

Research Trend of Rasch Model in the Development of Scientific Literacy Assessment Through Bibliometrics

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Abstract. Scientific literacy is fundamental ability to facing the complexity of problem solving in this 21 st century era. The Rasch model is needed as a measurement model that can provide detailed information about the quality of the items used. Therefore, it is crucial for educators and researchers to understand trends in measurement and the development of science literacy instruments within the Rasch model. This study aims to provide an overview of research trends on the measurement and the development of scientific literacy instruments, especially in rasch model, through search for articles that have been published since 2002-2023. The data consisted of articles derived from scopus (n=182) and google scholar (n=960), which were then processed using microsoft excel and vosviewer to obtain bibliometric mapping visualization. This process involves the application of statistical methods to generate accurate mappings and focuses on international publications and national journals, utilizing scopus and google scholar databases to compare their results. The result showed that the research of rasch model in scientific literacy instruments development in recent years has increased and it has the potential to be researched in the future. The findings are expected to provide an overview for othe researchers regarding rasch model in scientific literacy instruments development including affiliation, subject area, document type, source type, language, countries, and mapping visualization of the network on rasch model research.

Keywords: Rasch model, scientific literacy, publish or perish, VOSviewer, bibliometrics

Introduction

Science education has become one of the vital fields in the development of modern society. With the increasing breadth of scientific information and a growing emphasis on decision-making based on scientific evidence, the ability to have the scientific literacy competencies has become more important (Sunni & Sunarti, 2023). Scientific literacy is important because it represents the ability to apply knowledge and skills, as well as to analyze, reason, and communicate effectively when faced with a problem that requires solving and interpreting issues in various situations (OECD, 2019). Furthermore, scientific literacy emphasizes the analysis, prediction, and application of scientific concepts in everyday life for learners, thus fostering the

development of a new generation with a scientific mindset and attitude. On the other hand, scientific literacy skills are also utilized to comprehend environmental issues, health, economics, and other challenges faced by modern society in the 21st century, which heavily rely on technological advancements and scientific developments (Irwan, 2020).

Scientific literacy, as defined by "Project 2061" conducted by the AAAS (American Association for the Advancement of Science), is the capacity to use scientific knowledge, identify questions, and draw conclusions based on evidence to understand and assist in making decisions about the world and its interactions with the environment (Bautista-Puig et al., 2021). This aligns with the statement from the National Academy of Science in Narut & Supradi (2019) that scientific literacy emphasizes not only the aspects of knowledge and understanding of scientific concepts and processes but also aims for individuals to make decisions and participate in societal, cultural, and economic growth (Ding, 2022). Therefore, it is understood that scientific literacy is a fundamental skill to facing an increasingly complex world and highly important for educators and researchers to understand trends in the measurement and development of scientific literacy instruments.

The Rasch model is a measurement method commonly used in the development of scientific literacy (Susongko et al., 2019). It's a statistical tool employed to measure an individual's level of ability within a specific domain, one of which is scientific literacy. The Rasch model has been utilized in various analyses in assessment instrument development because it can provide detailed information about several aspects of test quality. In addition to its use in instrument development, the Rasch model can also be employed in analyzing the students ability (Desiriah & Setyarsih, 2021; Guttersrud & Petterson, 2015; Susongko et al., 2020). Thus, by utilizing the Rasch model, valid and reliable instruments can be developed to measure individuals' levels of scientific literacy.

Rasch model analysis supports the development and validation of invariant measurement by providing empirical evidence and insights into the important psychometric properties of tests and questionnaires (Azizah & Wahyuningsih, 2020; Briggs, 2019; Saidi & Siew, 2019; Tamsen, 2017). The main advantage of the Rasch model is its ability to account for the difficulty level of each item in the measurement instrument (Martha et al., 2021; Maryati et al., 2019; Mubarakah et al., 2021; Saidi & Siew, 2019). Thus, this model allows for accurate comparison of individual abilities against the difficulty levels of items in the instrument, enabling the creation of more efficient and objective scientific literacy instruments (Tesio et al., 2024). In scientific literacy, the Rasch model also enables the identification and correction of inconsistencies or irrelevancies, thereby directing the development of scientific literacy instruments more effectively and ensuring their validity (Susongko et al., 2020). Additionally, the Rasch model allows for more precise measurements to assess individual scientific literacy. These measurement outcomes can be used to gain a better understanding of the level of scientific literacy within a specific population and to identify areas that require attention.

Alongside technological advancements and research in science education, trends in the development of scientific literacy assessment instruments using the Rasch model have been evolved. Recent studies now focus on refining the development of scientific literacy instruments, applying the Rasch model in diverse science education settings, and exploring the potential use of technology in the process of measuring scientific literacy. However, there has been no research that specifically examines the research trends in measuring scientific literacy using the Rasch model. Therefore, this research aims to explore the latest trends in measuring scientific literacy with the Rasch model. By understanding these trends, educators and researchers will be better equipped to develop improved scientific literacy instruments and deepen the understanding of scientific literacy within the context of education and society.

