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RESEARCH TRENDS COMPUTATIONAL-ETHNOPEDOLOGY IN ELEMENTARY SCHOOL SCIENCE LEARNING: BIBLIOMETRIC ANALYSIS AND FIELD NEEDS EXPLORATION

Ibrahim*, Muhammad Erfan, Mohammad Archi Maulyda, Nurkhaerat Alimuddin
University of Mataram, Mataram, Indonesia
*Corresponding author: ibrahim14@unram.ac.id

Abstract: This study aims to identify the current state of elementary school students' critical and creative thinking skills in science learning and to explore the need for technology-based learning media and local wisdom as a basis for developing interactive e-modules based on computational ethnopedology. The study used a mixed-methods exploratory method through observation, questionnaires, and interviews and was supplemented by bibliometric analysis of global publications related to computational thinking, HOTS, and culture-based learning. Observational data showed that students' critical and creative thinking skills were still low, with scores of 54.5 and 58.2, respectively, in line with interview findings that learning was still dominated by lectures and textual materials. The questionnaire results showed that 87% of students needed visual teaching materials in the form of animation, while 90% of teachers considered the importance of integrating local wisdom in science learning. Bibliometric analysis showed a significant increase in computational thinking research from 2020 to 2022, but integration with local wisdom was still limited. These findings confirm the gap between learning needs in the field and global research trends. Therefore, the development of interactive e-modules based on computational ethnopedology has the potential to be a relevant innovation to support the development of critical and creative thinking skills in elementary school students. This research provides an empirical and theoretical foundation for the development of culture- and technology-based learning media in subsequent research phases.

Keywords: *Computational Thinking, Ethnopedology, HOTS, Primary School Science, Interactive E-Modules*

***Abstrak**: Penelitian ini bertujuan untuk mengidentifikasi kondisi terkini keterampilan berpikir kritis dan kreatif siswa sekolah dasar dalam pembelajaran sains dan mengeksplorasi kebutuhan media pembelajaran berbasis teknologi dan kearifan lokal sebagai dasar pengembangan e-modul interaktif berbasis etnopedologi komputasional. Penelitian ini menggunakan metode eksploratif metode campuran melalui observasi, kuesioner, dan wawancara serta dilengkapi dengan analisis bibliometrik publikasi global terkait pemikiran komputasional, HOTS, dan pembelajaran berbasis budaya. Data observasi menunjukkan bahwa keterampilan berpikir kritis dan kreatif siswa masih rendah, dengan skor masing-masing 54,5 dan 58,2, sejalan dengan temuan wawancara bahwa pembelajaran masih didominasi oleh ceramah dan materi tekstual. Hasil kuesioner menunjukkan bahwa 87% siswa membutuhkan bahan ajar visual berupa animasi, sementara 90% guru mempertimbangkan pentingnya mengintegrasikan kearifan lokal dalam pembelajaran sains. Analisis bibliometrik menunjukkan peningkatan signifikan dalam penelitian pemikiran komputasional dari tahun 2020 ke tahun 2022, tetapi integrasi dengan kearifan lokal masih terbatas. Temuan ini menegaskan kesenjangan antara kebutuhan pembelajaran di lapangan dan tren penelitian global. Oleh karena itu, pengembangan e-modul interaktif berbasis etnopedologi komputasional berpotensi menjadi inovasi yang relevan untuk mendukung pengembangan keterampilan berpikir kritis dan kreatif pada siswa sekolah dasar. Penelitian ini memberikan landasan empiris dan teoretis bagi pengembangan media pembelajaran berbasis budaya dan teknologi pada tahap-tahap penelitian selanjutnya.*

***Kata Kunci:** Berpikir Komputasional, etnopedagogi, IPA SD, E-Modul interaktif*

INTRODUCTION

Natural Science (IPA) learning in elementary schools plays a strategic role in shaping the foundation of students' scientific thinking from an early age. Science is not just a collection of concepts and facts but also a means to foster critical and creative thinking skills, as well as curiosity about natural phenomena (Akhtarieva et al., 2019; Amatullah & Komariah, 2021; Stępnik et al., 2017; Williams, 2018). At the operational level, science learning in elementary schools is ideally contextual, involving direct experience and facilitating students' observation, exploration, and scientific investigation according to their cognitive developmental characteristics (Kozibay & Zhanbekova, 2021; Nikolaeva et al., 2020). However, in school learning practices, science is often taught traditionally through lectures and assignments, resulting in students tending to be passive and lacking meaningful learning experiences. This condition indicates a gap between curriculum objectives and learning implementation in the field (Lavrynenko et al., 2020, 2020; Puspita & Ruhaliah, 2021; Rizakhojayeva et al., 2021).

