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A Bibliometric Analysis: A Tutorial for the Bibliometrix Package in R Using IRT Literature

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Abstract

The bibliometrix package in R programming language, which is frequently used in bibliometric analysis, was introduced in this research. The article aimed to illustrate the various analyses applied in a bibliometric study. For this purpose, articles containing the "item response theory" (IRT) or "item response modeling" or "item response model" terms in the abstract were searched in the Thomson Reuters Clarivate Analytics Web of Science (WoS at http://www.webofknowledge.com), and bibliometric data was downloaded. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) steps were followed in the study. Data from 3388 IRT-related articles on education and psychology, searched between 2001 and 2021, were used in the study. Data were analyzed with the *bibliometrix* package. Some of the stages in data analysis were shared with screenshots. As a result of data analysis through the real data set, the author's keywords related to IRT were item response model, differential item functioning, psychometrics, assessment, measurement, reliability, validity, Rasch model, and measurement invariance. The countries with the highest number of citations in IRT studies were the USA, Canada, Netherlands, United Kingdom, and China, respectively. Turkey ranked 12th in IRT studies with 434 citations. It was thought that bibliometric analysis of articles related to IRT would shed light on researchers in the field of psychometrics.

Keywords: bibliometric analysis, item response theory (IRT), biblioshiny, bibliometrix, R

Introduction

At the heart of science is the desire to know. Heike Kamerlingh Onnes (1882) said "Measuring is knowing" (as cited in van Raan, 2004, p. 21). Lord Kelvin said, "One's knowledge of science begins when he can measure what he is speaking about, and express it in numbers." (as cited in Eysenck, 1973). Horace (65–5 BC) said, "There is a measure in all things (Est modus in rebus)" (as cited in van Raan, 2004, p. 21). The scientific information produced today is increasing compared to the past (Linnenluecke et al., 2020; Ware & Mabe, 2015). In the globalizing world, borders are no longer important, information is spreading rapidly, and scientific knowledge is increasing. Science and technology change rapidly in the information age, and countries that follow this change achieve economic growth and social welfare and keep up with the competitive world as independent countries (National Science Foundation (NSF), 2007, p. vii). Two of the development indicators of science and technology are "education and advanced training" and "scientific publications, collaboration, and citations" (NSF, 2007, p. viii). Analysis of scientific publications, collaborations, and citations is possible with bibliometric research. Bibliometrics, scientometrics, informetrics, and librametrics were similar but non-synonymous concepts consisting of the combination of bibliography, science, knowledge, and the library, and the word "metrics", respectively (Egghe, 2005, p. 1311; Sengupta, 1992, p. 25). All these concepts were directly related to the measurement of information. Bibliometry was used in the construction of knowledge and the development of new ideas (Sengupta, 1992, p. 25).

The word bibliometric was derived from the Greek and Latin word "biblio", which means book, and the word "metrics," which refers to the measurement (Sengupta, 1992, p. 25). The term statistical bibliography was first used by E. Wyndham Hulme in 1922 as part of a course at the University of

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Cambridge (Pritchard, 1969). However, bibliometric studies had their origins dating back to the 1890s (Sengupta, 1992, p. 25). The main breakthrough in the improvement of bibliometrics was Garfield's (1955, 1964) development of a Science Citation Index (bibliographic databases). Bibliometric data began to be recorded with Science Citation Index. The purpose of bibliometrics is basically to evaluate the scientific literature in the relevant field. Therefore, researchers can apply bibliometrics to any field of science (Andrés, 2009, p. 1).

Due to the rapid publication of scientific research and the fact that there are many journals, the quality of scientific publications produced may decrease (Demir, 2018). Many bibliometric data such as citation numbers, keywords, titles, collaborations, and institutions can be produced from various databases. Bibliometrics research can be carried out using these databases. Bibliometric research can be discussed in terms of characteristics of the publications, citation impact, country analysis, and subject analysis. The bibliometric analysis differs from the systematic review and meta-analysis (Donthu et al., 2021).

Bibliometric analysis techniques were divided into main techniques and enrichment techniques. Main techniques include "performance analysis (publication-related metrics, citation-related metrics, citation-and-publication-related metrics) and science mapping (citation analysis, co-citation analysis, bibliometric coupling, co-word analysis, and co-authorship analysis)". Enrichment techniques include network analysis (network, metric, clustering, visualization) (Donthu et al., p. 288).

Bibliometric analysis methods

Bibliometric analysis methods are classified in various ways (e.g., Aria & Cuccurullo, 2017; Donthu et al., 2021; Durieux & Gevenois, 2010; Zupic & Cater, 2015). This study discussed citation analysis, co-citation analysis, co-author analysis, co-word, and bibliometric coupling analysis.

Co-author

In this method, links are established between co-authors of an article. The unit of analysis is the authors. This analysis reveals the networks and collaborations between the authors and their countries and institutions. The downside is that co-authoring is not always indicative of collaboration (Zupic & Cater, 2015).

Co-word

A co-word analysis is done by considering the keywords, titles, and common words in the abstract. The unit of analysis is words. Most importantly, it uses the actual content of the documents for analysis, while other methods use only bibliographic metadata. In addition, this method does not take into account the negative feature of words being handled in different ways and having different meanings (Zupic & Cater, 2015).

Citation analysis

Citation analysis is used to analyze the effectiveness of authors, documents, or journals by considering their citation rates. The unit of analysis is documents, authors, and journals. Its positive features are effective in finding essential studies in the field. The negative feature is that the cumulative citation rate of new publications will be low, the most citations are likely to be to older publications (Zupic & Cater, 2015).

Co-citation

This analysis analyzes the links between authors, documents, or journals by considering reference lists. As in citation analysis, the unit of analysis is authors, documents, and journals. Pros are that it is the most valid and frequently used bibliometric method (Zupic & Cater, 2015).

Bibliometric coupling

In this method, links are established between documents, authors, and journals based on references. The analysis unit is journals, documents, and authors, as in citation and co-citation methods. The positive aspect of this method is that it can be used immediately without the need to accumulate citations. It is crucial to reveal new publications and fields that have not been cited. The disadvantages of this method are that it can only be used for a limited time. Since this method does not focus on citations, it is difficult to know whether mapped publications are important (Zupic & Cater, 2015). Detailed information about which bibliometric method answers which research questions can be found in the literature (see Zupic & Cater, 2015).

In this research, articles related to Item Response Theory (IRT) were investigated. There were various theories in the emergence of psychometric characteristics in education and psychology. Two of these theories were Classical Test Theory (CTT) and IRT. The first signs of IRT can be seen in Louis Leon Thurstone's (1925) article entitled "A Method of Scaling Psychological and Educational Tests" (Bock, 1997, p. 21). The onset of IRT was usually based on Lord and Novick's (1968) classic textbook, “Statistical Theories of Mental Test Scores” in the United States (Embretson & Reise, 2013, p. 5). In recent years, research on IRT has increased due to the superiority of IRT over CTT. For the last 30 years, IRT has been frequently used by the largest test companies in the world for "design of tests, test assembly, test scaling, and calibration, construction of test item banks, investigations of test item bias and other common procedures in the test development process" (Hambleton et al., 1991, p. VII). Embretson and Reise (2013, p. 249) discussed IRT applications under three headings as differential item functioning (DIF), computerized adaptive testing (CAT), and scale construction. Besides this, IRT is used in many areas of psychometrics, such as test equating and standard-setting. In this bibliometric research, articles in WoS related to IRT were handled. After the 2000s, IRT research in WoS has shown a great improvement. In order to address this development, articles related to IRT after 2001 were taken into consideration in this study.

The Importance of Bibliometric Research

Synthesizing past research findings and bibliometric data is one of the most important steps for the cumulative advancement of scientific knowledge. Bibliometric research makes an objective assessment of the scientific literature using a quantitative approach. These studies provide a transparent, systematic, and reproducible literature review. This bibliometric review sheds light on those who want to research the relevant literature (Pritchard, 1969, p. 348; Zupic & Cater, 2015, p. 1). Bibliometrics is a set of statistical and mathematical methods used to measure and analyze the quality and quantity of articles, books, and other publications (Durieux & Gevenois, 2010, p. 342). Information and communication activities and scientific documentation are developed through a quantitative analysis of the production, dissemination, and use of information obtained from library collections and services such as WoS in bibliometric research. Thus, it is aimed to contribute to a better understanding of the scientific research mechanism in bibliometric research (Osareh, 1996, p. 150).

With bibliometric analysis, we gain information about both the intellectual structure and the conceptual framework. We get ideas about the progress of research on specific topics. In addition, bibliometric research helps journal editors make their decisions and evaluations (Zupic & Cater, 2015, p. 9). Durieux and Gevenois (2010, p. 342) mentioned three types of bibliometric indicators and their importance. These indicators are “quality indicators” that measure the quality (or "performance") of a particular

researcher's output; quantity indicators measuring the researcher's productivity; and structural indicators that measure the links between publications, authors, and research areas. Bibliometric indicators are vital for organizations and researchers in funding decisions, assignments, and promotions. Today, as more scientific discoveries occur, knowledge accumulation increases and bibliometric indicators are becoming more critical day by day (Durieux & Gevenois, 2010, p. 342).

When the bibliometric studies in the literature were examined, researches were found in the field of education (e.g., Gülmez et al., 2020), and in the field of educational administration (e.g., Gümüş et al., 2019; Hallinger & Hammad, 2019). In the field of measurement and evaluation in education, researches were conducted in the fields of CAT (e.g., Yurtçu & Güzeller, 2021), IRT (e.g., Aksu & Güzeller, 2019), and DIF (e.g., Gómez Benito et al., 2005). A completely similar study has not been found that performs bibliometric analysis of articles related to IRT according to specific criteria in WoS with an R tutorial.

It was aimed to conduct a bibliometric analysis of IRT articles searched in WoS with the *biblioshiny* interface obtained using the R *bibliometrix* package in this research. Another purpose of the research was to share the plots or figures, and tables obtained within the scope of the research by following the process steps in biblioshiny. In recent years, the number of bibliometric research has been increasing. Introducing the user-friendly *biblioshiny* interface was thought to guide future research.

Methods

Database, terms, inclusion and exclusion criteria

Research data were obtained from the Web of Science. The terms used in the study were "item response theory", "item response modeling" or "item response model". The terms "IRT" was also used in the research. However, since the abbreviation of the irrelevant words like "infrared thermography" was "IRT", this term was removed when the researches were examined. Initially, only the term item response theory was used, while the words "item response modeling" and "item response model" were also found at the end of the literature review. That's why these terms were included in the research. The inclusion criteria of the study (1) include "item response theory" or "item response modeling" or "item response model" terms in the abstract, (2) the publication type was the article, (3) the publications were published in the field of psychology, and education, (4) the publications were published between 2001 and 2021, and (5) all publications were searched articles in Social Sciences Citation Index (SSCI) or Emerging Sources Citation Index (ESCI) or Science Citation Index Expanded (SCI-E) or Arts and Humanities Citation Index (A&HCI).

Analysis of Data

Bibliometric analysis can be done with many software or package programs like CoPalRed (Bailón-Moreno et al., 2005), CitNetExplorer (van Eck & Waltman, 2014), SciMAT (Cobo et al., 2012), Bibexcel (Persson et al., 2009), BiblioMaps (Grauwin & Sperano, 2018), Sci^{2}Tool (Sci^{2}Team, 2009), Biblioshiny (Aria & Cuccurullo, 2017), CiteSpace (Chen, 2006), VOSviewer (van Eck & Waltman, 2010). Only two of them offer a web-based user interface. *Biblioshiny* was a free web-based interface with the R (R Core Team, 2021) operative system. R was a free open-source software. The steps to run the Biblioshiny interface were explained in order. To use the *"bibliometrix"* package (Aria & Cuccurullo, 2017), R programming language (R Core Team, 2021) must be downloaded first. To download the free up-to-date R programming language and information about the R programming language can be accessed from the cran website. You can have information about the R programming language by accessing the R introductory document prepared by Venables, Smith, and the R Development Core Team (2021). After downloading the R programming language, R Studio must be downloaded. The free version of R Studio can be accessed from the web address. After R Studio was installed, the *install.packages("bibliometrix")* command was run. At these stages, your computer must be connected

to the internet. Then the *bibliometrix* package was activated. The *library ("bibliometrix")* command was used for this purpose. The *biblioshiny()* command was also typed and executed to open the user-friendly interface. The image of R studio is given in Figure 1. After running *the biblioshiny()* command, the user-friendly *biblioshiny* interface opened (see Figure 2).

