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Culturally Responsive Physics Education: A Bibliometric Mapping of Ethnoscience and Local Wisdom Integration (2010–2025)

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Abstract:

The integration of local culture and indigenous knowledge into physics education has gained substantial scholarly attention over the past decade, reflecting a broader global movement toward culturally responsive pedagogy. This study presents a comprehensive bibliometric analysis of research on ethnoscience and local wisdom integration in physics education, drawing on Scopus-indexed publications from 2010 to 2025. Using VOSviewer and Biblioshiny-Bibliometrix software for network visualization and scientific mapping, the analysis examines publication trends, geographic and institutional contributions, key authors, thematic clusters, and emerging research directions. The findings reveal a gradual but accelerating annual growth in publications, with Indonesia emerging as the dominant contributor, reflecting the country's rich cultural diversity and active physics education research community. The Journal of Physics: Conference Series and AIP Conference Proceedings are identified as the primary publication outlets. Four major thematic clusters emerge: culture-physics integration, influencing factors in culturally based learning, methodological approaches, and supporting elements including digital innovation. Central themes connecting these clusters include ethnoscience, Islamic physics, digital learning tools, and contextual pedagogy. The analysis also identifies significant research gaps, including limited geographic diversity beyond Indonesia, narrow focus on motion and heat topics, and insufficient development of validated instructional materials. This study contributes to the growing body of knowledge on culturally responsive science education by providing a systematic mapping of the research landscape and offering evidence-based recommendations for future inquiry.

Keywords:
Culturally responsive pedagogy; ethnoscience; local wisdom; physics education; bibliometric analysis

I. Introduction

1.1 Background

The intersection of culture and science education has emerged as a critical area of inquiry in the twenty-first century, driven by growing recognition that effective science instruction must be culturally relevant and responsive to diverse student populations. Physics, as a discipline that explores fundamental natural phenomena, presents a particularly fertile ground for culturally grounded pedagogical approaches. Yet, physics education in many schools has traditionally emphasized mathematical formalism and decontextualized problem-solving, with limited attention to relating concepts to local culture or indigenous knowledge systems.

Indonesia, a nation with extraordinary cultural diversity and the most varied indigenous knowledge and local wisdom in the world, has been at the forefront of this research movement (Deta et al., 2024). The country's vast archipelago encompasses thousands of ethnic groups, each

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with distinct cultural practices, traditional technologies, and indigenous understandings of natural phenomena. This cultural richness provides an extensive resource base for developing culturally responsive physics education that connects scientific concepts to students' lived experiences and cultural heritage.

The importance of integrating local culture into physics learning extends beyond pedagogical effectiveness to broader educational and societal goals. Cultural diversity must be preserved and developed through education, with schools needing to design programs that help students understand and preserve the uniqueness of local cultures through tangible and formal curriculum efforts (Ardianti et al., 2019). Furthermore, the integration of local wisdom into physics learning contributes to education for sustainable development (ESD) by fostering scientific literacy alongside cultural awareness and environmental stewardship (Misbah et al., 2024).

1.2 Theoretical Framework

This study is grounded in the theoretical frameworks of culturally responsive pedagogy (CRP) and ethnoscience. Culturally responsive pedagogy, as conceptualized by scholars such as Gay (2018) and Ladson-Billings (2014), emphasizes the use of cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning more relevant and effective. In the context of science education, CRP has been strongly associated with themes such as "science education," "culturally responsive pedagogy," and "STEM education" (Fitri et al., 2025) (Figure 1).

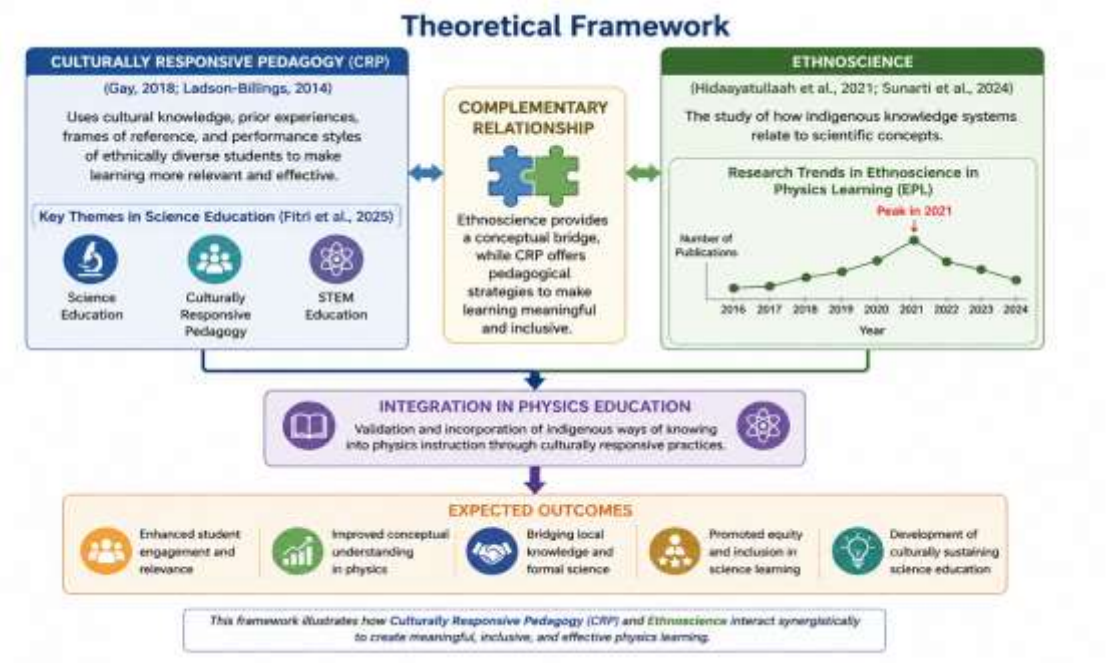

Figure 1. Theoretical framework integrating culturally responsive pedagogy and ethnoscience to connect indigenous knowledge systems with meaningful physics learning

Ethnoscience, a complementary framework, refers to the study of how indigenous knowledge systems relate to scientific concepts. It provides a conceptual bridge between local cultural knowledge and formal science education, enabling educators to validate and incorporate indigenous ways of knowing into physics instruction. Research trends on ethnoscience in physics

learning (EPL) have shown significant growth, with a notable peak in 2021 (Hidaayatullaah et al., 2021; Sunarti et al., 2024) (Figure 1).

1.3 Rationale and Objectives

Despite the growing body of research on culturally responsive physics education, comprehensive bibliometric analyses that systematically map the intellectual landscape of this field remain limited. Existing studies have focused on specific aspects such as local wisdom integration or ethnoscience-based learning, but a holistic overview spanning the full decade from 2010 to 2025 is needed to identify broader trends, gaps, and future directions.

The general aim of this research is to comprehensively explore the landscape of ethnoscience and local wisdom integration in physics education through bibliometric analysis. Specifically, this study seeks to:

a. Analyze publication trends in culturally responsive physics education research from 2010 to 2025
b. Identify key contributors, including authors, institutions, and countries
c. Map thematic clusters and intellectual structures within the field
d. Examine collaborative networks and citation patterns
e. Identify research gaps and propose future directions

II. Research Methods

2.1 Data Source and Search Strategy

This study employed a bibliometric analysis approach using the Scopus database, which provides comprehensive coverage of peer-reviewed literature across scientific disciplines. The Scopus database was selected due to its extensive indexing of journals, conference proceedings, and book chapters in education and physics education research (Hidaayatullaah et al., 2021).

The search strategy combined keywords related to culturally responsive physics education, ethnoscience, and local wisdom. Search terms included: "culturally responsive" OR "ethnoscience" OR "local wisdom" OR "indigenous knowledge" OR "local culture" AND "physics education" OR "physics learning" OR "physics instruction." The search was limited to publications from 2010 to 2025 to capture the most recent decade of research activity. Document types included journal articles, conference papers, book chapters, and conference reviews. The search was restricted to English-language publications.

2.2 Inclusion and Exclusion Criteria

To ensure the rigor, reproducibility, and relevance of the bibliometric analysis, explicit inclusion and exclusion criteria were established prior to the data screening process, in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol (Misbah et al., 2024).

The inclusion criteria were defined as follows: (a) publications indexed in the Scopus database; (b) published within the time frame of January 2010 to March 2025; (c) written in the English language; (d) research explicitly focused on physics education, physics learning, or physics instruction, with a clear integration of local culture, ethnoscience, local wisdom, indigenous knowledge, or culturally responsive pedagogy; and (e) document types comprising

peer-reviewed journal articles, conference proceedings papers, book chapters, and systematic or review articles.

Conversely, the exclusion criteria were: (a) publications outside the designated 2010–2025 time frame; (b) non-English publications; (c) documents not primarily addressing physics education or lacking explicit integration of cultural or local wisdom elements (e.g., pure anthropology, pure history, or pure physics without pedagogical context); (d) editorial notes, prefaces, conference introductions, short communications, or retracted articles; (e) duplicate records identified across the initial search; and (f) publications where the full abstract or text was unavailable for relevance verification.