Methods

This research employs a systematic review approach combined with bibliometric analysis to achieve a comprehensive understanding of the literature. This combined approach yields quantitative data through bibliometric analysis and qualitative insights through systematic review of the researched topic (Pizzi et al., 2020; Prahani et al., 2023). Bibliometric analysis used to visualize publication trends, evaluate the contributions of articles to knowledge advancement, and assess literature sources from various perspectives (Chhapola et al., 2018; Admoko et al., 2021; Prahani et al., 2023). This process involves applying statistical methods to generate accurate mappings. Scopus is selected as the primary database due to its coverage of international journals, support for comprehensive bibliometric analysis, and optimal scope (Dawana et al., 2022; Karakose et al., 2022; Mongeon & Paul-Hus, 2016; Yirci et al., 2023).

This study focuses on international publications and national journals, using the Scopus and google scholar databases to compare the results. Google scholar was used in conjunction with the Publish or Perish application as an alternative that provides indexed literature reviews from various nationally reputable publishers. Data were collected in March 2024, saved in CSV format, and then processed using Ms. Excel and VosViewer to obtain bibliometric mapping. The flow of this research is illustrated in Figure 1.

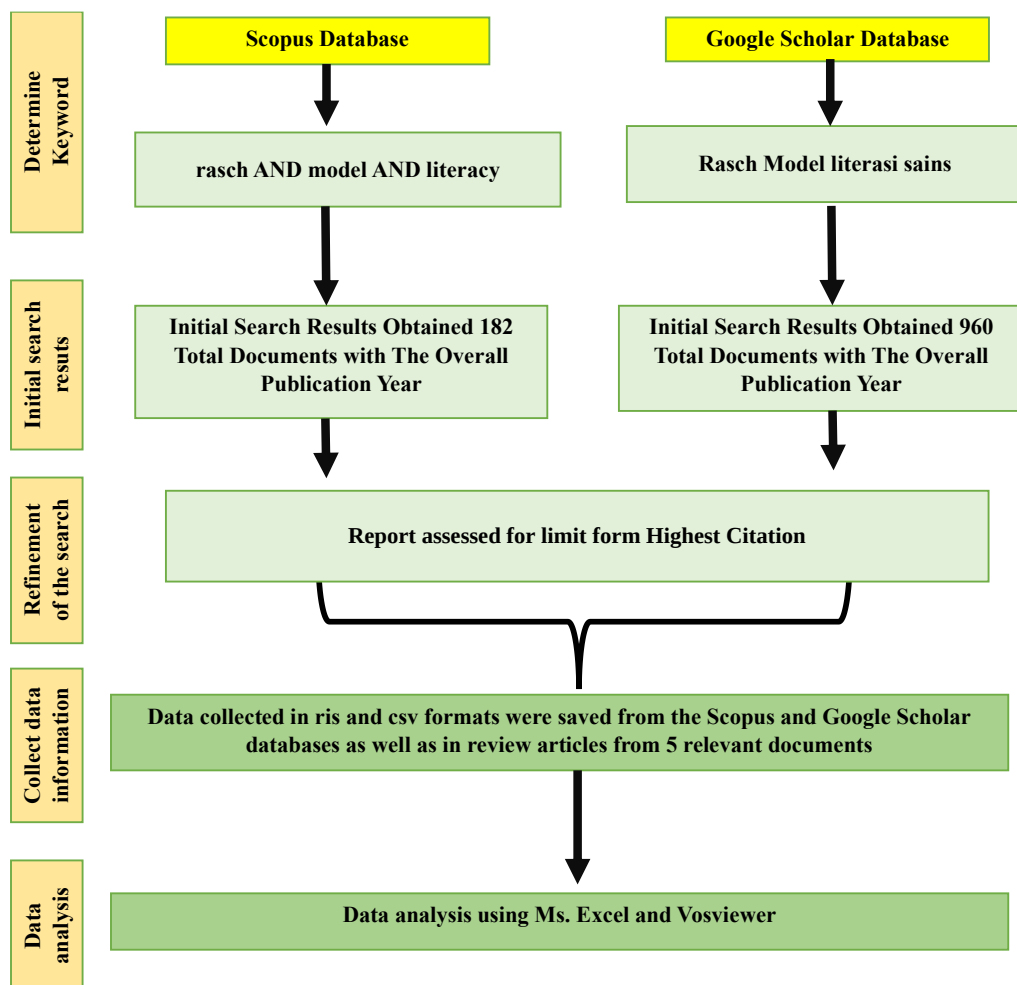


Figure 1. Five steps in performing a Bibliometric analysis (Dawana et al., 2022; Prahani et al., 2023)

Searches were conducted online through the scopus database and the google scholar database. The data was downloaded in .ris and .csv formats. Then, the data was processed using Ms. Excel and Vosviewer to produce graphs and tables that provide visualization of research patterns (Nisaa et al., 2023; Saphira et al., 2023). The bibliometric analysis process not only provides insights into the novelty and trends of research, but also highlights the impact and contribution of scientific works to the development of science in the use of the Rasch Model in science literacy analysis.

