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Research Trends of Flipbook-Integrated Collaborative and Deep Learning in Physics Learning: A Bibliometric Study

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Abstract: The rapid digital transformation in education has necessitated the development of innovative learning media to simplify abstract physics concepts, particularly in challenging topics such as Fluid Mechanics. This study aims to map the global research landscape and identify research gaps regarding the integration of flipbook-based e-modules with collaborative and deep learning approaches in physics education. Employing a bibliometric analysis method, metadata from 2015 to 2025 were retrieved from the Scopus database and visualized using VOSviewer. The results indicate a steady increase in publications related to digital interactive modules; however, a significant "structural gap" was identified between the technical development of flipbooks and the implementation of deep learning pedagogical frameworks. Keyword co-occurrence mapping reveals that while flipbooks are widely recognized for engagement, their synergy with collaborative-deep learning strategies remains largely unexplored in the context of high school physics. Furthermore, research specifically targeting fluid mechanics within this digital-pedagogical intersection is limited. These findings validate the novelty of developing a flipbook-based physics e-module integrated with collaborative-deep learning to foster higher-order thinking skills. This study provides a strategic "research compass" for educators and developers, suggesting that future innovations should transition from basic digitalization toward deeply rooted pedagogical integration to enhance conceptual mastery.

Keywords: Bibliometric analysis; Collaborative learning; Deep learning; Flipbook; Fluid mechanics; Physics learning

Introduction

Physics education in the era of digital transformation demands the adaptation of learning media capable of simplifying abstract concepts into more intuitive forms. Physics is frequently perceived as a challenging subject by students due to its involvement with complex mathematical representations and phenomena that are not visible to the naked eye (Munfaridah et al., 2021). To overcome these obstacles, the integration of information technology in the form of electronic modules (e-modules) has become crucial for creating a learning environment that is more dynamic and flexible compared to conventional printed books (Aladin et al., 2024; Holisoh et al., 2025).

One of the greatest challenges in high school physics is the topic of Fluids, where students are required to understand the characteristics of flow and pressure, which are dynamic in nature. Static learning media often fail to provide a profound (Kundu, 2024) depiction of principles such as Bernoulli's Law or viscosity (Kundu et al., 2024). Consequently, the use of flipbook-based e-modules emerges as an innovative solution, offering an interactive interface that can integrate videos, simulations, and animations, thereby enhancing students' visualization and information retention regarding fluid mechanics.

However, the sophistication of learning media will not yield a significant impact without being grounded in an appropriate pedagogical approach (Daniela, 2021).

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Collaborative Learning and Deep Learning are two approaches highly relevant for building deep conceptual understanding and teamwork skills (Chen et al., 2018; Shaik, 2025). Although both approaches have been proven effective individually, their integration within a flipbook-based e-module still requires a stronger theoretical foundation (Yuyun et al., 2022) and research mapping to ensure their effectiveness in physics learning (Kharomah et al., 2024).

The growth of research concerning digital media and active learning strategies has increased rapidly over the last decade. Nevertheless, the high volume ofpublications often results in information becoming scattered and difficult to map comprehensively. Researchers and curriculum developers require a "big picture" regarding the extent to which the topics of flipbooks, collaborative learning, and deep learning have been explored within the context of physics education. Without systematic mapping, there is a risk of research duplication or the neglect of crucial research gaps.

Bibliometric analysis serves as an essential instrument to resolve this problem of data fragmentation. By employing bibliometric techniques, publication trends, inter-researcher collaborations, and the evolution of keywords can be objectively visualized. Through this analysis, the position of the research titled "Development of Flipbook-Based Physics E-Modules Integrated with Collaborative-Deep Learning" can be validated for its novelty in comparison to existing studies on a global level. The primary objective of this study is to map global research trends regarding the use of flipbooks integrated with collaborative and deep learning approaches in physics education. Through this bibliometric study, it is expected that major research clusters, the most frequently occurring topics, and under-researched areas can be identified. The results of this analysis will serve as a solid academic foundation and a "compass" for the ongoing development of physics e-modules specifically for fluid mechanics.

