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Potential of the Discovery Learning Model with a Cognitive Conflict Approach on Students' Problem-Solving Skills: A Review

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Abstract: Problem-solving skills are one of the key 21st-century competencies that can be developed through active learning. Although various studies have demonstrated the positive impact of the discovery learning model on problem-solving skills, research that integrates current trends with a synthesis of findings regarding the role of learning approaches- particularly the cognitive conflict approach-remains limited. This study aims to analyze trends in research on the discovery learning model as it relates to students' problem-solving skills and to examine trends in the integration of learning approaches that support its implementation. The method used is a Systematic Literature Review (SLR) based on the PRISMA framework combined with bibliometric analysis. Bibliometric data were obtained from the Scopus database and analyzed using VOSviewer and Biblioshiny. Meanwhile, thematic analysis was conducted on 22 selected articles from Google Scholar and Scopus. Bibliometric findings suggest that research on discovery learning and problem-solving skills remains an active area of study, particularly in science and chemistry education. Recent research has explored the use of discovery learning alongside various approaches and strategies to promote active learning. Thematic synthesis further shows that discovery learning has generally been found to be effective in improving students' problem-solving skills. It can also be improved by using the right media, learning strategies, and teaching methods. The cognitive conflict method of learning, among others, has been highlighted in the literature as a learning approach that fits here, since it enables the restructuring of concepts.

Keywords: Bibliometric; Discovery Learning; Problem-Solving Skill; Systematic Literature Review.

Introduction

Education plays a vital role in preparing human resources to meet the demands of the 21st century. This century is characterized by rapid change, an open society marked by shifting mindsets, and rapid technological advancements [1]. Therefore, 21st-century education places greater emphasis on learning processes that support the development of students' skills [2]. The key competencies of this century are critical thinking, problem-solving, innovation and creativity, and the integration of technology [3]. In line with the demands of the 21st century, problem-solving skills have become essential competencies that students must possess. This is because it trains students to recognize the correlation between the concepts they are currently learning and their daily lives [4]. However, field observations indicate that students' problem-solving skills remain relatively underdeveloped [5–8]. Students are accustomed to theory alone without understanding how to apply the knowledge they possess. Therefore, active, student-centered learning is necessary to improve students' problem-solving skills.

One factor that can influence students' problem-solving skills is the learning model employed [9]. Research findings indicate that when learning is conducted in the conventional manner, students tend to be passive and indifferent [10]. Therefore, the solution is to implement active learning. In reality, however, learning in schools still relies on conventional methods, in which students merely listen to teachers' lectures delivered through presentations or to textbooks that support the learning process [11–13]. Field evidence also indicates differences in student learning outcomes between classes that implement active learning and those that use conventional learning [14]. Innovative learning models support an enjoyable learning process and also have the potential to achieve higher learning objectives than conventional models [15]. One model with potential for implementation is Discovery Learning.

The Discovery Learning model is a learning approach in which students discover the concepts being studied independently [16]. This model is student-centered. The use of discovery learning gives students a role in the learning process and also trains their thinking skills [17]. The application of this model can also improve competency outcomes and enhance students' problem-solving abilities [18–20]. In addition to learning models, learning approaches must also be considered to ensure students fully understand what they are learning. As research on discovery learning continues to grow, the focus of these studies is also evolving. Based on a review of the literature, most studies still focus on testing the effectiveness of the discovery learning model or its integration with instructional media. Meanwhile, research integrating discovery learning with learning approaches remains relatively limited. This situation indicates that there is still an opportunity to examine how learning approaches can support the potential of discovery learning to enhance students' problem-solving skills.

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Integrating instructional models and instructional approaches is one way to optimize the learning process.. An approach is a perspective on learning used to determine the methods to be employed in instruction, thereby facilitating the achievement of learning objectives [21]. In the classroom, the two can complement and support one another. Instructional models outline the stages of the learning process, while instructional approaches provide a foundation for guiding it so that learning objectives can be achieved more easily. Most previous studies that have focused on using the discovery learning model to enhance students' problem-solving skills have yielded positive results [22–24]. Therefore, the integration of approaches with the discovery learning model, which can optimize the learning process and strengthen students' conceptual understanding, needs to be studied in greater depth. On the other hand, the cognitive conflict approach supports learning by creating cognitive dissonance, which encourages students to reconstruct their conceptual understanding. However, there is a lack of research that focuses on how the cognitive conflict approach influences students' problem-solving abilities in discovery learning. Prior studies have focused on using the cognitive conflict approach to address students' misconceptions by restructuring their prior knowledge. Both approaches are well-suited to each other because both of them promote the idea of developing one's own knowledge. From a theoretical perspective, combining these two approaches can be beneficial.

There is a growing number of studies on discovery learning, which requires a consolidation of results obtained from multiple sources. Research trends analysis will help to identify how this area has developed so far and what the current trend is. In order to fill this gap, this paper uses the methodology of Systematic Literature Review (SLR) and bibliometric analysis to analyze the research trends and consolidate findings related to the usage of discovery learning for enhancing students' problem-solving skills. Moreover, this paper explores the role of the cognitive conflict strategy in enhancing learning effectiveness. Overall, this study not only maps research trends on discovery learning and problem-solving skills but also synthesizes research findings and identifies the role of learning approaches, particularly cognitive conflict, in supporting the potential of discovery learning. Based on these objectives, the research questions in this study are: 1) What are the trends in discovery learning research regarding problem-solving skills between 2015 and 2025? 2) What are the trends in research findings regarding the application of discovery learning to improve students' problem-solving skills? 3) What is the role of learning approaches in supporting the potential of discovery learning to improve students' problem-solving skills based on the literature review?