On the other hand, the era of technological disruption is driving a paradigm shift in education, including at the elementary school level. Digital technology-based learning has become a crucial need, not only as a medium for delivering material but also as a vehicle for developing digital literacy and computational thinking from an early age (Nurwidodo et al., 2023; Rosa et al., 2016). Computational thinking is the ability to think to solve problems through a systematic approach that includes abstraction, decomposition, algorithmic reasoning, and solution evaluation ("The Effect of Integrated Flipped Classroom with Local Cultural Values on Character Building in Higher Education," 2021; Vladlenov, 2022; Williams, 2018). This competency is not only oriented towards the ability to use digital devices but also shapes ways of thinking relevant to the needs of the 21st century. Therefore, the integration of computational thinking in science learning in elementary schools can be an important foundation for developing students' critical and creative thinking skills (Fedorenko, 2021; Hendrawan, 2020).

In addition to technological aspects, the local cultural context is also a fundamental element that cannot be separated from the educational process. Local wisdom, cultural values, and community perspectives on the environment can make significant contributions to science learning (Rasna & Tresnayani, 2021). In this context, the ethnopedology approach the study of the relationship between local community knowledge and ecology and the environment offers a new perspective in science learning (Amelia & Purwaningsih, 2021; Ibrahim, Bahtiar, et al., 2024). Ethnopedology enables students to understand science concepts through experiences and phenomena close to their daily lives, such as cultivation practices, natural resource utilization, and cultural values about the environment. Thus, the integration of local wisdom in science learning can create more relevant, contextual, and meaningful learning (Archi Maulyda & Wuryandani, 2025; Erfan et al., 2025).

Research developments indicate a growing trend toward integrating digital technology and local cultural values in education. The computational-ethnopedology concept is an innovative approach that combines computational thinking with local community knowledge in the context of science learning (Fitanti et al., 2024; Kozibay & Zhanbekova, 2021). This approach aims to develop higher-order thinking skills (HOTS), particularly critical and creative thinking through problem-solving rooted in the local cultural context. By utilizing digital technology and integrating it with traditional knowledge, students are expected to see the connection between scientific concepts and the cultural realities around them. As a result, science learning not only transfers knowledge but also builds awareness of cultural and environmental identity (Ibrahim, Maimun, et al., 2024).

Although the concept of computational ethnopedology offers innovative opportunities in science learning, empirical research supporting this concept remains limited both globally and nationally (Aquilani et al., 2020; Branco et al., 2021). Therefore, bibliometric analysis is needed to map the development, research direction, and research gaps regarding computational thinking, ethnopedology, and their integration into elementary science learning. Bibliometric analysis can

provide an overview of publications, research theme trends, researcher collaborations, and influential journals in the field. Furthermore, bibliometric mapping can also identify dominant themes and relevant current issues to serve as a basis for developing innovative learning models or products in elementary schools.

In addition to mapping global research trends, it is crucial to understand the actual needs and conditions on the ground as a basis for developing learning innovations. Exploring field needs through questionnaires and interviews with elementary school teachers and students can provide information on learning media needs, technological readiness, science learning challenges, and the potential for integrating computational ethnopedology in the school context. These field findings are crucial for ensuring the relevance, usefulness, and sustainability of the learning products to be developed. Thus, a needs analysis can ensure that learning innovations are not only theoretically sound but also appropriate for the context of elementary education in Indonesia.

Based on the description, this study aims to examine the research trends of computational ethnopedology in elementary science learning through bibliometric analysis and explore the field needs related to the application of this approach in science learning. The results of this study are expected to be the basis for the development of learning models or digital media, such as interactive e-modules that combine computational thinking with local wisdom. Ultimately, this study can provide theoretical contributions to the development of science education and provide practical contributions to improving the quality of science learning in elementary schools through innovative approaches relevant to the digital world and the cultural context of students.