Results and Discussion

Publication Trends in the Application of Rasch Models in Analysis

This study used two databases for keyword searches, namely using the Google Scholar and Scopus databases. The search findings show the trend of Rasch model research can be seen in Figure 2.

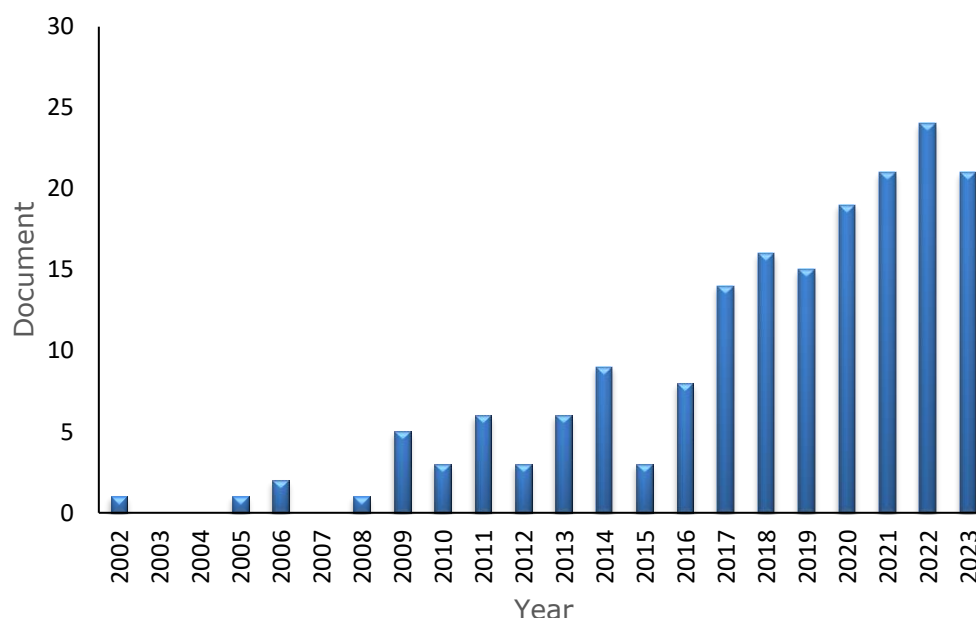


Figure 2. Research Trends Publications Rasch Model in Scientific Literacy (Scopus Database)

Based on data provided from google scholar and scopus, it can be seen that the use of Rasch models in science literacy has increased significantly from year to year, especially in recent years. On Google Scholar, the number of publications using the Rasch model began to increase significantly since 2014, with a sharp increase every year. From 2014 to 2023, the number of publications increased from 9 to 248. This shows an increasing interest in using the Rasch model in science literacy. Meanwhile, on the Scopus database, the trend also shows a consistent increase since 2009, although with smaller fluctuations. From 2014 to 2023, the number of publications in scopus also increased significantly, although not as much as the increase seen in google scholar.

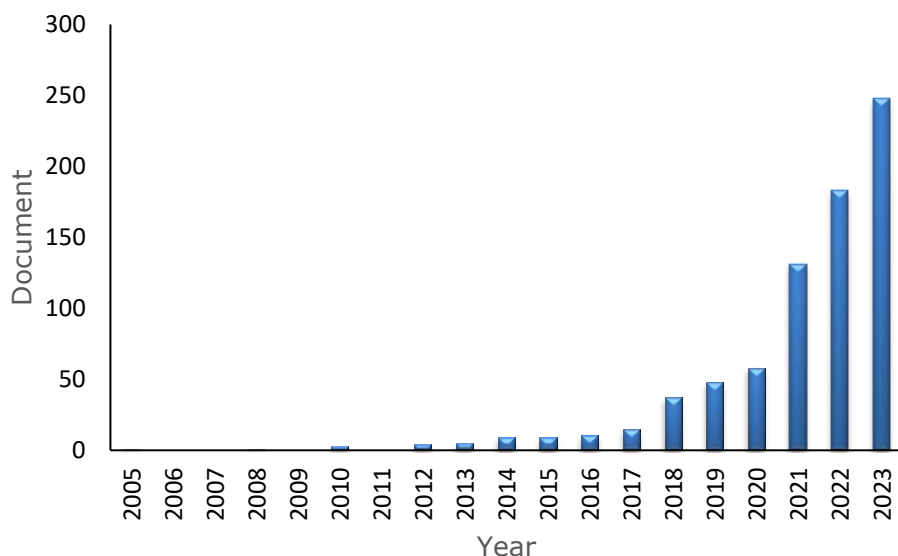


Figure 3. Research Trends Publications Rasch Model in Scientific Literacy (Scholar Database)