Figure 1

R Studio User Interface

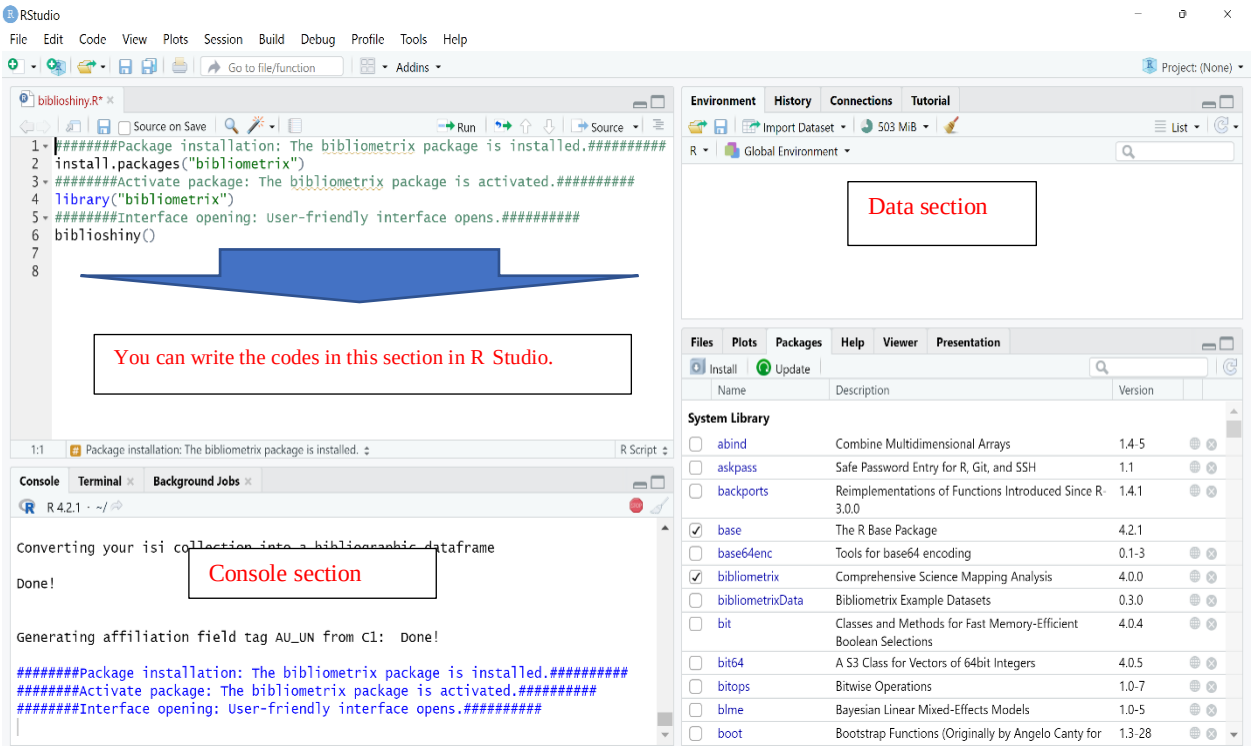
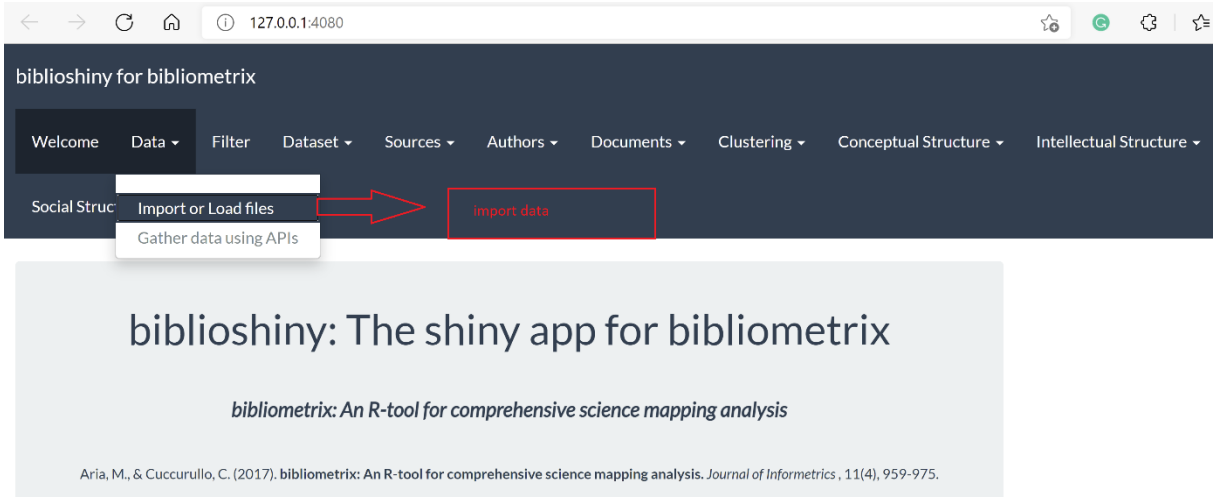


Figure 1 provides sections in R studio. Codes were written in the upper-right window and run in an orderly in Figure 1. As can be seen in Figure 2, this interface has 12 tabs. Bibliometric analysis can be performed by clicking on the tabs of the interface.

Figure 2

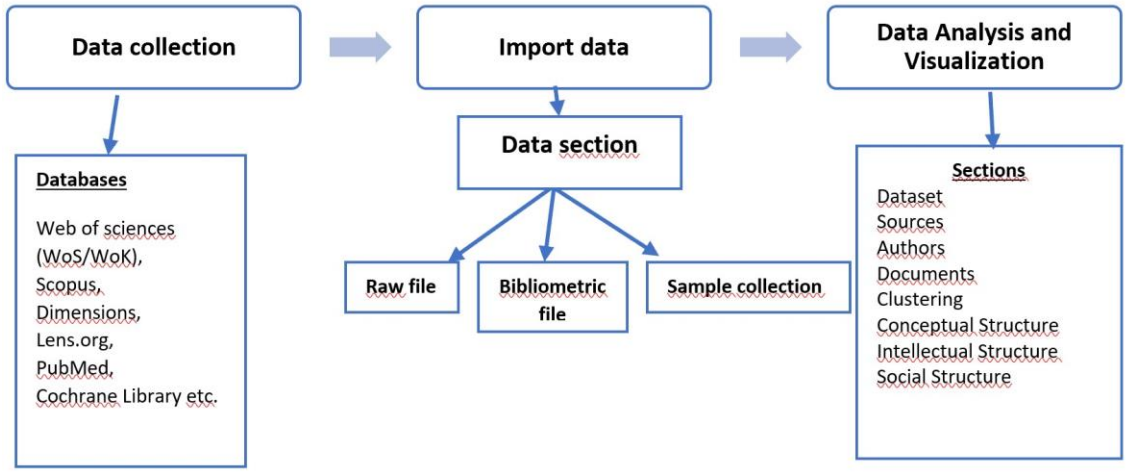
The Graphical User Interface (GUI) of the Biblioshiny and Loading the Data



It is seen that there were "data", "filter", "dataset", "sources", "authors", "documents", "clustering", "conceptual structure", "intellectual structure", "social structure", and finally "quit" options in Figure 2. Figure 3 displays bibliometric research's steps using *biblioshiny* (the shiny app for bibliometrix).

Figure 3

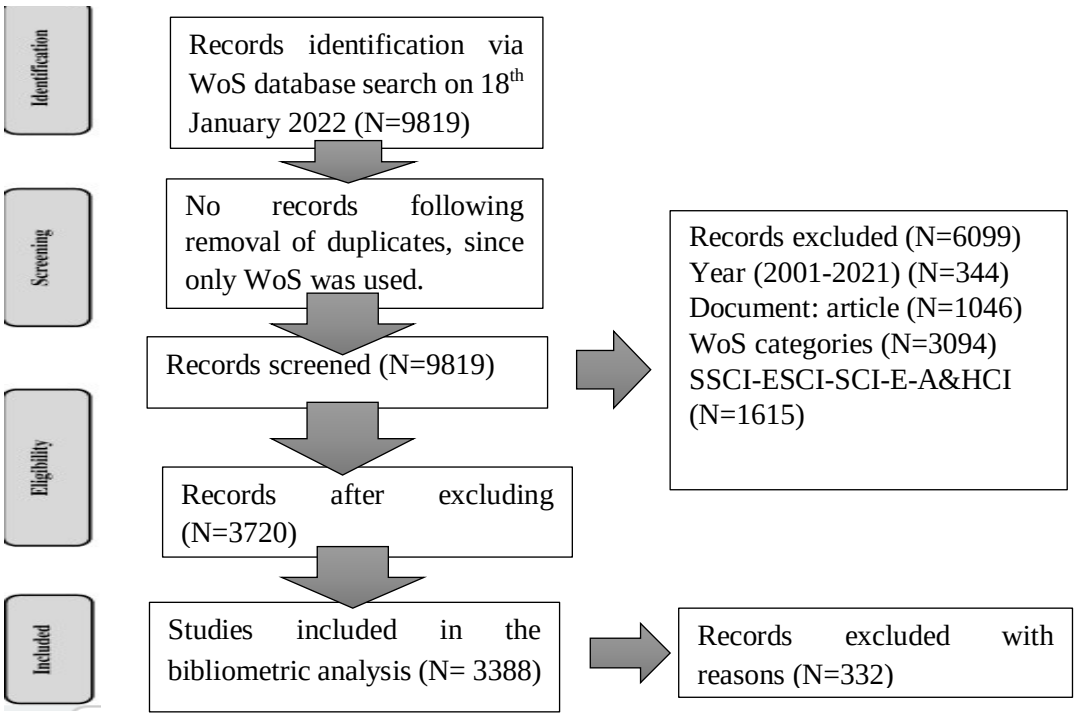
Bibliometric Research's Steps Using Biblioshiny



Bibliometric research consisted mainly of (1) decision on the research problem, (2) reviewing purpose-based literature (3) determining database, terms, inclusion and exclusion criteria, (4) decision on bibliometric method, and software to analyze data, (5) collection, and regulation of data within the framework of the research problem, and bibliometric method, (6) loading data into software and analyzing data, (7) visualizing, reporting findings, and writing impacts and recommendations. To analyze the data, bibliometric data must be uploaded to the *biblioshiny* first. Databases such as Web of Sciences (WoS/WoK), Scopus, Dimensions, Lens.org, PubMed, Cochrane Library can be used. WoS data was used within the scope of this research. PRISMA steps were followed in the study concerning the inclusion criteria of the research (see Moher et al., 2009). The PRISMA flow diagram used in the research is given in Figure 4.