METHOD

This research exploratory mixed-methods approach This study integrates bibliometric analysis with field needs exploration through surveys and interviews. The bibliometric analysis was conducted to map research trends related to computational thinking, ethnopedagogy, critical-creative thinking skills, and science learning in elementary schools. Bibliometric data were collected through Lens.org, using the search syntax:("Computational Thinking" OR "Ethnopedagogy") AND ("Critical Thinking" OR "Creative Thinking" OR "21st Century Skills") AND ("Elementary School" OR "Primary School" OR "Science Education"). The search results show that there are 1,452 scientific publications (scholarly works) relevant to the research topic. Publication data was downloaded in CSV format and then analyzed using software VOSviewer And Biblioshiny (R-Bibliometrix) to generate keyword co-occurrence maps, annual publication trends, top journal sources, and researcher collaboration networks. Bibliometric analysis was used to identify the direction of research development, the position of research themes, and potential research gaps related to the integration of computational thinking and ethnopedagogy in elementary science learning.

In addition, field needs exploration was conducted through the distribution of questionnaires and semi-structured interviews with teachers and students at several elementary schools selected purposively. The questionnaires were used to identify the need for digital-based science learning media, teachers' perceptions of critical-creative thinking skills, and readiness to implement computational thinking and local wisdom values in science learning. Interviews were conducted to obtain more in-depth information regarding the challenges of science learning in elementary schools and the potential for implementing the computational-ethnopedology approach in real classroom contexts. Quantitative data were analyzed descriptively, while qualitative data were analyzed using thematic analysis techniques. The integration of bibliometric analysis results and field findings is carried out at the interpretation stage to form the basis for developing interactive e-modules that are relevant to the needs of elementary school science learning and global research trends.

RESULT AND DISCUSSION

This study aims to identify the actual conditions of elementary school students' critical and creative thinking abilities in science learning, as well as to explore the need for technology-based

learning media and local wisdom as a basis for developing interactive e-modules based on computational-ethnopedology. Through observations, interviews, and questionnaires, this study found that the current science learning process still focuses on textual delivery of material and does not provide adequate stimulation for the development of higher-order thinking skills. Field findings indicate a gap between curriculum demands that emphasize scientific literacy and 21st-century competencies and classroom learning practices that are still predominantly lecture-based. Furthermore, both students and teachers demonstrated a strong need for visually interactive learning media that are relevant to the local cultural context so that science learning is more meaningful, contextual, and able to encourage critical and creative thinking. To clarify these findings, the following graph presents the results of observations of students' critical and creative thinking abilities, as well as the results of a questionnaire regarding the need for digital learning media based on local wisdom in science learning.

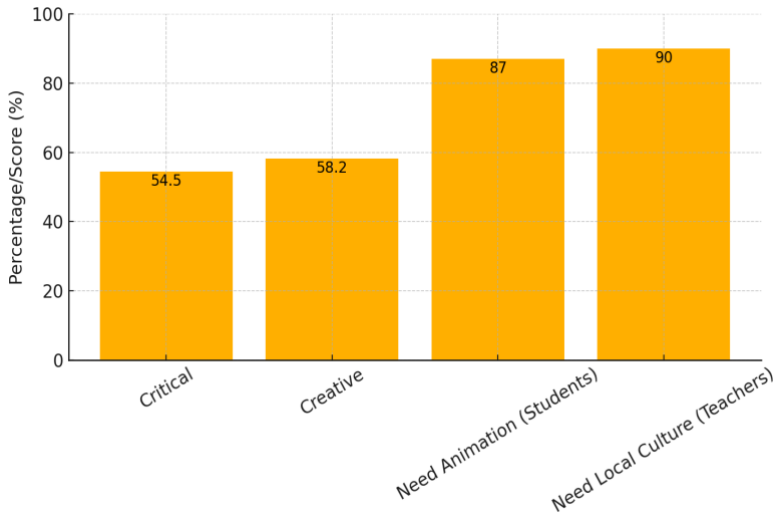

Figure 1. Observation Results and Questionnaire Distribution

The image above shows that students' critical and creative thinking skills are in the low category, with an average score of each.54.5 and 58.2, still below the KKM standard of 70. This condition indicates that science learning has not been able to develop high-level thinking skills as required by the curriculum. Based on the results of interviews with teachers, these low abilities are influenced by learning methods that are still teacher-centered, dominated by lectures, and use textbooks as the main learning source. Teachers revealed that the delivery of abstract material without the support of visual media makes it difficult for students to understand science concepts in depth. This is reinforced by the teacher's statement that the evaluation activities carried out are still in the form of multiple-choice questions and simple descriptions, so they do not provide space for students to conduct analysis, put forward arguments, or generate creative ideas during the learning process. This finding is consistent with students' inability to display indicators of critical thinking, such as identifying problems, making inferences, and designing alternative solutions in the context of scientific phenomena around them.