Research Methods

The method used in this study was Systematic Literature Review (SLR) mixed with bibliometric analysis and thematic synthesis. A systematic review was conducted to collect, evaluate, and synthesize research findings in a structured manner based on systematic procedures [25]. The bibliometric analysis was performed to explore research trends on the topic of discovery learning and students' problem-solving skills, and thematic synthesis was used to analyze research findings in more detail. The literature sources for this research were identified in two databases, Google Scholar and Scopus. The first one was chosen due to its high search volume, and the second one was used because it indexes international journals that pass through the selection procedure and have structured metadata.

For the bibliometric analysis, the Scopus search was conducted using the keywords "discovery learning" AND "problem-solving skills." It was restricted by parameters such as selecting scientific articles and specifying the publication period. A total of 190 articles were found and further analysed using Biblioshiny and VOSviewer.

Furthermore, for the thematic synthesis, a separate literature search was conducted using Publish or Perish to extract publications from Google Scholar and Scopus. The same keywords, "discovery learning" AND "problem-solving skills," were used as search terms with a maximum of 200 articles retrieved from each of the two databases. 187 and 84 articles were retrieved from Google Scholar and Scopus, respectively. To narrow the review to the most relevant literature, the top 50 articles were selected from both databases based on their relevance to the topic.

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was also used in this study to ensure transparency and accuracy in the article screening process. The stages in this framework are identification, screening, eligibility, and inclusion. The use of the PRISMA framework in this study is shown in Figure 1.

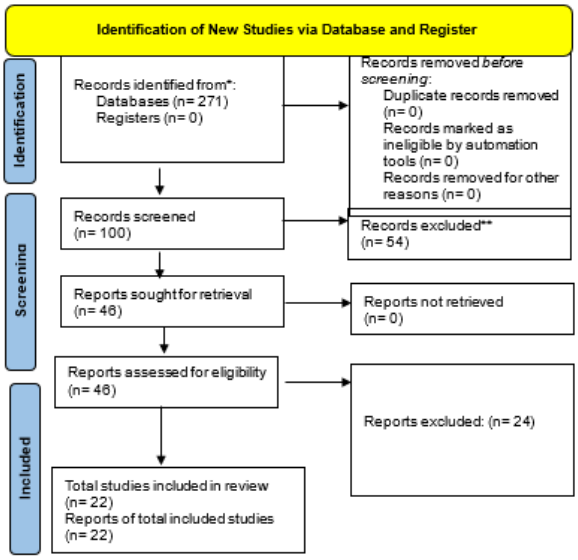

Figure 1. PRISMA framework used in this study

The PRISMA selection method was used to identify research articles relevant to the study topic, namely the application of discovery learning to students' problem-solving skills and studies on supporting learning approaches. The steps taken were as follows:

Identification. The search for articles in the identification stage was conducted using Google Scholar and Scopus. The keywords used in the search were "discovery learning" AND "problem-solving skills." A time restriction was applied to ensure more accurate results, specifically for the period between 2015 and 2025. The initial search yielded 271 articles. To focus the study on the relevant topics, the top 100 articles were selected for further review.

Screening. The articles found for each keyword were further screened based on their titles and abstracts, and duplicate articles were removed, resulting in the elimination of 54 articles. There are 46 articles that passed the screening stage.

Eligibility. This stage is based on the inclusion and exclusion criteria listed in Table 2. There are 24 articles that were eliminated because they did not match the topic under discussion, used different variables, or had research subjects that did not meet the inclusion criteria. 22 eligible articles were identified.

Inclusion. At this stage, 22 research articles were selected for further review and discussion.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles published between 2015 and 2025	Articles outside the specified time frame
Discussing the discovery learning model	Does not discuss the implementation of learning models
Examining problem-solving skills as a research variable	Does not address variables related to students' cognitive abilities
Articles in Indonesian or English	Articles in languages other than Indonesian or English
Research journal articles available in full	Articles in the form of conference proceedings, theses, or non-journal articles

The selected articles were then analyzed using bibliometric, which was described through descriptive analysis and followed by thematic synthesis. VOSviewer was used to generate network, overlay, and density visualizations of the relationships among research keywords. Biblioshiny provided descriptive information on the dataset, including annual scientific production, leading publication sources and authors, corresponding-author countries, institutional affiliations, highly cited articles, average citations per year, and keyword distribution in a word cloud. The selected articles were then analyzed using descriptive analysis methods, followed by thematic synthesis. Descriptive analysis was conducted on the articles to obtain a constructive overview of the data [26]. The results of this analysis were presented as statistical data to facilitate understanding of the articles' details and the identification of patterns within them.

Next, thematic synthesis was supposed to identify patterns in previous research. According to Rozali, this analysis began with understanding the data, open coding of the data and findings, identifying themes, and arranging the conclusions [27]. In this study, thematic synthesis was conducted by reviewing the selected articles, identifying relevant findings, classifying them by common themes, and drawing conclusions from the resulting patterns. The synthesis of findings from identifying similarities and differences among studies is expected to provide a more comprehensive picture and generate new insights into issues in science education.

Results and Discussion

The aim of this study was to analyze the application of discovery learning on problem-solving skills. The discussion is structured around the formulated research questions, so that each section systematically examines different aspects. The objective of this research is to identify trends in research on the discovery learning model in relation to students' problem-solving skills, as well as the tendency to integrate various forms of learning support in its implementation, such as other learning models, learning media, and complementary approaches and strategies. This study uses two analytical approaches: bibliometric analysis and thematic analysis. Bibliometric analysis was conducted on 141 articles retrieved from Scopus, while thematic analysis was conducted on 22 selected articles retrieved from Google Scholar and Scopus.

Research Trends on the Discovery Learning Model Regarding Students' Problem-Solving Skills

Bibliometric analysis was made using VOSviewer and Biblioshiny. The articles analyzed with VOSviewer were obtained from Scopus using the keywords "discovery learning" AND "problem-solving skill." This resulted in the network visualization shown in Figure 2.

