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Trends in Cognitive Diagnostic Research for Learning Evaluation in Educational Environment: A Bibliometric Analysis on Scopus Database

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Abstract: The analysis in this study aims to map the trends in research publications related to diagnostic cognitive assessment in the field of education in general, using bibliometric analysis. Using predefined keywords, the author analyzed 137 articles based on the Scopus database selected using the PRISMA methodology, followed by analysis using the R and VOSviewer programs. Based on the analysis, the topic of cognitive diagnostics in education began in 2006 and continued to grow rapidly until 2025, with the highest surge in publications occurring in 2023 and 2024. The United States and China dominate in terms of the number of publications and citations, indicating a significant impact in the field of cognitive diagnostics in education. Universities in Malaysia, China, and the United States stand out in publications related to cognitive diagnostic research. New trends are emerging in the grouping of keywords related to the application of cognitive diagnostics in education, marked by “educational data mining” and “educational computing,” indicating a new direction in cognitive diagnostic innovation in the education sector. These keywords can be used by subsequent researchers for further research to enrich the topic of cognitive diagnostics.

Keywords: Assessment, Bibliometrics, Cognitive diagnostics, Education, Vosviewer.

Introduction

The use of the term “evaluation” as a tool for obtaining information to inform decision-making has become common knowledge in both educational and non-educational contexts (Febriana, 2019). Educational evaluation refers to the process of assessing student learning based on the established curriculum guidelines of an educational institution. Mardapi (2012) outlines four terms related to evaluation activities, including measurement, testing, assessment, and evaluation. Learning evaluation is a method for determining the effectiveness of learning programs as a basis for policymaking, whether for classroom-level remediation as feedback on learning outcomes or for reviewing educational programs at the school and regional levels (Cronbach, 1985). In general, educational assessment is divided into three main components: (1) assessment for learning, (2) assessment as learning, commonly referred to as formative assessment, and (3) assessment of learning, which generally falls under the category of summative assessment. These three types of assessment focus on providing feedback based on students’ strengths and weaknesses as a form of learning evaluation, thus requiring adequate assessment tools and learning measurement methods to document students’ weaknesses and strengths throughout the learning process.

With the increasing need for learning assessment, numerous psychometric theories have been developed, such as Classical Test Theory (CTT) and Item Response Theory (IRT). Classical Test Theory (CTT) represents students’ abilities through total scores (Istiyono, 2020). If the total score is high, the student is automatically

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considered to have mastered the learning material, and vice versa. However, it cannot specifically identify students' weaknesses and strengths. Meanwhile, Item Response Theory (IRT) measures mastery of learning material through detailed item design that relies on the functionality of distractors, difficulty level, discriminative power, and the probability of guessing the answer (Istiyono, Supahar, & Pebriana, 2024; Retnawati, 2014). Nevertheless, IRT has not yet been fully capable of identifying the specific locations of students' weaknesses and strengths, the reasons why students answer questions, or how and why the answers they choose are considered correct or incorrect.

To address the shortcomings of these two psychometric frameworks, cognitive diagnostics emerged as a solution to the widespread concerns among teachers regarding the identification of students' weaknesses and deficiencies in learning materials, leading to the development of the theory of cognitive diagnostic assessment (CDA) and the cognitive diagnostic model (CDM). CDA focuses on designing attribute-based tests using a Q-matrix to obtain a profile of students' abilities. Meanwhile, the CDM framework is a psychometric tool used to analyze data by relying on attributes and the Q-matrix (Torre, 2008) in CDA to map out which competencies students need to master in the learning material. Attributes are the specific competencies required to answer a test. Attributes themselves do not have a specific standard in terms of number; rather, they depend on the scope of the material to be developed (Torre, 2009). Attribute mapping is directly related to the development of the Q-matrix as a reference for constructing test items (Kusaeri, 2011), serving the fundamental function of bridging conceptual material with data on students' ability test results.

CDM's capabilities in the field of psychometrics have opened up opportunities for interdisciplinary applications, such as in mathematics, science, language, and the social sciences. This is evident from the surge in CDM publications across various disciplines in numerous countries, making it necessary to map the direction of diagnostic cognitive research in education with a focus on the social sciences to understand and improve student learning processes within an educational context. Consequently, the social sciences have become a primary focus as they represent the implementation domain that determines the significance and tangible impact of CDM's application.