On the other hand, Figure 1 also shows that 87% of students need visual-based teaching materials such as animations and videos to understand science material better, while 90% of teachers stated the need for media that links material to the surrounding culture. The findings of this questionnaire are supported by the results of interviews with students who revealed that they felt bored with the presentation of material that only consisted of text without moving illustrations, making concepts such as energy, force, or the water cycle difficult to understand concretely. Students also said that science learning would be more enjoyable if linked to real-world examples in the environment, for example, farming practices, water use in villages, or household waste management. Teachers also added that local wisdom can actually be a powerful learning context

to foster students' curiosity and ecological sensitivity, but limited media means that this integration has not been optimally realized in the classroom. Thus, the results of the graphs, teacher interviews, and students indicate an urgent need to develop interactive e-modules based on computational-ethnopedology for those who are able to visualize science concepts dynamically and relate them to local cultural phenomena as a context for critical and creative thinking in science learning in elementary schools.

In addition to field findings, this study also strengthens the results of the initial bibliometric analysis, which shows that research on the development of critical, creative, and computational thinking skills in elementary education has continued to increase in the past five years. Based on the results of the Lens.org search and selection based on topic relevance, the top ten articles were obtained that demonstrate the global research focus on integrating educational technology, contextual approaches, and culture-based learning in the development of 21st-century competencies in elementary schools. These articles show a tendency that computational thinking is mostly developed through STEM, project-based learning design, scaffolding approaches, and creative learning models that encourage students to be actively involved in problem-solving. To provide an overview of these trends, the following presents the top ten articles related to computational thinking, scientific literacy, and critical-creative thinking skills in elementary education that serve as references in this study.

Table 1. Ten Articles Related to Computational Thinking, Scientific Literacy, and HOTS in Elementary Schools (2015–2025)

No	Title	Authors	Year	Sources
1	Improving Mathematical Critical Thinking Skill through STEM-PjBL: A Systematic Literature Review	Rina Dwi Setyawati, Agnita Siska Pramadyahsari, Iin Dwi Astutik, Sindi Nur Aini, Julia Puspita Arum	2022	International Journal on Research in STEM Education, Vol. 4, Issue 2, pp. 1–17
2	Effects of a Design-Based Research Approach on Fourth-Grade Students' Critical Thinking, Problem-Solving Skills, Computational Thinking, and Creativity Self-Efficacy	Emrah Çavuş, Şahin İdil, İsmail Dönmez	2025	International Journal of Technology and Design Education
3	Looking for Problem Scenarios with Robotic Coding: Primary School Example in Turkey	Sibel Demir Kaçan, Ahmet Kaçan	2022	International Journal of Psychology and Educational Studies, Vol. 9, Issue 2, pp. 525–538
4	Exploring the Development of Primary School Students' Computational Thinking and 21st Century Skills Through Scaffolding: Voices from the Stakeholders	Volkan Kukul, Recep Çakır	2020	International Journal of Computer Science Education in Schools, Vol. 4, Issue 2, pp. 36–57
5	ITiCSE – Introducing Computational Thinking to K-5 in a French Context	Vanea Chiprianow, Laurent Gallon	2016	Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education, pp. 112–117
6	Learning Science Through STEAM Approach Integrated Ethnoscience in the Context of Batik Culture for Pre-Service Teachers of Primary Education	Nailah Tresnawati, Ismail Saleh, Dede Trie Kurniawan, Sudarnim Sudarmin, Sri Wardani	2020	Proceedings of the International Conference on Agriculture, Social Sciences, Education, Technology and Health (ICASSETH 2019), pp. 243–246
7	The Effect of Unplugged Coding Education for Special Education Students on Problem-Solving Skills	Ümit Demir	2021	International Journal of Computer Science Education in Schools, Vol. 4, Issue 3, pp. 3–30