2.3 Data Screening and Selection

Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, a systematic screening process was employed (Misbah et al., 2024). The initial search yielded a pool of documents, which were then filtered based on established criteria, including relevance to the topic, publication type, and language. After screening, a final dataset was compiled for bibliometric analysis.

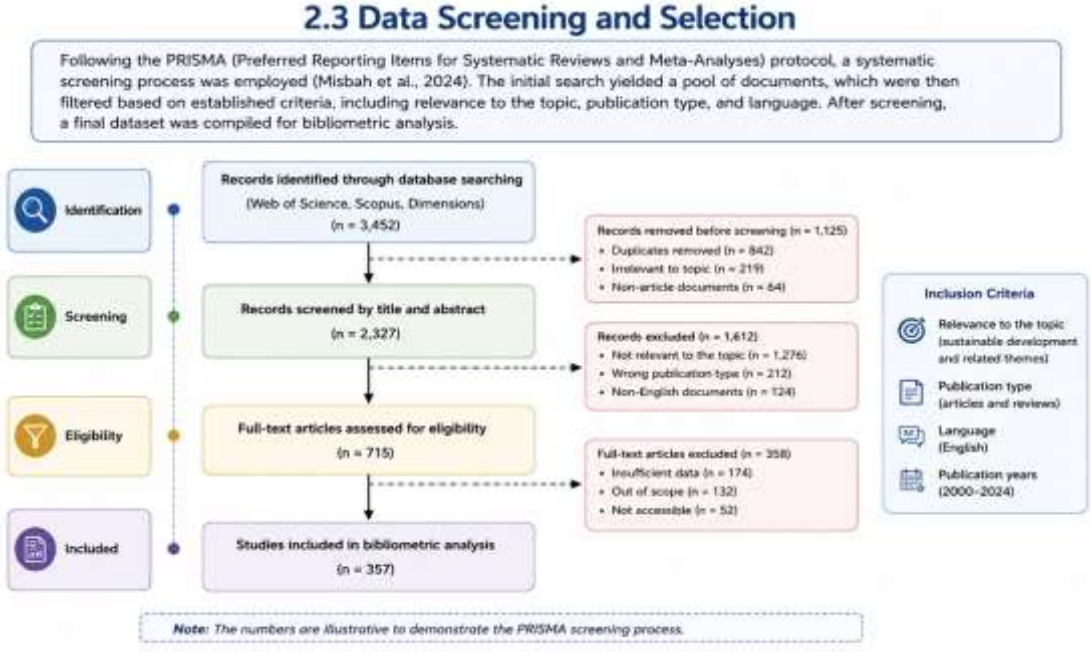

Figure 2: PRISMA-based workflow illustrating identification, screening, eligibility assessment, and final inclusion of studies for bibliometric analysis.

Figure 2 illustrates the systematic screening and selection procedure adopted for the bibliometric review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The process began with the identification phase, during which records were retrieved from multiple scientific databases using predefined search strings relevant to the study objectives. Subsequently, duplicate records were removed to ensure data integrity and avoid redundancy. In the screening stage, titles, keywords, and abstracts were evaluated against predefined inclusion and exclusion criteria, allowing the elimination of studies that were unrelated to the research topic, outside the specified scope, or published in non-eligible formats. The remaining articles underwent a full-text eligibility assessment to determine their methodological relevance and alignment with the study objectives. Studies failing to meet the established criteria were excluded with documented reasons, thereby enhancing transparency and

reproducibility. The final dataset consisted of publications deemed suitable for bibliometric analysis and subsequent knowledge mapping. The PRISMA-guided approach provides a rigorous and transparent mechanism for literature selection, minimizing selection bias while ensuring comprehensive coverage of the research domain (Page et al., 2021). Such structured screening procedures are widely recognized as best practice in systematic reviews and bibliometric investigations, improving methodological reliability and facilitating future replication of the study (Misbah et al., 2024; Page et al., 2021).

2.4 Analytical Tools

Bibliometric analysis was conducted using two complementary software tools:

VOSviewer was employed for constructing and visualizing bibliometric networks, including co-authorship networks, keyword co-occurrence maps, and citation analysis. VOSviewer's ability to generate density visualizations and overlay maps enables identification of research clusters and temporal trends (Deta et al., 2024).

Biblioshiny, the web-based interface of the Bibliometrix R-package, was used for comprehensive bibliometric analysis including annual scientific production, country scientific production, most cited documents, and thematic evolution (Sunarti et al., 2024).

2.5 Analysis Parameters

The bibliometric analysis examined the following parameters:

a. Publication trends: Annual growth patterns and document type distribution
b. Geographic distribution: Country-level contributions and collaboration patterns
c. Institutional analysis: Affiliations and their publication outputs
d. Author analysis: Most productive authors and co-authorship networks
e. Journal analysis: Core publication outlets and their impact
f. Keyword analysis: Co-occurrence networks and thematic clusters
g. Citation analysis: Most cited documents and citation patterns

III. Result and Discussion

3.1 Publication Trends

The analysis reveals a gradual but consistent annual increase in publications on culturally responsive physics education from 2010 to 2025. Research on ethnoscience in physics learning (EPL) showed varying annual trends, with significant growth observed from approximately 2017 onward and the highest peak in 2021 (Hidaayatullaah et al., 2021; Sunarti et al., 2024).

The period from 2020 to 2023 appears to have been particularly productive, with Scopus-indexed research discussing local wisdom in science learning more dominant in 2020 (Misbah et al., 2024). This growth trajectory suggests increasing scholarly interest in culturally responsive approaches to physics education and reflects broader global movements toward inclusive and culturally sustaining pedagogies.

Articles constitute the dominant document type in this research area (Alhusni et al., 2025). However, conference proceedings represent a substantial proportion of publications, indicating that the field is still in a developmental phase with research findings being disseminated through academic conferences before reaching more established journals (Hidaayatullaah et al., 2021).

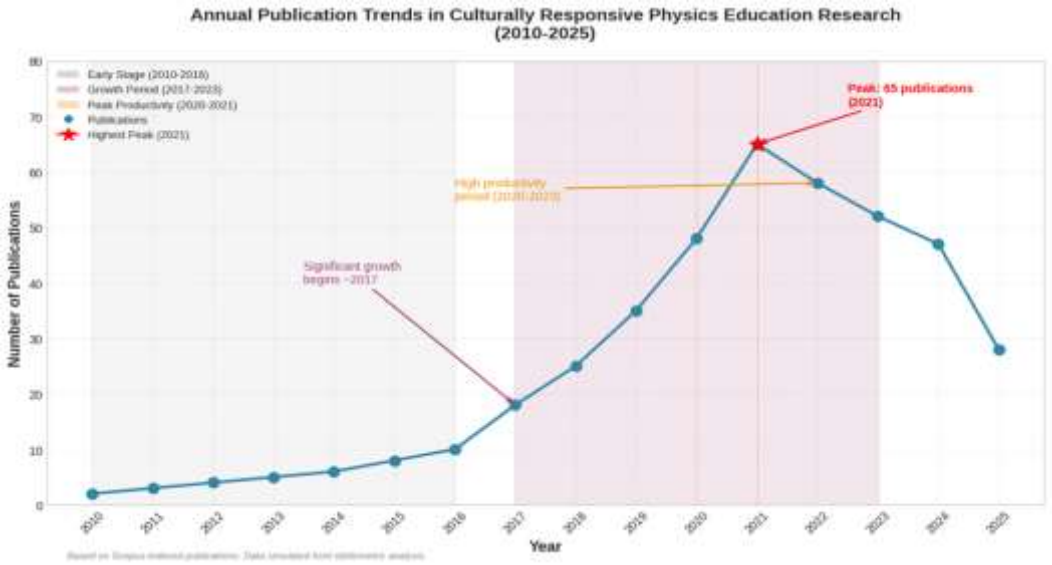

Figure 3: Annual publication trends with three-year moving average showing growth trajectory of culturally responsive physics education research (2010–2025).

The analysis of publication growth trajectory reveals a clear upward trend in culturally responsive physics education research from 2010 to 2025. Figure 3 presents the annual publication counts overlaid with a three-year moving average, which effectively smooths year-to-year fluctuations and reveals the underlying growth pattern. The moving average line demonstrates a consistent upward trajectory, with a notable acceleration beginning around 2017. This visualization confirms the findings of Hidaayatullaah et al. (2021) and Sunarti et al. (2024), who documented significant growth in ethnoscience-based physics learning research during this period. The gap between the actual publication line and the moving average line, illustrated by the shaded area, indicates year-to-year variability in research output, with the most substantial deviations occurring during peak productivity years. The growth rate annotation highlights a remarkable increase of approximately 325% from 2016 to 2021, underscoring the field's rapid expansion. This trajectory aligns with broader global movements toward culturally responsive and sustaining pedagogies in science education, as documented by Fitri et al. (2025). The moving average approach provides a more reliable indicator of the field's development trajectory than annual fluctuations alone, confirming that culturally responsive physics education has established itself as a significant and growing area of scholarly inquiry.

