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# CHALLENGES OF MULTIDIMENSIONAL SCIENCE EDUCATION: A PHILOSOPHICAL PERSPECTIVE

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**Abstract:** This study explores multidimensional science education's challenges and critically reviews philosophical aspects. The exploratory study was conducted by performing bibliometric analysis and literature reviews on the context related to the challenges of multidimensional science education from a philosophical perspective. Using data sources from SCOPUS and GOOGLE SCHOLAR, studies were found that align with multidimensional science education (studies that intersect with the application of disciplinary, multi-disciplinary, inter-disciplinary, and trans-disciplinary approaches). The literature review revealed challenges in science education, primarily related to pedagogical challenges. These pedagogical challenges are caused by the interdisciplinary nature inherent in science, thus requiring adequate adaptation of teachers' knowledge about science. The literature review uncovered effective pedagogy in science characterized by approaches that prioritize exploratory processes, authenticity, and a focus on encouraging critical thinking. In line with the principles of axiological philosophy in multidimensional science education, it is essential to prepare adequate pedagogical infrastructure to continue supporting efforts in developing contemporary and future science education. Ultimately, formulating effective pedagogy will serve as a foundation for teachers to impart meaningful and valuable science education from the perspective of axiological philosophy.

**Keywords:** *Challenge, Multidimensional Science Education, Philosophical Perspective, Science Pedagogy*.

## INTRODUCTION

The current challenges in science education are growing, especially in how science can serve as a bridge between knowledge acquisition and the skills needed for success in various challenges in the 21st century. This is one of the reasons science education is considered a benchmark for developing human resources within the education system, in addition to the fact that science is closely related to a country's global competitiveness [1]. Science education advances alongside progress in technology, engineering, and mathematics, and it plays a crucial role in human capacity development [2], potentially motivating students to engage in their future careers [3,4].

In contemporary education systems, science education has become a continuously evolving trend to prepare a bright future for students involved in it. For this reason, many education systems have included science as an essential part of their curriculum [5,6]. Furthermore, science education has permeated various aspects of regular curriculum instruction, reflecting the significance of science in the educational and learning system [7,8].

From a philosophical perspective, science cannot exist in isolation. Science in the educational system evolves as multidimensional or diverse knowledge becomes more prevalent at different levels in response to evolving thoughts, knowledge, technology, needs, and problems that require solutions. Therefore, science education presents itself as an integrated dimension of knowledge that coexists with or relates to other fields of study. This is the guiding principle in the philosophy of multidimensional science. The multidimensional integration of science is viewed at four levels, adopting knowledge integration within disciplines [9]: disciplinary, multi-disciplinary, inter-disciplinary, and trans-disciplinary.

First, in the context of the disciplinary level, concepts in each scientific discipline are studied separately. Second, at the multi-disciplinary level, concepts from each scientific discipline are studied separately but within the same theme. Third, concepts from two or more closely related scientific disciplines are studied at the interdisciplinary level to deepen knowledge and skills. Fourth, at the trans-disciplinary level, knowledge and skills learned from two or more scientific disciplines are applied to real-world problems, helping shape a comprehensive learning experience.

So far, the success of multidimensional integrative science education in the STEM (Science, Technology, Engineering, and Mathematics) field has been reported to progress in several developed countries, such as the United States, as a cornerstone of future industrial resource development [3]. This is partly due to educational reforms in developed countries that emphasize the need to develop students' complex scientific, engineering, and technological skills as a form of their participation in knowledge-based modern development [10,11]. However, other reports indicate that teachers face many challenges in implementing science education [12]. This is particularly true in developing countries in Asia [3]. The scarcity of science integration models in existing literature also presents a problem for teachers trying to implement integrated science education in schools [13]. Previous studies [3] suggest that more research

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should be conducted to explore the implementation of science education in schools, especially in light of the challenges faced in implementing science education.

Studying the challenges of multidimensional science education becomes essential to explore further, especially from a philosophical perspective, to provide a more detailed understanding of the challenges faced and how to address them in accordance with the needs of effective science pedagogy. Specifically, this study aims to explore the challenges of multidimensional science education and critically review philosophical aspects.

## RESEARCH METHODS

To achieve the objectives of this study, a literature review related to science education was conducted, specifically through bibliometric analysis. This analysis is a foundation for examining the multidimensional challenges in current science education. The bibliometric analysis was adapted from previous research studies [14,15]. Two primary sources were utilized to collect data relevant to the current study: the SCOPUS database (accessible at https://www.scopus.com) and GOOGLE SCHOLAR (accessible at https://scholar.google.com/). The selection of these data sources was made after careful consideration of their utility.