Method

Research Design

This study employed a quantitative bibliometric research design to systematically map the development, structure, and research trends concerning flipbook-integrated collaborative and deep learning in physics education. Bibliometric analysis is appropriate for examining large bodies of scientific literature through publication patterns, keyword relationships, collaboration networks, and other bibliographic indicators. The population consisted of all scientific documents indexed in Scopus that were potentially related to flipbooks, e-modules, collaborative learning, deep learning, and physics education during 2015–2025. The sample comprised 200 documents obtained from the initial Scopus search and subsequently screened according to the predetermined inclusion criteria. The sampling technique was purposive criterion-based sampling, in which documents were selected according to explicit eligibility criteria rather than through random selection. This approach is consistent with bibliometric research procedures that require a clearly defined search strategy, dataset construction, screening, and subsequent bibliometric analysis. The research variables consisted of publication year, document type, authorship, institutional affiliation, keywords, citation-related information, and relationships among keywords and research themes. Data were collected through structured searches of the Scopus database using Boolean combinations of the terms “flipbook,” “e-module,” “collaborative learning,” “deep learning,” and “physics education.” The inclusion criteria were publications in the form of journal articles and conference proceedings, written in English, published between 2015 and 2025, and relevant to the intersection of digital instructional media, collaborative learning, deep learning, and physics education. The research materials consisted of the bibliographic metadata retrieved from Scopus, including titles, authors, affiliations, abstracts, keywords, publication years, and citation-related information. The principal analytical tools were Scopus for data retrieval, Microsoft Excel or equivalent spreadsheet software for data organization and screening, VOSviewer version 1.6.20 for bibliometric network visualization, and Biblioshiny in R for bibliometric exploration and descriptive analysis. VOSviewer is specifically designed to construct and visualize bibliometric maps and relationships among bibliographic items.

Research Procedure

The research procedure consisted of five sequential stages. First, the research topic and analytical objectives were defined by focusing on the development of research concerning flipbooks, collaborative learning, deep learning, and physics education. Second, the literature search strategy was developed by determining the Scopus database, publication period (2015–2025), keywords, Boolean operators, document types, and language criteria. Third, the bibliographic records retrieved from Scopus were exported in CSV and RIS formats. The exported metadata included titles, authors, affiliations, abstracts, keywords, publication years, and other available bibliographic information. Fourth, data screening and cleaning were conducted to improve the relevance and consistency of the dataset. Records that were irrelevant to educational or pedagogical applications were excluded, particularly publications in which the term "deep learning" referred to technical applications in computer science, medical imaging, classification, or other non-educational contexts. The remaining records were organized into a dataset for bibliometric analysis. Fifth, the final dataset was analyzed and visualized using VOSviewer version 1.6.20 and Biblioshiny in R. The analysis included publication trends, keyword co-occurrence, co-authorship relationships, citation-related patterns, network visualization, overlay visualization, and density visualization. The resulting maps were subsequently interpreted to identify dominant research themes, emerging topics, relationships among research clusters, and areas with relatively limited research activity. This procedure follows the general stages recommended for rigorous bibliometric studies, including database selection, search strategy development, data collection, screening, analysis, visualization, and interpretation.

Research Data Analysis

The bibliographic data were analyzed using descriptive bibliometric analysis and science-mapping techniques. Descriptive analysis was used to identify the annual development of publications and the general characteristics of the research corpus. VOSviewer version 1.6.20 was used to construct bibliometric networks based on keyword co-occurrence, co-authorship, and citation relationships. In the keyword co-occurrence analysis, keywords were examined based on their frequency and strength of association to identify major thematic clusters. Network visualization was used to identify relationships among research themes, while overlay visualization was used to examine the temporal evolution of research topics according to publication year. Density visualization was used to identify areas with high concentrations of research activity and areas with relatively low research density that may indicate potential research gaps. Biblioshiny in R was used to support descriptive bibliometric analysis and exploration of the research corpus. The interpretation of bibliometric maps considered the frequency, proximity, linkage, and clustering of keywords rather than relying solely on the visual appearance of individual nodes. The analytical framework was designed to identify the development of flipbook-related research, the position of collaborative learning and deep learning within the research landscape, the extent of their intersection in physics education, and potential directions for future research.