No	Title	Authors	Year	Sources
8	Implementation of PBL and IBL Models Assisted by Video Media to Improve Critical Thinking Skills	Munawir Yusuf, Subagya, Iwan Maulana, Mochamad Kamil Budiarto	2022	Jurnal Ilmiah Sekolah Dasar, Vol. 6, Issue 3, pp. 375–384
9	Treffinger Creative Learning Model with RME Principles on Creative Thinking Skill by Considering Numerical Ability	Sabina Nidung, Nyoman Dantes, I Made Ardana, A A I N Marhaeni	2019	International Journal of Instruction, Vol. 12, Issue 3, pp. 731–744
10	Science, Technology, Engineering, and Mathematics (STEM) as a Learning Approach to Improve 21st Century Skills: A Review	Suci Fajrina, Lurfi Lurfi, Yuni Ahd	2020	International Journal of Online and Biomedical Engineering (iJOE), Vol. 16, Issue 7, pp. 95–104

The table above shows that the development themes computational thinking In the context of elementary education, it tends to be carried out through integrative approaches, such as STEM-PjBL, research-based design, problem-based learning, and the use of digital technology. Several studies have demonstrated the success of improving students' critical thinking, creative thinking, and problem-solving skills through the application of computational thinking to project activities, robotics, and specific cultural contexts. For example, research by Fedorenko, (2021) and Ibrahim, Bahtiar, et al., (2024) showed that STEM-PjBL integration was effective in improving mathematical critical thinking skills, while Branco et al., (2021) found that project-based research design had an impact on elementary school students' problem-solving abilities and self-efficacy. Furthermore, research by (Erfan et al., 2024, 2025) is interesting because it used the cultural context of batiks as a vehicle for ethnoscience-based science learning, thus demonstrating that local wisdom can serve as an authentic context that supports computational thinking and the development of 21st-century skills (Alimuddin et al., 2025). Overall, the results of this mapping confirm that the integration of computational thinking and local wisdom in science learning has not been widely explored, specifically in digital learning media forms such interactive e-module, thus providing a new opportunity for this research to develop an approach Computational-ethnopedology in science learning in elementary schools.

In addition, a bibliometric analysis was conducted to map global publication trends related to computational thinking, local wisdom, and the development of critical-creative thinking skills in elementary education. Data extraction results from Lens.org indicate a significant increase in publications on these topics over the past five years. This mapping is important for chronologically analyzing the development of research focus and identifying the momentum of increasing researcher interest in the integration of technology and cultural context in 21st-century learning. This increasing trend is presented in Figure 2, which illustrates the distribution of publications by year of publication and document type.

Based on the publication trend visualization in Figure 2, it can be seen that research related to computational thinking and the development of higher-order thinking competencies began to show a significant increase starting in 2016, then surged sharply in the 2020–2022 period. This surge in publications coincided with the massive implementation of technology-based learning during the COVID-19 pandemic, which encouraged researchers to explore digital learning models based on projects, coding, and STEM. The dominance of journal articles and conference proceedings during this period indicates a high interest in empirical research and the development of new learning models at the elementary school level. The trend then tended to stabilize in 2023–2025, with research focusing increasingly specifically on integrating computational thinking with local cultural contexts and character education based on local wisdom. This strengthens the justification for the approach. Computational-ethnopedology represents a new and prospective research area and still requires the development of concrete learning media such as interactive e-modules to fill the research gaps identified from bibliometric data.