Figure 4

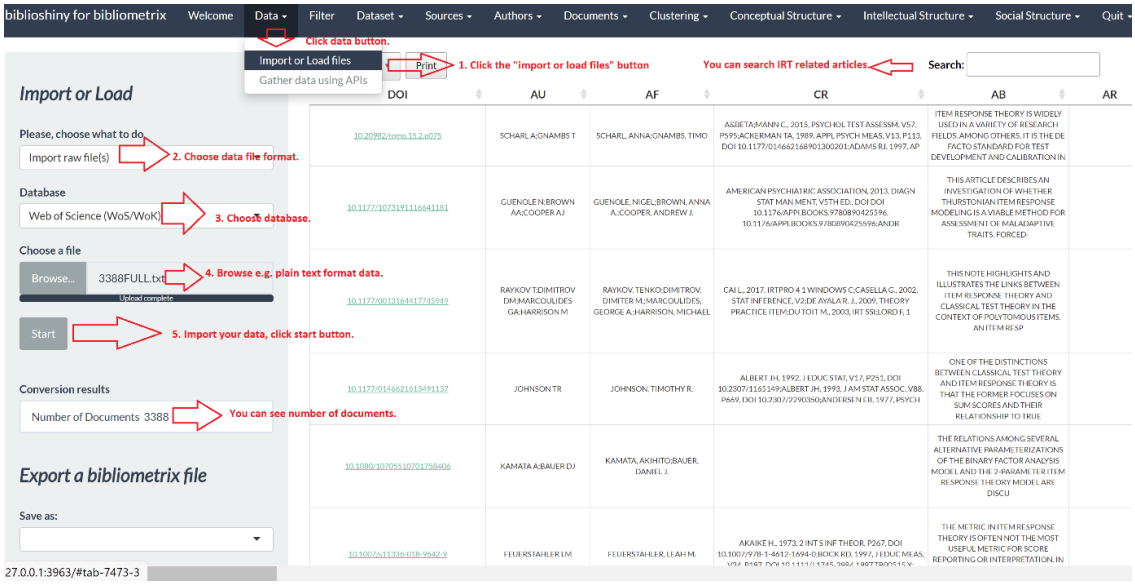
PRISMA Flow Diagram Steps in the Bibliometric Research



The data set obtained by following the PRISMA flow diagram steps had been downloaded from WoS in plain text format. Some records were extracted from plain text based on exclusion criteria, and the final file was created. In the study, analyses were carried out on 3388 publications related to IRT. Figure 5 shows a screenshot of uploading data in the *biblioshiny* interface.

Figure 5

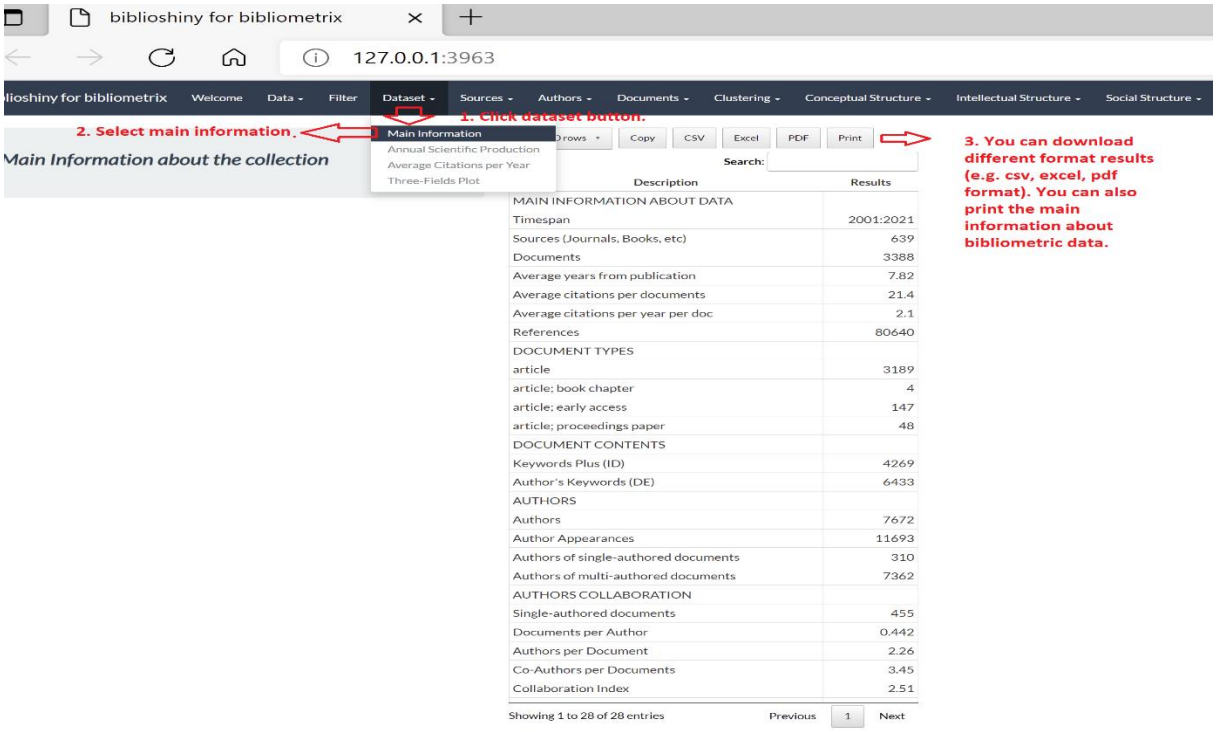
The View of the "3388" Dataset



In the interface that opened in the first step to analyze data downloaded from WoS, the import or load files option was clicked under the data tab. Then the data format was selected. This format can be a raw data file, a bibliometric file, or a sample collection. *"Import raw data file(s)"* was selected for the "*please choose what to do"* section because we used WoS data in the research. In the third step, "*Web of Science (WoS/WoK)"* was selected as the *database*. Data from databases such as Scopus, Dimensions, Lens.org, PubMed, and Cochrane Library can also be studied. In step four, the file was selected from the *browse* button in the *choose a file* section. Using their plain text format files was recommended to researchers in this step. Plain text format files can be downloaded from WoS or other sources. In the 5th and last step, after clicking the start button, the data was uploaded to the system and became ready for analysis. *Biblioshiny* had a user-friendly interface for bibliometric analysis. All analyses can be done by clicking on the relevant tabs/buttons. An example is given in Figure 6 to show how the analyses were done.

Figure 6

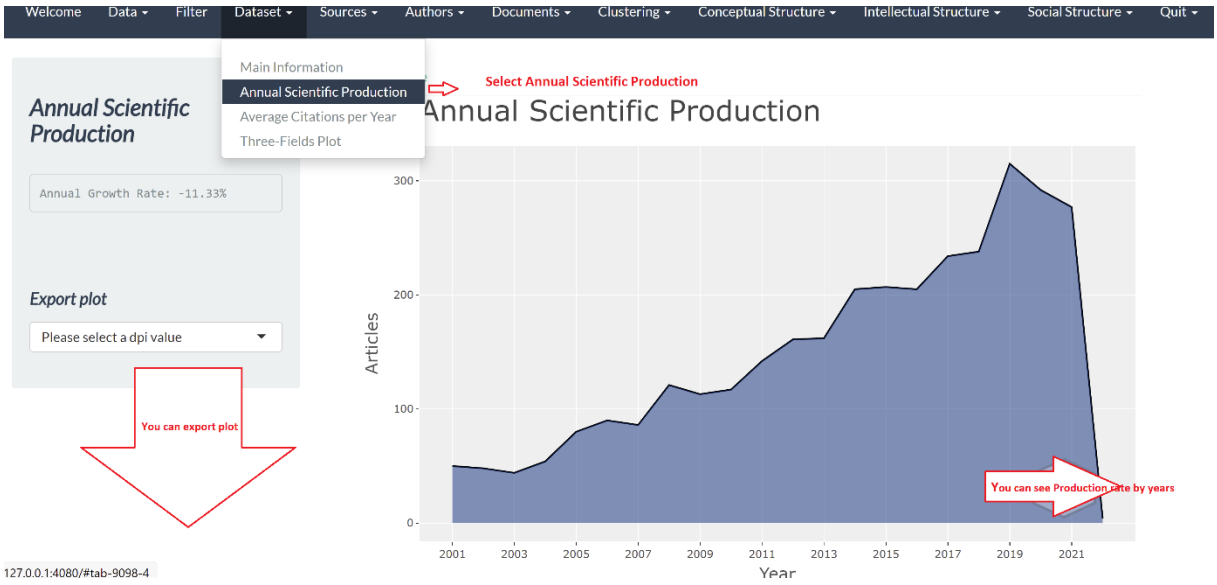
Main Information about the Bibliometric Data



When the general information about bibliometric data was examined, 3388 articles from 639 sources were included in the research. 7672 authors wrote 3388 articles related to IRT. The average citation amount of each document was 21.4. The average citation per year per doc was 2.1. The number of author's keywords was 6433. The annual production number of IRT-related publications was derived from the "annual scientific production" option on the shrinking tab. In addition, *biblioshiny* offered the option to download each plot in different dpis (dots per inch for resolutions). It is possible to export plots from 75 dpi to 600 dpi.

Figure 7

Annual Scientific Production

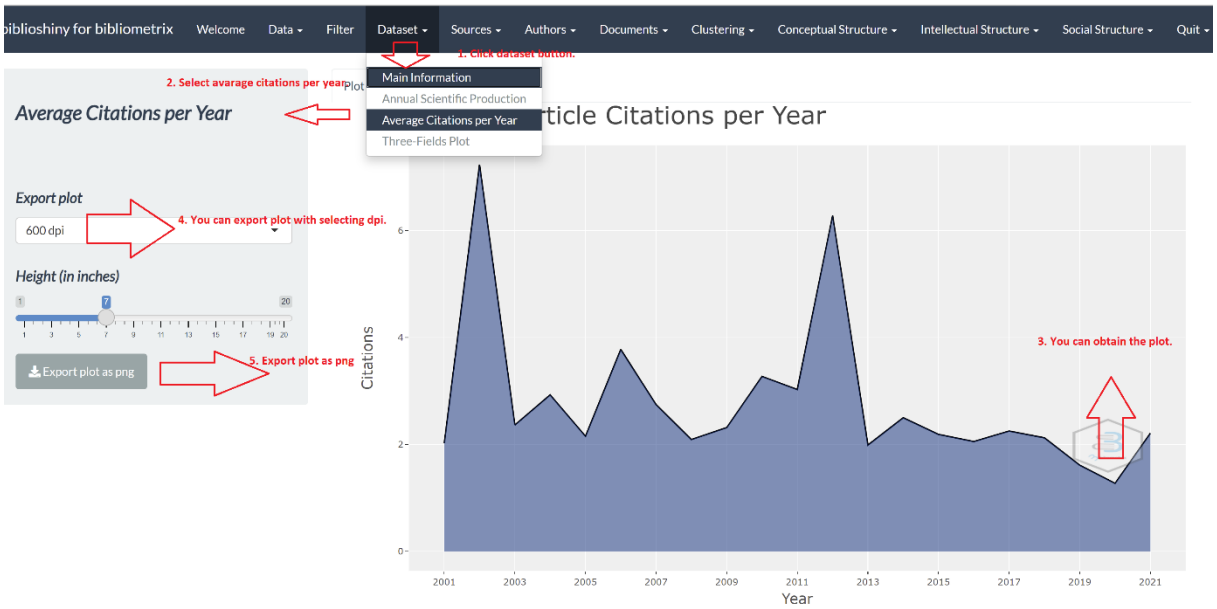


When Figure 7 was examined, the highest number of publications related to IRT was published in 2019 (N= 315). From 2001, the number of publications produced until 2021 was generally increasing. While there were 50 articles searched in WoS related to IRT in 2001, there were 292 articles in 2020. After 20 years, the number of articles increased to 277 in 2021.

A plot in Figure 8 was obtained from the dataset tab by clicking the "*average citations per year*" tab.

Figure 8

Average Article Citations per Year



In Figure 8, the annual citation amounts per article are given. When the plot was examined, the number of annual citations per article in 2002 was at its highest level. Considering the average citations per year, the mean total citations per article was the highest level (N= 144.67) although the number of articles in 2002 was very low (N= 48). Finally, you can see the plot from the Three fields plots option on the dataset tab. At this stage, there were seven steps to follow. After clicking the Three-fields plot tab, the variables and number of items in the middle, left, and right fields must be determined. Once these conditions are set, the apply button must be clicked, and the plot should be obtained. After all these steps, you can download the plot to your computer by clicking the camera-shaped icon on the plot.