This increase is due to several factors, including awareness of the need for more accurate and valid assessments in scientific literacy, increased data availability (Rosana et al., 2020), advances in computer technology for data analysis, and increased researcher interest in understanding the factors that influence scientific literacy (Susongko et al., 2019, 2020). A positive impact of the increased use of Rasch models in scientific literacy is the improved quality of assessments in the field. The Rasch model has been shown to provide a more accurate and objective measure in evaluating an individual's scientific literacy level (Romine et al., 2017). Thus, the increased use of Rasch models can help improve understanding and learning in scientific literacy and increase the effectiveness of educational programs related to scientific literacy.

Top 5 Affiliates, Subject Area, Document Type, Source Type, and Language with high productivity in each category of research topics

Table 1. Affiliates, Subject Area, Document Type, Source Type, and Language in Each Research Topic in Scopus Database

Affiliation	Total	Subject Area	Total	Document Type	Total	Source Type	Total	Language	Total
University of Oslo	9	Social Sciences	79	Article	145	Journal	150	English	175
Oslo Metropolitan University	8	Medicine	55	Conference Paper	25	Conference Proceeding	28	Portuguese	2
Universitas Sebelas Maret	7	Physics and Astronomy	21	Book Chapter	4	Book	3	Chinese	1

Affiliation	Total	Subject Area	Total	Document Type	Total	Source Type	Total	Language	Total
Universitas Negeri Yogyakarta	7	Psychology	19	Conference Review	3	Book Series	1	French	1
Universitas Pendidikan Indonesia	6	Computer Science	15	Review	3	-	-	German	1

Table 1 presents information on the top 5 affiliations, Subject Area, Document Type, Source Type, and Language distributions on the topic of Rasch Model in science literacy. The highest affiliate that published the most Rasch Model Research was the University of Oslo with a total of 9 documents. The University of Oslo is the affiliate that published the most research using the Rasch model in science literacy. This suggests that this institution has a significant role in developing knowledge in this area. The subject area that discussed Rasch models in science literacy the most was social sciences, indicating a wide use of social science perspectives such as science education or psychology of science. Articles were the most common document type used to publish research using the Rasch model in science literacy. This suggests that such research tends to focus on presenting empirical findings and analyzing data in detail. Overall, English was the most widely used language in these publications.

By understanding these trends, we can identify emerging research directions, see the contribution of articles to the development of science, and identify researchers and institutions that have significant influence in this field. In addition, bibliometric analysis can also help identify knowledge gaps and potential future research directions to enrich the scientific literature in science literacy (Hidaayatullaah et al., 2021).

