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Kuhnian perspectives in science education: a comparative review of proponents and skeptics

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ABSTRACT

Despite the abundance of literature discussing Kuhnian views, it is rare to find studies that comprehensively compare the arguments of Kuhnian supporters and skeptics. This study aims to fill the gap by providing a comparative review and synthesis between the two groups of views using the systematic literature review (SLR) analysis technique. The researcher found 1,413 articles reduced with the standard prism protocol to 32 articles that examined Kuhn's views. Proponents support the existence of Kuhn's scientific paradigm where they not only strengthen and consider the importance of Kuhn's theory, but also expand its application to various fields, showing the flexibility and relevance of the theory in understanding the scientific revolution that occurred in various disciplines. Skeptics criticize Kuhn's views such as the ambiguity of the term "paradigm", the non-recognition of scientific revolutions that lead to scientific evolution, and the doubt of the concept of incommensurability in various disciplines. This shows that Thomas Kuhn made a great contribution to the world of scientific education because it can provoke experts to study his thoughts for the benefit of science. The findings of this study are expected to contribute to policy makers and other researchers in applying and studying Kuhn's paradigm.

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1. INTRODUCTION

Science education has become a major focus in many countries, given the importance of both literature literacy and scientific literacy among students [1], [2] in the school education environment [3], [4] and in general education [5]–[8] in the current era of technology and information. This is true even for individuals without special needs or those with special needs [9], [10]. In undergoing changes and adaptations, science education is inseparable from various theoretical perspectives that underlie it. One of the most prominent is the Kuhnian perspective, originating from the thoughts of Thomas S. Kuhn in "The Structure of Scientific Revolutions" [11]. However, like any other major theory, many experts and researchers hold views that either support or criticize his ideas [12]–[24] referred to as "Kuhnian proponents" and those who are skeptical, known as "Kuhnian skeptics". Although there is much literature discussing science education from a Kuhnian viewpoint, comprehensive comparative studies between Kuhnian supporters' and skeptics' arguments in the context of science education are still rare. Moreover, the changes in the world due to the impact of COVID-19 allow for a significant paradigm shift in research. To understand both these perspectives, it is crucial to comprehend the current dynamics of science education and to determine more effective and inclusive future educational policies. Additionally, post-COVID-19 research investigations into Kuhnian perspectives by experts have become urgent. This study aims to bridge this gap by providing a comparative review and synthesis of both groups' viewpoints, considering their main arguments, strengths, and weaknesses. For this purpose, this research utilizes content analysis methods from selected literature, focusing on the main arguments, methodologies, and findings of both groups of views. The primary analysis technique utilized a systematic literature review (SLR), which allows researchers to systematically and objectively identify, select, and evaluate the quality of existing literature [25]–[27]. This technique is chosen because various experts [25], [26], [28]–[30] have highlighted its aspects ranging from objectivity and thoroughness, completeness, credibility, in-depth discussion, and evidence-based recommendations. With the advantages of this analysis technique, the goal of this research is to provide a deep understanding of how Kuhnian supporters and skeptics view science education. The findings from this review are expected to offer recommendations for educational practitioners, policymakers, and researchers in developing more holistic and responsive science education to meet current and future challenges.

2. METHOD

2.1. Data analysis technique

This study employs the SLR technique [26], [27], which offers significant advantages for literature researchers in identifying, selecting, and evaluating the quality of existing literature systematically and objectively. The foundation for choosing this technique lies in several offered benefits. First, the aspect of objectivity and thoroughness, where the SLR emphasizes clear and objective procedures in literature selection. This ensures that the chosen literature is truly relevant to the topic and free from researcher bias. Next, the aspect of completeness, where a systematic review ensures that most of the relevant literature discussing both Kuhnian supporters and skeptics in science education is included in the analysis. The aspect of credibility, where a SLR can enhance the credibility of findings, as it is based on rigorous and transparent methodology. The aspect of in-depth discussion, as examining literature from both perspectives (proponents and skeptics) systematically, will present a more profound and balanced discussion of Kuhnian views in science education. Finally, the aspect of evidence-based recommendations, where recommendations or conclusions made will be based on solid evidence, not just personal opinions or interpretations.