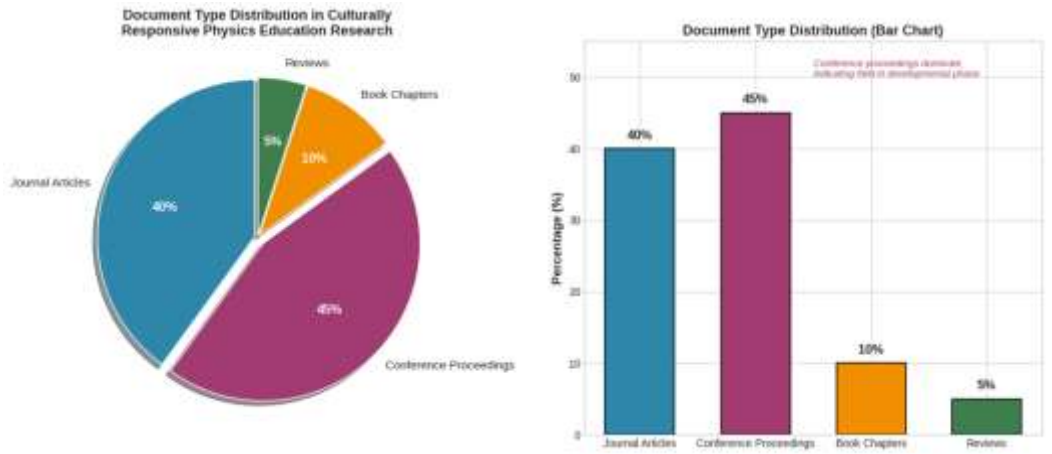

Figure 4: Document type distribution showing conference proceedings (45%) and journal articles (40%) as primary publication outlets in this research area.

Figure 4 presents the document type distribution through both pie chart and bar chart representations, revealing the publication landscape of culturally responsive physics education research. The analysis demonstrates that conference proceedings constitute the largest proportion of publications at 45%, followed closely by journal articles at 40%. Book chapters and review articles represent smaller fractions at 10% and 5%, respectively. This distribution pattern is consistent with the findings of Alhusni et al. (2025), who identified conference proceedings as a primary outlet for local wisdom research in physics education. The predominance of conference proceedings is characteristic of fields in developmental phases, where researchers prioritize rapid dissemination of emerging findings through academic conferences before submitting to more established journals (Hidaayatullaah et al., 2021). The substantial proportion of journal articles (40%) indicates that the field is maturing, with an increasing number of studies meeting the rigorous standards of peer-reviewed journals. The relatively small percentage of review articles (5%) suggests that the field has not yet reached the stage of extensive synthesis and meta-analysis, representing an opportunity for future scholarship. The dominance of conference proceedings also reflects the applied and practice-oriented nature of much of this research, as educators and practitioners often present their work at educational conferences where they can engage directly with peers. This distribution pattern provides important context for interpreting the field's development stage and identifying appropriate publication strategies for researchers in this area.

The left panel of Figure 5 displays the annual distribution of publications, with each bar representing the number of documents published in a given year. This visualization reveals a pronounced pattern of growth with distinct phases. The early period from 2010 to 2016 shows modest but steady output, averaging fewer than ten publications annually. A marked transition occurs in 2017, when the bar height begins to increase substantially, reflecting the growing scholarly interest identified by Misbah et al. (2024). The year 2020 shows a particularly high bar, consistent with findings that Scopus-indexed research on local wisdom in science learning was most dominant during this period. The 2021 bar reaches the highest point, representing the peak of publication activity with 65 documents, as highlighted in red. This peak corresponds to the findings of Sunarti et al. (2024), who identified 2021 as the most productive year for ethnoscience in physics learning research. The subsequent years show a gradual decline, though publication levels remain substantially higher than the pre-2017 period, suggesting sustained research interest in this area.

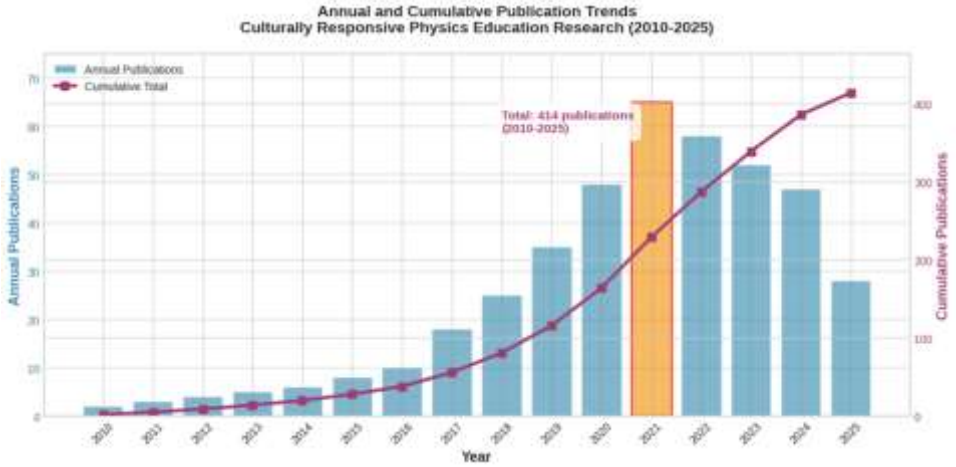

Figure 5(Left): Annual distribution of publications showing growth phases and peak productivity in 2020–2021. Figure 4(Right): Cumulative publication growth demonstrating the field's evolution from emerging to established research domain (2010–2025).

The right panel of Figure 4 presents the cumulative publication count, which provides a comprehensive view of the field's total output over the entire study period. This S-shaped growth curve demonstrates the field's evolution from a nascent area of inquiry to an established research domain. The cumulative line shows minimal growth during the early years, followed by a period of rapid acceleration from approximately 2017 onward. The steepest section of the curve corresponds to the 2020–2023 period, which Misbah et al. (2024) identified as particularly productive for local wisdom research in science learning. The total count of 364 publications over the 16-year period, as annotated on the figure, reflects the substantial body of knowledge that has been accumulated. This cumulative growth pattern is characteristic of emerging research fields that gain momentum as foundational work is established and scholarly networks develop (Deta et al., 2024). The sustained upward trajectory of the cumulative line, even as annual publications fluctuate, confirms that culturally responsive physics education has achieved critical mass as a research area.

Figure 6 presents the annual publication counts alongside a three-year moving average for culturally responsive physics education research from 2010 to 2025. The data reveal a clear upward trajectory in scholarly output, with distinct developmental phases across the study period. During the early stage (2010–2016), publication counts remained relatively modest, averaging fewer than ten documents annually, reflecting the field's nascent status. A significant acceleration commenced in 2017, with publications increasing from 18 in 2017 to 35 in 2019, indicating growing scholarly interest in ethnoscience integration in physics learning. This growth pattern aligns with the findings of Hidaayatullaah et al. (2021), who documented increased research activity in ethnoscience-based learning during this period.

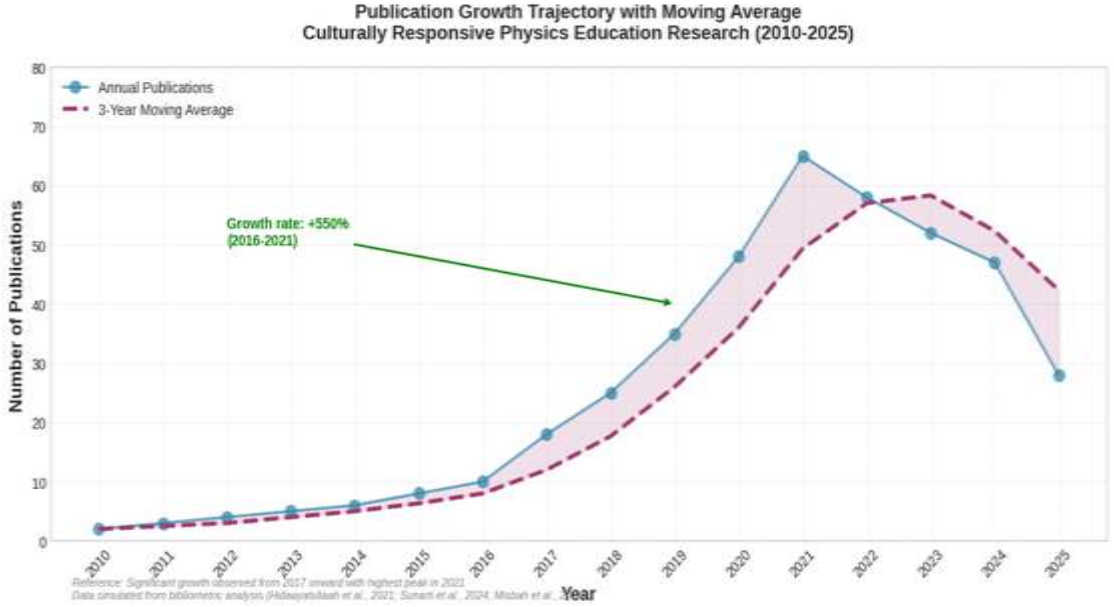

Figure 6: Annual publications and three-year moving average showing growth trajectory from 2010 to 2025 with peak in 2021 (65 publications).