Figure 9

Three-Fields Plot

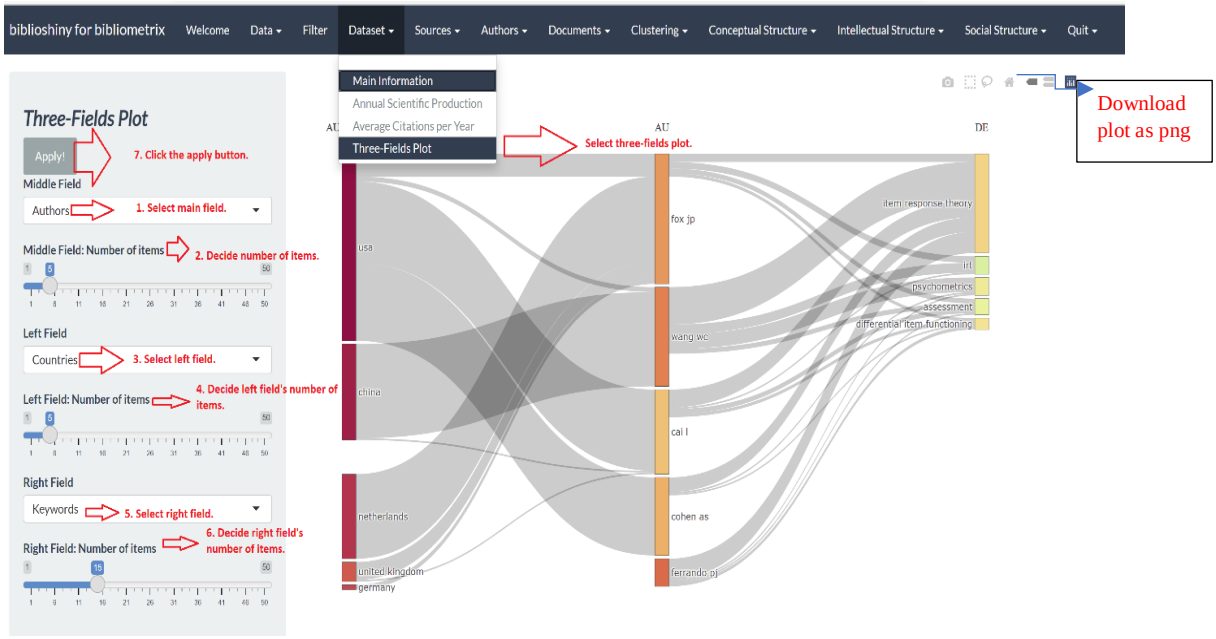


Figure 9 included the Three-Fields Plot. According to the objectives of the researchers in three fields, these fields can be selected from authors, affiliations, countries, keywords, keywords plus, titles, abstracts, sources, references, and cited sources. As part of the research, the author was selected as the middle field, the country as the left field, and the keywords as the right field. The number of items was selected as five for each field. In Table 1, the analysis under all tabs in the *biblioshiny* interface was handled.

Table 1

Sections in Biblioshiny (Adapted from Aria & Cuccurullo, 2017)

Sections	Frames	Bibliometric Technique	Unit of Analysis	Statistical Techniques
Dataset	Main information Annual Scientific production Average Citations per Year Three-Fields Plot			Descriptives

Table 1 (continued)

Sections in Biblioshiny (Adapted from Aria & Cuccurullo, 2017)

Sources	Most relevant Sources Most Local Cited Sources Bradford's Law Source Impact Source Dynamics		Sources	
Documents	Most Global Cited Documents Most Local Cited Documents Most Local Cited References Reference Spectroscopy Most frequent Words WordCloud TreeMap Word Dynamics Trend Topics		Documents, Cited references, Words	
Clustering	Clustering by Coupling			Clustering
Conceptual Structure	Co-occurrence Network Thematic Map Thematic Evaluation Factorial Analysis	Co-word	ID, DE (keywords), TI, AB, Full document	Network Analysis, Factorial Analysis (CA; MICA; MDS), Thematic mapping, Thematic evolution, Topic modeling
Intellectual Structure	Co-citation Network Historiograph	Co-citation, Citation	References, Authors, Journals	Network analysis, Historiograph
Social Structure	Collaboration Network Collaboration WordMap	Collaboration	Authors (co-authorship, Institution, Journal)	Collaboration network

Findings

In this section, the steps and findings of bibliometric analysis with IRT articles were shared.

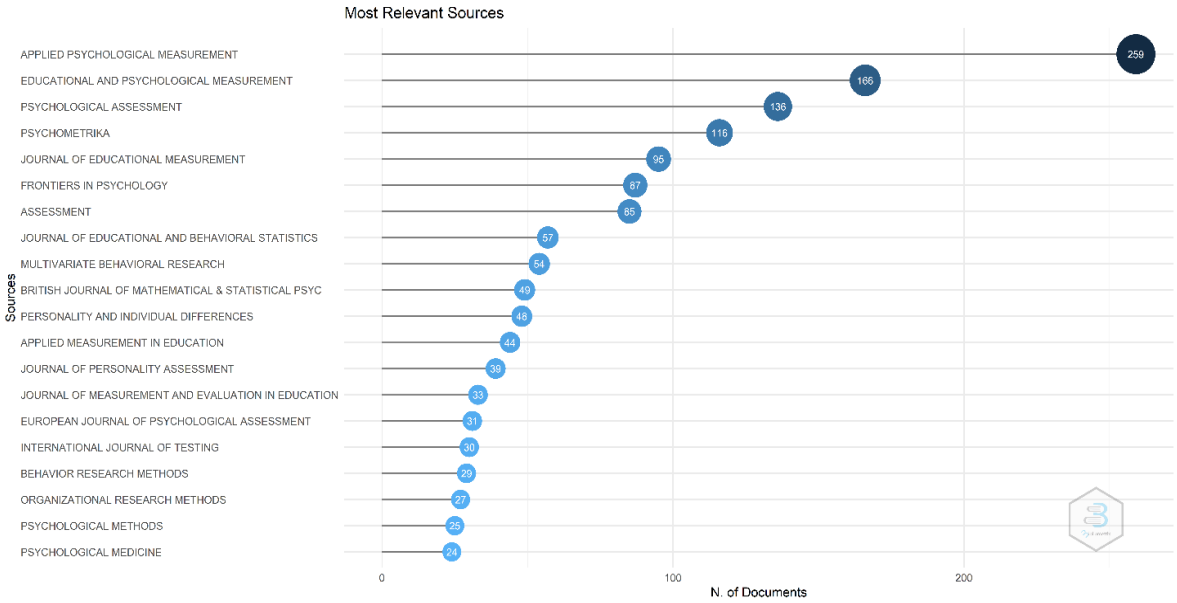
Sources

This section presents the findings of the articles included in this research within the scope of the source (most relevant source, source local impact by h index, source growth, and most local cited sources).

Figure 10 visualized which source most relevantly publishes articles addressing IRT. The Biblioshiny→Source→Most Relevant Source tabs were clicked respectively to obtain the plot in Figure 10.

Figure 10

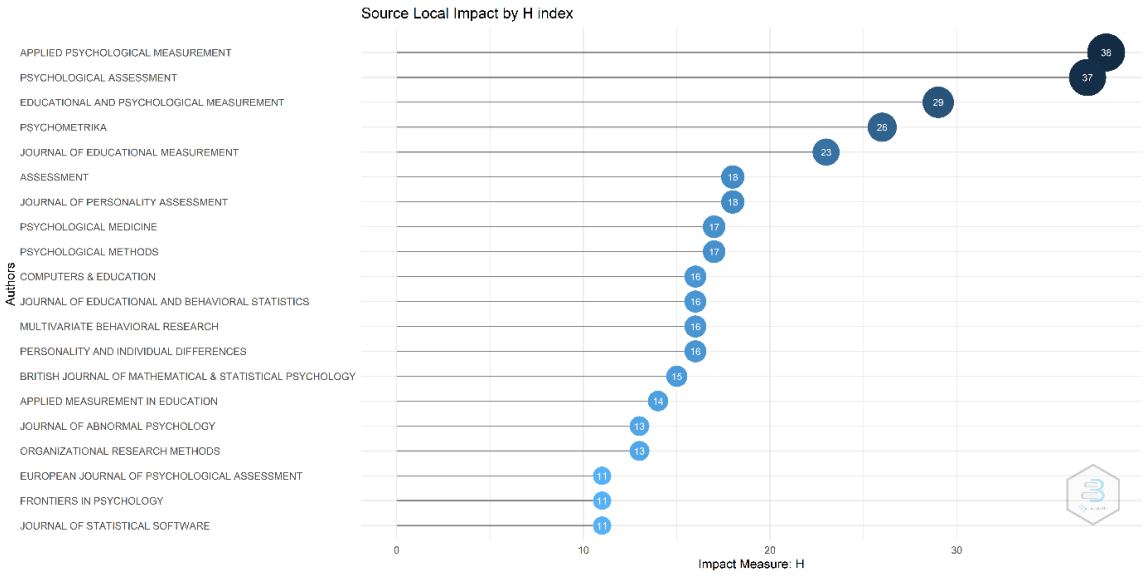
Most Relevant Sources



When the articles on IRT were examined in the field of Education and Psychology, these articles included in this research were most commonly published in Applied Psychological Measurement (N=259), Educational and Psychological Measurement (N=166), Psychological Assessment (N=136), Psychometrika (N=116), Journal of Educational Measurement (n=95). There are 33 publications related to IRT in the Journal of Measurement and Evaluation in Education and Psychology (JMEEP), which ranks 14th. The H index sequences of these journals are shown in Figure 11. The Biblioshiny→Source→Source Impact→H index→Apply tabs were clicked respectively to obtain the plot in Figure 11.

Figure 11

Source Local Impact by H index



Considering the source local impact by H index, Applied Psychological Measurement (H Index= 38), Psychological Assessment (H Index= 37), Educational and Psychological Measurement (H Index=29), Psychometrika (H Index= 26), Journal of Educational Measurement (H index= 23) journals were ranked, respectively (see Figure 11). In Figure 12, the ten journals that published the highest number of articles on IRT are given source growth plot by the year. Biblioshiny→Source→Source Dynamics→Cumulate/Per year→Apply stages have been followed to obtain these plots, respectively.

Figure 12

Source Growth

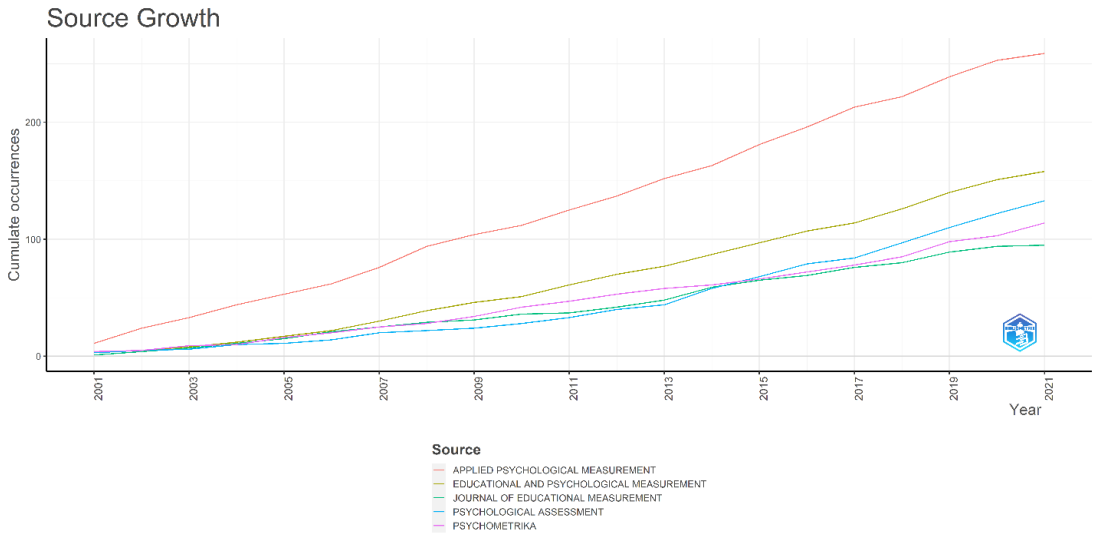
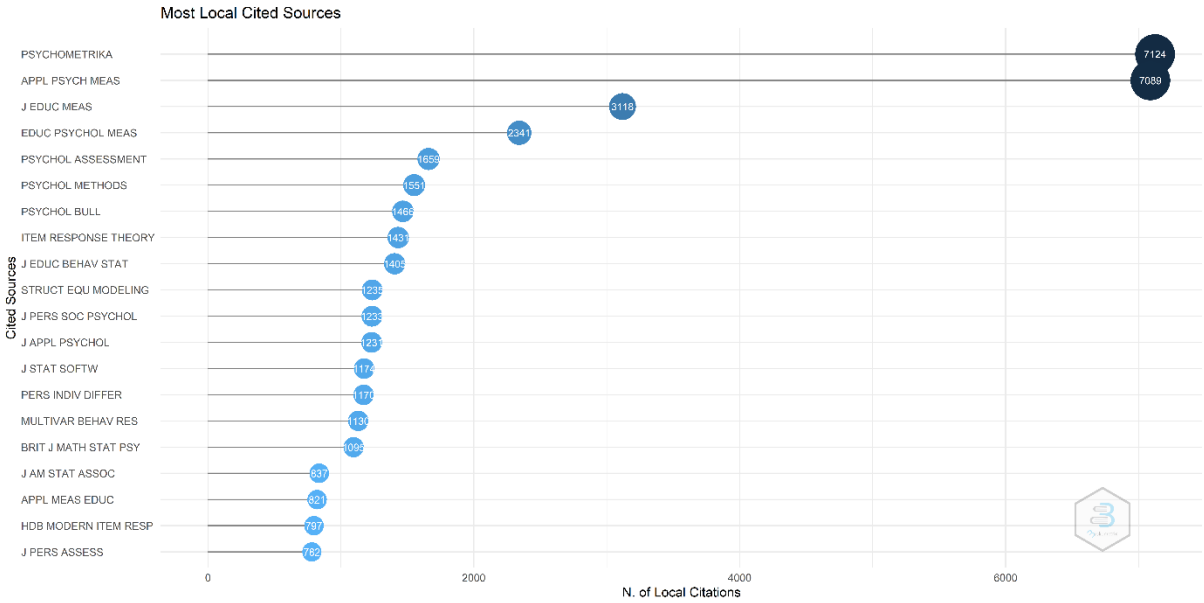