Trends in Rasch Model Research Worldwide

Top 10 Countries Contributing Rasch Model Applications to Scientific Literacy

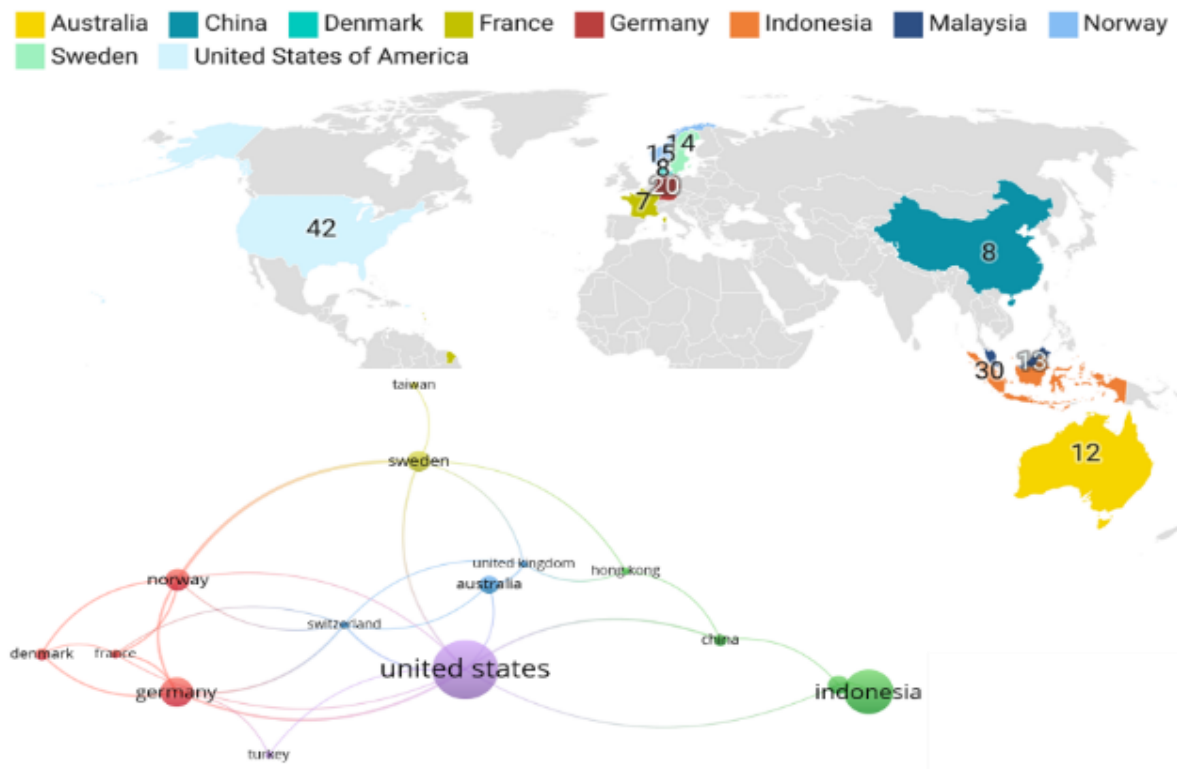


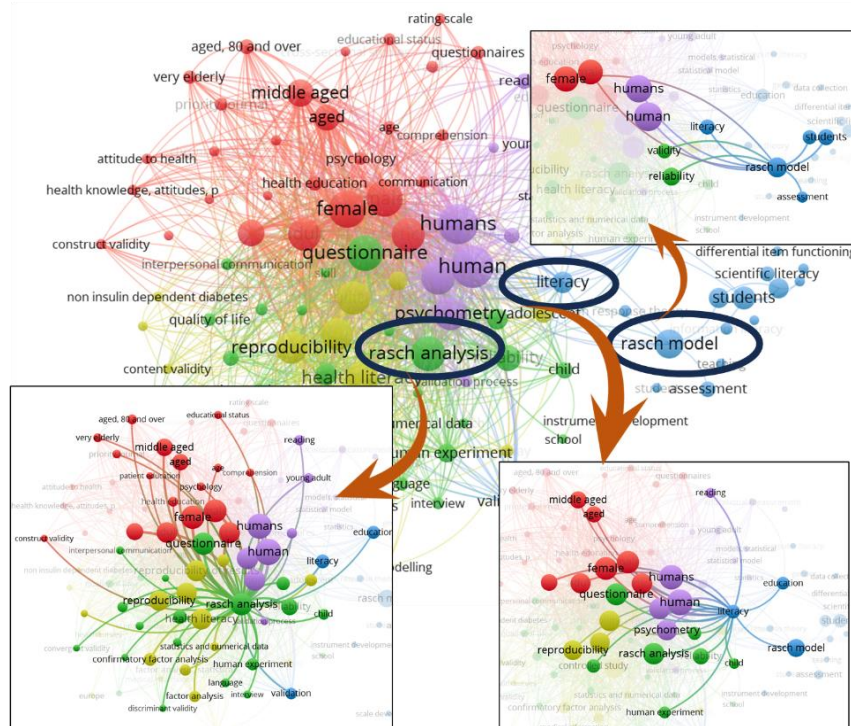
Figure 4. Top 10 countries' contribution to Rasch Model research and Mapping by Country

Figure 4 shows the results of the distribution of the number of Rasch Model publications. This data analysis illustrates the contribution of various countries in the research. The United States is the country that contributes the most to the publication of Rasch models for science literacy, with a total of 42 documents. Indonesia came second with 30 documents, showing a significant role in developing Rasch model applications. Furthermore, Germany, Norway and Sweden also made sizable contributions with 20, 15 and 14 documents respectively. Contributions from countries such as Malaysia, Australia, Denmark, China and France were also seen with significant numbers (de Oliveira et al., 2019), indicating global interest in the use of Rasch models in scientific literacy.

These contributions from different countries reflect the wide adoption of the Rasch model in science literacy analysis worldwide. The impact is an increased understanding of the factors that influence scientific literacy, the construction of more accurate evaluation tools, and the possibility to improve education and learning in the context of science literacy. In addition, with the varied contributions from different countries, research on Rasch models in science literacy can cover a wider range of perspectives.

