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Trend of Applying the Conceptual Change Model in Physics Learning: Systematic Literature Review

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ABSTRACT

Physics learning often faces challenges in improving students' conceptual understanding. Conceptual change models are widely used to address this. This study aims to analyze these gaps, review the materials used, and identify improvements made. The study examined fifty-seven articles from four good-quality journal databases: Scopus, Science Direct, Eric, and Sage Journal. This study uses a systematic literature review method using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) technique. The analyzed data was visualized based on selected articles in the form of mapping tabula, including the country of origin of the research, the physics content studied, the frequency of topic material, and the focus of the problem in the research over the last five years (2019-2024). The findings show that the trend of applying learning models in various physics learning materials over the past five years has varied, with ten countries implementing conceptual change model research. The content of matter has varied, including complete kinematics, fluids, pendulums, temperature and heat, sound waves, light waves, Pascal's laws, and quantum. The benefits of integrating conceptual change models in physics learning include diagnosing students who experience misunderstandings and improving conceptual understanding. One of the next research recommendations is to apply momentum and impulse materials while still using a conceptual change model in physics learning.

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INTRODUCTION

Physics embraces a fundamental position within the Indonesian education system and is taught continuously from elementary to high school levels to foster students' scientific understanding and problem-solving abilities (Hidayat et al., 2020; Zhai & Yanfang., 2024). However, various studies indicate that this prolonged exposure does not always lead to correct scientific comprehension, as many students still interpret physics concepts in ways that deviate from scientifically accepted views (Kibiringe & Mamashela, 2022; Maharani et al., 2022; Deringol, 2019). Such misunderstandings are often rooted in students' preconceptions, initial ideas developed before formal instruction, that, if not properly addressed, may evolve into entrenched misconceptions (Docktor, 2014; Inggit 2021; Kibirige & Mamashela, 2022; Turgut et al, 2011). In response, physics educators are required not only to convey scientifically valid concepts but also to guide students in reconstructing their cognitive frameworks by reinforcing accurate understandings and correcting inaccurate ones (Potvin, 2017; Wulandari, 2023).

Preconception can cause misunderstandings. This happens when students' preconceptions contradict scientific understanding (Caleon, 2010; Zuccarini, 2024). Previous research has stated that

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physics learning in Indonesia still faces obstacles in terms of understanding basic concepts due to a suboptimal learning approach (Listianingrum et al., 2024; Sari et al., 2020).

The Conceptual Change Model (CCM) is widely recognized as an effective approach for overcoming students' misconceptions in physics, particularly when conventional teaching strategies prove insufficient (Treagust & Duit., 2024; Syuhendri, 2022). In line with this, several studies have also emphasized the model's effectiveness in improving conceptual understanding and correcting misconceptions in physics learning (Amiruddin et al., 2022; Juniartini et al., 2017; Posner et al., 1982). This model focuses on fundamental changes in the way students understand certain concepts by changing incorrect or incomplete knowledge with a more accurate and comprehensive understanding, especially for students who have experienced misconceptions (Asgari et al.,2018; Li et al, 2023; Munawaroh et al, 2020). Conceptual change occurs when learners realize a mismatch between their initial understanding and a more accurate scientific explanation, and they are then willing to adapt their initial thinking (Syuhendri, 2022; Vosniadou, 2024). The conceptual change model encourages learners to identify their misconceptions and actively reconstruct the correct understanding. Thus, learners not only memorize physics concepts but also understand the scientific reasons behind them, which creates a more in-depth and meaningful learning process (Syuhendri, 2022; Vosniadou, 2024).

Several previous studies have discussed the effectiveness of the conceptual change model in improving students' conceptual understanding in the field of physics and found that this model is not only effective in reducing misconceptions but also stimulates students' critical thinking skills (Treagust & Duit.,2024; Amiruddin et al., 2022; Juniarti et al., 2017; Ugwuanyi et al., 2023; Sari et al., 2020). The effectiveness of the application of the conceptual change model in overcoming misunderstandings, especially in physics learning, has been well documented in various studies (Judijanto & Auliani, 2025). The research uses systematic reviews or meta-analyses as well, which aim to integrate studies that investigate the effectiveness of three types of contextual change strategies: cognitive conflict, cognitive bridging, and ontological category shifts in science learning (Pacaci et al., 2022; Samsudin et al., 2024). This method is decisive as it offers an inclusive fusion of patchy research, quantifies overall effects across multiple contexts, and identifies consistent patterns or gaps in the literature (Cooper et al., 2019; Gough et al .,2017). Such systematic evidence is essential for informing instructional design and guiding future research in science education.