Figure 12 shows the publications by the years given on the left and the developments for each year given on the left. Since 2001, the number of articles related to IRT has been increasing for each journal. For example, while there were 11 articles on IRT in 2001, there were 259 articles in 2021 in the Applied Psychological Measurement Journal. Figure 13 presents the local citation amounts of the 20 most cited journals related to IRT. Biblioshiny→Source→Most Local Cited Sources→Apply stages were followed to obtain the most local cited sources plot, respectively.

Figure 13

Most Local Cited Sources



According to Figure 13, the most local cited sources for IRT-related articles were Psychometrika (Number of local citations/N=7124), Applied Psychological Measurement (N=7089), Journal of Educational Measurement (N=3118), Educational Psychological Measurement (N=2341), and Psychological Assessment (N=1659), respectively.

Authors

The findings of the analyzes of the authors conducting research related to IRT (most relevant authors, top-authors' production over time, most relevant affiliations, corresponding author's country, most cited countries) were handled in this section. Figure 14 provides the number of publications of the twenty authors who have published the highest number of articles about IRT. Biblioshiny→Authors→Most Relevant Authors→N of Documents →Apply stages were followed to obtain this plot respectively.

It was seen that Ferrando PJ had 39 publications in Figure 14. Other most relevant authors are Wang WC (Number of articles=36), Fox JP (N=26), Cohen AS (N= 25), and Cai L (N=24). In Figure 15, these authors' publications and citation amounts were shown by year. To obtain this plot, Biblioshiny→Authors→ Authors' Production over Time→Apply stages were followed respectively.

Figure 14

Most Relevant Authors

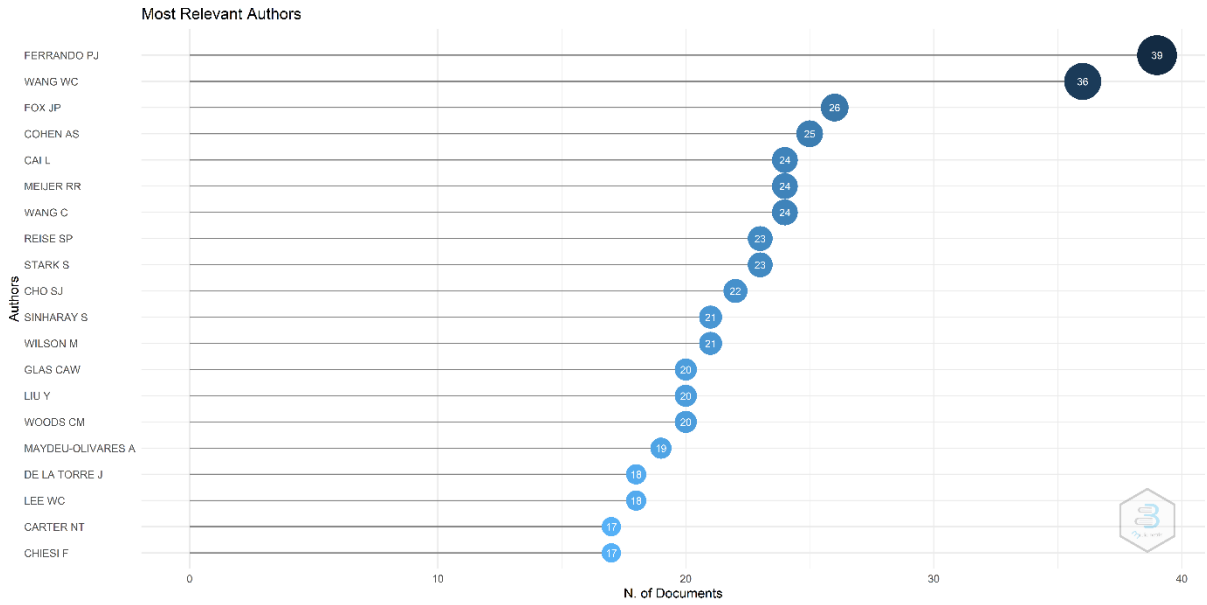


Figure 15

Top-Authors' Production Over the Time

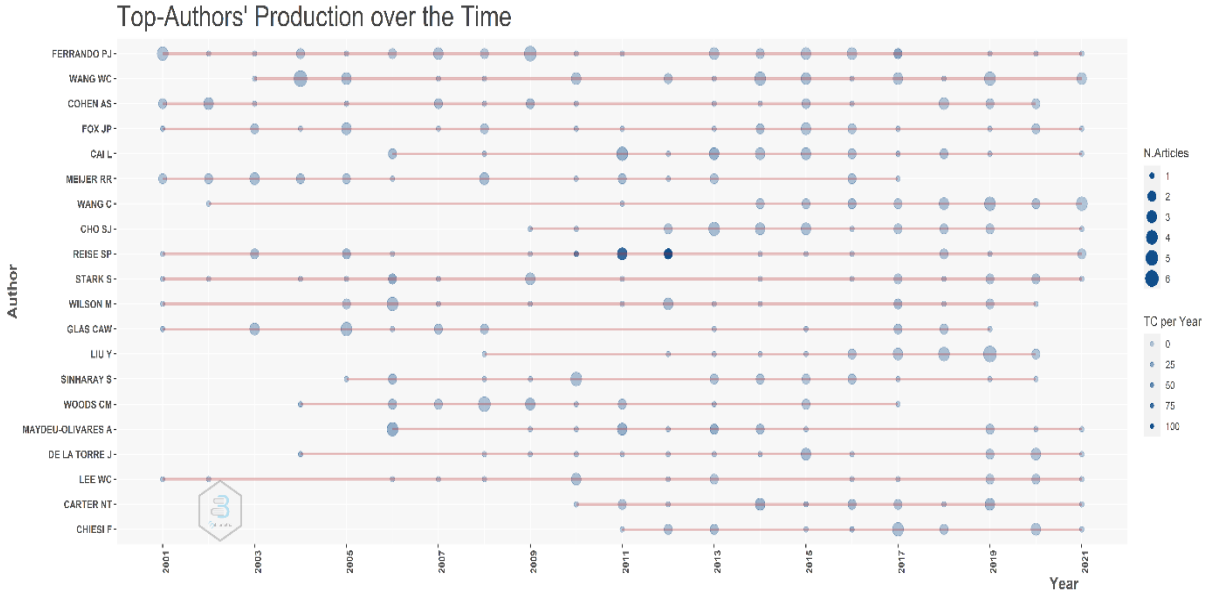
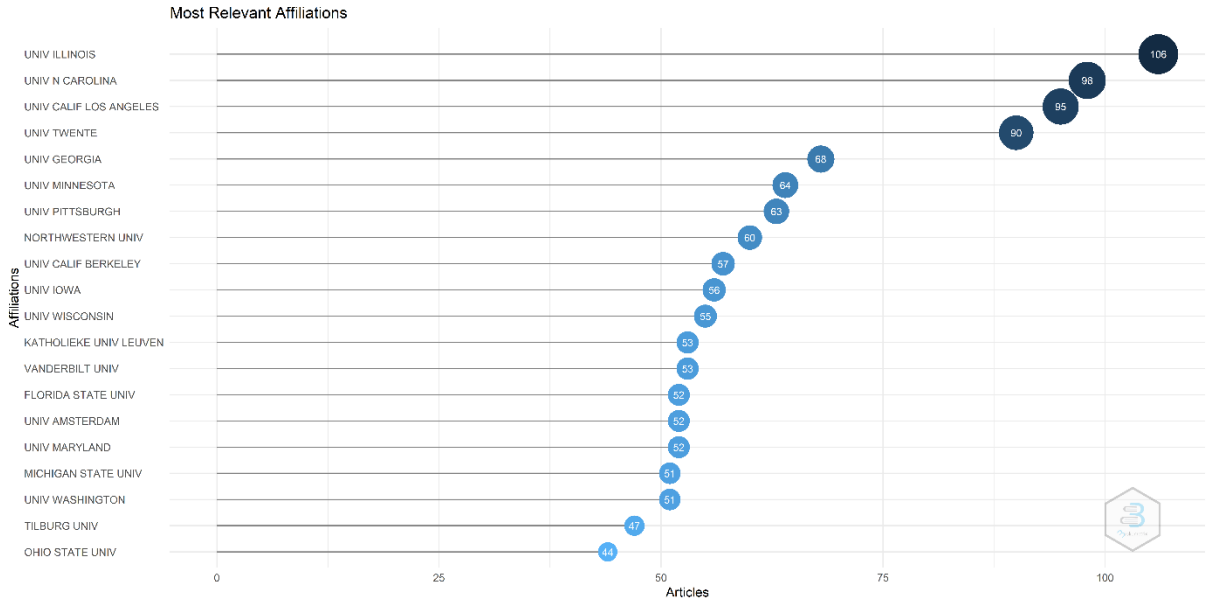


Figure 15 illustrates top-authors' production over time; for example, the circles were darker and larger since Reise SP had more articles and citations in 2011 than in other years. Reise SP had three publications in 2011 and an average of 76.83 citations per year. In Figure 16, the organizations of the authors of the articles were given. To obtain this plot, the Biblioshiny→Authors→ Most Relevant Affiliations→ Affiliation Name Disambiguation-Yes→Apply stages were followed, respectively.

Figure 16

Most Relevant Affiliations



The authors of IRT-related articles were mainly from the University of Illinois Urbana-Champaign (Number of articles= 106), University of North Carolina at Chapel Hill (N= 98), University of California, Los Angeles (N= 95), University of Twente (N= 90), and University of Georgia (N= 68) (see Figure 16). Considering the universities in Turkey within the scope of the research criteria, the most relevant affiliation was Hacettepe University (Number of articles=29) in Turkey. In Figure 17, the authors' countries of the articles were given. Table 2 and the red bar in Figure 17 indicate the multiple country publication (MCP), and the turquoise bar represents the single country publication (SCP). To obtain this plot, Biblioshiny→Authors→ Corresponding Author's Country→Apply stages were followed respectively.

Figure 17

Corresponding Authors' Country

Figure 17 states that the corresponding authors were most commonly found in the USA. China (Number of articles= 200), Netherlands (N= 184), Germany (N= 161), and Spain (N=138) ranked the top five corresponding author's countries. Turkey, on the other hand, was the 9th country with a corresponding authors rate who conducted IRT studies. Table 2 provides the number, ratio, and frequencies of IRT-related publications according to the country and the status of being single country publications (SCP) or multiple-country publications (MCP).