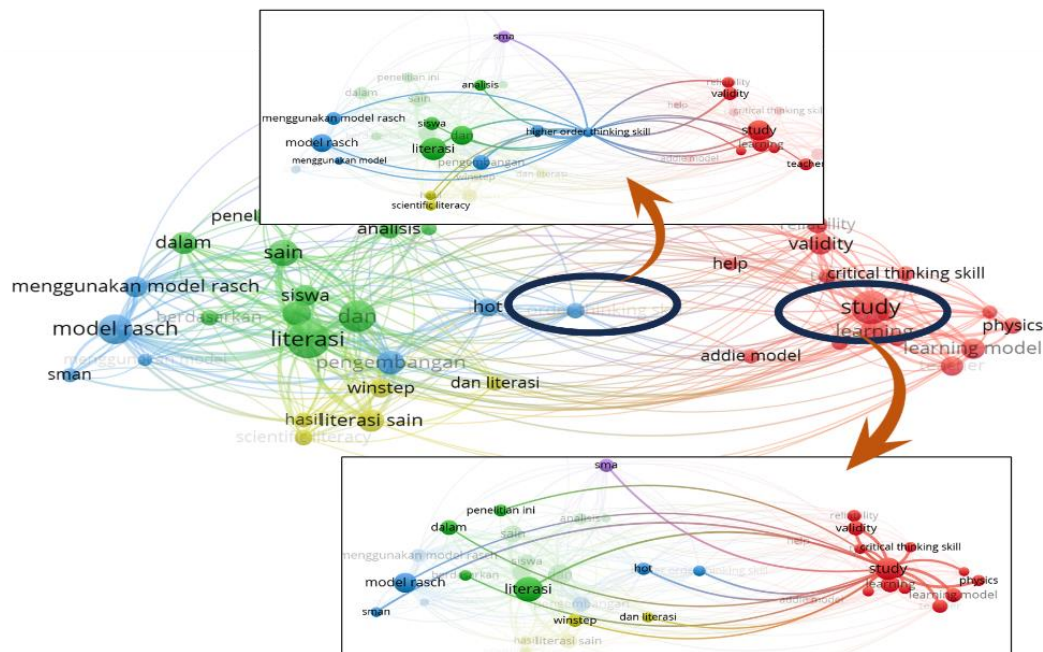
Novelties publications on the Use of Rasch Models in Assessment Analysis

Visualization of Trends in the Rasch Model of Scientific Literacy in the Scopus Database



a

Visualization of Trends in the Rasch Model of Scientific Literacy in the Google Scholar Database



b

Figure 5. Keyword visualization mapping of various occurrences of keyword mapping results more specifically on the topics Rasch Model and Scientific Literacy

Figure 5a displays the results of mapping specific keywords related to the application of the Rasch model in science literacy. Overall, the use of the Rasch model shows strong linkages and relevance to several concepts, such as validation, confirmatory factor analysis, construct validity, questionnaires, education and literacy. Rasch models are used in analysis to measure the validity of measurement instruments, such as literacy questionnaires, ensuring that they provide valid and reliable data (Saidi & Siew, 2019). In addition, Rasch Analysis assists in checking the construct validity of measurement instruments, evaluating the instrument's ability to measure the intended construct consistently and accurately (Lia et al., 2020).

Rasch analysis also has advantages in education, particularly in providing objective measurements that can be directly interpreted in logit units (Briggs, 2019), which are useful for validating the theoretical structure of an instrument (Planinic et al., 2019). As a measure in Rasch analysis, logits enable more precise results by transforming ordinal data into interval data that can be analyzed more accurately without distortion caused by differences in item difficulty (Mubarokah et al., 2021). This offers significant benefits in education, where measurement accuracy is crucial for assessing students' progress and abilities (Purnami et al., 2023). In practice, the Rasch model is applied to analyze questionnaires, particularly in educational and literacy contexts, helping to understand questionnaire characteristics such as difficulty levels or comprehension ability (Kazemi et al., 2020). Through Rasch analysis, educators can more easily identify whether the instruments used truly measure what they are intended to measure and evaluate whether these instruments are sensitive to differences in students' abilities (Nur et al., 2022). This allows teachers to make adjustments in their teaching and assessment instruments to ensure the relevance and accuracy of the data obtained (Sakdiah & Syahrani, 2022).

In the field of education, Rasch Analysis is used to measure students' literacy abilities, which helps educators to understand the strengths and weaknesses of students and design learning programs that are appropriate (Rahayu et al., 2020). Furthermore, Rasch Analysis also helps in understanding the literacy levels of individuals or groups within a specific context, identifying areas that require improvement, and designing appropriate interventions. Therefore, with more detailed information, educators can optimize their teaching methods, easily adjust learning materials to match students' ability levels, and subsequently design more targeted interventions to improve learning outcomes (Planinic et al., 2019). By utilizing Rasch Analysis, educators and researchers can make more informed decisions about the individual learning progress of students and the effectiveness of educational programs (Lans et al., 2018). The impact of using the Rasch Model includes improving the validity and reliability of measurement instruments, ensuring accuracy in assessment, identifying specific learning needs, and assisting in designing more effective learning programs. Rasch Model analysis also allows the identification of the difficulty level of each item or question in a test or questionnaire (Planinic et al., 2019; Van Zile-Tamsen, 2017). Thus, teachers or instructors can adjust learning programs by selecting materials that are appropriate to the students' ability levels.