Other analytical studies improved students' achievement scores of conceptual change and self-efficacy more than cognitive conflict learning models, as evaluated by differences in average self-efficacy ratings (Ugwuanyi et al.,2023; Sari et al., 2021). However, in recent years, there are still not many in-depth scientific mapping analyses in the systematic review of the application of conceptual change models in the content of physics learning materials and the focus of problems in the research that has been applied, so it is important to do so that gaps and novelties in future research can continue to be carried out. This research aims to systematically review the literature concerning the use of the Conceptual Change Model (CCM) in physics education from 2019 to 2024. The review focuses on identifying research gaps, examining the physics topics covered, tracking progress and innovations in the application of CCM, and outlining research patterns in terms of geographic origin, subject focus, frequency of themes, and central issues addressed. The outcomes of this review are intended to offer meaningful insights and recommendations for future studies, particularly regarding the integration of CCM in teaching momentum and impulse concepts in physics.

This systematic review approach contributes to help in understanding the network of collaboration between researchers, citation analysis, analysis of research studies, institutions, and the scope of integration that is sought in this research process (Amiruddin et al.,2022; Gunawan & Gunawan, 2023). To support the research review, the author asks several questions in the research as follows:

RQ 1. What are the research trends on conceptual change models in physics learning when viewed based on the year of publication, the state of beginning the research, and the source of the journal article?

RQ2. What are the characteristics of the conceptual change model developed in the context of physics learning in terms of the content of physics material and the focus of the problem?

RQ3. What is the impact of the integration of the conceptual change model in Physics learning on the physics learning process and outcomes? Based on the Request Question above, it can be continued using systematic literature review analysis. This study contributes to filling the existing gap based on the set request question.

METHOD

Research Design

This study used the Systematic Literature Review (SLR). Systematic Literature Review is a systematic and structured method to identify, assess, and integrate findings from various studies that are relevant to a particular topic (Page et al., 2021; Liberati, 2009; Romli, 2023). This study uses the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) technique. PRISMA is designed to help systematic reviewers transparently report on why the review was conducted, what the authors did, and what they found, which serves to ensure that the process of searching, selecting, and synthesizing articles is carried out with transparency and rigor in answering relevant research (Liberati, 2009; Romli, 2023; Ionescu, 2024). PRISMA provides clear guidelines for conducting systematic reviews to ensure the quality of research results. Its use is essential in reducing bias during literature selection and enhancing the accuracy of literature analysis, thereby promoting a systematic, comprehensive, accurate, and transparent approach to reviewing relevant studies (Liberati, 2009; Meline, 2006; Moher, 2015; Page, 2021).

This technique is widely used in research in various fields, including physics education and learning, to unearth the best available evidence about a phenomenon. Research using the PRISMA technique to align with the research question and identify the main search terms begins with identifying relevant articles from various predetermined sources. The first step is to search for articles using the right keywords related to the research topic, in this case, regarding the conceptual change model in physics learning. In this study, data search was carried out through four databases, Scopus, Science Direct, SAGE, ERIC, and Semantic Scholar, as the basis for selecting quality articles because the indexers of the journal are reputable and can be held accountable. Namely Scopus, Science Direct, SAGE, ERIC, and Semantic Scholar (Moher, 2015; Treagust,2024; Winarno et al., 2020).