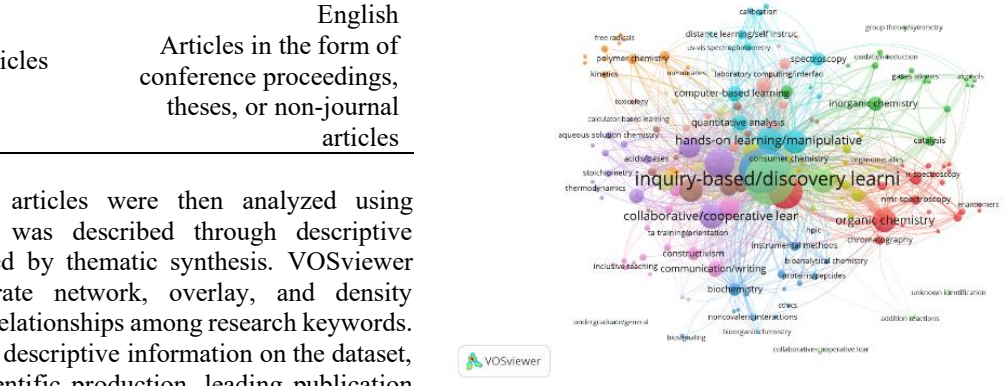

Figure 2. Network Visualization

Based on the results of the network visualization conducted by VOSviewer, a network map was obtained as shown in Figure 2. Every color represents a different research focus group. The size of the circles indicates the prominence of variables in the research. Variables located in larger circles indicate that the topic has been studied more extensively. Furthermore, the lines represent the connections among the topics. The closer the lines are, the more frequently the topics are studied together; conversely, the farther apart they are, the less frequently the topics are connected. The topic of inquiry-based/discovery learning has emerged as a central focus of study, linked to several approaches, including hands-on learning, collaborative/cooperative learning, and computer-based learning. The core research dominating this network map is around the landscape of learning pedagogy. It can be seen that discovery learning does not exist in isolation; rather, it is linked to other approaches that engage students more. Moreover, some of the key words related to particular domains of knowledge, for example, chemistry and science, imply that the discovery learning approach is widely applied

in science education where knowledge is obtained through concepts and experiments.

It becomes clear that the new approaches imply that previous research on discovery learning has focused mainly on developing this approach through particular strategies that facilitate collaboration in the learning process. Not all of the approaches are equally interconnected in this research domain. It becomes clear from the network that there is a general tendency for models of discovery learning to diverge into different approaches, but the current research focuses on the problem-solving approach in particular. Therefore, further research should be conducted to determine how specific approaches affect the learning process.

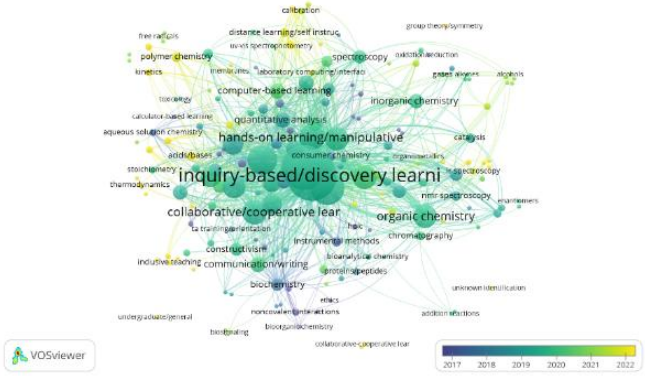

Figure 3. Overlay Visualization.

An overlay chart illustrated in Figure 3 demonstrates the average year of publication of the chosen articles according to their colors corresponding to certain periods. The brighter the color is, the newer the article. The majority of the colors in the map are green, which means that the selected articles were actively written in the middle of the time period that was considered; this suggests that the development of the research topic is rather stable. The topics associated with the lighter-coloured nodes, which represent the most recent years, include "collaborative-cooperative learning," "inclusive teaching," and "distance learning." It can be concluded that research on the topic is going in diverse directions with the emphasis on making learning experience more comfortable for the learners.

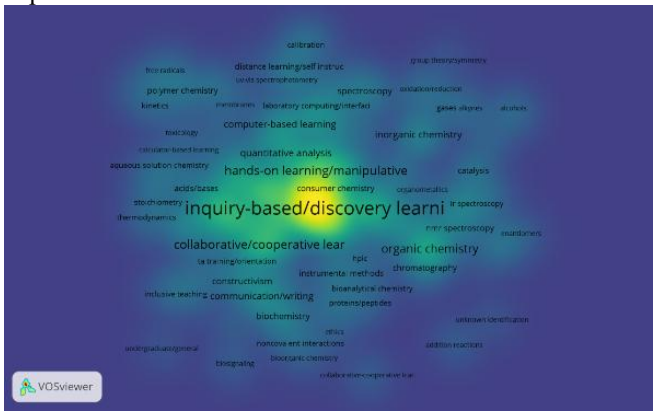

Figure 4. Density Visualization.

Figure 4 demonstrates a density visualization produced using VOSviewer. Such visualization shows the density or prominence of research themes depending on the frequency of their appearance and the strength of links between the keywords. Colors from light to dark demonstrate how prominent and intensively studied the research theme is.

From the presented visualization it is possible to say that a considerable amount of research is concentrated within the domain of chemistry. The other themes, less dominant, usually concern the instructional processes used. It may be said that research on "discovery learning" as it concerns problem-solving skills takes place mostly within scientific fields, such as chemistry, that strongly depend on theory, but also extends to instructional processes and pedagogical approaches.

Based on the analysis using VOSviewer, it can be concluded that the research topic concerning discovery learning and its impact on students' problem-solving abilities remains an actively developing area of study.)The visualization results show that research is no longer focused solely on the effectiveness of discovery learning on its own, but also supports integration that promotes the achievement of goals with better outcomes. Other topics connected to the main topic also have a fairly broad scope, suggesting that this research trend continues to be explored in other fields. Meanwhile, extensively researched topics tend to focus on integrating discovery learning with methods or approaches to increase the likelihood of successful model implementation.

Further analysis was conducted using Biblioshiny with the Scopus database, using the keywords “discovery learning” AND “problem-solving skills.”