Then, in Figure 4b, the overall use of the Rasch model is related to various aspects in the context of studies, learning, and evaluation, particularly in the fields of physics, critical thinking, higher-order thinking skills (HOTS), and scientific literacy. In relation to scientific literacy, the Rasch model provides a robust framework for understanding the complex aspects of scientific literacy competencies. Scientific literacy involves three main competencies: explaining phenomena scientifically, designing and evaluating scientific explanations, and interpreting data and evidence scientifically (OECD, 2019). In the context of physics learning, the Rasch model enables educators to evaluate how students demonstrate these competencies in various situations (Marfu'i et al., 2019). By applying the Rasch model, educators can understand the distribution of students' abilities across each of these scientific literacy competencies while ensuring that assessments of students' abilities are objective, valid, and reliable (Ratnaningsih et al., 2024). This is crucial in helping students develop higher-order thinking skills and applying science to solve real-world problems. It supports designing more effective learning strategies, diagnosing students' weaknesses, and identifying areas that need improvement (Van der Lans

et al., 2018). For instance, scientific literacy in physics may include topics such as heat and its transfer (Lestari & Samsudin, 2020). By using the Rasch model, the evaluation of these abilities becomes more systematic, allowing educators to assess whether students can think critically and provide science-based solutions to global challenges (Hizqiyah et al., 2023).

WinSteps, a software used in Rasch analysis, provides powerful tools for researchers and educators to understand students' abilities and the effectiveness of learning programs (Boone & Noltemeyer, 2017). This software simplifies the analysis process by offering data visualizations that depict the alignment between students' abilities and item difficulty (Khalaf & Omara, 2022). This feature enables researchers and educators to make data-driven decisions, allowing them to redesign items or learning materials more effectively. Additionally, the software supports bias detection analysis in items using differential item functioning (DIF), ensuring fair assessment for students from diverse backgrounds (Khalaf & Omara, 2022). However, despite its many advantages, the Rasch model also has limitations. One of these is the need for adequate technical training for educators or researchers to understand the fundamental principles and interpret the analysis results effectively (Azizah & Wahyuningsih, 2020; Tarigan et al., 2022). Furthermore, implementing the Rasch model requires specialized software and a sufficiently large dataset to produce statistically significant results (Babcock & Hodge, 2020). Therefore, collaboration among educators, researchers, and technology developers becomes essential to ensure optimal use of this model. Thus, the application of the Rasch model not only enhances the quality of classroom learning through more accurate evaluations but also drives curriculum development and evidence-based learning strategies. This establishes the Rasch model as an essential tool for advancing modern education, particularly in fostering a generation capable of critical thinking and applying scientific knowledge to solve real-world problems (Marfu'i et al., 2019).

The implications of research trends utilizing Rasch analysis in education and literacy include an increase in the validity and reliability of measurement instruments (Ratnaningsih et al., 2024). With higher validity and reliability, evaluation and learning decisions become more dependable, ensuring that learning strategies and interventions based on evaluation data are built on a solid foundation (Martha et al., 2021). Higher validity ensures that the instruments used truly measure the intended aspects, such as conceptual understanding, critical thinking skills, or scientific literacy (Aryani et al., 2023; Woudstra et al., 2019). Meanwhile, improved reliability ensures consistency in measurement results, even when the instrument is applied in different contexts or repeated at different times (Andrich, 2019; Chi et al., 2023). With these two aspects, evaluation decisions—such as assessing students' needs or designing learning interventions—become more accurate and trustworthy.

Findings from the application of the Rasch model in education and literacy demonstrate significant contributions across various aspects of learning and research. The implications of Rasch analysis include improved validity and reliability of measurement instruments, the design of more targeted learning programs, and the identification of specific learning needs at both individual and group levels (Darman et al., 2024; Ratnaningsih et al., 2024; Susongko et al., 2019). Furthermore, the use of the Rasch model enables the development of better tests and measurement instruments, more sensitive evaluations of student progress, and the creation of adaptive learning models (Avinç & Doğan, 2024). These implications not only affect classroom teaching practices but also contribute to the development of relevant curricula and multidisciplinary research in education (Erfan et al., 2020). Therefore, these findings highlight the importance of using the Rasch model as a powerful tool to enhance the quality of education, understand students' individual learning needs, and promote equity in assessment and access to education.