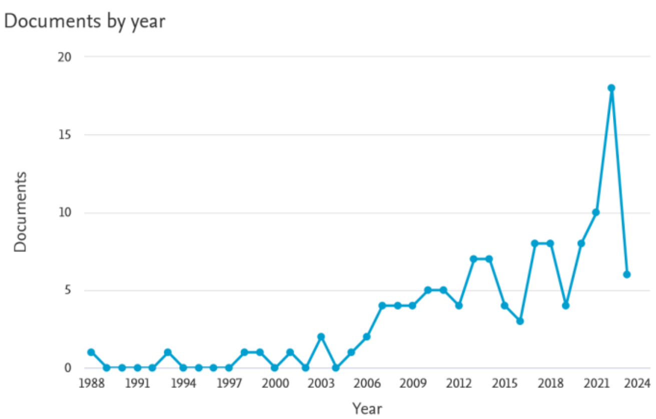
SCOPUS, in particular, serves as a global benchmark for evaluating the quality of scientific articles. The SCOPUS database offers a rich collection of abstracts and citations from diverse scientific literature, encompassing various sources and disciplines, making it a precious source of information. In addition to its comprehensiveness, the array of features within the SCOPUS database simplifies the search process for experts, authors, data, metrics, and visualizations that explain current research trends in various scientific fields. Using keywords aligned with the focus of the current study, namely "challenges in multidimensional science education," researchers extensively explored documents that included articles, conference papers, and books related to the defined thematic exploration.

The bibliometric analysis was conducted on September 19, 2023, by searching the SCOPUS database and entering the study theme's keywords in English to ensure they could be adequately read and explored by SCOPUS. The inserted keyword was 'challenges in multidimensional science education' [TITLE-ABS-KEY (challenges AND in AND multidimensional AND science AND education)]. This screening process did not restrict the year, subject area, document type, or other limitations. Each search result was documented (data curation) in (.ris)/(.csv) files for subsequent visualization. A screenshot (prt-scr) of the SCOPUS database display was taken for each dataset to facilitate the analysis and discussion process.

Following the data collection process through SCOPUS, researchers conducted further review by delving into the found documents. Careful curation of document content was performed to align it with the study's core focus as per the search document keywords. This process involved filtering various articles, conference papers, and books, with each selection made based on its direct relevance to the theme of "challenges in multidimensional science education." This selection ensured that the review process was based on a strong scholarly foundation and contributed significantly to the existing body of knowledge. The current study utilized a database based on the GOOGLE SCHOLAR search engine to ensure a comprehensive literature review. This approach encompassed all relevant literature related to the study's topic. Both sources (SCOPUS and GOOGLE SCHOLAR) were chosen for their ability to offer broad and in-depth coverage, facilitating the identification of materials related to the challenges in multidimensional science education.

## RESULTS AND DISCUSSION

The bibliometric analysis, coherent with the theme of the study 'challenges in multidimensional science education' [TITLE-ABS-KEY (challenges AND in AND multidimensional AND science AND education)], which was analyzed from various research sources and documents based on SCOPUS data, indicates that a total of 119 documents were found in the period from 1988 to 2023. The distribution of documents is presented in Figure 1.




**(a)**

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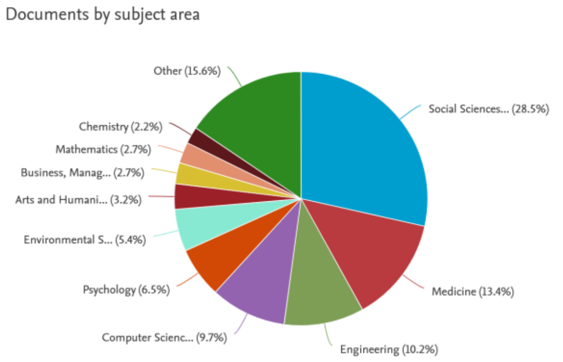
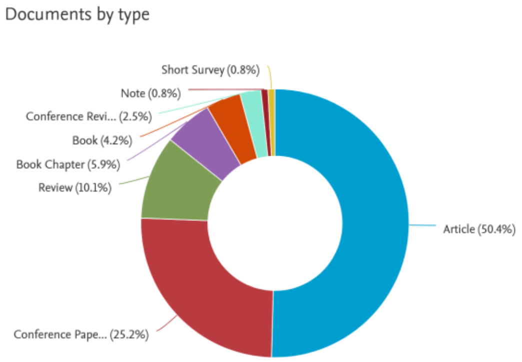



**(b)**




**(c)**

Figure 1. The results of the SCOPUS data analysis related to 'challenges in multidimensional science education' are as 1(a). Distribution of documents based on the year; 1(b). Distribution of documents based on subject area; and 1(c). Distribution of documents based on type.

The results in Figure 1 show that a total of 119 documents were found from 1988 to 2023 that are coherent with the theme of the study 'challenges in multidimensional science education'. The search results were more prevalent in subject areas related to social sciences (28.50%), as well as in areas related to medicine (13.40%), engineering (10.20%), computer science (9.70%), psychology (6.50%), environment (5.40%), and others (Figure 1. b). This is because the keywords are related to multidimensional science education, so dimensions that intersect with science education also became part of the detected articles on the SCOPUS page. The distribution based on document types was predominantly articles (50.40%), followed by conferences (25.20%), and others (Figure 1. c).