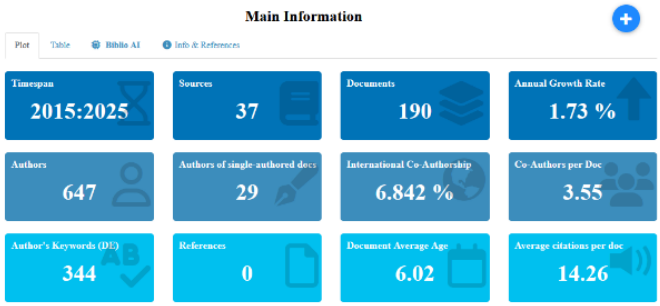

Figure 5. Main Information

The preliminary analysis presents key information from the collection of articles analyzed. Based on the provided keywords, which were further filtered to the 2015–2025 time period, 190 articles from 37 selected sources were identified for analysis. The selected timeframe—covering the past 10 years—is relatively recent, as evidenced by the Annual Growth Rate, which continues to rise by approximately 1.73%. This indicates that the topic of discovery learning and its impact on students’ problem-solving abilities remains a subject of active scholarly discussion. The total of 647 authors further demonstrates that this topic remains a relatively popular area of research. The results also indicate a tendency among authors to remain non-collaborative and locally focused, as evidenced by the Co-Author figure of 3.55 and the International Co-Authorship rate of 6.842%. This research also spans a wide range of fields, as evidenced by the large number of indexed keywords, totaling 344. The average citation count for the articles is 14.26, which is quite high and indicates that the selected articles are influential and of high quality.

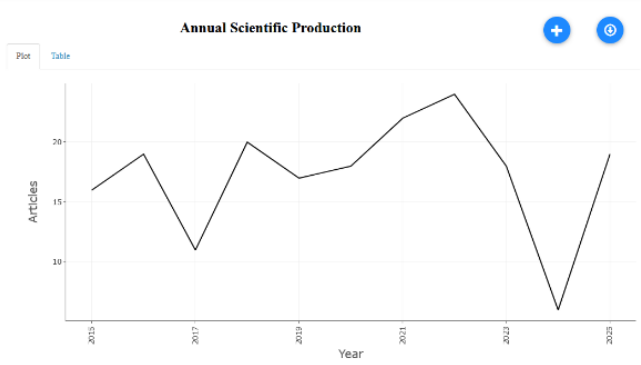

Figure 6. Annual Scientific Production.

The following figure shows a plot of the fluctuations in the number of articles published each year over the 2015–2025 period. In 2015, a significant number of articles related to the research topic were published. This number declined in 2017. However, in the following years, it remained stable and did not vary significantly. However, in 2024, it declined again. It can be concluded that studies on the impact of the discovery learning model on students' problem-solving skills remain an area of extensive research. In the modern era of education, models that promote student participation are crucial and offer greater opportunities to achieve objectives.

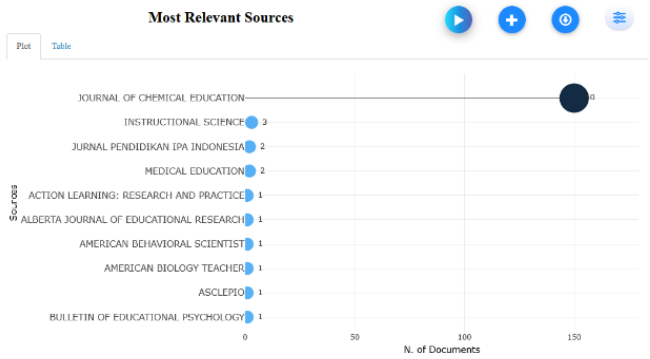

Figure 7. Most Relevant Source.

The table shown below is of the ten leading sources which have made significant contributions of articles in the field of study. The five leading sources include: Journal of Chemical Education, Instructional Science, Indonesian Journal of Science Education, Medical Education and Action Learning: Research & Practice. All these sources have distinct areas of research, but it is clear that most sources on this topic are education-related, with chemistry as the primary subject area.

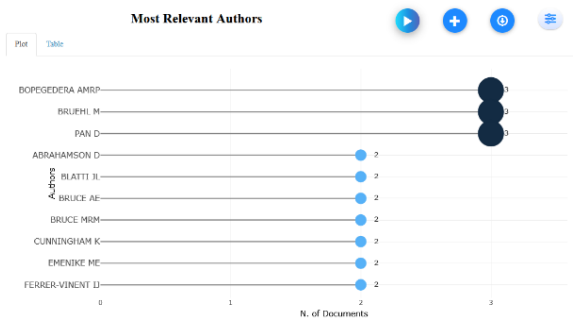

Figure 8. Most Relevant Authors.

Analysis of the ten most productive authors regarding this research subject will follow next. In the visualization "Most Relevant Authors," the productivity of authors in the research field has been illustrated. The top three authors regarding their productivity are Bopegedera AMRP, Bruehl M, and Pan D, who have produced three documents each. Other authors have, on the other hand, produced two documents each. It can be observed from the findings that author productivity in the research field is relatively equal among all authors.

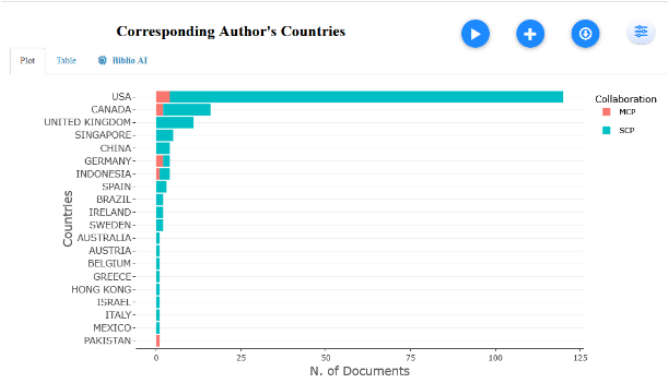

Figure 9. Corresponding Author's Countries.