2.2. Inclusion criteria

The Author's background, research method, interest issues, comparisons, article conclusions are used to establish inclusion criteria [31]. The inclusion criteria are using literature review design, observing, analyzing, and synthesizing Kuhn's thoughts on science education from both proponents and skeptics perspectives, with publication years limited from 2020 to 2023. Studies that are excluded or not taken include those not in English, not available in full-text format or accessible, not from a journal, not an article or review, and data or results not related to Kuhn's thoughts. The credible criteria in this research use reputable indexes like Scopus.

2.3. Comparisons

Researchers compare the viewpoints of experts discussing Kuhn's thoughts on science education. Specifically, the comparison is made by dichotomizing experts into proponents and skeptics categories. In this article, the researcher remains impartial between these two dichotomies, to maintain the neutrality of the article.

2.4. Search strategy

The PRISMA (preferred reporting items for systematic reviews and meta-analyses) diagram protocol [25] is used to identify relevant and reliable studies, with a comprehensive search conducted using reputable databases (Scopus). The search uses specific keywords “Thomas S. Kuhn” OR “Kuhn” AND “Science education” OR “The Structure of Scientific Revolutions” OR “Scientific Revolutions” OR “Education Revolutions” OR “Revolutions” OR “Conceptual Change” OR “Promoting Conceptual” OR “Wrong Turning” OR “Wrong Idea” OR “Critical” OR “Proponent” OR “Skeptical”. The search results, including and excluding article data, are depicted in the PRISMA diagram is shown in Figure 1.

2.5. Screening

As illustrated in Figure 1, the article screening process occurs in three stages: identification, screening, and inclusion. In the identification stage, researchers identified 1,413 manuscripts from the Scopus source using predetermined keywords. Then, 1,138 manuscripts were excluded as they were outside the 2020 to 2023 range. During the screening stage, in the “records screened” section, 51 manuscripts were excluded because they were book, book series, and conference proceedings. Additionally, 89 manuscripts were excluded because they were not in English. In the "Reports assessed for eligibility" section, further exclusions were made based on criteria including Erratum 1 (n=4), Note 2 (n=3), Letter 3 (n=1), Editorial 4 (n=1), Close Access 5 (n=96), and Not a Context of Kuhn's theory or views 6 (n=64). In the final inclusion stage, 32 manuscripts were found to be suitable and successfully filtered according to the criteria of this study, which is adapted from the standard PRISMA protocol [25].