Result and Discussion

Publication Trend and Research Overview

The initial search in the Scopus database yielded a total of 200 documents published between 2015 and 2025. The data indicates a steady increase in publications related to digital learning media in physics, with a significant peak occurring after 2020. This trend reflects the global shift toward digital transformation in education accelerated by the COVID-19 pandemic. While research on "e-modules" and "physics learning" is abundant, the specific intersection of "flipbooks" and "deep learning" remains relatively niche, suggesting that while the tools are available, their integration with advanced pedagogical strategies is still an evolving area of study.

Network Visualization: Mapping the Research Clusters

The VOSviewer visualization reveals three primary clusters that map the current research landscape. The first cluster (red) is dominated by keywords such as "development", "critical thinking skill", and "kvisoft flipbook maker", indicating that research in this group focuses on developing interactive media to enhance higher-order thinking skills. The second cluster (blue) centers on "collaborative learning", "impact", and "case study", demonstrating a robust body of literature regarding the effects of implementing collaborative learning across various educational case studies. Meanwhile, the third cluster (green) is dominated by the term "deep learning", which tends to be closely associated with technical terms such as "classification", "medical imaging", and "medicine". This confirms the initial finding that the term "deep learning" in global databases is still largely dominated by computer science and medical fields, rather than a pedagogical perspective in physics education.

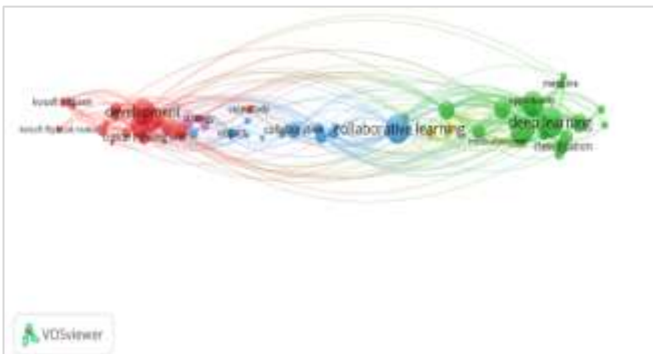

Figure 1. Network visualization

The most crucial aspect of this map is the visual distance and the density of the lines between nodes. Although connecting lines exist between "development" (red) and "collaborative learning" (blue), the intensity of the connections linking the three main elements—Flipbook, Collaborative Learning, and Deep Learning—into a single unified entity remains very sparse and rarely found. The keyword "deep learning" in the green cluster appears almost isolated from the e-module "development" process in the red cluster. This void between clusters serves as strong evidence that the research titled "Development of Flipbook-Based Physics E-Modules Integrated with Collaborative-Deep Learning" is an innovation that fills the gap in integrating media technology (flipbook), social methods (collaborative), and cognitive depth (deep learning).

Overlay Visualization: The Evolution of Research Topics

Based on the Overlay Visualization provided, the development of research trends can be analyzed over time according to the year of publication. The color scale at the bottom indicates a timeframe ranging from 2018 (purple) to 2021 (yellow).

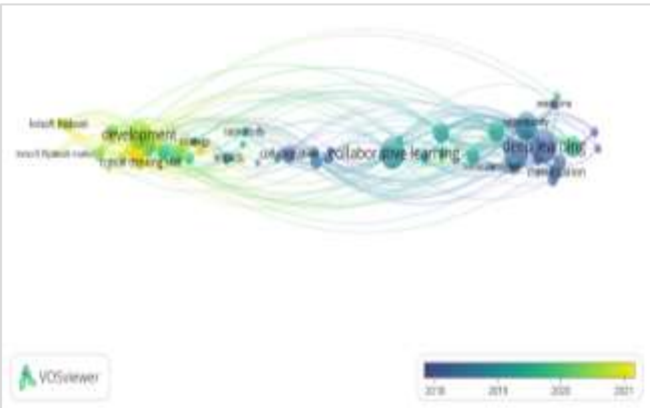

Figure 2. Overlay Visualization

Based on figure 2, Overlay Visualization Analysis are: Early Trends (2018 - 2019): This period is dominated by topics shaded in purple and dark blue. Keywords such as "deep learning", "classification", and "medical imaging" are prominently located in this area. This confirms that, initially, the term "deep learning" was explored more extensively in technical and medical domains rather than in the field of education.