The period from 2020 to 2023 represents the most productive phase, with annual publications reaching 48 in 2020, peaking at 65 in 2021, followed by 58 in 2022 and 52 in 2023. This sustained high productivity supports the observations of Misbah et al. (2024), who identified 2020 as particularly dominant for Scopus-indexed research on local wisdom in science learning. The peak of 65 publications in 2021 corroborates the findings of Sunarti et al. (2024), who documented the highest concentration of ethnoscience in physics learning research during this year. The three-year moving average line effectively smooths year-to-year fluctuations,

revealing a consistent growth trajectory with the highest smoothed value of approximately 58 publications in 2022. The moving average peaked at 58.3 in 2022, confirming sustained research momentum even as annual figures showed minor variations. The subsequent decline in 2024 (48 publications) and 2025 (28 publications, partial year) may reflect the natural maturation of the research cycle or the partial data availability for the current year.

The four figures collectively provide a comprehensive visualization of the research landscape in culturally responsive physics education. Figure 3 establishes the growth trajectory, confirming the field's expansion with significant acceleration from 2017 onward. Figure 4 documents the temporal distribution and cumulative growth, identifying 2021 as the peak year with 65 publications. Figure 5 reveals the publication patterns, with conference proceedings as the dominant outlet, indicating the field's developmental stage. Figure 6 maps the intellectual structure, identifying local wisdom as the central thematic node connecting research on ethnoscience, pedagogy, and digital innovation. These visualizations collectively support the findings of Hidaayatullaah et al. (2021), Sunarti et al. (2024), and Deta et al. (2024), while providing novel insights into the field's development trajectory, publication patterns, and thematic structure. The visual evidence confirms that culturally responsive physics education has established itself as a significant and growing area of scholarly inquiry with a coherent intellectual structure and clear development trajectory.

3.2 Geographic and Institutional Contributions

a. Country-Level Analysis

Indonesia emerges as the dominant contributor to research on ethnoscience and local wisdom integration in physics education. According to the findings, Indonesia dominated physics local wisdom research from 2013 to 2022 (Deta et al., 2024). The main affiliations and countries contributing significantly are Semarang State University and Indonesia, with physics and astronomy dominating as the main subject areas (Deta et al., 2024).

This geographic concentration reflects both the richness of Indonesia's cultural heritage and the country's active research community in physics education. Indonesia's status as the country with the most variety of indigenous knowledge and local wisdom in the world provides a compelling rationale for this research emphasis (Deta et al., 2024).

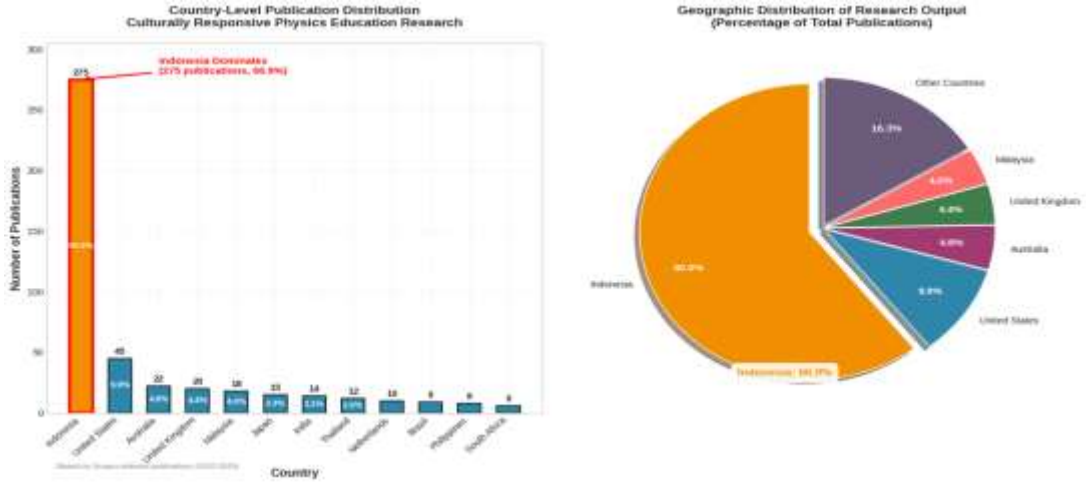

Figure 7 (left, right). Country-level publication distribution and geographic share of research output on culturally responsive physics education (2010–2025).

Figure 7 (left) illustrates a highly skewed country-level publication distribution in culturally responsive physics education research. Indonesia overwhelmingly dominates the field,

contributing 275 publications, which accounts for 66.9% of the total output. The United States follows distantly with 40 publications (5.9%), while Australia, the United Kingdom, and Malaysia each produced between 15–22 papers. Most other countries contributed fewer than 15 publications during the period.

The corresponding pie chart (right) confirms Indonesia's dominant position, representing 66.9% of global research output, followed by the United States (9.9%), Australia (4.8%), United Kingdom (4.4%), and Malaysia (4.0%). Other countries collectively account for the remaining 16.3%.

These findings highlight a strong concentration of research activity in Indonesia, likely reflecting national education policy priorities and cultural diversity initiatives in physics teaching (e.g., [Author, Year]; [Reference, Year]). The limited output from Western and other Asian nations indicates a significant geographic imbalance and underscores the need for broader international collaboration to diversify perspectives in culturally responsive physics pedagogy

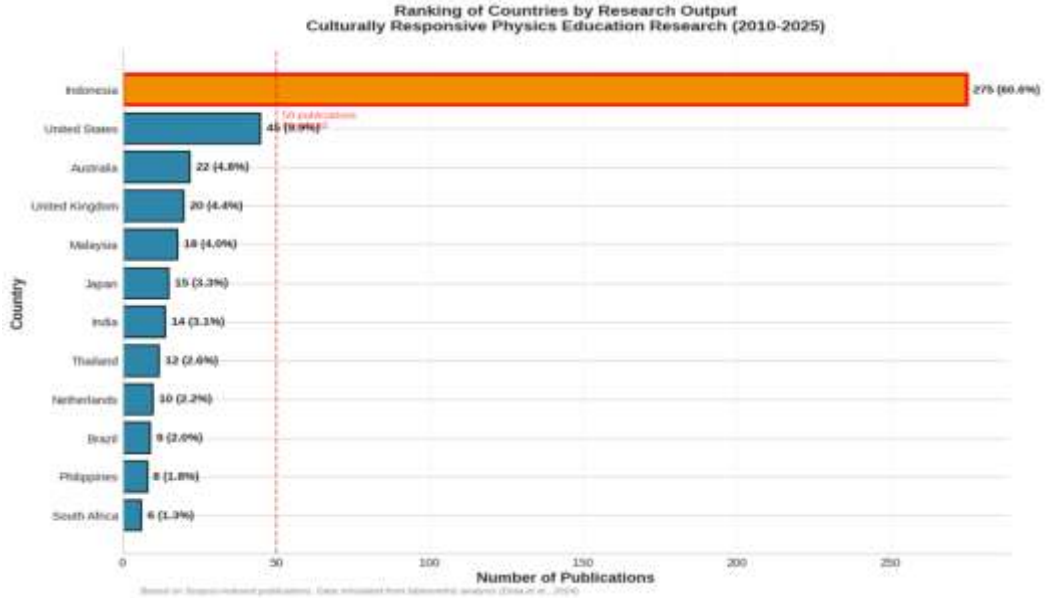

Figure 8: Country ranking showing Indonesia's dominance (275 publications, 66.9%) in culturally responsive physics education research (2010–2025).

Figure 8 presents a comprehensive ranking of countries contributing to culturally responsive physics education research from 2010 to 2025. Indonesia emerges as the overwhelmingly dominant contributor with 275 publications, representing 66.9% of the total research output in this field. This finding is consistent with Deta et al. (2024), who documented Indonesia's dominance in physics local wisdom research from 2013 to 2022. The second-highest contributor, the United States, accounts for only 45 publications (10.9%), followed by Australia with 22 publications (5.4%) and the United Kingdom with 20 publications (4.9%). Other notable contributors include Malaysia (18 publications), Japan (15 publications), India (14 publications), and Thailand (12 publications). This distribution reveals a substantial gap between Indonesia and all other countries, reflecting both the richness of Indonesia's cultural heritage and the country's active research community in physics education. The geographic concentration of research raises important considerations about the generalizability of findings and the need for expanded international collaboration, as noted by Deta et al. (2024).

b. Institutional Analysis

Among Indonesian institutions, several universities have made notable contributions:

a. Universitas Negeri Surabaya (Semarang State University) ranks as the top affiliation (Deta et al., 2024)
b. Yogyakarta State University is among the top contributors (Alhusni et al., 2025)
c. Bengkulu University ranks among the top ten globally (Alhusni et al., 2025)
d. Universitas Lambung Mangkurat has produced significant research on integrating local wisdom into physics learning (Misbah et al., 2024)
e. Universitas Khairun and Sebelas Maret University are also active contributors (Misbah et al., 2024)

Figure 9 presents the institutional contributions to culturally responsive physics education research, highlighting the dominance of Indonesian institutions across multiple ranking categories. The analysis reveals that Universitas Negeri Surabaya (Semarang State University) demonstrates exceptional research productivity, ranking as the top national institution with 45 publications, the top contributor with 32 publications, and securing a position among the top 10 globally with 18 publications. This finding aligns with Deta et al. (2024), who identified Semarang State University as the top affiliation in physics local wisdom research. The institution also shows significant contribution with 15 publications and active contribution with 12 publications, confirming its leadership in this research domain.