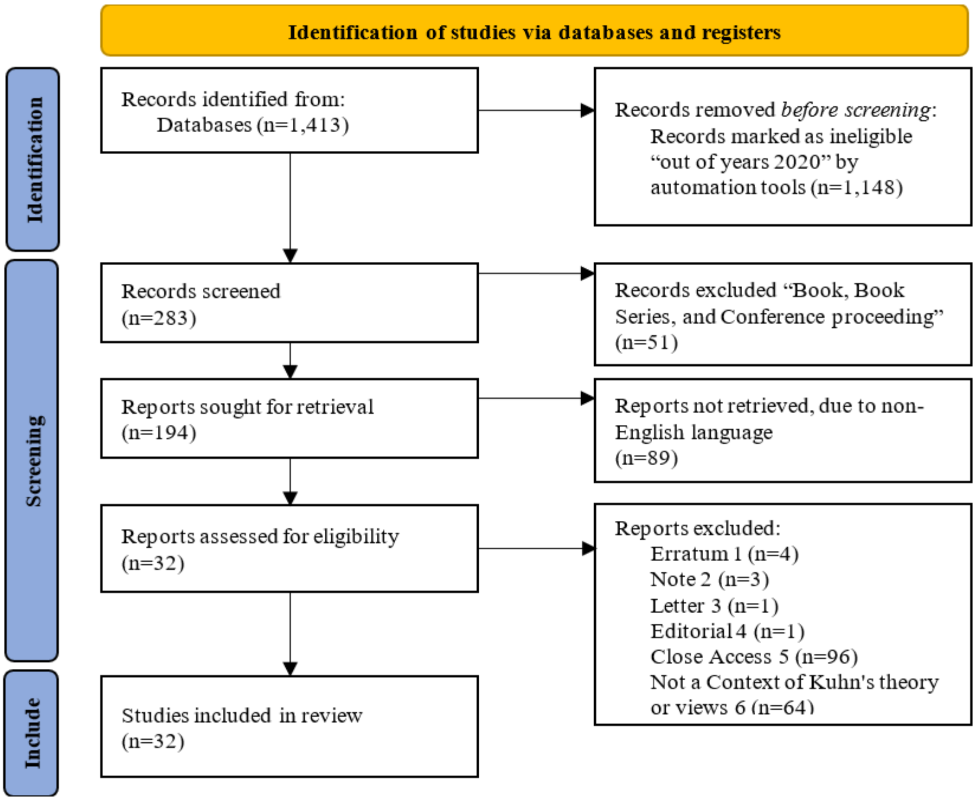

Figure 1. PRISMA diagram

2.6. Data extraction and analysis

Details of each study are recorded in an Excel Spreadsheet, including the author, year of publication, findings, and the dichotomy of views "proponents or skeptic." Descriptive analysis is used to understand the focus of the study, key views, and the context of proponents and skeptics. Each manuscript is categorized into proponents and skeptics based on the main findings' context in the analyzed manuscript. These results are then analyzed in more depth and reported in this study.

2.7. Limitations

There are several limitations in this review, starting from covering a small number of literatures due to the restrictions applied after the systematic review protocol. Then, the diversity of scientific fields investigated in various studies. Additionally, the year limitation, as this study aims to investigate more deeply with these restrictions, even though it will lead to limitations due to these constraints. These limitations create gaps that are interesting to be addressed by researchers or other researchers in similar future studies.

3. RESULTS AND DISCUSSION

This research identified 32 articles that passed the strict PRISMA standard protocol [25] from an initial pool of 1,413 articles, reduced to 32 after thorough screening. Based on this data reduction, an in-depth analysis was conducted by noting the name, year of publication, findings, and dichotomy of views as "supporters or skeptics". Researchers performed a deeper analysis on articles that apply, examine, or analyze the views of Thomas Kuhn during the period from 2020 to 2023. This study reveals the extent to which Kuhn's views have influenced thought and development in several disciplines. Through his perspectives, Kuhn has provoked various experts to test his views for the advancement of various fields of knowledge. This has shown that Kuhn has an influence in many scientific fields. During this period, findings concern the approaches of "proponents" and “skeptics” as shown in Tables 1 and 2.

Table 1. Findings of proponent’s part 1

Expert	Key findings	Positioned as proponents because
Expert 1 [32]	Application of Kuhn's model, concept of crisis and revolution, advocacy of paradigmatic change, mismatch between old law and new science.	Regards science as evolving through paradigm shifts, not merely through knowledge accumulation.
Expert 2 [33]	Utilization of Kuhn's philosophy as an analytical framework, identification of paradigmatic crisis according to Kuhn's theory, discussion about paradigm revolution, understanding of scientific paradigm evolution	Emphasizes that science progresses through paradigm shifts, in line with Kuhnian analytical approach to psychosis revolution.
Expert 3 [34]	Use of Kuhn's framework to describe paradigm shifts, identification of paradigmatic crisis, proposition of new paradigm, consistency with Kuhnian revolutionary principles.	Applies his concepts to explain the dynamics of change in molecular biology regarding scientific revolution through paradigm shifts.
Expert 4 [35]	Use of Kuhn's framework in analysis, acceptance and implementation of 'normal science' concept, acknowledgement of theory dependence in science, focus on philosophical aspects in ecology.	Utilizes Kuhnian concepts and their application in ecology.
Expert 5 [36]	Use of Kuhn's framework for scientific revolution argument, understanding of crisis in current paradigm, support for scientific paradigm shift.	Reviews the approach and use of Kuhn's framework in cross-cultural psychology to address existing crises and advance science.
Expert 6 [37]	Support for applying Kuhn's theory to EES, consideration of reformulating Kuhnian paradigm, discussion about EES's connection with Kuhn's later evolutionary philosophy, critique of views rejecting Kuhn's theory relevance.	Suggests that understanding Kuhn's concept of scientific change can help explain and understand the dynamics behind EES in biology.
Expert 7 [38]	Use of Kuhn's model, dynamics of belief change, rational process of belief change, acknowledgement of uncertainty and dynamics.	Integrates and expands his concepts into the analysis of belief change, demonstrating the relevance and application of Kuhn's theory in a broader scientific context.
Expert 8 [39]	Application of Kuhn's concepts in financial paradigm analysis, description of Kuhnian paradigm shift, acknowledging relevance of Kuhn's theory in new contexts, adoption of Kuhn's principles in addressing paradigm shift resistance.	Applies Kuhn's concept of scientific revolution to understand and explain paradigm shifts in financial theory and business valuation.
Expert 9 [40]	Application of Kuhn's concepts in scientific debate analysis, incommensurability between MS and EES in semantic, methodological, and ontological domains, discussion on scientific change à la Kuhn, recognizing incommensurability compatibility with rational theory comparison.	Focuses on Kuhn's concept of incommensurability, in analyzing and understanding paradigm shifts in the context of scientific debates in evolutionary biology.
Expert 10 [41]	Parallelism with Kuhn's work, use of Kuhn's concept of revolution to understand change, deep understanding of Kuhn's scientific revolution.	Uses his concepts as tools for understanding and explaining phenomena of social and intellectual change, in the context of Bourdieu's field theory, reflecting acceptance and application of Kuhn's ideas in broader analysis.
Expert 11 [42]	Use of Kuhn's paradigm theory as a framework, emphasis on scientific revolution and paradigm change, recognition of creativity in 'normal science', integration of scientific creativity with philosophy of science education.	Uses Kuhn's theory to understand and teach about scientific creativity, showing acceptance of Kuhn's paradigm theory in the context of education and scientific research.