Table 2

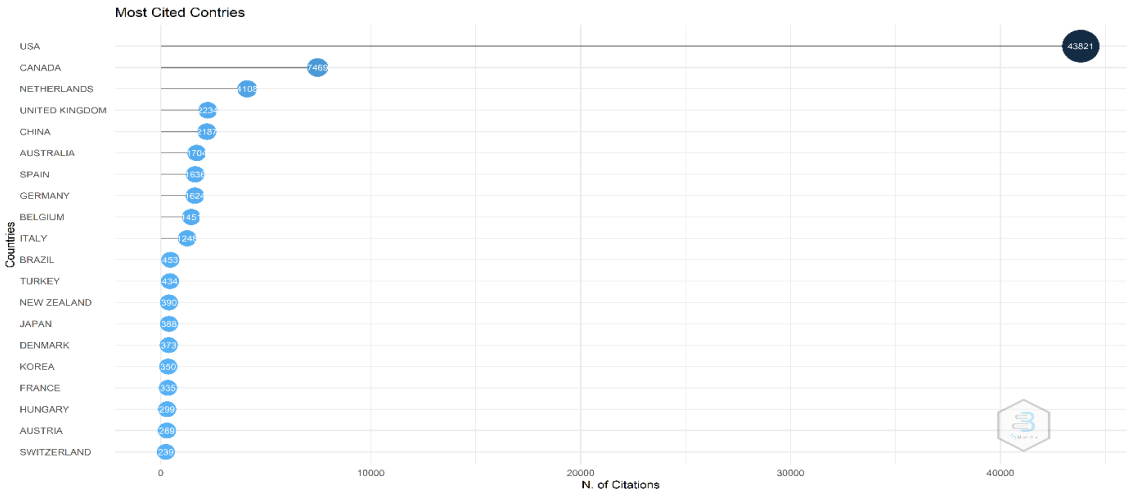
Corresponding Author's Country

Country	Articles	Frequency (f)	SCP	MCP	MCP_Ratio
USA	1605	0.47	1378	227	0.14
China	200	0.06	151	49	0.25
Netherlands	184	0.05	145	39	0.21
Germany	161	0.05	120	41	0.25
Spain	138	0.04	114	24	0.17
Italy	105	0.03	77	28	0.27
Canada	102	0.03	58	44	0.43
United Kingdom	94	0.03	46	48	0.51
Turkey	93	0.03	84	9	0.10
Australia	90	0.03	61	29	0.32

When the corresponding author's country was analyzed, the USA ranked first with 1605 articles (f= 0.47). Table 2 shows that authors mostly wrote the articles in the USA from a single country (N= 1378), but 227 studies were conducted in collaboration with authors from other countries. The number of articles on IRT in the USA was about eight times higher than the number of articles in China, which ranks second. As can be seen from Table 2, for example, there were 93 articles (searched in SSCI, SCI-E, ESCI, and A&HCI) in Turkey according to the criteria set out in WoS. Only 9 of these articles were multiple-country studies. The most cited countries are shown in Figure 18. To obtain this plot, the Biblioshiny→Authors→ Most Cited Countries→Measure-Total citations→Apply stages were followed respectively.

Figure 18

Most Cited Countries



In Figure 18, the most cited countries were the USA (Number of citations= 43821), Canada (N= 7469), Netherlands (N=4108), United Kingdom (N= 2234), and China (N= 2187), respectively. A total of 43821 citations were made to articles in the USA, compared to 27.303 citations per article. Although the total number of citations in Canada, which is in second place, was approximately one-sixth of that of the USA, the average number of article citations in Canada had the highest value with 73.23. When these numbers were examined for Turkey, there were 434 total citations, while the average number of article citations was 4.667.

Social Structure

The collaboration network was shown in this section.

Figure 19

Collaboration Network

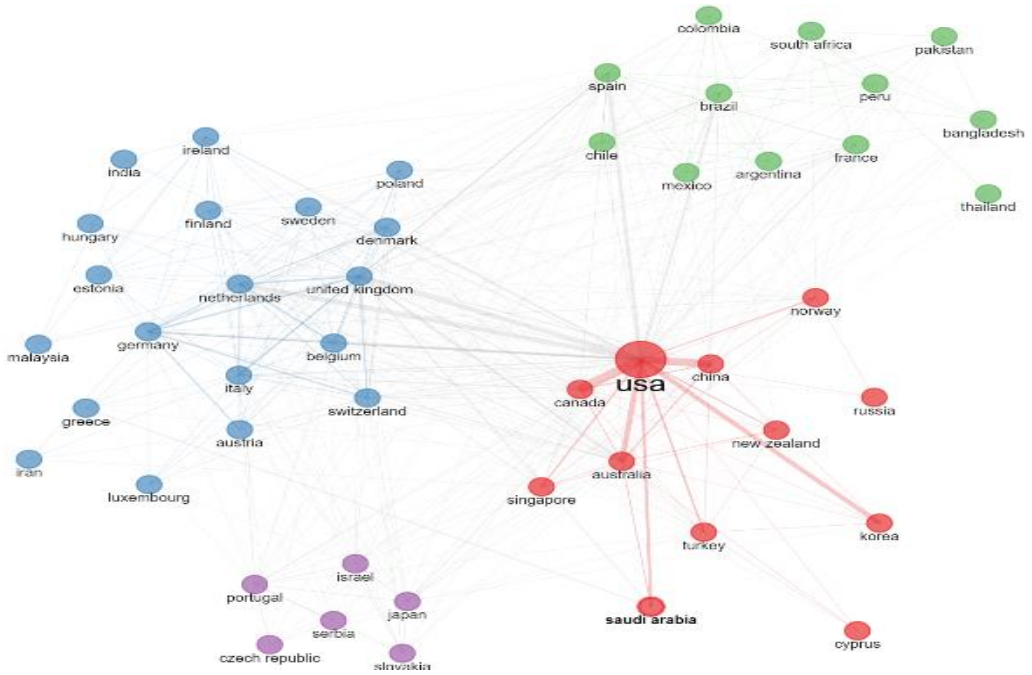


Figure 19 displays a collaboration network for countries. To obtain this figure, the Biblioshiny→Social Structure→ Collaboration Network→Field-Countries→Apply stages were followed respectively. In this analysis, we used 50 number of nodes, we chose Louvain clustering algorithm, and used association as normalization.

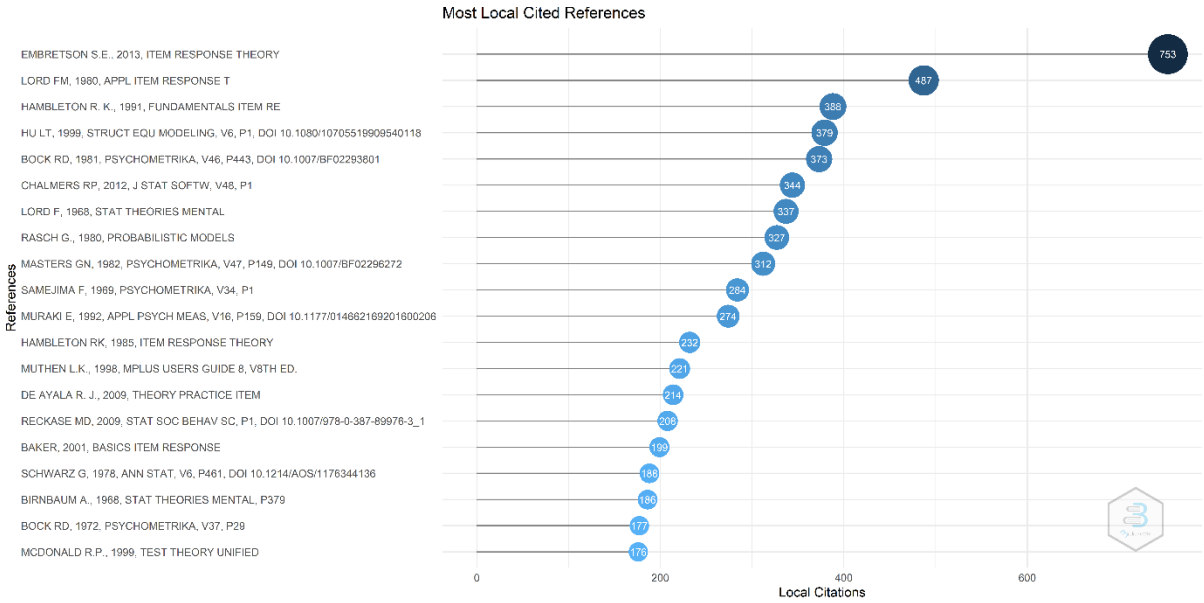
As can be seen in Figure 19, there were five clusters. Each cluster is represented by a color. It can be interpreted that the countries in the same cluster were in cooperation. These clusters were shown in different colors. USA, China, Canada, Australia, Turkey, Korea, Norway, New Zealand, Singapore, Russia, Saudi Arabia, and Cyprus were among the first cluster. Netherlands, Germany, United Kingdom, Italy, Belgium, Switzerland, Austria, Denmark, Sweden, Finland, Poland, Iran, Greece, Ireland, India, Estonia, Hungary, Luxembourg, and Malaysia were among the second cluster. Spain, Brazil, France, Argentina, Peru, Chile, Colombia, South Africa, Mexico, Thailand, Pakistan, and Bangladesh were among the third cluster. Japan, Portugal, Czech Republic, Serbia, Slovakia, and Israel were among the fourth cluster.

Documents

Most local cited references, reference spectroscopy, most frequent words, tree map, word dynamics, and trend topics (based on keyword-plus and author's keyword) were shown in this section. In Figure 20, according to the inclusion criteria in WoS, most local cited references were listed. To obtain Figure 20, the Biblioshiny→Documents→ Most Local Cited References→Apply stages were followed respectively.

Figure 20

Most Local Cited References



Regarding Figure 20, the greatest number of citations were done to Embretson's and Reise's Item Response Theory (2013) (N= 753) in the research included in this bibliometric research. Then the most local references were publications of Lord FM, 1980 (N= 487), Hambleton R. K., 1991 (N=388), Hu LT, 1999, (N= 379), Bock RD, 1981, (N= 373), Chalmers RP, 2012 (N= 344), Lord F, 1968 (N= 337), Rasch G., 1980 (N= 327), Masters GN, 1982 (N=312), and Samejima F, 1969, (N= 284). Reference publication year spectroscopy is given in Figure 21. To obtain this plot, the Biblioshiny→Documents→ Reference Spectroscopy→Apply stages) were followed respectively.