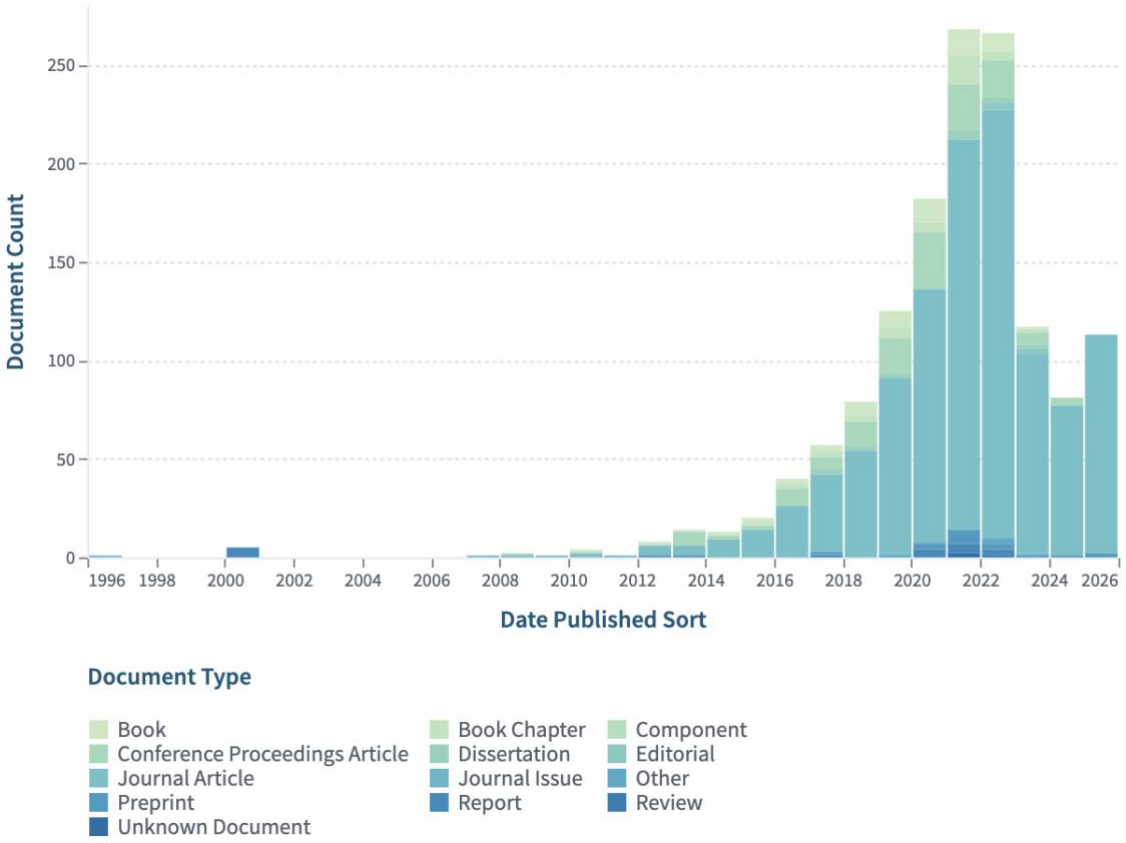

Figure 2. Global Publication Trends on Computational Thinking, Local Wisdom, and HOTS in Elementary Education Based on Publication Year and Document Type (Data: Lens.org, 1996–2025)

In addition to analyzing publication trends based on year of publication, this study also conducted keyword mapping (keyword co-occurrence) to identify key emerging themes in research related to computational thinking in elementary education. This mapping was conducted using bibliometric data from Lens.org processed using VOSviewer software. Keyword analysis is important because it reveals relationships between research concepts, dominant topics frequently studied together, and potential underexplored research gaps.The results of the keyword network map visualization are presented in Figure 3.

The visualization in Figure 3 shows that "computational thinking" becomes a research network center with strong links to various supporting themes such as STEM education, science education, robotics, coding education, and design-based learning, as well as critical thinking and creativity as the expected learning outcomes. In addition, supporting concepts such as decomposition, algorithmic thinking, problem solving, and design thinking, which is a core element of computational thinking. Interestingly, several nodes show the relationship between computational thinking and informal literacy, local wisdom, And ethnoscience, even though the node size is still small. This shows that the study of the integration of computational thinking with local cultural contexts is starting to emerge in academic discourse but has not been studied in depth, especially in the form of interactive digital learning media. Thus, this keyword map confirms previous findings that the approach of computational ethnopedology is a new, prospective area and still has extensive research space, especially in the development of interactive e-modules to improve the critical and creative thinking skills of elementary school students.