The "Main Information" section displays a small number of international articles, which is reflected in the "Countries of Corresponding Authors" table as well. It is a list of countries with the number of articles written on the topic "discovery learning" concerning the problem-solving abilities of students. The leader is the United States, with the total of 125 published articles, and it is followed by Canada, the UK, Singapore and China. Apart from the information provided by the table, one can notice that this research area is characterized by its localization rather than internationalization. In the table, the orange color stands for "Multiple Country Publications" (MCP), or articles written by researchers from different countries, and the green color stands for "Single Country Publications" (SCP), or articles written by researchers from the same country.

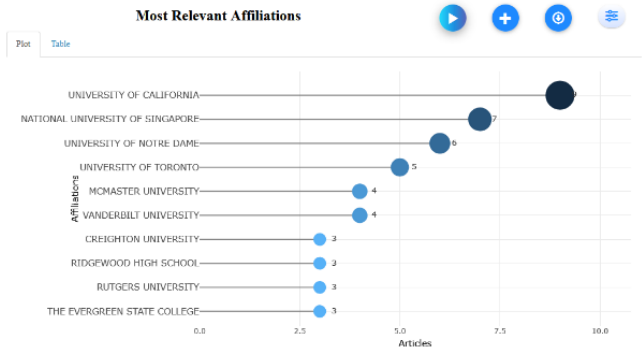

Figure 10. Most Relevant Affiliations.

Following this, a visual illustration of the "Most Relevant Affiliations" is provided. Institutions that are actively participating in research on the topic under study are included in these results. Additionally, the distribution of the number of publications among the different affiliations also shows that research on this topic does not only take place within one organization but there are contributions from multiple universities and research organizations to the studies.

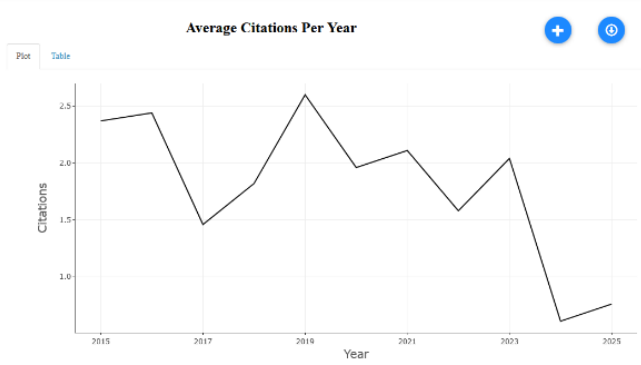

Figure 11. Average Citations Per Year.

In this case, the following analysis is presented in a table titled "Average Citations Per Year," which shows how many times the chosen articles were cited in a given year. According to the data presented above, the highest average number of citations was observed in 2019 (2.6), indicating considerable attention to the problem that year. On the contrary, the average number of citations decreased in the following years, including 2024 and 2025. This trend can be explained by the fact that the articles were published quite recently, and there was not enough time for citations. On the whole, these results indicate that the degree of influence that works devoted to this subject have is subject to change depending on how the science develops and on how actively research takes place in this area.

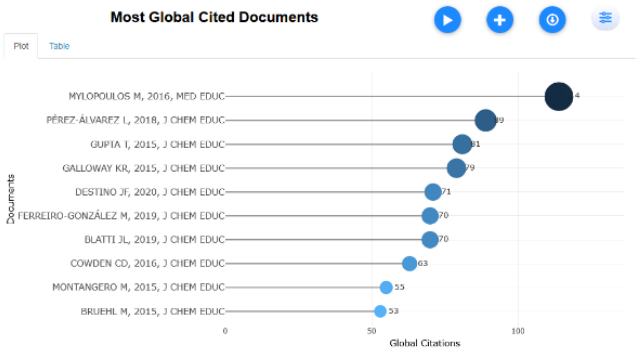

Figure 12. Most Global Cited Documents.

In the table above, 10 authors have the most cited articles. The number of citations is quite considerable, totalling 114 for these articles. Also, the range of years covered by the ranking is evenly distributed, which means that in every year, articles on the key issues of discovery learning and students' problem-solving skills are well-written and widely cited.

Table 2. The Most Cited Article

Author	Title	Total Citation	Year
Maria Mylopoulos, Ryan Brydges, Nicole N Woods, Julian Manzone, Daniel L Schwartz	Preparation for future learning: a missing competency in health professions education?	114	2016
Leyre Pérez-Álvarez Leire Ruiz-Rubio Jose Luis Vilas-Vilela	Determining the Deacetylation Degree of Chitosan: Opportunities to Learn Instrumental Techniques	89	2018
Tanya Gupta K. A. Burke Akash Mehta Thomas J. Greenbowe	Impact of Guided-Inquiry-Based Instruction with a Writing and Reflection Emphasis on Chemistry Students' Critical Thinking Abilities	81	2015
Kelli R. Galloway and Stacey Lowery Bretz	Measuring Meaningful Learning in the Undergraduate Chemistry Laboratory: A National, Cross-Sectional Study	79	2015
Joel F. Destino and Katie Cunningham	At-Home Colorimetric and Absorbance-Based Analyses: An Opportunity for Inquiry-Based, Laboratory-Style Learning	71	2020

Table 2 lists the five authors with the most cited articles. The titles indicate that most articles focus on inquiry-based science/chemistry education and meaningful learning, which fall under the broader categories of active learning and critical thinking skills, and are linked to the main topic: the impact of the discovery learning model on students' problem-solving abilities.



Figure 13. WordCloud.

The most dominant terms in the WordCloud visualization for the research topic of discovery learning and problem-solving skills during the 2015–2020 period are problem-solving/decision-making, laboratory instruction, and upper-division undergraduate. Big words in the visualisation imply a high frequency of their appearance and consequently represent the main point of the research. Besides the main keywords, many different words are used in the visualisation, which allows specifying the area of the

research, for example, the chemical field, the target audience, and the type of learning.