Figure 21

Reference Publication Year Spectroscopy

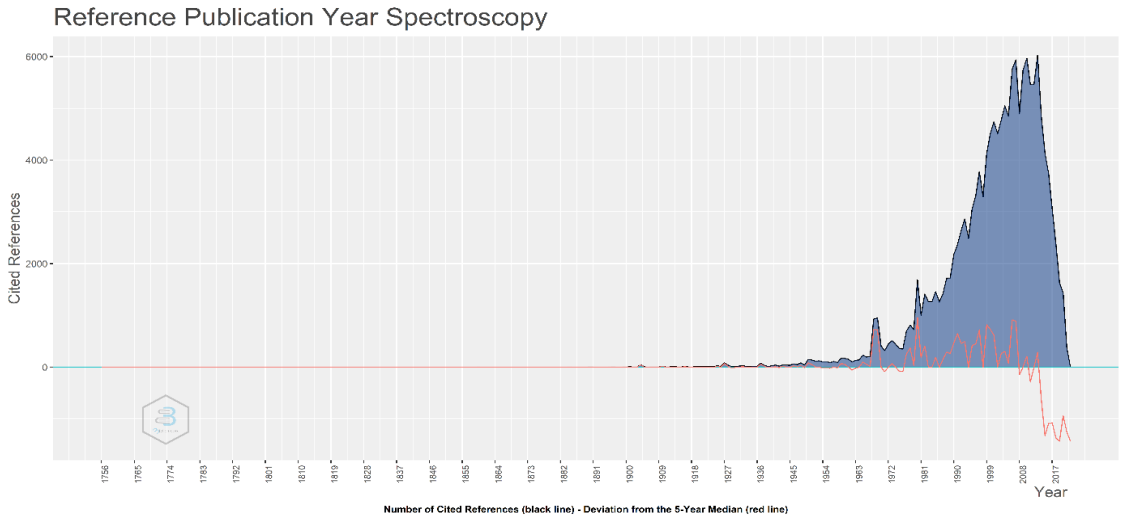
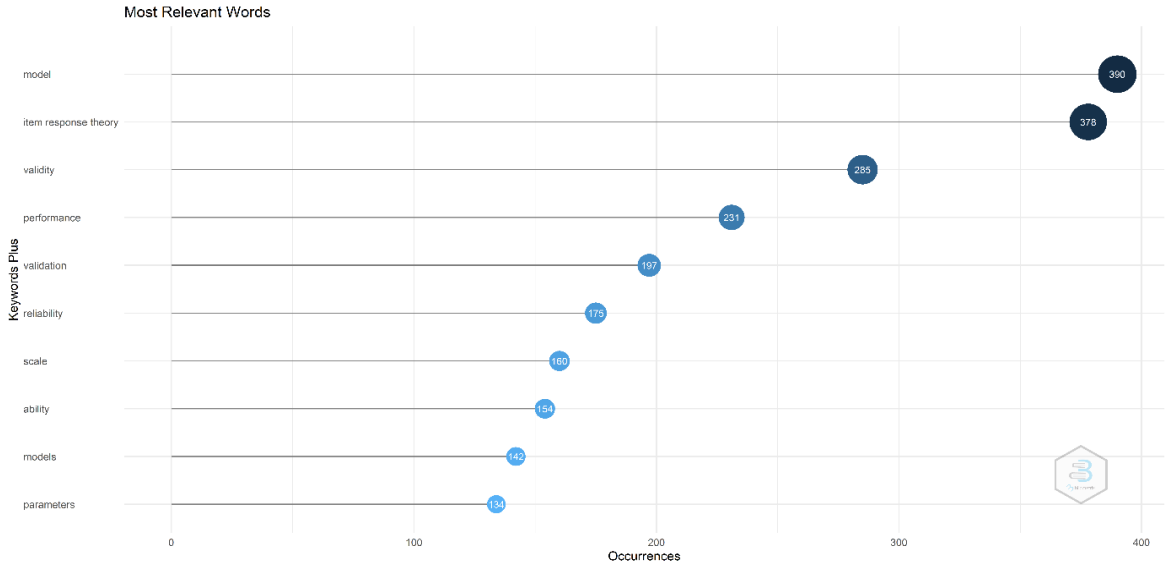


Figure 22 gives the most relevant words. To obtain this plot, the Biblioshiny→Documents→ Most Frequent Words→Field-Keywords plus→Apply stages were followed respectively.

Figure 22

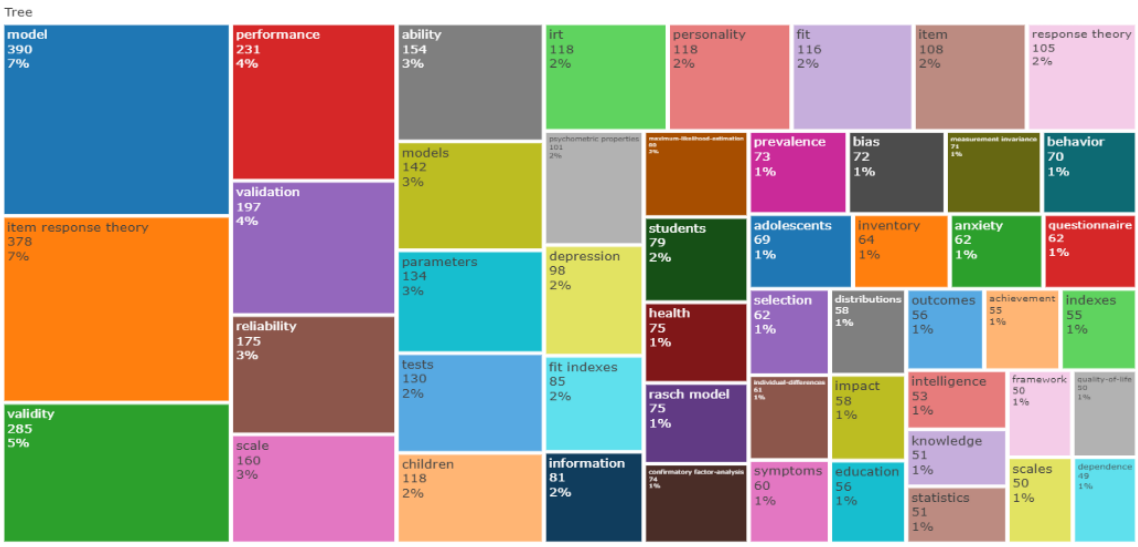
Most Relevant Words



When the articles including in this research were examined, it was seen that keywords such as model (f= 390), item response theory (f=378), validity (f=285), performance (f=231), validation (f= 197), reliability (f=175), scale (f= 160), ability (f= 154), and parameters (f= 134) were used (see Figure 22). Figure 23 gives tree map based on keywords. To obtain this plot, the Biblioshiny→Documents→ TreeMap→Field-Keywords plus→Apply stages were followed respectively.

Figure 23

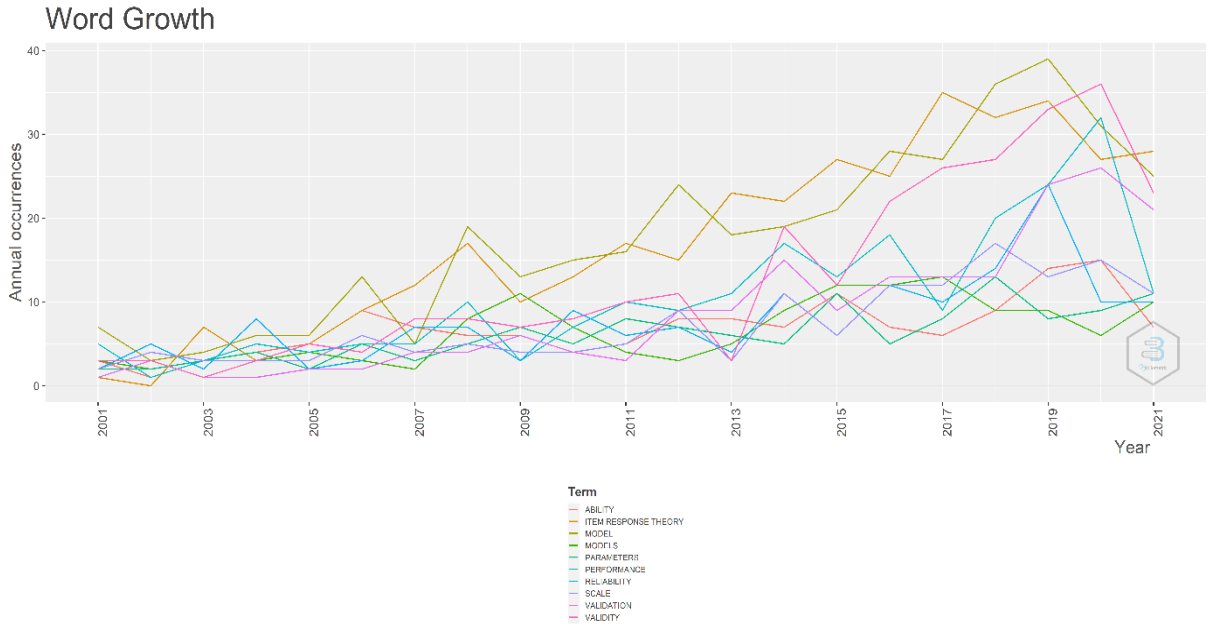
Tree Map Obtained from Keywords Plus



When Figure 23 was examined, it was seen that concepts such as validity (N=285, %5), performance (N=231, %4), validation (N=197, %4), and reliability (N=175, %3) stood out in the articles included in the analysis. The frequency with which these concepts have been used in articles over the years is given in Figure 24 with the word growth plot. This plot was obtained by following the Biblioshiny→Documents→ Word Dynamics→Field-Keywords plus→ Occurrences-Per Year→Apply stages respectively.

Figure 24

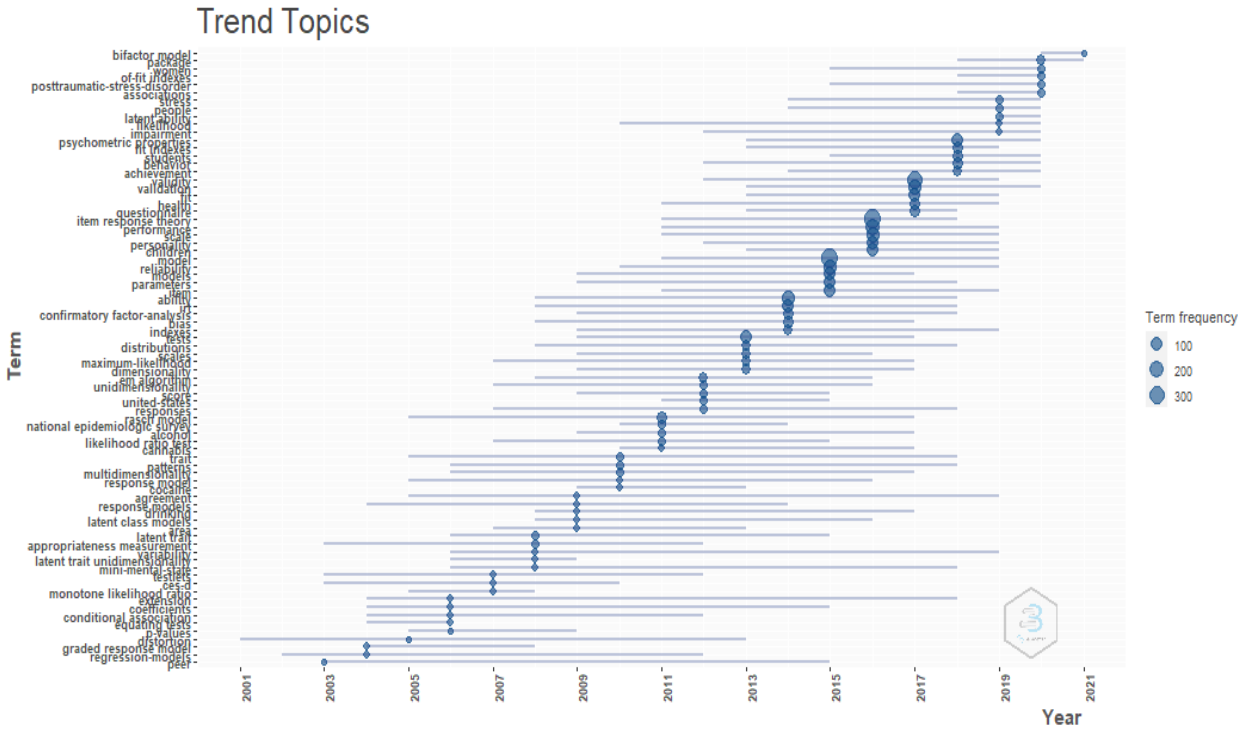
Word Growth



When Figure 24 was considered, for example, it was seen that the concept of validity was included three times in 2001, 27 times in 2018, 33 times in 2019, 36 times in 2020, and 23 times in 2021. Figure 25 is given a trend topics plot. "Word minimum frequency" parameter was taken as five and the "number of words per year" parameter was taken as three when constructing trend topics plots. This plot was obtained by following the Biblioshiny→Documents→ Trend Topics→Field-Keywords Plus →Apply stages respectively.