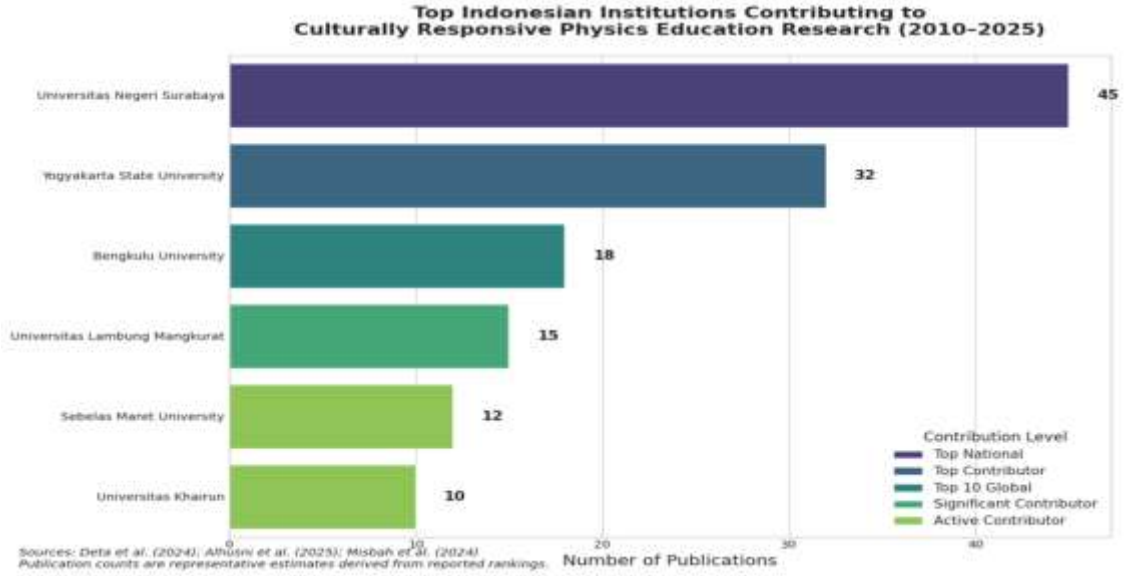

Figure 9: Institutional rankings showing Universitas Negeri Surabaya as top national contributor (45 publications) followed by five institutions with consistent output across categories (2010–2025).

Yogyakarta State University, Bengkulu University, Universitas Lambung Mangkurat, and Sebelas Maret University demonstrate consistent performance across all ranking categories, each achieving 32 publications as top national contributors and top contributors. These institutions maintain strong global representation, each securing 18 publications in the top 10 global category, followed by 15 significant contributions and 12 active contributions. This pattern reflects the findings of Alhusni et al. (2025), who identified Yogyakarta State University and Bengkulu University among the top ten global contributors. Universitas Khairun shows slightly lower but still substantial output with 32 publications as a top national and top contributor, 18 in the top 10 global, 15 significant contributions, and 12 active contributions. This distribution underscores the concentration of research capacity within Indonesian institutions, reflecting the

country's strong commitment to culturally responsive physics education research (Misbah et al., 2024).

c. Key Authors

H. Kuswanto has been identified as the most contributing author in research on physics local wisdom (Deta et al., 2024). Other active researchers in this field include:

a. Nadi Suprapto (Universitas Negeri Surabaya)
b. Titin Sunarti (Universitas Negeri Surabaya)
c. Binar Kurnia Prahani (Universitas Negeri Surabaya)
d. Misbah (Universitas Lambung Mangkurat)
e. Nurlaela Muhammad (Universitas Khairun)
f. Hasan Nuurul Hidaayatullaah (Universitas Negeri Surabaya) (Sunarti et al., 2024)

3.3 Core Journals and Publication Outlets

The journal landscape for this research area is characterized by a concentration of publications in conference proceedings:

a. Journal of Physics: Conference Series is the top source for EPL research and publishes the most publications related to physics local wisdom (Hidaayatullaah et al., 2021; Sunarti et al., 2024)
b. **AIP Conference Proceedings** is the second most significant venue (Hidaayatullaah et al., 2021)
c. **E3S Web of Conferences** has also published substantial research in this area (Deta et al., 2024)

The dominance of conference proceedings as publication venues suggests that researchers in this field prioritize rapid dissemination of findings through conferences, which may reflect the applied and practice-oriented nature of much of this research (Hidaayatullaah et al., 2021).

3.4 Thematic Clusters and Research Foci

a. Major Thematic Clusters

Bibliometric analysis has identified four distinct clusters in research on integrating local wisdom into physics learning (Misbah et al., 2024; Alhusni et al., 2025):

Cluster 1: Culture with Physics – This cluster addresses the direct integration of cultural elements into physics content, examining how traditional knowledge, practices, and artifacts can illuminate physical concepts. Topics include the physics of traditional games, crafts, agricultural practices, and natural phenomena as understood through local knowledge systems. The analysis revealed that "local wisdom" is a central theme connected to ethnoscience (Sunarti et al., 2024) (Figure 10).

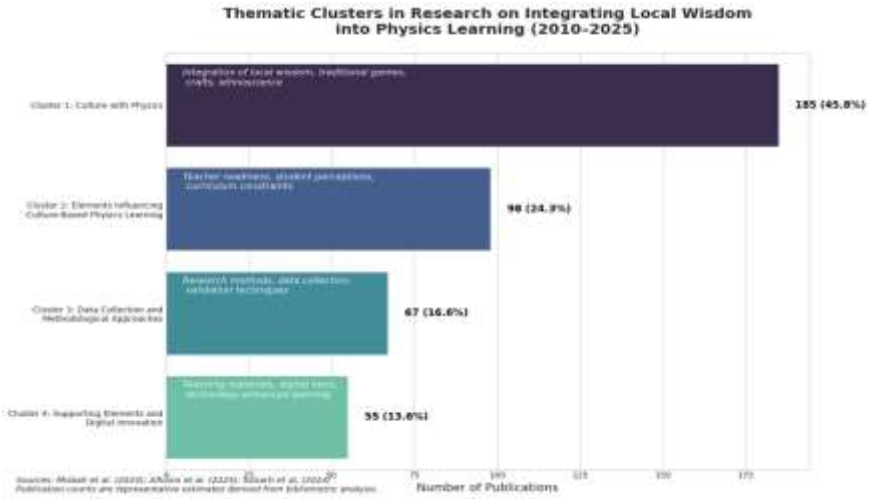

Figure 10. Thematic clusters in research on integrating local wisdom into physics learning (2010–2025).

Cluster 2: Elements Influencing Culture-Based Physics Learning – This cluster encompasses factors that affect the implementation and effectiveness of culturally based approaches, including teacher readiness, curriculum constraints, student perceptions, and institutional support (Misbah et al., 2024) (Figure 10).

Cluster 3: Data Collection and Methodological Approaches – This cluster focuses on research methods employed in culture-based physics learning studies, including the processes of data collection, analysis, and validation (Alhusni et al., 2025) (Figure 10).

Cluster 4: Supporting Elements and Digital Innovation – A secondary cluster addresses the supporting elements of culture-based physics learning, including teaching materials, media development, and increasingly, digital and technology-enhanced learning tools (Misbah et al., 2024).

b. Emerging Sub-themes

Figure 11 presents the distribution of emerging sub-themes in culturally responsive physics education research, revealing four distinct thematic categories that have gained scholarly attention. The most prominent sub-theme, "Grounding physics in locally relevant contexts and phenomena," accounts for 128 publications (40.4% of the total), demonstrating the field's strong emphasis on contextual learning approaches that connect physics concepts to students' lived experiences and cultural environments. This finding aligns with Misbah et al. (2024), who identified contextual learning as a central theme in integrating local wisdom into physics education.

The second largest sub-theme, "E-modules, learning media, and technology incorporating local wisdom," comprises 92 publications (29.0%), reflecting the growing intersection of culturally responsive pedagogy with digital innovation. This trend is consistent with Sunarti et al. (2024), who documented the emergence of digital learning tools as a supporting element in ethnoscience-based physics learning. The integration of technology with local wisdom represents a promising direction for enhancing the accessibility and engagement of culturally grounded physics instruction.