Thus, based on the results from the Biblioshiny analysis, research on the discovery learning model has focused on its implementation in specific learning situations. This method is usually used in science education, a field where abstract knowledge and student participation are required. Chemistry is the most common field of study in such studies, meaning that more research can be done in other subjects. It should be noted that the research trends shown by the results of the VOSviewer and Biblioshiny analyses have been identified. It is possible to state that the research of the topic under consideration is usually conducted in higher education institutions, mostly in the sphere of chemistry, and that it has been the relevant topic of investigation during the 2015–2025 period. These results also answer the first research question.

The next step was a thematic analysis of the 22 articles selected using the PRISMA method. The articles were obtained through Publish or Perish using databases from Google Scholar and Scopus, then analyzed in depth and grouped according to research topics. The results of the review and analysis of the selected articles are presented in Table 3.

Table 3. Review and Analysis of the Selected 22 Research Papers

Title	Method	Research Result	Author, Year
Upaya Meningkatkan Kemampuan Pemecahan Masalah Siswa dengan Model Discovery Learning pada Materi Pemanasan Global	PTK	Teaching that incorporates discovery learning can improve students' problem-solving skills	[28]
The Effect of Discovery Learning Model Towards Biology Problem Solving	Eksperiment	The ability to solve problems using the Discovery Learning model is better than conventional learning models	[29]
Profile of Student Problem Solving Skills Using Discovery Learning Model with Cognitive Conflict Approach	RnD	There was an improvement in students' problem-solving skills across all indicators following the implementation of the discovery learning model and the cognitive conflict approach	[30]
Pengaruh Model Discovery Learning terhadap Kemampuan Pemacahan Masalah Siswa pada Materi Tekanan Zat di SMP NEGERI 7 Kupang Tengah	Pre-experiment	Based on the research findings, it can be concluded that the use of the Discovery Learning model can significantly influence students' problem-solving skills in understanding and applying the concept of pressure.	[31]
Pengembangan Perangkat Pembelajaran Model Discovery Learning pada Materi Getaran Gelombang Dan Bunyi untuk Meningkatkan Kemampuan Problem Solving	RnD	Learning materials based on the discovery learning model can increase student participation and improve students' problem-solving skills	[32]
Identifikasi Miskonsepsi Siswa pada Materi Laju Reaksi serta Perbaikannya Menggunakan Model Pembelajaran Learning Cycle 5E (LC 5E) dengan Strategi Konflik Kognitif	Descriptive	The use of the 5E learning cycle model combined with cognitive conflict strategies can help address students' misconceptions	[33]
Penerapan Strategi Pembelajaran Konflik Kognitif dalam Mereduksi Miskonsepsi Siswa pada Materi Gelombang Bunyi	Eksperiment	The use of cognitive conflict strategies in teaching can reduce misconceptions among students.	[34]
Komparasi Penerapan Strategi Konflik Kognitif dan Strategi Peta Konsep dalam Pembelajaran Team Games Tournament Terhadap Pemahaman Konsep IPA Siswa Sekolah Dasar di Kabupaten Pinrang	Qualitative comparative	Based on the increase in students' average scores, the use of cognitive conflict strategies was found to be more effective than concept map strategies	[35]
Kontribusi Pengetahuan Awal dan Motivasi Belajar terhadap Miskonsepsi Siswa pada Pembelajaran Fisika	Eksperiment	Motivation influences the occurrence of misconceptions among students.	[36]
Tinjauan Literatur: Pengaruh Media Video Animasi Dalam Pembelajaran Ipa Terhadap Pemahaman Konsep Dan Motivasi Belajar Siswa Sekolah Dasar	Descriptive	Engaging media boosts motivation, which in turn improves conceptual understanding	[37]

Using Discovery Learning to Improve Students' Chemical Problem-Solving Skills	Quasi-experiment	The results show that the discovery learning model is effective in improving students' problem-solving skills compared to conventional methods.	[38]
Visual-Assist-Guided-Discovery: A Strategy for Enhancing 10th-Grade Students' Geometric Problem-Solving Skills	Eksperiment	VAGDLS improves students' problem-solving skills, with the greatest improvement observed in the "understanding the problem" indicator. This increased understanding also boosts students' self-confidence.	[39]
Effect of Google Sites-assisted Flipped Classroom Discovery Learning Model and Cognitive Style on Mathematics Problem-Solving Skills and Student Learning Independence	Quasi-experiment	The results of the study indicate that the implementation of the DFC model supported by Google Sites can significantly improve students' problem-solving skills and independent learning abilities.	[40]
The Potential of The Discovery Learning Model Integrated the Reading, Questioning, and Answering Model on Cross-Cultural High School Students' Problem-solving Skills	Quasi-experiment	A discovery learning model integrated with RQA is capable of improving students' problem-solving skills compared to conventional learning models.	[41]
The Effectiveness of Physics Learning Tools Based on Discovery Model with Cognitive Conflict Approach toward Student's Conceptual Mastery	Quasi-experiment	The results of the study indicate that the use of physics learning materials based on the discovery learning model, combined with the cognitive conflict approach, is effective in improving penguasaan konsep siswa.	[42]
The Potential of Discovery Learning Models to Empower Students' Critical Thinking Skills	Qualitative	The implementation of a discovery learning model enriched with additional support is more effective at improving students' critical thinking skills than the implementation of discovery learning without the use of other media.	[43]
Instructional Materials for Discovery Learning with Cognitive Conflict Approach to Improve Vocational Students' Achievement	RnD	Based on the results and analysis conducted, it was found that instructional materials that utilize the discovery learning model with a cognitive conflict approach have a positive impact on students' conceptual understanding, particularly regarding the topic of heat.	[44]
Impact of Learning Model Based on Cognitive Conflict toward Student's Conceptual Understanding	RnD	In general, the cognitive conflict-based learning model has a positive impact on improving conceptual understanding and addressing misconceptions, particularly among students with high academic ability.	[45]
The Effect of Cognitive Conflict-Based Learning (CCBL) Model on Remediation of Misconceptions	Quasi-experiment	This study can be used by educators as an effective alternative instructional model for addressing misconceptions. The CCBL model is specifically designed to enhance conceptual understanding and correct students' misconceptions.	[46]
The Effect of STEM-PjBL and Discovery Learning on Improving Students' Problem-solving Skills of The Impulse and Momentum Topic	Quasi-experiment	The results of the study indicate that STEM-PjBL has a significant positive effect on improving students' problem-solving skills compared to discovery learning.	[47]