Diagnostic research, including both CDA and CDM, has advanced rapidly over the past two decades, including literature reviews. Several previous literature reviews have focused on literature review research, such as Herlina et al. (2025), who mapped and analyzed 56 articles based on the Scopus database (2015–2025), intending to map global and interdisciplinary trends and methodological innovations in CDA; however, they were unable to provide quantitative accuracy regarding the level of collaboration among authors, institutions, or countries. Meanwhile, Zhang et al. (2021) conducted a literature review covering the past 20 years through the mapping of CDA and CDM concepts; however, as the study was conceptually and descriptively focused, quantitative research was not yet conducted to assess the extent of collaboration among authors and publication surges in each country. Other studies have also examined CDA in detail, but focused on the field of linguistics (Noh, 2024).

To address the gaps in the statistical presentation of literature review data regarding the mapping of concepts, publication trends, research themes, author collaborations, the number of article citations, and the productivity of countries dominating cognitive diagnostic publications in the field of social sciences education, it is deemed necessary to immediately introduce a new perspective through a bibliometric approach. Relying on 173 articles in the Scopus database (2006–2025) as a preliminary step to analyze large-scale publication data, this study aims to identify publication patterns and contributions, map collaboration outcomes among authors, institutions, and across countries, while presenting a distinct perspective on cognitive diagnostic research. Based on these research questions, the results of this study are expected to provide a broader and deeper perspective and contribute to strengthening the theories of cognitive diagnostic psychometrics, both CDA and CDM, in the field of social sciences education as a reference for modern measurement theory.

Method

Research Design

This study employs a bibliometric approach to analyze the surge in publications related to the cognitive diagnostic model (CDM). All articles obtained through a search of the Scopus database represent one of the most widely published international and interdisciplinary references, thereby providing access to a wealth of research findings. Eligible articles were subsequently analyzed using Vosviewer and the R application. Both applications are widely used in bibliometric studies as tools for data mapping and visualization.

The objective of this study is to identify publication patterns and contributions, map collaboration outcomes among authors, institutions, and across countries, while presenting diverse perspectives on cognitive diagnostic model (CDM) research. The article search in the Scopus database required a set of keywords relevant to the CDM research topic to retrieve appropriate articles. Using the keywords (TITLE ("cognitive diagnostic") OR TITLE ("cognitive diagnosis") AND TITLE-ABS-KEY (learn*) OR TITLE-ABS-KEY (school*) OR TITLE-ABS-KEY (educat*)), this study is limited to the scope of social sciences in the field of education.

Search Strategy

This study utilized the Scopus database to identify a number of empirical research articles in the social sciences as the primary focus of the search; consequently, articles containing literature reviews, such as meta-analyses or systematic reviews, were excluded because they did not meet the criteria for empirical articles. Furthermore, data collection techniques and the selection of articles that meet the previously established standards and criteria utilize the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. Generally, this aims to help improve the transparency of every search and article selection process so that it is more structured and easier to understand for researchers and readers.

Inclusion and Exclusion Criteria

A search of the Scopus database on the topic of diagnostic cognition in education yielded a total of 454 articles. Based on the data, 137 of these articles met the inclusion criteria, which focused on the social sciences, empirical research, and diagnostic cognition in education. Meanwhile, 317 articles were excluded based on the exclusion criteria, such as research reviews, mathematics, and computer science. The PRISMA data mapping of the article screening process, from the search stage to the identification of articles meeting the primary research criteria, is shown in Figure 1 below.