*Note: The "Findings of Proponents" table section was made into two parts due to page limitations and considerations of layout effectiveness and efficiency.

Beginning with the proponents' findings as shown in Tables 1 and 2, from 2020 to 2023, analysis was conducted on various manuscripts that showed strong support for Kuhn's perspective in science education. The analysis of each manuscript from diverse disciplines specifically found that these experts integrate and apply Kuhn's paradigm to reflect and explain the dynamics of scientific change. For instance, in biology [34], [37], [40], [43], physics [44], economics [39], [45], toxicology [46], educational media [47], [48], law [32], psychology [33], [36], religion [38], and the context of sustainability science [49]. This reflects a trend where science is viewed not just as an accumulation of knowledge but significantly as a series of paradigm shifts. For example, Tanghe *et al.* [43] studying the history of evolutionary biology through Kuhn's model found that it demonstrates acceptance and application of Kuhn's theory as a relevant and useful analytical tool for understanding changes in the history of that scientific discipline. Additionally, Tanghe *et al.* [43] uses his theoretical framework to offer new insights and enhance understanding of scientific development. Then, Fuller [44] examines the quantum context in physics, comparing Popper's and Kuhn's views. Despite comparing Kuhn with Karl Popper, the focus on paradigm shifts and the dynamics of scientific revolution indicates that Fuller [44] considers Kuhn's views relevant and significant.