Detailed analysis of the titles of the documents (journal articles, conferences, books, and others) did not specifically discuss the context of multidimensional science learning. Therefore, a deeper search was conducted within the document content, revealing multidimensional contexts in four terminologies: disciplinary, multi-disciplinary, inter-disciplinary, and trans-disciplinary. Elaboration on literature related to these four contexts was also done using Google Scholar as a source. Some fundamental findings in the SCOPUS and Google Scholar documents are that science has historically been studied as separate disciplines (disciplinary and multi-disciplinary). This follows the rhythm of the philosophy of science, particularly concerning the ontological and epistemological aspects of science. However, in its development, science is currently integrated inter-disciplinarily and trans-disciplinarily to provide value in advancing more beneficial knowledge in line with axiological philosophical perspectives.

Interdisciplinary science education aims to deepen knowledge and skills, while transdisciplinary primarily serves practical purposes to address various authentic problems. For example, environmental pollution or waste management issues require solutions from a combination of interdisciplinary and transdisciplinary knowledge in biology, chemistry, and engineering. Weather forecasting issues require a mix of interdisciplinary and transdisciplinary knowledge in biology, chemistry, physics, and technology. Matters related to radiation technology require knowledge from all areas of science (biology, chemistry, physics), engineering, and advanced technology. Even current robotics system automation integrates interdisciplinary and transdisciplinary knowledge from complex sciences. Many other contexts require integrative knowledge in the field of science. Axiologically, the multidimensional nature of science in its integration across various disciplines inspires science education in tandem with technology, engineering, and mathematics, collectively known as STEM.

An elaboration of the analysis of articles from SCOPUS and Google Scholar data reveals that almost all studies coherent with multidimensional science education (studies that intersect with the application of disciplinary, multi-disciplinary, inter-disciplinary, and trans-disciplinary) find that areas focusing on content pedagogy or practical science contexts have had an impact on the development of knowledge and literacy [16], problem-solving abilities [17,18], critical and creative thinking skills [19–24], metacognition [25], curiosity [26], design thinking [27], computational thinking [28], facilitating the learning process with learning resources [29], and much more. Nevertheless, reviewing other literature finds challenges in science education, primarily related to pedagogical challenges. These challenges align with other studies [4], and previous research has discussed pedagogical issues [6,30–32].

From the axiological philosophical perspective, integrating multidimensional science education brings benefits to the development of science education, inspiring the emergence of STEM education. However, integrating science education into established pedagogical principles appears daunting to educators, especially teachers, leading some teachers to believe they are unprepared to implement integrated science pedagogy [33]. This requires instructional methods

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emphasizing student leadership in learning, necessitating a new pedagogical system [34,35]. Additionally, previous researchers [6,31] state that teachers are concerned about aligning their pedagogy with integrated science curricula, such as STEM curricula. Meeting the diverse needs of students is another concern [35,36]. Finally, teachers may worry that multidimensional science integration may reduce the teaching of essential content concepts in science [37]. Specifically, these pedagogical challenges are caused by interdisciplinary characteristics, requiring adequate adaptation of teachers' beliefs and knowledge about science itself [30]. Every science instructor must also understand and build adequate pedagogical infrastructure in their teaching [38], the biggest challenge in science pedagogy today.

In line with the maturity of axiological philosophical principles in multidimensional science education, adequate pedagogical infrastructure must be prepared to continuously support the development efforts of current and future science education. This effort relies on the support of all stakeholders for practitioners or experts to continue developing effective pedagogy for teaching science using effective pedagogical resources. Many literatures have discussed effective pedagogy, especially those associating science pedagogy with approaches that prioritize exploration, authenticity, and fostering thinking processes. Ultimately, formulating effective pedagogy will be the foundation for teachers in teaching meaningful and valuable science, per axiological philosophical perspectives. It is considering that teachers are the main determinants of all forms of education policy in implementing science education and the science pedagogy system in the field.

## CONCLUSION

An exploratory study has been conducted with bibliometric analysis and a literature review of contexts related to the challenges of multidimensional science education from a philosophical perspective. Utilizing data sources from SCOPUS and GOOGLE SCHOLAR studies coherent with multidimensional science education (studies overlapping with the application of disciplinary, multi-disciplinary, inter-disciplinary, and trans-disciplinary approaches) were identified. The literature review revealed challenges in science education, primarily related to pedagogical challenges. These pedagogical challenges stem from the interdisciplinary nature inherent in science, thus requiring adequate adaptation of teachers' knowledge about science. Every science instructor should also grasp adequate pedagogical infrastructure, which constitutes the most significant challenge in current science pedagogy.

In line with the establishment of axiological philosophy principles in multidimensional science education, it is essential to prepare adequate pedagogical infrastructure to continuously support efforts in developing contemporary and future science education. These efforts rely on the support of all parties, whether practitioners or experts, to continually develop effective pedagogy for teaching science using efficient pedagogical resources. Ultimately, this effective pedagogy formulation will serve as the foundation for teachers to impart meaningful and valuable science education in accordance with axiological philosophical perspectives.

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