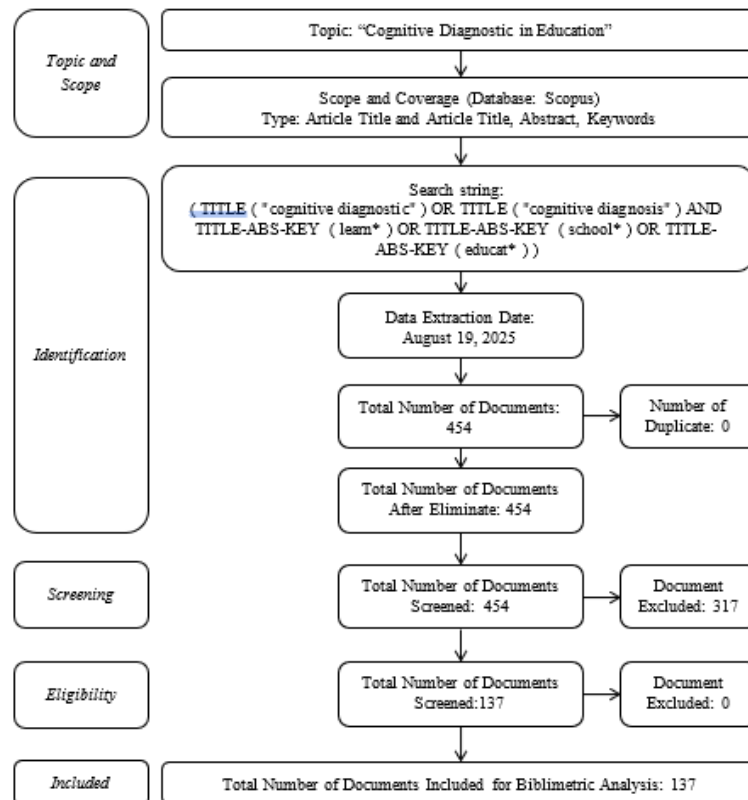


Figure 1. Document selection using the PRISMA method flowchart

Results and Discussion

Main Information

Research on the development of cognitive diagnostics in the social sciences within the field of education was consistently conducted from 2006 to 2025; thus, when analyzed by publication year, there were 137 eligible articles published in 73 journals. Referring to Figure 2, researchers' interest in cognitive diagnostic topics focused on the social sciences in the field of education reached 15.71% annually. A total of 320 authors participated, either individually or through international collaborations. On the other hand, regarding content depth, 395 keywords were used, along with 5,416 supporting references, indicating that the topic of cognitive diagnostics is conceptually and practically mature. Meanwhile, the average number of articles published annually over the past 5.4 years, with 16.12 citations per article, indicates that this topic remains relevant and will continue to develop rapidly in the future.



Figure 2. Main information analysis with R program

A trend in publications on cognitive diagnostics in the field of social sciences has been observed over the past two decades. During the first five years (2006–2010), publication numbers remained low and stagnant, at three to four publications per year. However, by the end of the first decade (2012–2014), cognitive diagnostic publications showed an improvement (7–9), albeit with fluctuations. The second period has continued to show positive trends since 2018, with the topic demonstrating publication stability and a steady increase, reaching a peak of 19 articles per year for two consecutive years (2023 and 2024). As shown in Figure 3, which illustrates the number of publications per year, the social sciences have been explored and recognized for enriching the body of knowledge on cognitive diagnostics in the field of education.

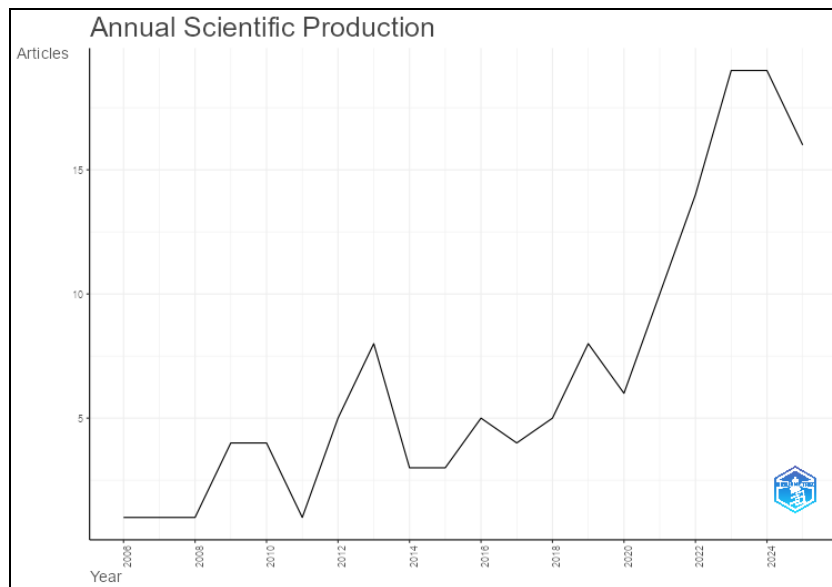


Figure 3. Number of publications from 2006 to 2025

The adaptation and implementation of cognitive diagnostics continue in developed countries and have spread to developing nations. The United States, for example, with 48 publications, ranks first as the country whose publications (588) are cited an average of 23.7 times per year in research. China ranks first and has the highest number of publications (52), but receives fewer citations (393), averaging 11.2 citations per article. Meanwhile, Canada ranks fourth in publications (10), yet has a very high citation count, averaging 36 citations per published article. This stands in stark contrast to the situation. Based on these three points, the number of publications is not the primary factor as a research reference; rather, a focus on breadth, depth, and detailed discussion serves as a key benchmark, as demonstrated by Iran and Georgia. Implicitly, these results indicate that the quality of