Research Procedure

Initial searches in academic databases yielded the following results (see Table 1): Scopus – 845,517 articles; SAGE Journals – 55,441 articles; ERIC – 483,200 articles; and ScienceDirect – 574,195 articles, totaling 1,104,195 article titles. Through this process, the articles that answered based on the request question (RQ 1) until the request question (RQ 3) were only fifty-seven articles with a model of conceptual change in physics learning. Of the many articles found, they were omitted for several reasons: combined articles of publication type, ex, book review, article review, proceeding, not answering RQ1-RQ3, and not discussing physics learning content in this stage of research, three stages were carried out, namely, Screening, filtering or data selection; Eligibility, determining the article to be used as literature

evaluation material; and Inclusion, combining and reporting results (Moher, 2015; Treagust, 2024). The process of making a systematic literature assessment (PRISMA) consists of three steps (see Figure 1),

Table 1. Database Request Question

Criterion	Inclusion	Exclusion
Publication Date	Last 5 years (2019 – 2024)	Others
Publication Type	Journal Article	Review, editorial, conference proceeding
Language	English	Any language other
Publication stage	Final	Article in press
Accessibility	Full-text article or open access	Review articles or others
Keywords	"*Conceptual Change Model*" or "*Physics Learning*"	Others

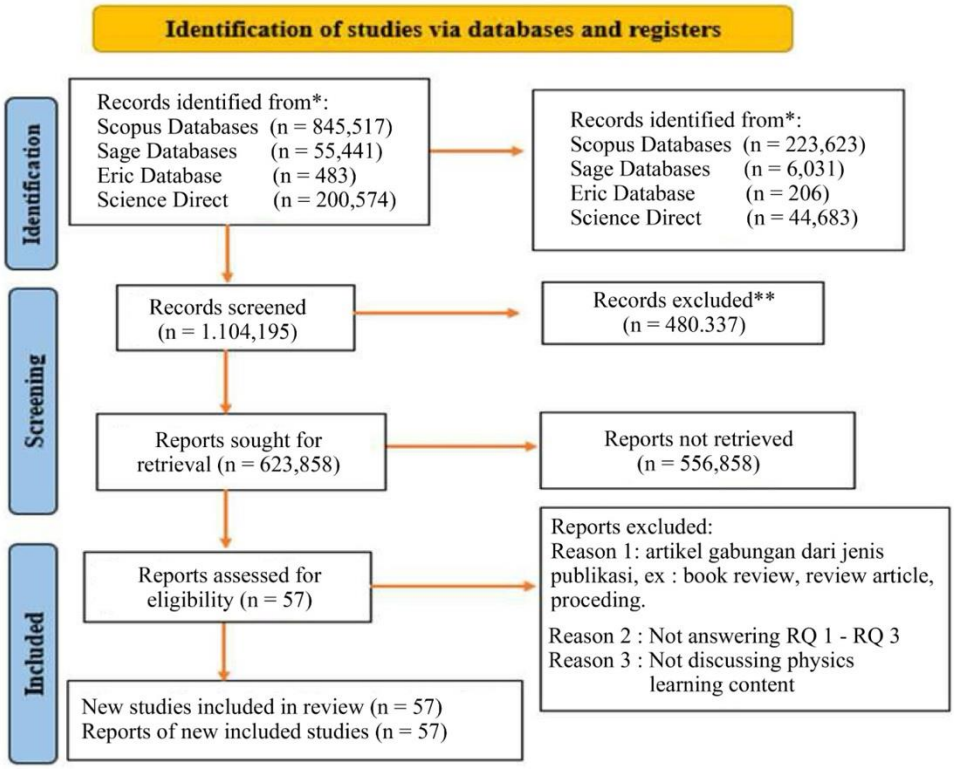

Figure 1. The PRISM Diagram

After the articles were identified, the next stage was the selection of articles based on the inclusion and exclusion criteria set (see Table 1), such as only including peer-reviewed articles and limiting articles published within a certain time frame, such as 2019-2024. This process ensured that only relevant, high-quality research was analyzed. Once the relevant articles had been filtered, the next step was data extraction, where important information from articles that met the criteria was collected and synthesized. Data extraction includes the identification of the main findings of each article, including the methodology used, the results of the study, and recommendations for further research.

This process provided a comprehensive overview of the development of the conceptual change model in physics learning. The results of this analysis were then systematically compiled, both in narrative and tabular form, to compare the findings of various articles that

have been analyzed. Ultimately, the final stage in PRISMA was compiling a report that summarizes all the findings obtained and provides recommendations based on the available evidence for further research (Fan et al., 2018; Zhang & Liu, 2022).

