reflect the strategic role of integrating local wisdom and utilizing technology in driving educational transformation oriented towards sustainability [20]. The context of the COVID-19 pandemic is a driver in accelerating the need for adaptive and contextual learning innovations [21,22].

### 3.2 Thematic network analysis using keywords and co-occurrence mapping

Keyword co-occurrence analysis yielded seven thematic clusters that reflect research directions in STEM education, local wisdom, sustainability, and science education. The first cluster with the red node in Fig.4 indicates the integration of local wisdom, creativity, PBL, and science literacy, emphasizing the importance of pedagogical innovation based on local context [23]. Clusters two to four feature themes such as indigenous knowledge, curriculum, inclusion, and decolonization of education, reflecting the global trend toward more equitable, culturally relevant, and participatory science education [24,25]. Clusters five to seven cover contemporary issues such as STEM/STEAM, climate change, sustainability, and digital technology integration, demonstrating the synergy between modern approaches and local values. The interconnectedness of keywords emphasizes that the integration of local wisdom is not only content-based, but also supports the strengthening of sustainability through the development of substantive thinking skills [5,26].



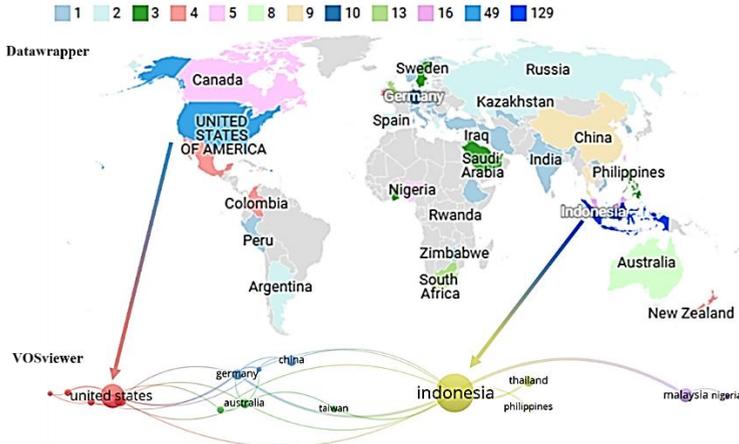


Fig. 5. Countries Participating in Research

### 3.4 Subject area that participated in STEM education and local wisdom for sustainability

Subject area analysis places Social Science as the dominant field, followed by Computer Science and Psychology as shown in Fig.6.

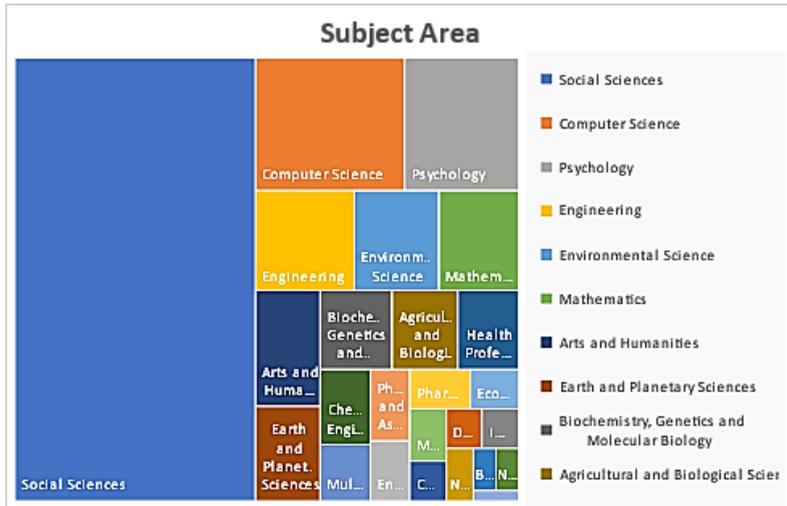


Fig. 6. Subject Area with High Relevance to STEM Education and Local Wisdom For Sustainability

This shows a transdisciplinary approach that emphasizes not only pedagogical aspects, but also social, cognitive, and technological dimensions in STEM education [34].

### 3.5 Review of the most cited and most relevant papers on STEM education and local wisdom for sustainability (2014 to 2024)

Based on Table 1, the discussion of these four articles demonstrates the importance of integrating Indigenous knowledge and culturally responsive approaches in science education. Indigenous knowledge can enrich science education with holistic and cultural values, but needs to be carefully

integrated into the curriculum [35]. Inquiry practices and culturally responsive approaches complement each other, but have not been optimally utilized in K-12 contexts [36].

**Table 1.** Most Cited and Most Relevant Papers (2014–2024)

Authors	Title	Cited by	Methods	Findings	Recommendations
Zidny R.; Sjöström J.; Eilks I. (2020)	A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability	170	Literature review	Indigenous knowledge enriches science education with a holistic view and cultural values.	Careful integration of indigenous knowledge into the curriculum, with respect for cultural values
Brown J.C. (2017)	A metasynthesis of the complementarity of culturally responsive and inquiry-based science education in K-12 settings: Implications for advancing equitable science teaching and learning	97	Metasynthesis	Inquiry and culturally responsive practices are complementary, although some practices are underutilized.	Expand the integration of inquiry practices into cultural approaches; further exploration.
Djonko-Moore C.M.; Leonard J.; Holifield Q.; Bailey E.B.; Almhgyirah S.M. (2018)	Using culturally relevant experiential education to enhance urban children’s knowledge and engagement in science	50	Mix Method	Increase student knowledge and engagement through experiential learning.	Implement culturally relevant experiential learning; continue research.
Trumbull E.; Nelson-Barber S. (2019)	The Ongoing Quest for Culturally-Responsive Assessment for Indigenous Students in the U.S.	45	Qualitative	Common assessment practices are not culturally appropriate for Indigenous people; local languages improve outcomes.	Use culturally responsive assessments and language accommodations; change policies.

Culturally relevant experiential learning can increase student engagement and knowledge in urban environments [37]. Assessments that are responsive to local culture and language to improve Indigenous student learning outcomes. These four studies emphasize the need for more inclusive, culturally relevant, and local context-adaptive approaches to science education [38].

## 4 Conclusion

A decade-long bibliometric study (2014–2024) shows that the integration of STEM education, local wisdom, and sustainability has experienced significant development, both in terms of publication intensity and thematic depth. These findings highlight a paradigm shift towards more contextual, inclusive, and long-term sustainability-oriented education. The dominance of the themes of curriculum, educational technology, and decolonization of knowledge shows that science education is no longer merely technical, but also social and ecological. Indonesia emerged as a major contributor to related publications, reflecting the strategic role of developing countries in promoting local values as the foundation of sustainable education. Keywords such as scientific literacy, ethno-STEM, and inquiry-based learning indicate a new direction that emphasizes the relationship between science, culture, and environmental sustainability. The results of this study recommend the importance of strengthening the integration of local wisdom in the STEM curriculum, developing learning models based on culture and real experiences, and encouraging research that is not only methodologically inclusive, but also geographically relevant to support the global sustainable education agenda.

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