publications does not hinge on quantity, but rather that quality is far more significant. To further emphasize this, for example, Malaysia ranks in terms of the number of publications (15), but is cited only 24 times, or an average of 3 citations per article.

Table 1. The top 10 most productive countries

Rank	Country	Continent	TC	NP	Average Article Citations
1 st	USA	North America	688	48	23,7
2 nd	CHINA	Asia	393	52	11,2
3 rd	CANADA	North America	256	10	36,6
4 th	IRAN	Asia	153	2	15,3
5 th	GEORGIA	Europe	141	1	35,2
6 th	AUSTRALIA	Oceania	36	2	36
7 th	SINGAPORE	Asia	36	2	18
8 th	MALAYSIA	Asia	24	15	3
9 th	AUSTRIA	Europe	9	1	9
10 th	HONG KONG	Asia	8	2	8

Description: NP= Number of publications, TC= Total of citations

While the previous section outlined publication productivity by country, it is deemed necessary to map it by affiliation and the most relevant authors. Figure 4 shows the institutions with the highest number of publications on cognitive diagnostics in the field of social sciences education. As shown, Universiti Sains Malaysia leads with 15 publications, making it the most productive university on the topic of cognitive diagnostics. It is followed by the University of Science and Technology of China (12 publications), East China Normal University (11 publications), and the University of Alberta (11 publications). Other institutions, such as National Taichung University of Education (9 publications) and Wenzhou University (8 publications), also play significant roles, indicating that the topic is gaining attention in diverse regions across Asia and North America. Meanwhile, Central China Normal University (7 publications), Beijing Normal University (6 publications), Hefei University of Technology (6 publications), and Northeast Normal University (6 publications). Based on the distribution of these affiliation data, the Asian region dominates the topic of cognitive diagnostics in the field of education in the social sciences, making it a global research hub.

Identifying the most relevant authors in cognitive diagnostics research is crucial because it can provide insight into leading researchers, the direction of scholarly development, as well as opportunities for collaboration and strong theoretical references in the field. Figure 5 shows the most relevant authors on the topic of cognitive diagnostics in the social sciences. De la Torre J and Zhang Y occupy the top positions as researchers, each having published six articles. The next authors, such as Chiu C-Y, Chew C-M, Chinn H, Wang S, and Wu X, have published five articles. This highlights the importance of research in this area.