Table 2. Findings of proponent's part 2

Expert	Key findings	Positioned as proponents because
Expert 12 [50]	Recognition of paradigm shift, application of Kuhn's theory in practice, critical examination of existing practices, emphasis on the evolution of scientific understanding, promotion of philosophical and scientific inquiry.	Acknowledges the role of paradigm shift in scientific advancement, applies Kuhn's concepts to ophthalmology, and advocates for critical examination of established practices in line with Kuhn's philosophy of scientific progress.
Expert 13 [51]	Use of Kuhn's paradigm model to understand religious change, parallel with Kuhn's 'gestalt switch', reflection of Kuhn's incommensurability theme, individual case approach as Kuhnian method, depicting religious change as paradigm shift.	Applies Kuhn's paradigm in the context of religious belief change, emphasizing the concept of incommensurability, and using an individual case study approach consistent with Kuhn's method.
Expert 14 [52]	Use of Kuhn's concepts, analysis of various Kuhnian units of analysis, focus on Kuhn's social epistemology, contribution to understanding Kuhn's social epistemology.	Takes an approach that supports and expands understanding of Kuhn's theory, especially in the context of social epistemology and analysis of scientific development, oriented towards the development and integration of Kuhn's ideas.
Expert 15 [45]	Use of Kuhn's framework, assessment of behavioral economics, institutional position in the scientific community, intellectual and sociological continuity of mainstream paradigm.	Supports and uses Kuhn's theory as a lens to understand and evaluate developments in economics, especially the role of behavioral economics.
Expert 16 [53]	Recognition of current paradigm shift, integration with modern technology, influence of new paradigm on society.	Emphasizes the importance of scientific community awareness of this change and the need for developing new theories and technologies that support the new paradigm.
Expert 17 [46]	Description of scientific progress process according to Kuhn, application of Kuhn's theory to toxicology, acknowledgement of traditional paradigm crisis, evidence of paradigm shift	Applies as a framework to analyze changes in the field of toxicology.
Expert 18 [43]	Application of Kuhn's theory, discussion on Kuhnian paradigm, positive approach to Kuhn's theory.	In the context of its application as understanding the dynamics of scientific change in evolutionary biology.
Expert 19 [44]	Use of Kuhnian framework, discussion on scientific paradigm, comparison with popper, integration of quantum epistemology.	Overall approach indicates acceptance and support for Kuhn's core ideas about scientific revolution and the dynamics of paradigmatic change in science.
Expert 20 [47]	Application of Kuhn's theory in film analysis, education and philosophy of science, positive approach to Kuhn's theory.	Utilizes Kuhn's theory in the context of education and media interpretation, demonstrating its position as a supporter of the theory.
Expert 21 [48]	Exploration of the relationship between Kuhn and Piaget, use of hauntology concept, emphasis on influence and interaction of thought, deep and critical analysis.	The 'hauntology' approach reflects recognition of the depth and ongoing relevance of Kuhn's thinking, although it may be interpreted differently from traditional interpretations.
Expert 22 [49]	Application of Kuhn's framework, recognition of paradigm crisis, proposal of paradigm change, consistency with Kuhn's theory of scientific progress.	Scientific paradigm dynamics, particularly how a paradigm crisis can trigger fundamental changes in scientific thought and practice.

*Note: The "Findings of Proponents" table section was made into two parts due to page limitations and considerations of layout effectiveness and efficiency.

Further, Tzotzes and Milonakis [45] studies the context of financial crisis and the acceptance of behavioral economics, finding that using Thomas Kuhn's views on normal science combines science as a social and ideational system to evaluate changes in the discipline of economics. It depicts behavioral economics as a factor ensuring intellectual and sociological continuity of the mainstream economic paradigm, in line with Kuhn's thoughts on scientific development. In the field of toxicology, Hartung and Tsatsakis [46] applies Kuhn's concepts to toxicology, showing how traditional paradigms reliant on animal testing face significant challenges due to technological advances and shifts in societal values. Additionally, the crisis in the traditional toxicology paradigm caused by the accumulation of anomalies aligns with Kuhn's theory that paradigm crisis triggers paradigm change. In educational media, Oliveira *et al.* [47] analyzes animated films using Kuhn's theory, concluding that such films can be effective tools for teaching Kuhn's concepts, demonstrating support for applying Kuhn's theory in an engaging and accessible context. In the legal context, Hilton *et al.* [32] uses Kuhn's model from "The structure of scientific revolutions" to analyze and propose a revolution in the science of regulation, demonstrating a paradigm evolution cycle from normality, anomalies, crisis, revolution, to a new normal. It posits that the current science of regulation is in a 'crisis' phase due to the accumulation of anomalies and scientific advances no longer fitting with 'normal science', with a legal framework failing to keep up with current advancements. Thus, a revolution towards a 'new normal' integrating modern methods and technologies, requiring an adaptive regulatory process and a flexible legal framework, is proposed. In psychology, Hwang [36] uses Kuhn's framework from "The structure of scientific revolutions" to argue that a crisis is needed to initiate a scientific revolution against western, educated, industrialized, rich, and democratic (WEIRD) psychology. The expert identifies that the current cross-cultural psychology paradigm, dominated by WEIRD perspectives, faces a crisis as it fails to adequately explain or accommodate cultural diversity. This aligns with Kuhn's view that science undergoes a period of crisis when the existing paradigm can no longer explain new phenomena or anomalies, using Kuhn's thinking to support the idea that a scientific paradigm shift is needed in cross-cultural psychology.