PRISMA (see Figure 1), as a technique in the Systematic Literature Review, provides significant advantages in physics learning, especially in the understanding and application of the conceptual change model. By applying PRISMA, researchers can identify and combine findings from a variety of studies focused on physics learning and thus provide a solid basis for implementing more effective learning strategies. Several studies using the PRISMA method have successfully summarized findings from various articles that demonstrate the effectiveness of the conceptual change model in overcoming students' misconceptions and improving their understanding of physics concepts (Ainley & Ainley, 2021).

Nevertheless, most of these educational programs concentrate mainly on general outcomes without providing an in-depth synthesis of how specific instructional designs, particularly those integrating structured inquiry-based approaches like PDEODEE, contribute to conceptual change in physics. Unlike previous reviews, this study not only maps the effectiveness of the conceptual change model but also systematically identifies key instructional elements and their impact on both conceptual understanding and scientific reasoning, particularly in the context of momentum and impulse topics.

Data Analysis

The stages of PRISMA followed in this study include several main steps. The first step involved searching for relevant literature using predetermined keywords, such as “conceptual change model in physics education” and its variations. The selected articles were then filtered based on inclusion and exclusion criteria, including publication year (2019–2024), article type (peer-reviewed journals only), and relevance to physics learning content. The type of article (peer-reviewed journals only) and focus on physics learning. The selection process is carried out by paying attention to the quality of the methodology and its contribution to the development of the theory of conceptual change in physics education. After selection, articles that meet the criteria are then analyzed to identify key findings and novelty recommendations. The distribution of research in the analyzed articles shows that most of the studies focus on secondary and tertiary education levels, with the main topic being the application of conceptual change models in the learning of complex physics concepts, such as force, motion, and energy (Ainley &Ainley, 2021).

The data obtained then enters the tabulation stage in the form of a table and classification of mapping according to the framework that has been set in the Request Question. Based on the results of the search in the long and detailed selection process of screening for the last five years, namely January 2019 to 2024, in four databases: Scopus, Sage, Eric, and Science Direct, can be seen in Figure 2.

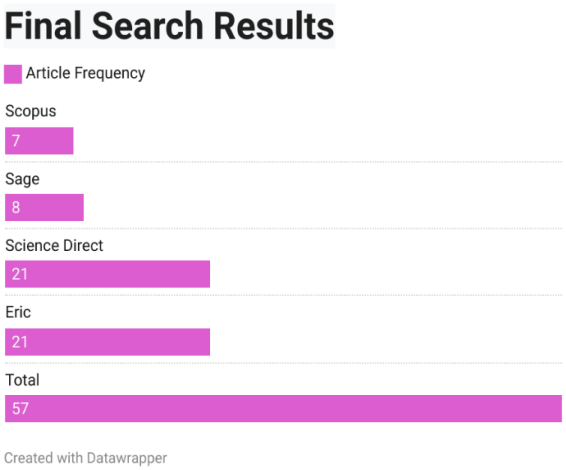

Figure 2. Research Distribution by Year of Publication

RESULTS AND DISCUSSION

Results

Research Question (RQ 1): What is the research trend on the Conceptual Change Model in physics learning when viewed based on the year of publication, the country of origin of the research, the source of the journal article publisher, the focus of this research is reviewed from 2019-2024 with

initial results of 1,104,195 and the results of detailed and comprehensive in-depth selection in fifty-seven journal articles that will be reviewed systematically. There are 10 countries over the past five years, which can be seen in full in Table 3.

Table 3. Highest Percentage of Countries

Country of Origin Journal Publisher	Frequency	Percentage (%)
Indonesia	13	22.81
Germany	9	15.79
Netherlands	9	15.79
United States	7	12.28
Turkey	7	12.28
England	5	8.77
Europe	3	5.26
Malaysia	1	1.75
Pakistan	1	1.75
Australia	1	1.75
Total	57	100

Based on the data available above, Indonesia is the country that publishes the most research results in the field of conceptual change models in physics learning, followed by Germany and the Netherlands; three countries have not discussed conceptual change models in physics learning, namely Malaysia, Pakistan, and Australia. Indonesia's ascendancy is thoroughly correlated to national curriculum reorganizations that inspire the implementation of conceptual models in science education. On the other hand, European countries and the United States tend to produce high-quality publications (Q1), while developing countries more frequently publish in Q2–Q3 journals.