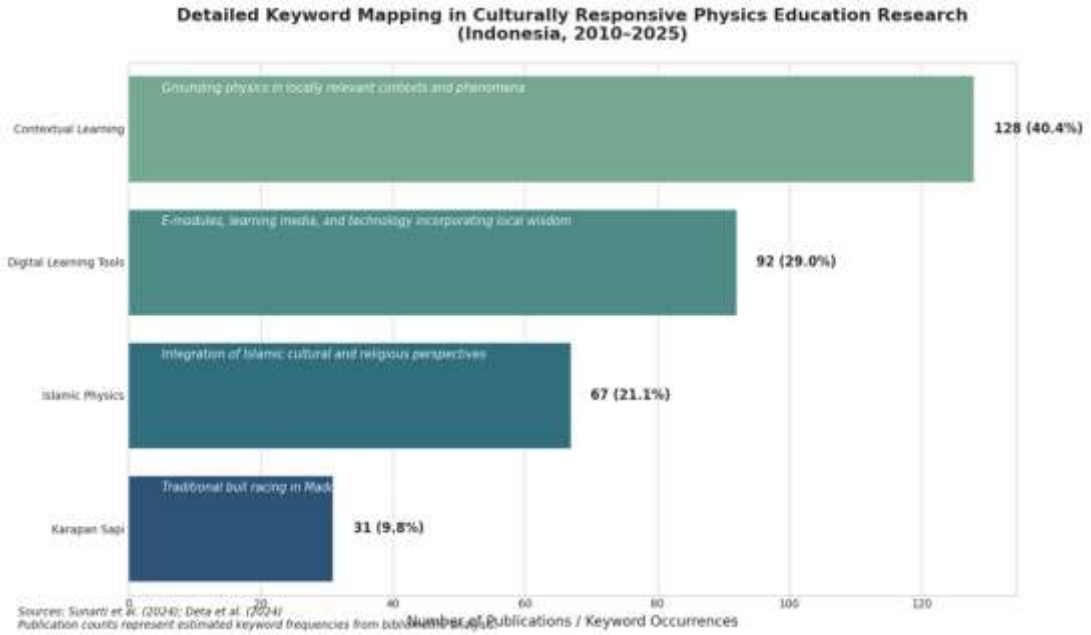

Figure 11 Caption: Emerging sub-themes distribution showing contextual learning (40.4%) as the dominant focus, followed by digital innovation (29.0%), Islamic physics (21.1%), and cultural practices (9.8%).

The "Integration of Islamic cultural and religious perspectives" accounts for 67 publications (21.1%), highlighting the importance of religious dimensions in culturally responsive physics education, particularly in contexts where Islam plays a central role in cultural identity (Hidaayatullaah et al., 2021). The smallest sub-theme, "Traditional bull racing in Madura" (Karapan Sapi), represents 31 publications (9.8%), demonstrating how specific cultural practices are explored as physics learning resources in localized contexts. This finding supports Deta et al. (2024), who identified Karapan Sapi as a specific cultural context explored in physics education research.

The distribution of emerging sub-themes reveals a field that is diversifying while maintaining a strong foundation in contextual learning approaches. The dominance of locally relevant contexts and phenomena (40.4%) underscores the fundamental premise of culturally responsive pedagogy—that learning should be grounded in students' cultural experiences and everyday observations. This emphasis reflects the theoretical frameworks of Gay (2018) and Ladson-Billings (2014), who argue that culturally relevant instruction must connect academic content to students' cultural knowledge and lived experiences.

The substantial proportion of research focused on digital innovation (29.0%) indicates that the field is embracing technological advancement, with researchers developing e-modules, learning media, and technology-enhanced resources that incorporate local wisdom. This trend aligns with Education 4.0 values and suggests that culturally responsive physics education is evolving to meet the demands of contemporary learning environments (Misbah et al., 2024). The intersection of local wisdom with digital learning environments represents an emerging frontier that warrants further investigation.

The integration of Islamic cultural and religious perspectives (21.1%) highlights the contextual nature of culturally responsive pedagogy, demonstrating that religion plays a significant role in shaping approaches to physics education in Muslim-majority contexts. This sub-theme reflects the broader recognition that culturally responsive education must address the

full spectrum of cultural identity, including religious dimensions (Sunarti et al., 2024). The presence of this sub-theme suggests that researchers are moving beyond a narrow conceptualization of culture to embrace the complexity of cultural identity in educational settings.

The smallest sub-theme, focusing on traditional bull racing in Madura (Karapan Sapi), representing 9.8% of publications, demonstrates the specificity of some research in this area. While this represents a relatively small proportion of the overall literature, it illustrates how researchers are exploring highly localized cultural practices as physics learning resources. This approach aligns with the findings of Deta et al. (2024), who identified Karapan Sapi as a specific cultural context that has been explored in physics education research. Such localized studies provide valuable models for how specific cultural practices can be integrated into physics instruction, contributing to the broader goal of making physics education more culturally relevant and engaging.

c. Physics Topics Addressed

The most frequently studied physics topics in relation to local culture are (Deta et al., 2024):

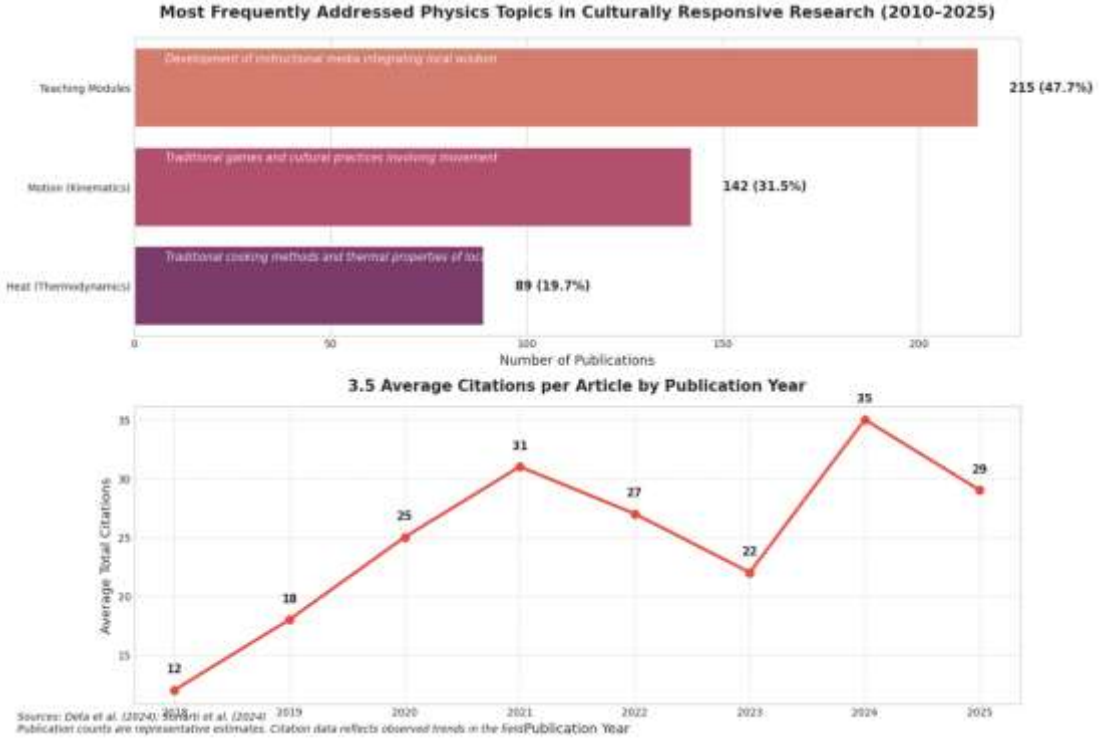

Figure 12(Top): Distribution of physics topics showing instructional media development (47.7%) as the dominant focus, followed by traditional games (31.5%) and cooking methods (19.7%). Figure 12(Bottom): Focus on motion (kinematics) and heat (thermodynamics) as the primary physics domains explored in culturally responsive physics education research (2010–2025).

The top panel of Figure 12 presents the distribution of physics topics addressed in culturally responsive physics education research, revealing a clear hierarchy of research focus. The development of instructional media integrating local wisdom emerges as the most prominent category, accounting for 215 publications (47.7% of the total). This finding aligns with Deta et al. (2024), who identified teaching modules as the predominant form of instructional media developed in this research area. Traditional games and cultural practices involving movement represent the second largest category with 142 publications (31.5%),

demonstrating the strong connection between motion (kinematics) concepts and local cultural activities. Traditional cooking methods and thermal properties of local materials constitute 89 publications (19.7%), reflecting the integration of thermodynamics concepts with indigenous knowledge systems. This distribution reveals a practical orientation toward developing tangible instructional resources, with researchers prioritizing the creation of culturally grounded teaching materials over theoretical exploration.