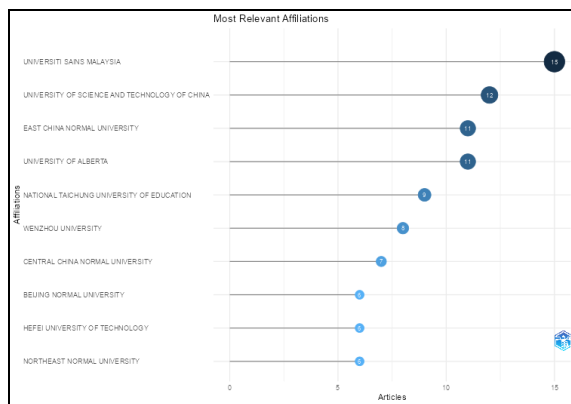


Figure 4. Most relevant affiliation on the topic of cognitive diagnostics

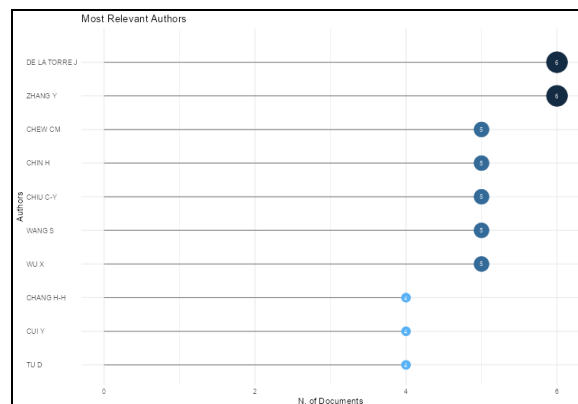


Figure 5. Most relevant authors on the topic of cognitive diagnostics

The analysis also focused on journals with a high level of relevance, which is important for identifying key publication sources, quality standards, and reliable references that serve as the hub for the dissemination of knowledge in the field of cognitive diagnostics within the social sciences in education. As shown in Figure 6, the journals Applied Psychological Measurement, Journal of Educational and Behavioral Statistics, and Journal of Educational Measurement lead with 10 publications. Other less prominent journals include Educational Psychology, the International Journal of Language Testing (5 publications), Language Testing, and Studies in

Educational Evaluation (4 publications), as well as journals such as *Assessment in Education: Principles, Policy and Practice*, *Education and Information Technologies*, and *Educational and Psychological Measurement* (3 publications). This distribution indicates that the most influential works are published in journals specializing in educational measurement, statistics, and psychology, which aligns with the methodological and theoretical foundations of cognitive diagnostic research. It also suggests that the field is well-supported by both measurement-focused and applied education journals, ensuring a balance between theory and practice.

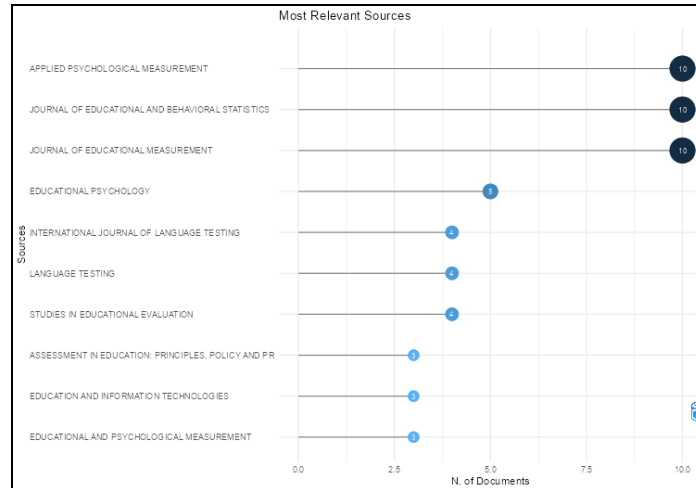


Figure 6. Most relevant sources on the topic of cognitive diagnostics

Focus of Research

The visualization of keyword distribution is associated with several different colors corresponding to areas of educational research. The red cluster highlights its role in learning assessment, such as formative assessment, feedback, and adaptive learning. The blue cluster focuses on methodological approaches through diagnostic models such as G-DINA. The green cluster relates to experimental design and statistical modeling, while the purple cluster represents theoretical and psychometric foundations. The yellow cluster represents the use of technology through data mining and educational computing. Overall, cognitive diagnostics integrate theory, methods, and technology to support more personalized assessment and learning.