The use of the Rasch model is highly significant in various fields, particularly in scientific literacy, due to several fundamental reasons. First, the Rasch model provides a robust statistical approach for analyzing assessment data and measuring complex abilities or characteristics, such as conceptual understanding in scientific literacy (Susongko et al., 2019). By utilizing the Rasch

model, it is possible to generate accurate estimates of individual or group abilities within the context of scientific literacy (Susongko et al., 2021). Second, the Rasch model enables more objective and reliable measurement (Blanchin et al., 2020). In the context of scientific literacy, this is crucial as assessment instruments must deliver valid and reliable data to evaluate science understanding (Maryati et al., 2019). Through the Rasch model, ambiguous or biased items can be identified and improved, enhancing the quality of assessment instruments. Third, the application of the Rasch model in scientific literacy helps provide a deeper understanding of students' ability levels (Avinç & Doğan, 2024; Susongko et al., 2022). This enables educators to design learning experiences better tailored to students' needs and identify areas where students require additional support. With a more comprehensive understanding of students' abilities, educators can offer more focused and effective feedback to improve science concept comprehension. Fourth, the Rasch model facilitates fairer comparisons between individuals or groups regarding scientific literacy skills (Afifa et al., 2024; Darman et al., 2024). The model allows for the measurement of student abilities by accounting for the difficulty level of each test item, thereby reducing bias and ensuring fairness in assessments.

Overall, the use of the Rasch model in scientific literacy plays a crucial role in enhancing the measurement of students' science abilities, improving the validity and reliability of assessment instruments, providing a deeper understanding of students' capabilities, and creating a more inclusive and equitable learning environment. From this discussion, relevant findings emerge to examine themes related to the assessment and evaluation of science learning outcomes both theoretically and empirically. The use of the Rasch model in scientific literacy allows for in-depth research into the evaluation of science learning outcomes in a more objective and accurate manner. By applying the Rasch model, researchers can measure students' abilities in understanding science concepts with greater precision, enabling a more accurate evaluation of science learning outcomes. This not only supports the improvement of assessment instruments but also contributes to the development of more effective teaching methods. Additionally, the use of the Rasch model allows for a more in-depth evaluation of specific aspects of students' science understanding, such as data analysis, problem-solving, and scientific reasoning skills. Theoretically, the use of the Rasch model in scientific literacy aids in the development and testing of theories related to the evaluation of science learning outcomes.

Melalui data empiris yang diperoleh dari analisis Rasch, peneliti dapat menguji hipotesis tentang faktor-faktor yang memengaruhi pemahaman sains siswa dan efektivitas berbagai strategi pembelajaran dalam meningkatkan hasil belajar sains. Selain itu, penggunaan model Rasch juga memungkinkan pengembangan teori baru tentang evaluasi hasil pembelajaran sains yang didasarkan pada pemahaman yang lebih mendalam mengenai karakteristik siswa dan pengaruh lingkungan belajar. Dengan demikian, analisis Rasch tidak hanya meningkatkan kualitas evaluasi pembelajaran, tetapi juga mendukung inovasi dalam pengajaran dan penelitian di bidang literasi sains.

Empirically, the use of the Rasch model in science literacy allows researchers to conduct more in-depth field research to test and validate science assessment instruments. Using Rasch analysis, researchers can evaluate the validity and reliability of these instruments, as well as identify and correct items that are irrelevant or inappropriate for students' abilities. This enables the development of better and more valid science assessment instruments for use in the evaluation of science learning outcomes.

Thus, the use of the Rasch model in science literacy provides important results for examining themes related to assessment and evaluation of science learning outcomes theoretically and empirically. The model not only helps in developing stronger theories on science learning outcomes evaluation but also enables more in-depth empirical research to test and validate science assessment instruments.

Conclusion

Based on the results of this research, it is evident that research on the Rasch model in the development of scientific literacy assessment has increased since 2014. The institution with the highest affiliation publishing research on the Rasch model is the University of Oslo. The research primarily focuses on the social sciences subject area and predominantly consists of articles. Most of the research originates from journals and is published in English. The country contributing the most to publications on the Rasch model for scientific literacy is the United States. Additionally, the results obtained using VOSviewer reveal strong connections and relevance between the Rasch model and several concepts in the google scholar database, such as validation, confirmatory factor analysis, construct validity, questionnaires, education, and literacy. In the Scopus database, it is found that the overall use of the Rasch model is associated with various aspects in the contexts of study, learning, and evaluation, particularly in the fields of physics, critical thinking, higher-order thinking skills (HOTS), and scientific literacy. This research is essential to provide an overview of the utilization of the Rasch model in the development of scientific literacy instruments, which can serve as a consideration for other researchers conducting research on the same topic.

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