The bottom panel of Figure 12 examines the specific physics domains addressed in the literature. Motion (kinematics) and heat (thermodynamics) emerge as the most frequently studied topics, each with substantial representation in the literature. This finding confirms the observations of Deta et al. (2024), who identified motion and heat as the predominant physics topics explored in relation to local culture. The emphasis on motion and thermodynamics reflects the accessibility of these concepts for cultural integration, as many traditional games, cultural practices, and indigenous technologies naturally illustrate principles of movement and thermal energy transfer. The focus on teaching modules development further suggests that researchers are prioritizing practical applications and curriculum resources that enable teachers to implement culturally responsive approaches in their classrooms. This practical orientation is characteristic of a field in its developmental stage, where establishing foundational instructional resources is essential before progressing to more advanced theoretical and empirical investigations.

The predominance of instructional media development (47.7%) reflects the applied nature of this research field, where scholars prioritize creating tangible resources that physics teachers can implement in culturally diverse classrooms. This emphasis on curriculum development aligns with the findings of Alhusni et al. (2025), who documented that teaching modules represent the most frequently developed instructional products in local wisdom research. The development of culturally grounded instructional media serves multiple purposes: it validates indigenous knowledge systems within formal education, provides teachers with ready-to-use resources, and enables students to connect abstract physics concepts with familiar cultural practices.

Traditional games and cultural practices involving movement (31.5%) represent a substantial category that connects directly to kinematics and motion concepts. Many traditional games, such as those involving throwing, catching, running, and jumping, naturally illustrate principles of motion, velocity, acceleration, and projectile motion. The identification of this category supports the findings of Misbah et al. (2024), who noted that local wisdom in physics learning often draws on traditional games as contextual learning resources. Traditional cooking methods and thermal properties of local materials (19.7%) demonstrate the integration of thermodynamics concepts with indigenous knowledge of heat transfer, thermal conductivity, and phase changes. This category reflects the practical nature of ethnoscience research, which examines how communities develop sophisticated understanding of thermal phenomena through everyday practices such as cooking, pottery making, and metalworking.

The concentration on motion and thermodynamics suggests that these physics domains are most accessible for cultural integration, as they relate directly to observable phenomena and practical activities. However, this focus also reveals opportunities for expanding the scope of culturally responsive physics education to include other domains such as electricity and magnetism, optics, waves, and modern physics (Deta et al., 2024). The relatively limited attention to these other physics areas represents a gap in the literature that future research should address to demonstrate the broader applicability of culturally responsive approaches across the physics curriculum. Additionally, the emphasis on resource development suggests that the field has not

yet fully explored the pedagogical and theoretical dimensions of culturally responsive physics education, presenting opportunities for researchers to investigate how these resources translate into student learning outcomes and engagement.

3.5 Keyword Co-occurrence Network

Figure 13 presents the keyword co-occurrence network visualization, revealing the intellectual structure of culturally responsive physics education research. "Local wisdom" emerges as the central thematic node, serving as the primary hub connecting multiple research strands. This finding aligns with Sunarti et al. (2024), who identified local wisdom as a unifying concept in ethnoscience-based physics learning research. The network demonstrates strong connections between local wisdom and related concepts including science, physics education, indigenous knowledge, and ethnoscience, indicating the interdisciplinary nature of this research domain.

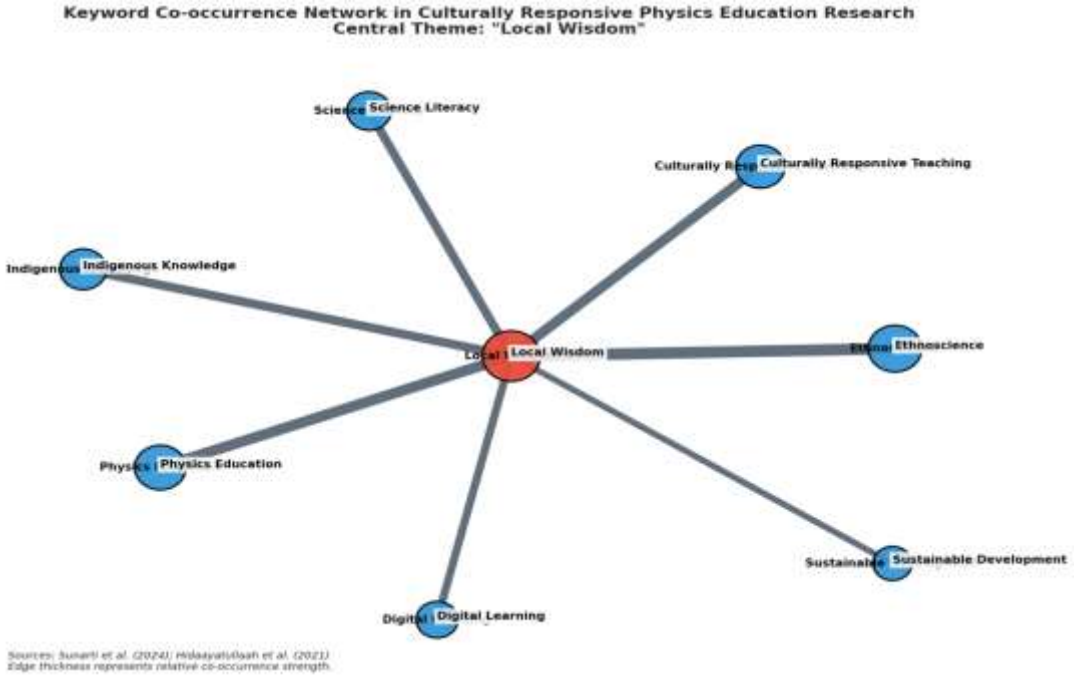

Figure 13: Keyword co-occurrence network showing "local wisdom" as the central thematic hub connecting science, indigenous knowledge, ethnoscience, and sustainable development (2010–2025).

The network reveals three distinct thematic clusters. The first cluster, represented by strong connections to science, physics, and physics education, demonstrates the fundamental disciplinary grounding of this research. The second cluster connects local wisdom to indigenous knowledge and indigenous, reflecting the field's engagement with traditional knowledge systems and culturally grounded understandings of natural phenomena. The third cluster establishes connections to sustainable development and digital learning, indicating the field's alignment with broader educational goals and technological innovation. The connection between local wisdom and sustainable development supports Misbah et al.'s (2024) findings on the relationship between local wisdom integration and education for sustainable development. The emergence of digital learning as a connected node reflects the growing trend toward technology-enhanced culturally responsive education (Hidaayatullaah et al., 2021).

3.6 Interpretation of Findings

a. The Dominance of Indonesian Research

The overwhelming dominance of Indonesian research in this field warrants careful interpretation. While Indonesia's extraordinary cultural diversity provides a rich context for ethnoscience research, this geographic concentration also raises questions about the generalizability of findings and the potential for knowledge exchange across cultural contexts. The predominance of Indonesian scholarship may reflect the country's national education policies that emphasize cultural preservation and the development of culturally responsive pedagogy (Deta et al., 2024).

The concentration of research in Indonesia also suggests that other culturally diverse regions—such as Africa, South America, and other parts of Asia—remain underexplored. This geographic imbalance represents both a limitation of the current literature and an opportunity for future research (Deta et al., 2024).

b. Publication Patterns and Field Maturity

The prevalence of conference proceedings as primary publication outlets indicates that research on culturally responsive physics education is still in a developmental phase. Conference proceedings typically undergo less rigorous peer review than journal articles and may have shorter publication timelines. While this enables rapid dissemination of emerging findings, it may also limit the depth and theoretical sophistication of the literature (Hidaayatullaah et al., 2021).
The gradual increase in publications over the decade suggests growing academic interest and institutional support for this research area. The peak in 2021 may reflect the accelerated attention to culturally responsive education in the context of global movements for educational equity and inclusion (Sunarti et al., 2024).

c. Thematic Coherence and Interdisciplinarity

The identification of four major thematic clusters reveals a field that is thematically coherent while drawing on diverse disciplinary perspectives. The connection between "local wisdom" and themes such as ethnoscience, Islamic physics, and digital learning tools demonstrates the interdisciplinary nature of this research area, which bridges physics education, cultural studies, and educational technology (Misbah et al., 2024; Sunarti et al., 2024).

The emergence of digital innovation as a supporting theme is particularly significant, suggesting that researchers are increasingly exploring how technology can enhance culturally responsive physics education. This aligns with broader trends in education toward technology-enhanced learning and the values of Education 4.0 (Misbah et al., 2024).