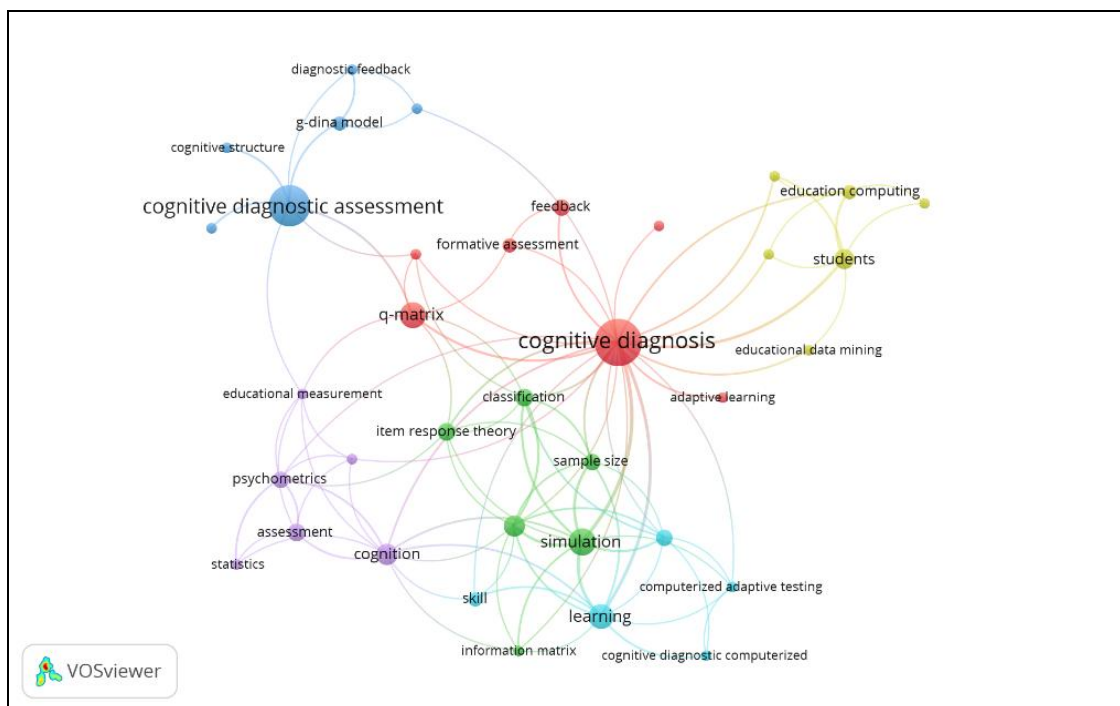


Figure 7. Keyword grouping on network visualization menu

Keyword Novelty

An analysis of keyword novelty reveals the distribution of cognitive diagnostic research themes based on their level of development and relevance. The motor skills quadrant (upper right) is dominated by well-established and central topics such as cognition, assessment, adaptive learning, and diagnostic models (CDA and CDM). The niche quadrant (upper left) contains topics in educational computing. The foundational theme quadrant (bottom right) covers fundamental areas such as cognitive diagnostic analysis and basic mathematics, which offer opportunities for new directions in future cognitive diagnostic research, while the bottom-left quadrant includes feedback, dynamic assessment, and nonparametric diagnostics as emerging or declining topics. In general, research focuses on diagnostic and assessment models, with emerging trends toward technology integration and student-centered approaches.