The analysis similarly exposes that countries change their methods to emerging the Conceptual Change Model (CCM): European countries tend to adopt computer simulation-based approaches. In contrast, Asian countries rely more on simple experimental methods such as PDEODEE. However, a thematic gap was identified in momentum and impulse topics, which continue to rarely be explored using CCM, despite actuality being rich in misconceptions that could be effectively addressed through this approach.

Furthermore, to visualize the map of the country that publishes the most research, it is shown in Figure 3.

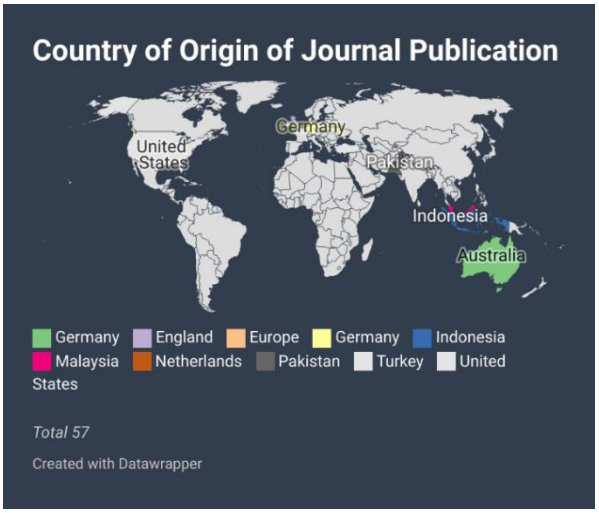

Figure 3. Map of the Country of Origin of Journal Publication

The source of journal article publishers to answer the last Request Question (RQ 1) is shown in Table 4 of the TOP 10 sources of journal article publishers in the study in 2019-2024,

Table 4. TOP 10 Sources of Journal Name

No	Source Journal Publisher	Q	SJR
1	Journal Research Science Teaching	Q1	1,91
2	Science & Education	Q1	1,54
3	International Journal of Educational Research	Q1	1,06
4	Research in Science Education	Q1	1,05
5	International Journal of Science and Mathematics Education	Q1	1,04
6	International Journal of Science Education	Q1	0,97
7	The Journal of Mathematical Behavior	Q1	0,79
8	Sage Open	Q1	0,51
9	Journal of Turkish Science Education	Q2	0,5
10	Eurasia Journal of Mathematics, Science and Technology Education	Q2	0,45

Studies from European countries and the United States tend to be published in high-impact journals (Q1), while articles from Southeast Asia are more commonly found in Q2 and Q3 journals. This reflects differences in research capacity and publication access across countries.

Research Question (RQ2): What are the characteristics of the conceptual change model developed in the context of physics learning in terms of the content of physics material and the focus of the problem? Based on a systematic review that includes the findings are described in Table 5**.**

Table 5. Physics Material Content and Problem Focus

No	Physics Material Content	Problem Focus
1	Sound Waves	Understanding Concepts and Cognitive Conflicts
2	Light Waves	Improving and changing students' mental models
3	Force	Reducing Students' Misconceptions and Conceptual Changes
4	Electrostatic	Conceptual Changes of Students
5	Basic, Quantum and Electrical Electronics	Validity of Teaching Modules and Reducing Misconceptions
6	Newton's Law, Selenoid	Conceptual Change Learners
7	Quantum	Correcting Misconceptions
8	Heat &Temperature	Conceptual Changes of Students
9	Pendulum, Harmonious Vibration	Misconceptions of Concepts and Problem Solving
10	Optics, Wave Optics	Critical Thinking and Misconceptions of the Concept
11	Thermodynamics, Gas Kinetic Theory Pressure, Pascal's Law and Static Fluids	Understanding Concepts