Also found in the context of religious belief, Snoke [38] integrates Kuhn's model of scientific revolution in analyzing changes in belief. Applying Kuhn's concepts in broader contexts, such as personal and religious belief changes, demonstrates acceptance and appreciation of the utility of Kuhn's theory beyond the scientific scope. The expert proposes a dynamic model of belief change, similar to Kuhn's idea of scientific paradigm shift. This aligns with Kuhn's view on how fundamental changes occur, both in science and in personal beliefs. In the context of sustainability science, González-Márquez and Toledo [49] uses Kuhn's framework on scientific paradigms to analyze sustainability science, showing that the evolution of sustainability science has followed Kuhn's model of scientific paradigm development. The expert recognizes a paradigm crisis in sustainability science, aligning with a crucial concept in Kuhn's theory, González-Márquez and Toledo [49] highlights shortcomings in sustainability science's problem-solving ability, consistent with Kuhn's idea of anomaly accumulation causing a paradigm crisis.

The findings of these experts [32]–[34], [36]–[40], [43]–[49] reaffirm the importance of Kuhn's thinking in modern scientific contexts. By adopting Kuhn's paradigmatic approach, these experts not only strengthen Kuhn's theory but also extend its application to various fields, demonstrating the flexibility and relevance of the theory in understanding the scientific evolution occurring across different knowledge disciplines. Moving on to the findings regarding skepticism as shown in Table 3, from 2020 to 2023, an analysis was conducted on various manuscripts that showed a tendency towards skepticism towards Kuhn's perspective in science education. The analysis of each manuscript from various disciplines, such as chemistry [54], physics [55], neuroscience [56], physical education and sport pedagogy [57], history of science [58], science education [19], [20] and general philosophy of science [59]–[61]. highlights shortcomings in Kuhn's theory, and in some cases, identifies the negative impact of its application in their fields of study. These experts generally underline the deficiencies in Kuhn's theory, and in certain instances, they identify the adverse effects of its application across various scientific domains.

In the field of chemistry, Scerri [54] criticizes the application of Kuhn's criteria for scientific revolutions in the context of discovering atomic numbers and isotopes. The argument is that while these criteria may be appropriate for the shift from the Ptolemaic to Copernican models in astronomy, they do not apply in the same way to cases in chemistry or atoms, where changes in chemistry do not represent a significant paradigm shift as in astronomy. Scerri [54] criticizes Kuhn's shift in focus from internal scientific issues to lexical considerations in his later works, arguing that this focus is more on terminology than the actual nature of scientific entities, expressing doubt about the evolution of Kuhn's thought. In physics, Yang [55] investigates Kuhn's thesis that there are two separate aspects of theoretical change from Newtonian to Einsteinian physics supporting his incommensurability thesis. Kuhn proposes a conceptual change in the meaning of "mass" during this theoretical shift. The result is a rejection of the cases Kuhn proposed to support his incommensurability thesis. Specifically, Yang [55] argues that the conceptual change in the meaning of "mass" and the absence of a neutral observational basis for space-time measurement are insufficient as evidence. Despite space-time measurements being theory-laden, there remains a neutral observational basis to evaluate the relative strength of Newtonian and Einsteinian physics, contradicting Kuhn's claim about the absence of a neutral observational basis. Yang [55] criticizes Kuhn's concept of "relativistic mass" as physically meaningless and inconsistent with the principles of relativity.

In neuroscience, Petrovich and Viola [56] argues that considering the transition from traditional cognitive psychology to cognitive neuroscience as a Kuhnian paradigm shift is a misconception. To support this argument, the expert uses scient metric data to counter the paradigm shift view. The findings show a mismatch with the narrative of a Kuhnian paradigm shift. Petrovich and Viola [56] criticizes the idea that the transition from cognitive psychology to cognitive neuroscience represents a Kuhnian paradigm shift and presents evidence supporting the view that "there is no significant ontological incommensurability between cognitive psychology and cognitive neuroscience," suggesting that this change is more an integration and evolution process rather than a revolution. In the field of physical education and sport pedagogy, Kiremitci and Boz [57] finds that research in Turkey may be stagnant and resistant to the type of paradigm changes that Kuhn considered essential for genuine scientific advancement. This is indicated by characteristics that align with the "normal science" phase in Kuhn's theory, where research is conducted within the existing paradigm framework without challenges or efforts to change it. This is evident from the use of established and economical research methods and the avoidance of more complex or innovative approaches. Resistance is reflected in the preference for traditional, resource-efficient research methods and a lack of tendency to explore new theories or methodologies that might challenge the existing paradigm.