Mid-term Trends (2019 - 2020): A shift toward green hues is observed, encompassing keywords like "collaborative learning", "impact", and "case study". This indicates that during this period, researchers began to extensively explore the impact of collaborative learning strategies within various educational case study contexts.

Recent Trends (2020 - 2021+): The bright yellow areas represent the most current research trends. Keywords emerging in this period include "development", "kvisoft flipbook maker", and "critical thinking skill". This suggests that contemporary research is actively focusing on the development of interactive digital learning media, such as flipbooks, specifically designed to train and improve students' critical thinking skills.

Density Visualization

Visually, density is represented by the brightness of the colors; the more yellow and bright an area is, the higher the research volume on that specific topic.

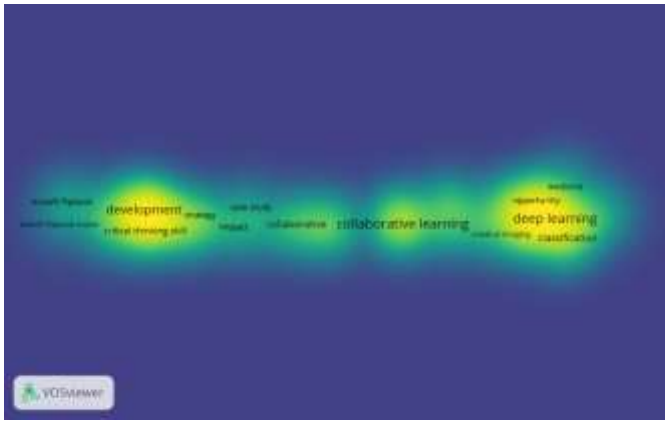

Figure 3. Density visualization

Based on figure 3, the analysis is as follows:

High-Density Areas (Research Saturation Points)

There are three highly saturated centers of research gravity. The first is the "deep learning" area, which shows a very large volume of publications but remains dominated by technical domains such as classification, medical imaging, and medicine. The second is the "development" and "critical thinking skill" area, indicating that research on interactive media development is currently a major focus for many researchers. The third is the "collaborative learning" area, which stands as an established pillar of instructional methods.

Low-Density Areas (Research Gap Identification)

The faded green colors and dark areas between the "development", "collaborative learning", and "deep learning" nodes indicate a low research density connecting these three topics simultaneously. Although the main nodes are very bright, the integrative connections between the three remain very thin (low density). This serves as visual evidence of a significant research gap.

Discussion

The bibliometric findings reveal a significant upward trajectory in the adoption of digital interactive media within physics education, particularly over the last decade. The surge in publications related to "flipbooks" and "e-modules" indicates a transition from static instructional materials to more dynamic, multi-modal platforms. This shift is driven by the need to overcome the limitations of traditional textbooks in representing time-dependent physics phenomena.

However, while the technical development of these tools is well-documented, the bibliometric map suggests that their implementation is often focused on student engagement and satisfaction rather than being deeply rooted in rigorous cognitive frameworks. This highlights a critical need for research that moves beyond "digitalization" toward "pedagogical integration."