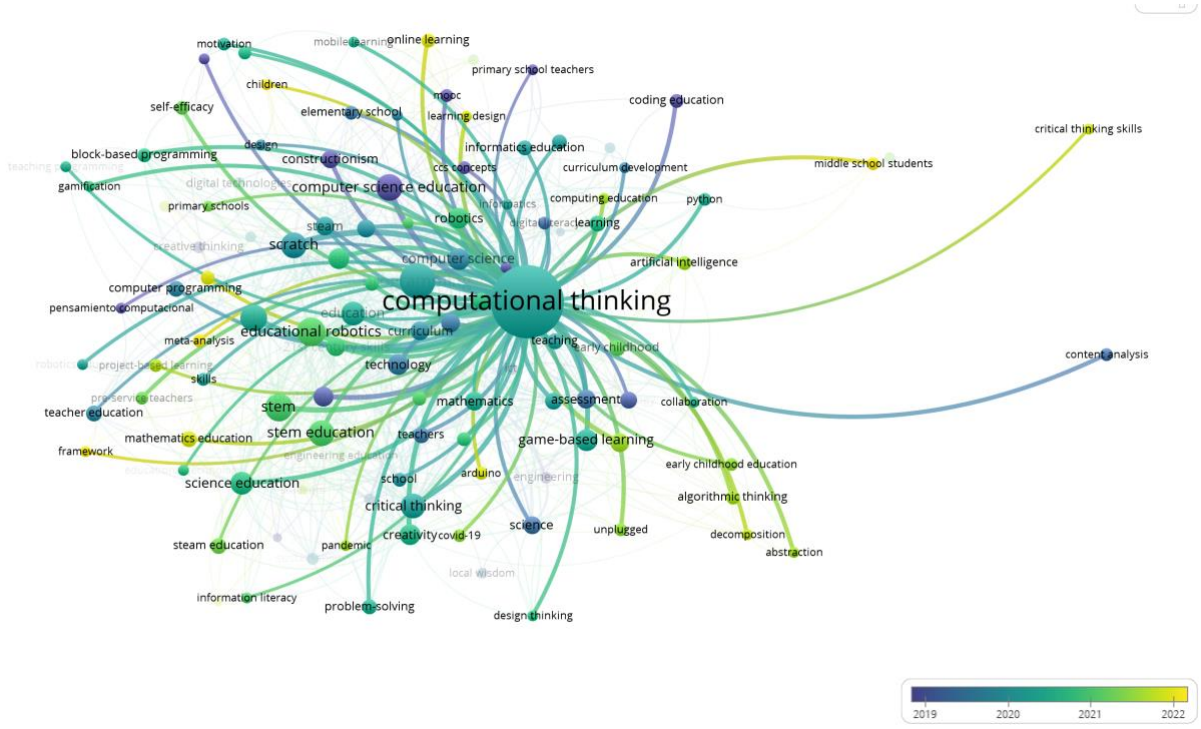

Figure 3. Visualization of Keyword Co-occurrence Maps in Computational Thinking Research in Elementary Education (2019–2022)

Note: color indicates year of publication, node size indicates frequency of occurrence, and line thickness indicates strength of association between keywords.