Table 3. Findings of skeptics

Expert	Key findings	Positioned as skeptics because
Expert 23 [19]	Critique of important aspects in Kuhn's theory, fundamental errors in "the structure of scientific revolutions", uncritical acceptance of Kuhn in science education.	Highlights the theory's flaws and its negative impact on science education. Matthews emphasizes the need for a more critical and philosophically grounded approach in this area.
Expert 24 [20]	Critique of Kuhn's epistemological relativism and ontological idealism, problems in applying Kuhn in laboratory ethnography, critique of separating cultural studies from philosophy.	Underlines the deficiencies in its application in science education and cultural studies, advocating for a more philosophical and principled approach in these fields.
Expert 25 [54]	Critique of applying Kuhn's theory in chemistry cases, emphasis on differences between astronomy and chemistry cases, critique of Kuhn's shift from internal scientific issues to lexical ones, views on limitations of Kuhn's theory in chemistry.	Expresses doubts about the relevance and universality of Kuhn's theory for specific cases in chemistry, especially its application in the context of chemical studies.
Expert 26 [59]	Comparison with Kuhn's views, Cournot's views more similar to Comte than Kuhn, Renouvier's critique of Kuhn's exclusive paradigm concept, critique of applying Kuhn's concepts to Cournot and Renouvier.	Highlights differences and often contradicts Kuhn's views on scientific revolution theory.
Expert 27 [58]	Critique of Kuhn's interpretation, differences between Kuhn's and 'Kuhnians' views, post-Kuhnian era, critique of the scientific community.	Challenges certain aspects of his views and critiques how these views are received and interpreted within the scientific community.
Expert 28 [60]	Critique of Kuhn's views, alternative development cycle model, integration of opposing insights.	Criticizes, challenges, and proposes alternatives to expand and refine understanding of scientific development
Expert 29 [56]	Rejection of Kuhnian paradigm-shift, scient metric analysis opposing paradigm shift, no clear ontological incommensurability, integration rather than separation of scientific communities.	Criticizes the idea that this transition represents a Kuhnian paradigm shift and presents evidence supporting the view that this change is more an integration and evolution process than a revolution.
Expert 30 [55]	Rejection of cases proposed by Kuhn, critique of the "relativistic mass" concept, opinions on space-time measurement	Challenges his claims by presenting contrary arguments and evidence, indicating skepticism towards specific aspects of Kuhn's theory.
Expert 31 [61]	Critical analysis of the use of the term "paradigm", discussion on Kuhn's own discomfort, critique from mentors and other critics, focus on terminological implications.	Based on critical analysis of the frequency and distribution of the term "paradigm," discussion on Kuhn's discomfort with its usage, criticism received from mentors and other critics, and a focus on the implications of terminology.
Expert 32 [57]	Dominance of "normal science" characteristics, resistance to paradigm change, focus on economical and easy research, limitation of theoretical and methodological diversity.	Implies that research in Physical Education and Sport Pedagogy in Turkey may be stagnant and resistant to the type of paradigm changes that Kuhn considered essential for true scientific advancement.

In the field of the history of science, Kokowski [58] provides a critical analysis of Kuhn's views on the Copernican revolution, distinguishing between ideas that can be "reasonably attributed to Kuhn himself" and 'Kuhnian' ideas that have developed beyond Kuhn's original thoughts. The method of analysis used is the hypothetico-deductive correspondence thinking approach, which is systematic and critical. The skeptical approach is evident in the way the author actively challenges and evaluates the interpretations and consequences of Kuhn's views. Kokowski [58] highlights the emergence of a post-Kuhnian era, where Kuhn's achievements are only considered to have historical significance and are no longer seen as a basis for ongoing scientific development. In the field of science education, [19], [20] underline the shortcomings of Kuhn's theory and its negative impact on science education, as well as deficiencies in its application in science education and cultural studies. Expert Matthews [19] focuses on Kuhn's ontological idealism inspired by Kant and his claims about incommensurability between paradigms. According to Matthews [20], this results in ongoing negative effects, and he also raises the issue of uncritical acceptance of Kuhn in science education as a systemic problem. He emphasizes the importance of enhancing philosophical competence in science education in response to this issue. Furthermore, raises problems stemming from the commitment of science education and cultural studies to Kuhn's epistemological relativism and ontological idealism. He also criticizes the application of Kuhn's theory in laboratory ethnography, highlighting the lack of adequate selection principles in documenting and understanding scientific activity. This critique indicates his skepticism about the effectiveness of Kuhn's approach in scientific research.