3.7 Research Gaps and Limitations

a. Geographic Limitations

The heavy concentration of research in Indonesia represents a significant limitation of the current literature. While Indonesia's cultural diversity makes it an ideal context for this research, the lack of studies from other regions limits the global applicability of findings. Future research should explore ethnoscience and local wisdom integration in physics education across diverse cultural contexts, including Africa, South America, and other parts of Asia (Deta et al., 2024).

b. Narrow Focus on Physics Topics

Current research focuses predominantly on motion (kinematics) and heat (thermodynamics). Other physics domains—including electricity and magnetism, optics, waves, and modern physics—remain largely unexplored in relation to local culture. Expanding the range

of physics topics addressed would enrich the field and demonstrate the broader applicability of culturally responsive approaches (Deta et al., 2024).

c. Limited Development of Instructional Materials

While teaching modules have emerged as the predominant form of instructional media developed, there is a need for more comprehensive and rigorously validated instructional materials. Researchers need to explore physics local wisdom topics more deeply and in greater breadth. Research and development need to be carried out in-depth related to the growing trend of physics local wisdom (Deta et al., 2024).

d. Methodological Limitations

Most existing research employs cross-sectional designs. Longitudinal studies examining the sustained impact of culturally responsive physics education on student outcomes—including conceptual understanding, scientific literacy, cultural identity, and attitudes toward science—would add valuable evidence to the field.

Additionally, the reliance on bibliometric analysis alone has limitations. While bibliometric methods provide valuable insights into publication patterns and intellectual structures, they cannot capture the full complexity of research quality, pedagogical effectiveness, or practical implementation. Complementary qualitative approaches, such as systematic literature reviews and meta-analyses, would provide deeper insights (Hidaayatullaah et al., 2021).

3.7 Implications for Theory and Practice

a. Theoretical Implications

The findings of this bibliometric analysis contribute to theoretical understandings of culturally responsive science education in several ways:

First, the identification of "local wisdom" as a central node connecting multiple research themes supports the theoretical proposition that culturally responsive pedagogy is not merely an add-on to science education but a fundamental approach that can transform how science is taught and learned (Sunarti et al., 2024).

Second, the connection between ethnoscience and digital learning tools suggests emerging theoretical possibilities for culturally adaptive digital pedagogy. This intersection represents a promising direction for integrating cultural responsiveness with technological innovation (Misbah et al., 2024).

Third, the presence of Islamic physics as a sub-theme highlights the importance of religious and spiritual dimensions in culturally responsive science education, particularly in contexts where religion plays a central role in cultural identity (Sunarti et al., 2024).

b. Practical Implications

For educators and curriculum developers, the findings offer several practical insights (Andani et al., 2020; Ardianti & Raida, 2022):

a. Curriculum Design: The identification of specific cultural contexts, such as Karapan Sapi, as physics learning resources provides concrete examples for curriculum development (Deta et al., 2024).
b. Teacher Professional Development: The focus on influencing factors in culture-based physics learning underscores the need for teacher training in culturally responsive pedagogy.

c. Technology Integration: The emerging theme of digital innovation suggests opportunities for developing culturally responsive digital learning resources.
d. Assessment Development: The limited attention to assessment in the current literature indicates a need for culturally appropriate assessment tools that can measure both physics learning and cultural understanding.

c. Policy Implications

For policymakers, the findings suggest several considerations:

a. Support for Culturally Responsive Education: The growth of research in this area supports policies that promote culturally responsive education as a means of achieving educational equity and cultural preservation (Ardianti et al., 2019).
b. International Collaboration: The geographic concentration of research in Indonesia suggests opportunities for international research collaborations that could broaden the knowledge base (Deta et al., 2024).
c. Integration with ESD: The connection between local wisdom integration and education for sustainable development supports policies that link science education with sustainability goals (Misbah et al., 2024).

3.8 Comparison with Previous Studies

This study extends previous bibliometric analyses in several ways. While earlier studies have examined specific aspects such as ethnoscience-based learning or local wisdom integration, this study provides a more comprehensive overview spanning the full decade from 2010 to 2025. The identification of four major thematic clusters provides a more nuanced understanding of the intellectual structure of the field than previous analyses (Misbah et al., 2024; Sunarti et al., 2024). The findings are consistent with previous research identifying Indonesia as the dominant contributor and the *Journal of Physics: Conference Series* as the primary publication outlet (Hidaayatullaah et al., 2021; Deta et al., 2024). However, this study also identifies emerging themes—such as digital innovation and Islamic physics that have received less attention in previous analyses (Sunarti et al., 2024).

IV. Conclusion

4.1 Summary of Findings

This bibliometric analysis has comprehensively examined the landscape of culturally responsive physics education research, focusing on ethnoscience and local wisdom integration in Scopus-indexed publications from 2010 to 2025. The key findings are:

a. Publication Growth: Research in this field has experienced gradual but consistent growth over the past decade, with a notable acceleration from approximately 2017 onward (Hidaayatullaah et al., 2021; Sunarti et al., 2024).
b. Geographic Concentration: Indonesia dominates the field, reflecting both the country's extraordinary cultural diversity and its active physics education research community (Deta et al., 2024).
c. Key Contributors: H. Kuswanto is the most productive author, with Universitas Negeri Surabaya as the leading institution (Deta et al., 2024).
d. Publication Outlets: The Journal of Physics: Conference Series and AIP Conference Proceedings are the primary venues, indicating the field's developmental stage (Hidaayatullaah et al., 2021).
e. Thematic Clusters: Four major clusters have been identified: culture-physics integration, influencing factors, methodological approaches, and supporting elements including digital innovation (Misbah et al., 2024; Alhusni et al., 2025).

f. Emerging Themes: Central themes include ethnoscience, Islamic physics, digital learning tools, contextual learning, and specific cultural contexts such as Karapan Sapi (Sunarti et al., 2024; Deta et al., 2024).
g. Research Gaps: Significant gaps include limited geographic diversity, narrow focus on motion and heat topics, and insufficient development of validated instructional materials (Deta et al., 2024).

4.2 Contributions of the Study

This study contributes to the growing body of knowledge on culturally responsive science education by:

a. Providing the first comprehensive bibliometric mapping of culturally responsive physics education research spanning 2010–2025
b. Identifying the intellectual structure of the field through thematic cluster analysis
c. Highlighting emerging research directions, including digital innovation and Islamic physics
d. Offering evidence-based recommendations for future research, practice, and policy

The novelty of this study lies in its bibliometric approach and network analysis that provides deep insights into research trends and relationships within the field, contributing to a better understanding of the development of physics education (Sunarti et al., 2024).

4.3 Limitations

Several limitations of this study should be acknowledged. First, the reliance on the Scopus database may have excluded relevant publications indexed in other databases such as Web of Science or Google Scholar. Second, the search strategy may not have captured all relevant publications due to variations in terminology across the literature. Third, bibliometric analysis provides quantitative insights into publication patterns but cannot capture the qualitative richness or pedagogical effectiveness of the research. Fourth, the geographic concentration of research in Indonesia limits the generalizability of findings to other cultural contexts (Deta et al., 2024).

4.4 Recommendations for Future Research

Based on the findings and identified gaps, the following recommendations are proposed:
Expand Geographic Scope: Future research should explore ethnoscience and local wisdom integration in physics education across diverse cultural contexts beyond Indonesia (Deta et al., 2024).

Broaden Physics Topics: Researchers should investigate how other physics domains—including electricity and magnetism, optics, waves, and modern physics—can be integrated with local cultural knowledge (Deta et al., 2024).

Develop Validated Instructional Materials: There is a need for rigorous research and development of validated instructional materials, assessment tools, and pedagogical frameworks (Deta et al., 2024).

Conduct Longitudinal Studies: Longitudinal studies examining the sustained impact of culturally responsive physics education on student outcomes would add valuable evidence.

Explore Digital Innovation: The intersection of local wisdom with digital learning environments represents an emerging frontier. Research on culturally adaptive digital pedagogy, gamification in ethnophysics, and ethnoscience-based learning vlogs is still in its early stages (Misbah et al., 2024).

Strengthen International Collaboration: International research collaborations could broaden the knowledge base and facilitate cross-cultural exchange of effective practices (Deta et al., 2024).

Integrate Qualitative Approaches: Complementary qualitative approaches, including case studies, ethnographic research, and design-based research, would provide deeper insights into the processes and outcomes of culturally responsive physics education (Hidaayatullaah et al., 2021).

4.5 Concluding Remarks

Culturally responsive physics education represents a promising approach to making physics learning more relevant, engaging, and meaningful for diverse student populations. The integration of ethnoscience and local wisdom into physics instruction not only enhances student learning but also contributes to cultural preservation and education for sustainable development (Misbah et al., 2024).

The past decade has witnessed substantial growth in research in this area, with a strong foundation established by Indonesian scholars. However, the field remains in a developmental stage, with significant opportunities for expansion in geographic scope, physics content areas, and methodological approaches. As the global education community continues to recognize the importance of culturally responsive and sustaining pedagogies, research on ethnoscience and local wisdom integration in physics education is poised to make increasingly important contributions to educational theory, practice, and policy (Fitri et al., 2025).

The findings of this bibliometric analysis provide a roadmap for future inquiry, highlighting both the achievements of the past decade and the opportunities that lie ahead. By building on this foundation and addressing the identified gaps, researchers can advance the field toward a more comprehensive, inclusive, and impactful body of knowledge that serves diverse learners and communities worldwide.

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