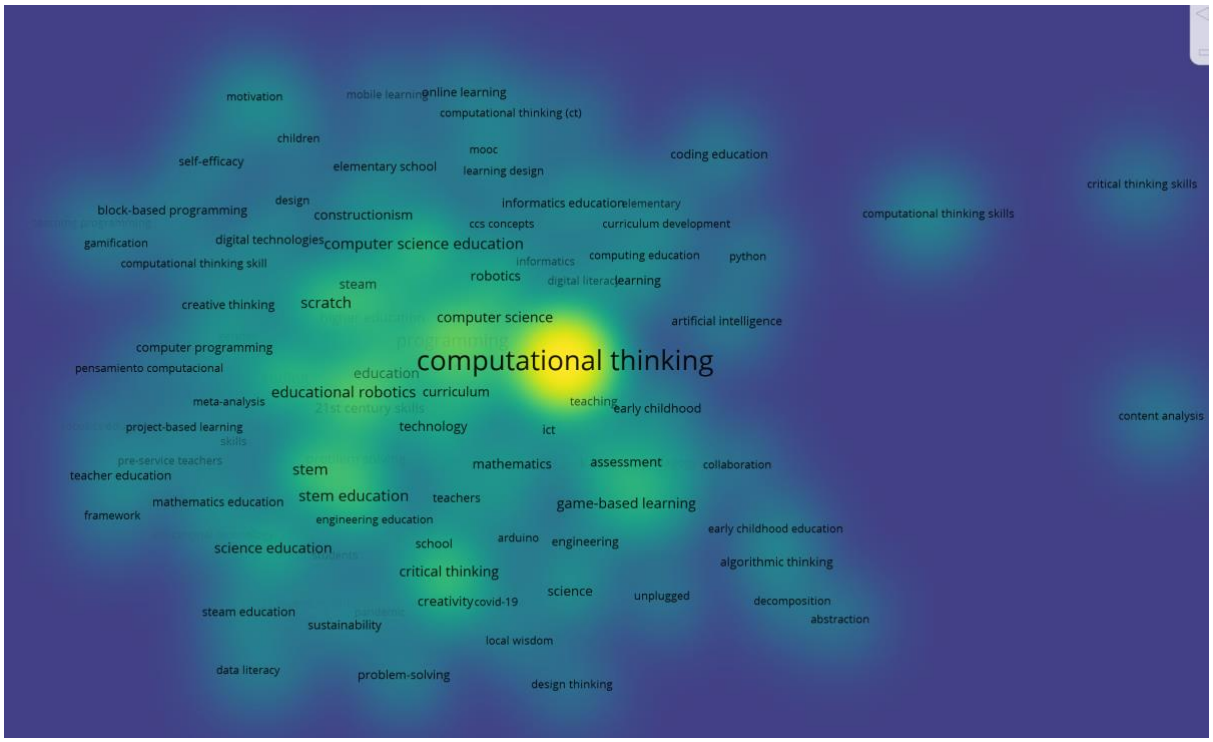

Figure 4. Heatmap of Keyword Co-occurrence in Computational Thinking Research in Elementary Education (Bibliometric Data 2019–2022, Lens.org & VOSviewer)

Note: yellow indicates high intensity of keyword occurrence in the publication; green–blue indicates low to moderate intensity.

To complement the co-occurrence analysis in Figure 3, this study also presents a heatmap visualization to show the intensity of keyword occurrences in global research publications related

to computational thinking in elementary education. The heatmap provides a clearer picture of the topics most dominantly discussed by researchers, indicated by brighter colors or high intensity in certain areas. This visualization is important for identifying established research focuses and identifying themes that still appear sporadically or marginally, including the potential integration of computational thinking with local wisdom in the context of science learning. The heatmap visualization results are shown in Figure 4.

Figure 4 shows that computational thinking is the center of highest intensity in the related publication, marked by the yellow color and the dominant area size. Surrounding it is visible the concentration of intensity on keywords such STEM. education, science education, computer science education, educational robotics, And coding education, which shows that the application of computational thinking at the elementary school level is most developed through the context of STEM, robotics, and block-based programming such as Scratch. In addition, areas of moderate intensity are seen in the topics of critical thinking, creative thinking, And problem-solving, which shows that computational thinking is often associated as a means of developing higher-order thinking skills. Meanwhile, keywords such as "local wisdom," "ethnoscience," and "contextual learning" appear at a low intensity, indicating that the integration of local wisdom in computational thinking research is still in its early stages and has not yet become the main focus of this field. This pattern confirms the previous analysis that the approach Computational-ethnopedology has the potential for novelty because it fills a research space that has not been filled by much previous scientific work, especially in the form of interactive digital learning media to support the development of HOTS in science learning in elementary schools.

CONCLUSION

Based on the research results and discussion, it can be concluded that science learning in elementary schools is currently still not optimal in developing students' critical and creative thinking skills, as reflected in the low HOTS test scores and the dominance of lecture methods and textual learning resources in the learning process. Interview results indicate that teachers face limitations in providing digital-based learning media that are able to visualize abstract concepts while linking them to local phenomena. On the other hand, the questionnaire results revealed that both students and teachers have a strong need for interactive, animation-based learning materials and contextual approaches based on the surrounding culture. These findings are reinforced by bibliometric results that show a global trend of increasing computational thinking research in elementary education, especially through STEM, robotics, and problem-based learning approaches. However, the integration of computational thinking with local wisdom is still a new research area that has not been widely developed. Thus, the results of this study emphasize the urgency of developing interactive e-modules based on Computational-Ethnopedology as a learning innovation that is relevant to 21st-century competencies while being rooted in the cultural context of students and has significant opportunities for innovation in the realm of science education research and practice in elementary schools.

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