In the context of general philosophy of science, critiques of Kuhn's views [59]–[61], include [60] pointing out critical shortcomings in Kuhn's theory, especially in its psychological aspects, by challenging Kuhn's commitment to a fully developed theory of development. Schmaus [59] compares Cournot and Renouvier's views on scientific revolution with Kuhn's theory, finding that their views significantly differ from Kuhn's. Cournot and Renouvier have a more open view of scientific revolution, not fully aligning with Kuhn's concept of paradigmatic change. Renouvier emphasizes the plurality of interpretations and collaboration within the scientific community, contrary to Kuhn's view of exclusive scientific paradigms. Cournot views scientific revolution as a cumulative development, similar to Comte's view and not consistent with Kuhn's theory emphasizing fundamental and abrupt paradigm changes [59]. Then, Wray [61] conducts a detailed analysis of the frequency and distribution of the term "paradigm" in Kuhn's book. The focus on frequency and distribution indicates a more critical approach, highlighting the inconsistency and potential overuse of the term. The ambiguous and inconsistent use of the term "paradigm" seems to challenge the assumption that the term is always clear and useful in the context of science. The findings of [19], [20],[54]–[61] lead to a skeptical view of Kuhn's theory. These experts critically evaluate Kuhn's theory, revealing various shortcomings and negative impacts of its application. A substantial amount of criticism of Kuhn's view of science has emerged in recent years, underlining doubts about the concept of incommensurability and its application across various disciplines. These findings provide important insights into existing doubts and critiques of Kuhn's theory, which will spur further discussion and research efforts to understand and develop comprehension of science and paradigm shifts.

Finally, based on the findings of this study, Kuhn's view as a scientific lens is indeed divided into two perspectives: proponents and skeptics of his theory. The proponents support that there are paradigm shifts or "scientific changes," not only reinforcing and valuing Kuhn's theory but also extending its application to various fields, demonstrating the flexibility and relevance of the theory in understanding the scientific evolution occurring across different knowledge disciplines. On the other hand, the skeptics criticize Kuhn's views, such as the ambiguity of the term "paradigm" as expressed by Kuhn, the non-recognition of a scientific revolution but more towards scientific evolution, the lack of critical perspective of Kuhn's views, and doubts about the concept of incommensurability and its application in various disciplines. This indicates that Thomas Kuhn has made a significant contribution to the scientific education world by provoking experts to examine more deeply and broadly for the benefit of the development and improvement of scientific knowledge.

4. CONCLUSION

This research identified 32 articles through the PRISMA screening procedure reduction process. Among these, a dichotomy of views with 22 articles being proponents of Kuhn's theory and 10 articles adopting a skeptical viewpoint. Observations were made on several proponents' perspectives across various fields such as biology, physics, economics, toxicology, educational media, law, psychology, religion, and even in the context of sustainability science. This reflects a trend where science is viewed not just as an accumulation of knowledge, but more significantly as a series of paradigm shifts. By adopting Kuhn's paradigmatic approach, these experts not only reinforce Kuhn's theory but also extend its application across various fields, demonstrating the flexibility and relevance of the theory in understanding the scientific evolution occurring in different disciplines of knowledge. On the other hand, articles from diverse disciplines such as chemistry, physics, neuroscience, physical education and sport pedagogy, history of science, science education, and general philosophy of science critique Kuhn's views. Generally, these experts highlight deficiencies in Kuhn's theory, and in some cases, they identify negative impacts of its application in their respective fields. A substantial amount of criticism has emerged in recent years against Kuhn's view of science, underlining criticisms such as the ambiguity of the term "paradigm" as articulated by Kuhn, a leaning towards scientific evolution rather than recognizing a scientific revolution, a lack of critical perspective in Kuhn's views, and doubts about the concept of incommensurability and its application across various disciplines. These findings provide important insights into the support and criticism existing against Kuhn's theory, which will spur further discussion and research efforts to understand and develop comprehension of science and paradigm shifts. The study makes an important addition to worldwide discussions about the essence of scientific understanding, the mechanisms of paradigm changes, and the interactions among various academic fields. It encourages readers from around the world to participate in these conversations, providing a foundation for collective education and the expansion of insight that transcends cultural and academic divides.

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