Comparison of Mathematical Representation Skill and Science Learning Result in Classes with Problem-based ad Discovery Learning Model	Eksperiment	The results of the study indicate that there is no difference in mathematical representation skills and science learning outcomes between the problem-based learning model and the discovery learning model. However, there is a positive and significant linear relationship between mathematical representation skills and science learning outcomes in both the problem-based learning and discovery learning models.	[48]
The Patterns of Skills of Science Process in Discovery Learning: a Case Study of Science Learning in Coffee Plantation School	Descriptive	The results of the study indicate that the science process skills model in discovery learning can develop students' science process skills. The science process skills model is highly effective in developing students' science process skills	[49]

A thematic analysis was conducted to answer RQ2 and RQ3. The study identified two main areas of discussion in the selected articles: trends in research findings on the application of discovery learning to improve students' problem-solving skills, and the role of learning approaches in supporting discovery learning's potential. Furthermore, the discussion of the approach's role in implementing the model was examined in greater depth by studying the integration of discovery learning with the cognitive conflict approach to improve students' problem-solving skills.

Research Findings on Discovery Learning and Students' Problem-Solving Skills

The results of the review indicate that numerous studies have examined the impact of implementing the discovery learning model on students' problem-solving abilities. The above studies show a positive effect: an improvement in students' problem-solving skills, compared with students trained through the traditional approach. The discovery learning approach enables students to participate actively in the process across various phases, during which they can learn and develop their own ideas and knowledge [29]. The systematic approach within the phases of discovery learning helps students develop their cognitive processes, thereby improving their problem-solving abilities [38]. Studies have shown that the use of discovery learning improves the problem-solving skills in scientific subjects (IPA) [28]. One way to prove this is by examining the score difference between the pre-test and post-test [31]. This shows that the discovery learning model helps improve students' problem-solving skills. Furthermore, the findings highlight that active student engagement contributes to the development of these problem-solving skills. The student-centered characteristics of discovery learning foster positive outcomes in its implementation. Science (IPA) has frequently been used as a subject area to investigate the application of this model.

Furthermore, in addition to directly improving problem-solving skills, the discovery learning model also helps develop other skills that contribute to students' problem-solving abilities. Through nature-based learning that applies the discovery learning model, students' scientific process skills also improve [49]. These skills also support the improvement of problem-solving skills because they involve stages of scientific thinking, such as identifying problems, formulating problems, and evaluating results. Another skill that supports the improvement of problem-solving skills is critical thinking. This ability involves active engagement with knowledge. Critical thinking can be applied to more structured and analytical problem-solving and decision-making. The discovery learning model also influences the improvement of students' critical thinking skills [43]. This indicates that discovery learning not only directly enhances problem-solving skills but also helps develop other interrelated higher-order thinking skills. The system used in implementing this model supports students in exploring their knowledge and satisfying their curiosity, enabling them to gain a more comprehensive understanding of the concepts being taught. Therefore, the use of discovery learning in teaching may improve students' problem-solving skills, either directly or by developing complementary skills. This will, therefore, answer the second research question.

Moreover, the findings from the above-mentioned research studies have generally been positive, although they are confined to the realm of science at the secondary school level. An enabling environment for students to discover knowledge is another essential factor to take into consideration while implementing this approach to teaching. The research studies in other areas are yet limited, so care should be taken in generalizing the findings.

Approaches and Integration in Discovery Learning

Also, the success of the discovery learning model is assessed from other perspectives, such as its connections to other learning models, learning strategies, and learning media. From the findings in this paper, it is clear that many studies have established discovery learning models in connection with other models and strategies. The RQA (reading, questioning, and answering) model, when used together with discovery learning, will be more effective at developing learners' problem-solving ability, since it involves problem analysis [41]. The use of appropriate learning media further supports the effectiveness of implementing the discovery learning model. Engaging media can help students stay more focused and motivated [40]. This is further evidenced by improvements in students' problem-solving skills when using discovery-based visual media [39]. Additionally, a comparison was conducted

regarding the improvement in students' problem-solving skills using the STEM-PjBL model. The results indicated that both models can enhance students' problem-solving skills, though they focus on different indicators. STEM-PjBL fosters students' ability to independently evaluate solutions, while discovery learning helps students think systematically when formulating solutions to problems [47]. In comparison with the problem-based learning model, no significant differences were found in learning outcomes. However, PBL helps students develop representational skills, while discovery learning helps structure students' understanding [48]. The results of this study indicate that discovery learning is a learning model that affects students' abilities, and that its implementation, when supported by media or other strategies, has greater potential to enhance students' problem-solving skills. This also answers the third research question, which concerns the role of this integration: to complement the characteristics of discovery learning. The integration is always aimed at strengthening the learning process to maximize outcomes. Each integration plays a distinct role and contributes differently to the achieved results while still supporting the goal of enhancing students' higher-order thinking skills. This also indicates that no single approach or model currently dominates as the one to be integrated with discovery learning.