Based on the data of the systematic review that has been carried out in the last five years of research, the application of the conceptual change model has been applied in a variety of materials: sound waves, light waves, kinematics, rotational dynamics, Newton's law, selenoid, centripetal force, reaction action force, friction force, string tension force, gravitational force, quantum, temperature and temperature, pendulum, harmonic vibration, optical waves, optics, thermodynamics, gas kinetic theory, Pressure, Pascal's law, and static fluids, with an average problem focus reduces misconceptions and improves conceptual understanding towards improved student learning outcomes. It has also been proven in several studies over the past five years that conceptual change models can play an important role in overcoming misunderstandings experienced by students in physics learning. For example, it evaluated interactive simulation-based learning that focused on conceptual change and found that this approach improved students' conceptual understanding as well as inquiry skills compared to learning methods other than the conceptual change model. Previous research has shown that conceptual change models have a focus and address problem-solving in physics learning with a variety of roles in improving conceptual understanding, reducing misunderstandings, and improving critical thinking and problem-solving skills, in addition to addressing persistent misunderstandings in physics (Ainley & Ainley, 2021).

The influence of collaborative learning in a conceptual change in physics shows that interaction between peers can accelerate the process of changing students' conceptual understanding. They argue that collaborative learning approaches reinforce the conceptual change model by allowing students to share perspectives and improve understanding together (Ainley & Ainley, 2021).

Request Question (RQ 3). What is the integration impact of the conceptual change model physics learning in the physics learning process and outcomes?

Based on the analysis and classification of the results of research, it can be found that the conceptual change model has ever been applied in various physics materi, including

dynamics, thermodynamics, electromagnetism, the concept of force, namely action-reaction, centripetal force, frictional force, rope tension force, Newton's Law, Selenoid, optics, light waves, pendulum, harmonious vibration, Pacsal's law, there is a lot of material content that has been carried out using conceptual change models with various research objectives. For example, it shows that the use of conceptual change models facilitates various learners' understanding of physics concepts better, as well as reduces common misconceptions about these concepts. The study revealed that through the process of reflection and evaluation, students are better able to adjust their understanding of reach a more scientific and accurate understanding of basic physics concepts, a relevant approach in concept-based teaching in the 21st century 21 (Zhang & Liu, 2022).

Other research supports this view, one of which is in the context of electrostatics. In this study, the conceptual change model was proven to improve students' understanding of electrostatic forces through activity-based learning methods and pre-post tests, allowing students to replace misconceptions with more in-depth and scientific understanding. These studies reinforce the recommendation that conceptual change models be applied more widely in physics learning, not only to unveil misconceptions but also to develop critical thinking skills (Addido et al., 2022).

Some articles also highlight the use of technology and simulation in supporting changes in student understanding. The novelty recommendations of each scientific article lead to the importance of integrating the conceptual change model with inquiry-based approaches and interactive technologies to improve students' conceptual understanding. In addition, there is also an emphasis on the requirement for additional study on the submission of this model in a broader context (diSessa, 1993; Ainley & Ainley, 2021; Moynihan et al., 2022).

Discussion

Through the analysis of the collected articles, this study examines 57 articles from international journals that are of good quality; these articles were taken for the last five years, 2019-2024. The year of research and publication is chosen so that the research remains up-to-date and by the current situation. Ten countries apply the conceptual change model in physics learning: Indonesia, Germany, Netherlands, United States, Turkey, England, Europe, Malaysia, Pakistan, and Australia. The country with the highest level of research is Indonesia, followed by Germany, and the least in Malaysia, Pakistan, and Australia.

This study found that most researchers agree that conceptual change models are important in unveiling misconceptions in physics learning. Based on these findings, it is recommended that this model be applied more widely while still paying attention to the specific learning context and student needs. Furthermore, some articles provide suggestions for future research on integrating conceptual change models with other learning theories, such as constructivism and cognitive theory, to create a more comprehensive approach to physics learning (Zhang & Liu, 2022).