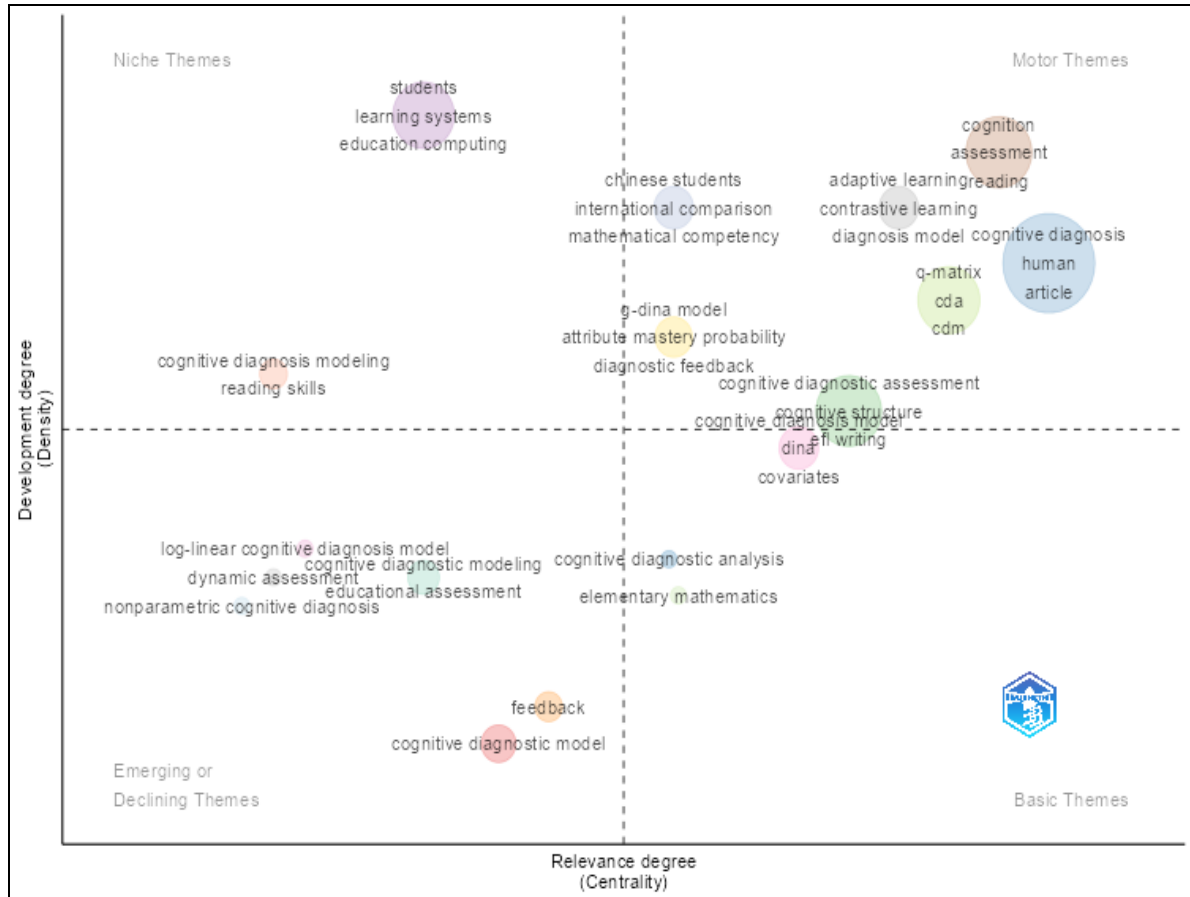


Figure 8. Keyword novelty analysis with overlay visualization on R

Discussion

The authors' analysis indicates that several key figures, such as De la Torre and Zang, have made substantial contributions, followed by several other studies with significant contributions. This confirms that the development of cognitive diagnostics in education is largely influenced by a consistent core group of researchers who play a role in shaping the direction of research (Li et al., 2020; Noor & Lian, 2022; Zhan, 2020). In terms of publication output, several major journals serve as hubs for research dissemination, particularly those focused on psychometrics, measurement, and psychology. This indicates that the field of diagnostics is deeply rooted in these three disciplines and is supported by journals emphasizing educational evaluation and publication (Fan et al., 2021; Thi-Nga et al., 2024).

The keyword visualization indicates that cognitive diagnostics serves as a central concept linking instructional, methodological, and theoretical aspects. Furthermore, the emergence of technology-related keywords signifies the important role of data analytics and computing in the development of this field (Cui, 2021). The thematic map indicates that major topics such as cognition, assessment, and diagnostic models are well-established (Chen & Torre, 2018; Shang et al., 2021), while other topics, such as learning systems and computation, are more

specialized. Foundational themes form the basis of research, whereas some emerging topics indicate directions of growth or declining interest. Overall, cognitive diagnostics is a rapidly evolving field characterized by the integration of theory, methods, and technology. Research is not only focused on model development but is also beginning to shift toward real-world applications, adaptive learning, and student-centered approaches, thereby potentially leading to more personalized and accurate assessments (Choi & McClenen, 2020; Maghsudi et al., 2021; Minn, 2022).

Conclusion

The conclusion of the overall analysis shows that research on *Cognitive Diagnostics in Education* is rapidly growing, with significant contributions from key authors, institutions, countries, and leading journals that serve as main publication outlets. Publications are largely concentrated on journals focusing on psychometrics, measurement, and educational evaluation, highlighting the field's strong scientific foundation. In terms of countries and institutions, Asia, particularly China and Malaysia, has shown strong research productivity, while North America has had a major influence through highly cited works. Keyword and thematic map analyses reveal that CDM research is not only grounded in models and theory but is also expanding toward practical applications in education. Thus, this field holds strong potential to support more personalized, adaptive, and data-driven assessments that align with the needs of modern education.

Recommendations

Based on the findings, it is recommended that future research in *Cognitive Diagnostics in Education* strengthen collaboration between highly productive countries, institutions, and authors to enhance both the quality and global visibility of the field. Researchers should also focus on applying CDM models to diverse educational contexts, especially in mathematics, sciences, and technology-enhanced environments, to expand their practical impact. Additionally, attention should be given to emerging themes such as dynamic assessment, feedback mechanisms, and the integration of artificial intelligence, as these areas show promise for innovation. Finally, policymakers and educators are encouraged to utilize insights from CDM research to design more personalized, accurate, and adaptive assessments that improve student learning outcomes in real-world classrooms.

Scientific Ethics Declaration

* The authors declare that the scientific, ethical, and legal responsibility of this article, published in EPESS journal, belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest.

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