Integration of the Discovery Learning Model with the Cognitive Conflict Approach to Enhance Students' Problem-Solving Skills

In addition to integrating learning media, instructional materials based on the discovery learning model also help enhance problem-solving skills. Learning tools that facilitate the stages of discovery learning help students become more systematic, thereby improving their problem-solving skills [32]. This indicates that integration in the application of the discovery learning model is quite common. Another form of integration that can be implemented involves learning approaches. Learning approaches can help students structure their thinking processes more effectively. Network visualization created using VOSviewer shows various often-used keywords such as "hands-on learning" and "collaborative learning." One more keyword is "constructivism." Discovery learning, as a model, is itself based on constructivist theory, as it is the process by which students create knowledge for themselves. It seems to me that employing methods aligned with discovery learning and grounded in constructivist theory is more likely to improve students' problem-solving skills. Cognitive conflict as a method is one example of how this can be done.

A review of the analyzed articles shows that cognitive conflict is widely used as a tool for resolving misconceptions and improving students' conceptual understanding. Using instruction aligned with the approach reduces the rate of student misconceptions [34]. The approach helps identify students' misconceptions and reduces them by creating conceptual contradictions. Additionally, using a cognitive conflict approach in combination with the learning cycle model is effective at reducing student misconceptions [33]. As student misconceptions decrease, their conceptual understanding improves. As students experience cognitive conflicts, they become interested in resolving these contradictions by reconstructing their knowledge on the issue [35]. This allows students to construct their knowledge base while helping the teacher avoid giving new information before determining what the students know [45]. Therefore, the use of cognitive conflict is not only important for correcting misconceptions but also for building conceptual understanding among students.

The use of cognitive conflict in addressing misconceptions is enhanced by a learning process that ensures students face conceptual disequilibrium. In reality, the use of the cognitive conflict technique has been divided into four stages, namely, pre-conception activities, which refer to examining the students' prior knowledge, the introduction of the cognitive conflict, which puts into question that prior knowledge, discovering the correct concept, and lastly, reflection [46]. Students' prior knowledge is an important element that should not be overlooked, since all students have some form of prior knowledge when they attend any lesson. At times, this prior knowledge may not align with scientific concepts, leading to misconceptions. Nonetheless, misconceptions may not necessarily originate from students' prior knowledge only; they may arise due to the mode of instruction or even motivation, among other reasons [36]. In many cases, those with prior knowledge of the subject are more motivated. Alternatively, if there is no interest in the subject at the very beginning, the learner will not be interested in learning the concepts behind it, and thus the motivation to learn the material will be low [50]. High motivation to learn makes the concept easier to understand, hence minimizing misconceptions [37]. This illustrates that the cognitive conflict strategy can effectively resolve misconceptions by helping restructure learners' knowledge.

In this connection, the cognitive conflict approach is not just a remedy; it can also be incorporated within the discovery-learning-based learning process. According to the study's results, the combination of discovery learning and the cognitive conflict approach improves conceptual knowledge, which in turn improves learners' problem-solving skills. It should be noted that combining discovery learning with the cognitive conflict approach implies that all stages of the discovery learning process incorporate the cognitive conflict approach. The cognitive conflict approach makes the discovery process undertaken by students analytical. Until now, students have been accustomed to identifying and immediately selecting formulas, but they are less accustomed to using diagrams or graphs and explaining existing problems in detail. A student-centered learning process, which takes into account students' prior knowledge and involves active activities such as experiments or worksheets, promotes a significant improvement in students' problem-solving skills [30]. The combination of the two has been shown in research to be effective in improving students' problem-solving skills [42]. This indicates that the application of discovery learning with a cognitive-conflict approach has great potential to enhance students' problem-solving skills. The approach and model work synergistically to foster deep understanding among students through active learning and conceptual restructuring. Nevertheless, it is evident that the relationship between the discovery learning model and the cognitive conflict approach remains relatively limited compared with studies conducted individually on either method.

In addition, the cognitive conflict approach is an important contributor to discovery learning. It is true that discovery learning, when properly guided, has greater positive outcomes in helping students improve their problem solving capabilities [43]. Teachers are not just responsible for guiding students to discover information on their own, but must also give guidance using triggering questions, contradictory phenomena, and experiments. This is very important because students need a solid foundation so that the information they gather does not become a source of misconceptions. Although discovery learning helps students in examining what they know, the cognitive conflict approach enables them to build their comprehension. Hence, combining the discovery learning model with the cognitive conflict approach is highly effective in improving students' problem-solving skills. The discovery learning model is based on constructivist theory, while the cognitive conflict approach is the tool for this theory.

Nevertheless, even though the vast majority of the literature reviewed shows positive results, the success of implementation of the integration process may be affected by several other factors, such as learning materials, students' attributes, learning setting, and readiness to present the information. Thus, the success of the integration process cannot be explained solely by the features of the discovery learning model and the use of the cognitive conflict strategy.

Moreover, there are some limitations of this research. In particular, the articles selected for the analysis were limited to the database's coverage and the selection criteria used. There is also the possibility of publication bias because only articles demonstrating positive results are typically published. Thus, future research should include additional databases to obtain more reliable results.

Conclusion

From the analysis performed, it can be noted that there has been an increase in topics and research directions related to the discovery learning model, with an emphasis on the development of problem-solving skills. There is a positive correlation between model use and problem-solving skills. Moreover, there are efforts made on the integration of the model with other methods in order to attain the desired outcomes. From the findings, learning models based on constructivism assist in the realization of the capabilities of discovery learning, especially in helping the learners gain a conceptual understanding. Therefore, the integration of appropriate methods, such as the cognitive conflict method, into the discovery learning process can greatly enhance the optimization of students' problem-solving skills. However, the findings of this study must be considered in light of the limitations of the database's scope, the inclusion and exclusion criteria, and the possibility of publication bias. In practice, the results of this study may serve as a model for educators preparing science lessons. It is suggested that future research should conduct empirical studies to assess the effectiveness of combining the discovery learning and cognitive conflict models.

Author's Contribution

L.S. Nurwati: in charge of article identification through the use of a database, followed by the screening procedure, further screening, and article review and analysis based on the previously set criteria. S. Aji: responsible for writing the research report and compiling the findings systematically and academically as part of the final documentation of the study.

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