From several studies on the conceptual change model (CCM), it can be interpreted that CCM is a learning model that presents an initial strategy for diagnosing students who experience misconceptions. Consequently, there is a lack of conceptual understanding of students in understanding scientific conceptions; from the application of the Conceptual Change Model, students can realize the misconceptions they hold. The utilization of CCM can have a great impact on improving concept understanding and reducing the number of students who experience misconceptions. Furthermore, it can also be an alternative to improving students' argumentation skills. When examined through the knowledge-in-pieces framework, the success of the Conceptual Change Model (CCM) appears to lie in its

deliberate elicitation of cognitive conflict and its reorganization of students' p-prims (pre-scientific knowledge) rather than merely delivering correct explanations (diSessa, 1993).

From Table 5, it can be realized that the conceptual change model can be utilized in various ways, such as by combining the process of cognitive conflict, students' self-efficacy, and the combination of the application of the approach used. The use of this learning model in several studies has not combined many approach strategies in learning. Some studies do not explain the specific measured results used in implementing CCM. The application of the strategies castoff is surveyed in the last five years, namely with the PDEODEE, POE, 5E, and DIM approach strategies.

Furthermore, research that uses the conceptual change model is mostly carried out on Physics learning. Consequently, there is still a lack of research at the high school level, especially on Physics concepts. Some of the concepts that have been used are in the material of the concept of force, namely action-reaction, centripetal force, frictional force, rope tension force, Newton's Law, and Selenoid.

Thus, other physics concepts have not been developed. For example, the concepts in the Momentum and Implus materials are advanced concepts of very complex styles. Therefore, further research can be carried out using the Conceptual Change (CCM) combined with the PDEODEE learning method at the secondary school level for Momentum and Implus materials and Implus, where the material is an advanced concept of a very complex style. Therefore, further research can be carried out using the Conceptual Change Android Model (CCM) combined with the learning PDEODEE at the high school level for Momentum and Implus materials.

This research also has advantages and disadvantages. The advantages of this research lie in several variations of selected journals that are quality and up-to-date, such as Scopus, Science Direct, Eric, and Sage. This is supported by the fact that the selected articles come from journals that have SJR and have been indexed by Scopus with Quartile (Q1 and Q2 in the last five years.

The results of this study are very useful because they describe the content of physics materials that have been applied in the last five years of research by previous researchers, describe the focus of the problem, the approaches that have been used in previous research, and the results of the research in the student learning outcome process. In addition, the results of this study can be useful for further educators or researchers to implement the physics learning process by using conceptual learning models in physics education or other fields. Meanwhile, the weakness of this study is that the aspects related to the methods of processing the stages of research results in science education have not been explained, such as qualitative, quantitative, mixed methods, and calculation methods in the research process, so they can be explained in further research.

CONCLUSION

Based on the results and discussions, the conceptual change model on the application of physics learning in the last five years has greatly reduced misconceptions and improved student learning outcomes. The application of maetri-material variations in previous research has been applied with useful results in the world of education, especially in physics. These benefits include the benefits of reducing misconceptions, the benefits of improving the understanding of concepts, and the benefits of skills and attitudes. The process of applying the conceptual change model using learning strategies has varied in previous studies such as PDEODEE, POE, 5E, and DIM.

In the last five years, the conceptual change model has been studied in various countries. In this study, 10 countries with diverse results are listed, such as Indonesia, Germany, Netherlands, United States, Turkey, England, Europe, Malaysia, Pakistan, and Australia, with various reputable publishers, both from the quality of journals and the SJR index of

publishers. The results of this review study provide evidence that the conceptual change model can function as an effective learning model strategy in the physics learning process. On the other hand, this systematic review also identifies gaps that exist in knowledge-based, concrete recommendations from the results of the analysis that have been carried out on materials that have not been applied, one of which is momentum and impulse while still using the conceptual change model.

This releases substantial prospects for further investigation that integrates the Conceptual Change Model (CCM) with the PDEODEE approach or other inquiry-based models at the secondary education level. Using an applied implication, the results of this study can serve as a valuable reference for educators and researchers in selecting the most context-appropriate conceptual learning approaches and as a foundation for developing curricula that emphasize conceptual understanding and the strengthening of scientific reasoning.

AUTHOR CONTRIBUTION

EW contributed to drafting and realizing this research article, AS contributed to the formal analysis process and wrote the original draft, and DS contributed to methodology, validation of conceptualization, and resources.

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