A key finding in this study is the relatively weak connection between "flipbooks" and "Deep Learning" in the existing literature. Most current studies on flipbooks emphasize surface-level benefits, such as accessibility and ease of use (Bhakti et al., 2025; Purwati et al., 2025). In contrast, deep learning which involves critical thinking, relating new ideas to previous knowledge, and applying concepts to problem-solving is rarely explored as a primary outcome of flipbook usage (Nirmala & Puspita, 2025; Prihatiningtyas et al., 2025). This gap presents a significant opportunity for the development of e-modules that are specifically designed to stimulate higher-order thinking skills (Farhan et al., 2025; Suha et al., 2020). By integrating deep learning strategies into a flipbook, educators can ensure that the interactive features (such as simulations and embedded videos) serve a cognitive purpose rather than acting as mere visual distractions (Harefa et al., 2025; Jayaraman & Aane, 2024).

Furthermore, the bibliometric analysis shows that "Collaborative Learning" forms a robust research cluster, yet it remains somewhat isolated from the "e-module" cluster in the context of physics education. Many digital modules are still designed for individual (Fitri, 2025), self-paced study (Ranieri et al., 2017), which neglects the social-constructivist nature of learning physics. The integration of collaborative elements into an e-module, such as peer-discussion prompts or shared problem-solving tasks can bridge this gap. Combining collaborative and deep learning within a single digital platform creates a powerful synergy (Ayodele & Zhou, 2024), where social interaction acts as a catalyst for deeper conceptual mastery, a combination that this bibliometric study identifies as a high-value but under-researched area (Panori et al., 2021; Pratap et al., 2022).

The specific application of these tools to the topic of Fluid Mechanics is another area where this study identifies a "research niche." Fluid dynamics is notoriously difficult for students to visualize due to the invisible nature of pressure and flow variables (Raissi et al., 2020). While the bibliometric data shows that mechanics and thermodynamics are frequently researched topics, Fluid Mechanics is less prominently featured in the context of interactive flipbook development. The ability of a flipbook to host interactive animations of Bernoulli's principle or viscosity makes it a superior tool for this specific subject. Therefore, focusing on fluid mechanics provides a concrete and much-needed context to test the effectiveness of the collaborative-deep learning approach (Jane, 2021).

Ultimately, this bibliometric study provides a clear "research compass" for the development of future instructional materials. The lack of overlap between interactive flipbooks, collaborative frameworks, and deep learning strategies in current global publications validates the novelty of the proposed e-module. By addressing the fragmentation identified in the research landscape, the development of a "Collaborative-Deep Learning Integrated Flipbook" for fluid mechanics does not merely add to the volume of existing literature but directly fills a strategic gap. This research path ensures that technological innovation in physics learning remains tethered to high-quality pedagogical principles, providing a more holistic learning experience for high school students (Bhakti et al., 2025).

Conclusion

This bibliometric study provides a comprehensive overview of the research landscape concerning flipbook-integrated collaborative and deep learning within physics education from 2015 to 2025. The analysis reveals a significant growth in digital learning media publications, particularly following the global shift toward remote and hybrid learning environments. However, the most critical finding is the identified "structural gap" in current literature: while flipbooks are popular for their interactive interfaces and collaborative learning is a well-established pedagogy, their combined integration with "Deep Learning" strategies—especially within the complex domain of fluid mechanics—remains largely unexplored. This confirms that the development of a flipbook-based e-module that prioritizes deep conceptual mastery through collaboration is not only timely but possesses a high degree of academic novelty. The visualization of research clusters further emphasizes that current digital modules often lean toward technical interactivity rather than cognitive depth. By mapping the co-occurrence of keywords, this study highlights that the synergy between collaborative frameworks and deep learning levels is the "next frontier" in physics education technology. Ultimately, the results of this bibliometric analysis serve as a strong empirical justification for researchers to move beyond basic digitalization and focus on creating instructional tools that foster higher-order thinking skills, ensuring that technology serves as a meaningful bridge to understanding the invisible and dynamic principles of physics.

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Author Contributions

Conceptualization: I.A.D.A.; Methodology: P.P.; software, I.A.D.A.; validation, P.P. and S.M.; formal analysis, M.D.; investigation, M.D.; T.F; data curation, I.A.D.A.; writing—original draft preparation, S.M.; writing—review and editing, S.M and I.A.D.A.; funding acquisition, I.A.D.A.; P.P.

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Conflict of Interest

The authors declare no conflict of interest.

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