Figure 25

Trend Topics Based on Keywords Plus

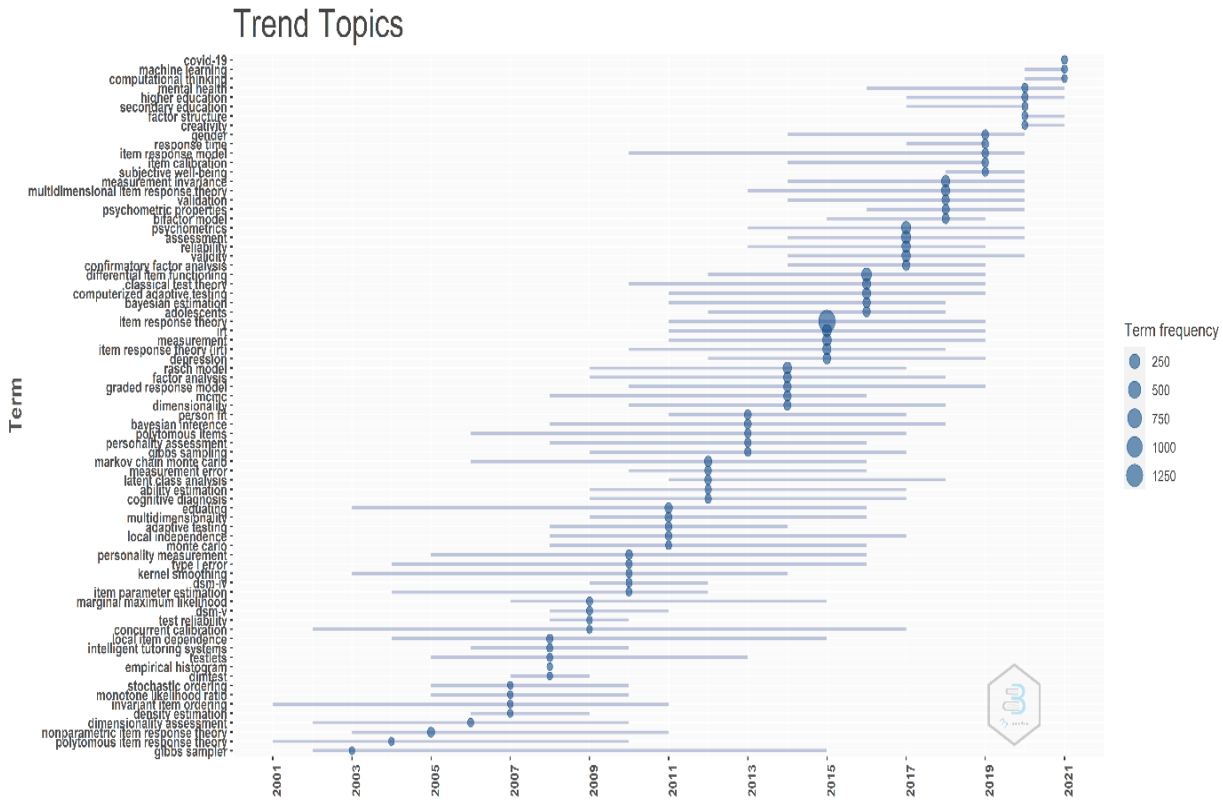


When Figure 25 was examined, it had been seen that the most bi-factor models have been trending topics based on keywords plus in recent years. In other words, the bi-factor model has been studied in research on IRT in recent years. In the trend topics plot, the size of the circles shows the frequency of the term and the length of the lines shows how long it has been studied. In Figure 26, the Trend topics plot was given based on authors' keywords. This plot was obtained by following the Biblioshiny→Documents→ Trend Topics→Field-Author's Keywords →Apply stages respectively.

It is seen that COVID-19 has been a trending topic based on author's keywords in recent years (see Figure 26). COVID-19 was a trending topic even in research on IRT. In recent years, two other trend topics in IRT research are machine learning and computational thinking based on author's keywords. The most commonly used author's keywords were ranked as item response theory (f=1279), differential item functioning (f= 185), psychometrics (f= 137), assessment (f= 135), IRT (f= 118), measurement (f= 105), reliability (f= 94), Rasch model (f= 89), measurement invariance (f= 74), multidimensional item response theory (f= 72), classical test theory (f= 68), computerized adaptive testing (f= 65)), factor analysis (f= 50), graded response model (f= 41), Markov Chain Monte Carlo (f= 39), equating (f= 36), and validation (f= 34).

Figure 26

Trend Topics Based on Author's Keywords

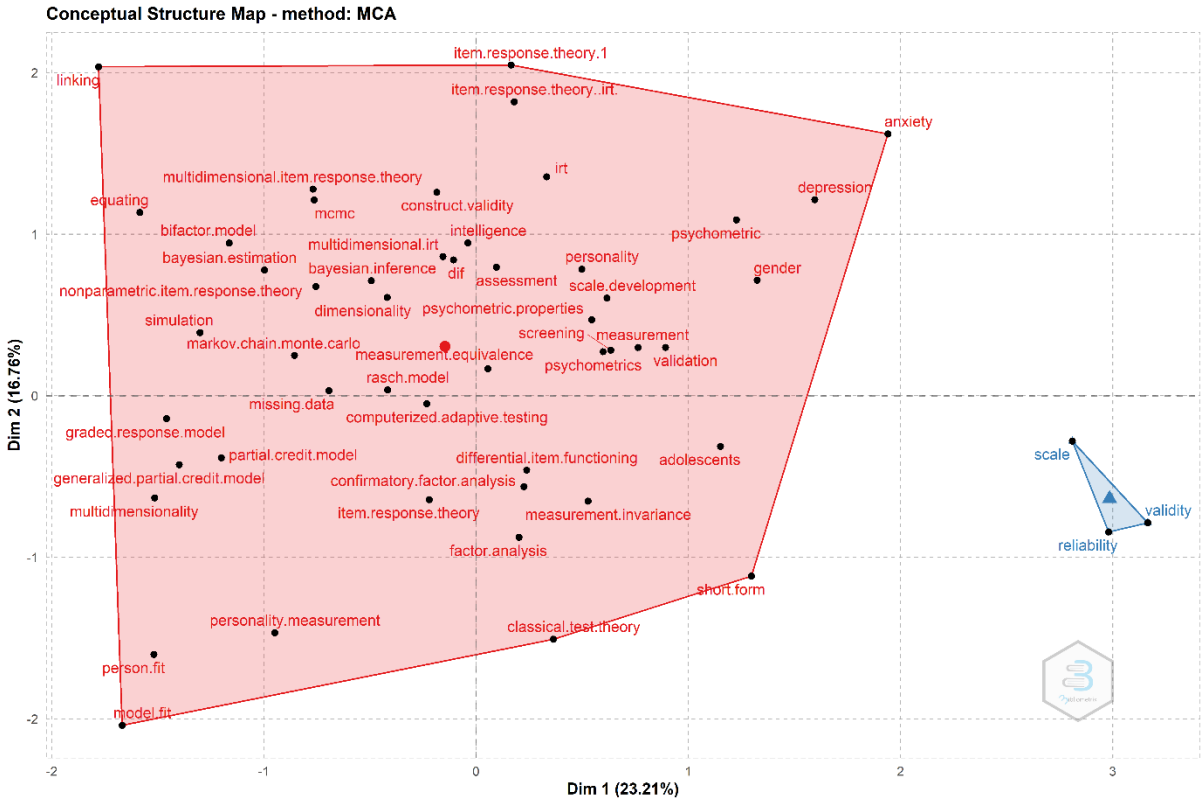


Conceptual Structure

This section displays a conceptual structure map, topic dendrogram, network map based on author's keywords, and thematic map. Figure 27 was illustrated a conceptual structure map. This plot was obtained by following the Biblioshiny→Conceptual Structure→ Factor Analysis→Method-Multiple Correspondence Analysis→Field-Author's Keywords →Apply→Word Map stages respectively.

Figure 27

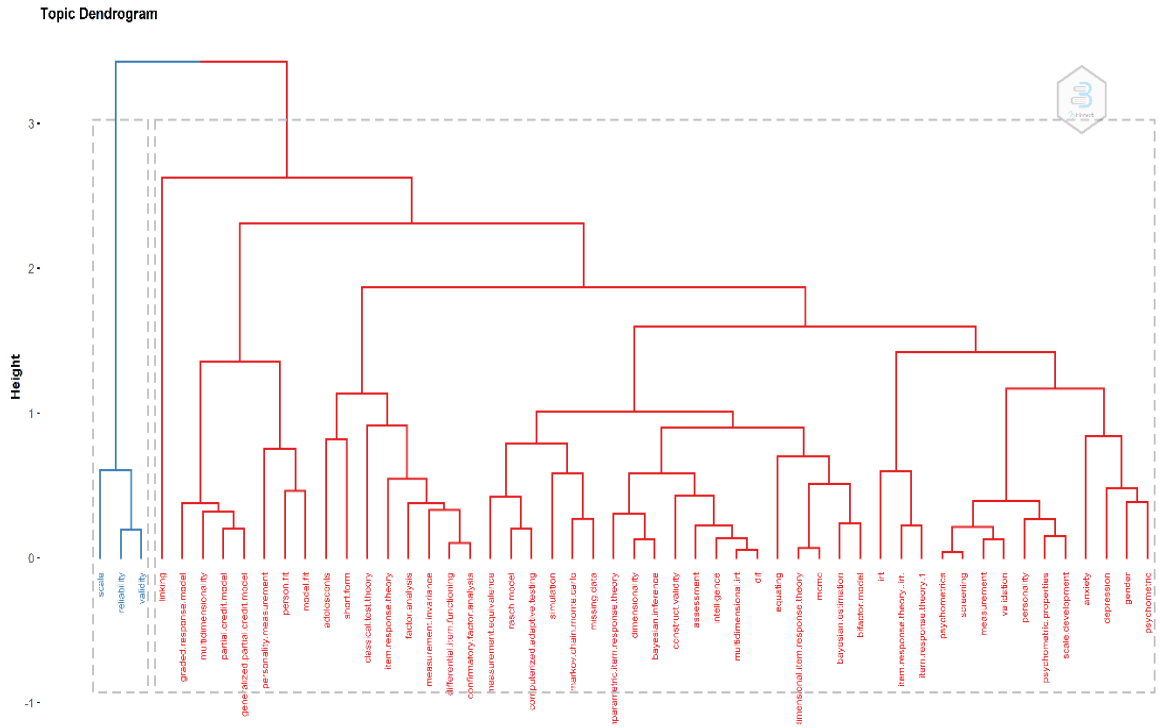
Conceptual Structure Map



As a result of the factorial analysis, when the keywords of the articles about IRT are examined in this study, the following concepts are placed in the first cluster with a high factor load in the first dimension: item response theory, differential item functioning, psychometrics, assessment, IRT, measurement, Rasch model, measurement invariance, multidimensional item response, classical test theory, computerized adaptive testing, depression, factor analysis, graded response model, confirmatory factor analysis, bayesian estimation, Markov Chain Monte Carlo, equating, MCMC, adolescents, validation, personality, partial credit model, psychometric properties, bi-factor model, missing data, scale development, simulation, dimensionality, nonparametric item response theory, linking, short form, measurement equivalence, construct validity, multidimensionality, personality measurement, screening, anxiety, gender, generalized partial credit model, person fit, bayesian inference, intelligence, model fit, psychometric keywords were collected in a single factor. Scale, reliability, and validity were included in a second dimension/cluster (see Figure 27). The dendrogram is given in Figure 28. This figure was obtained by following the Biblioshiny→Conceptual Structure→ Factor Analysis→Method-Multiple Correspondence Analysis→Field-Author's Keywords →Apply→Topic Dendrogram stages, respectively.

Figure 28

Topic Dendrogram



When the Topic Dendrogram was examined, the distance between the clusters was seen on the y-axis of the dendrogram. On the X-axis, there were subject concepts of the data points that make up the clusters. The keyword network map is given in Figure 29. This figure was obtained by following the Biblioshiny→Conceptual Structure→ Co-occurrence Network→Field-Author's Keywords →Apply→Network Map stages respectively.

Regarding the network map based on author's keywords; item response theory, differential item functioning, psychometrics, assessment, measurement, Rasch model, measurement invariance, item response theory(IRT), classical test theory, computerized adaptive testing, graded response model, confirmatory factor analysis, validation, personality, partial credit model, psychometric properties, data missing, scale development, simulation, dimensionality, nonparametric response item theory, construct validity, multidimensionality, screening, gender, generalized partial credit model, person fit, model fit keywords were found in the first cluster (see Figure 29). Different colors were used for each cluster. When Figure 29 was considered, there were 50 concepts and 6 clusters. Keyword thematic map based on author's keyword was given in Figure 30. This figure was obtained by following the Biblioshiny→Conceptual Structure→ Thematic Map→Field-Author's Keywords →Apply→Map stages, respectively. The number of words was taken as 6433, minimum cluster frequency (per thousand docs) was taken as 20. Louvain clustering algorithm was selected for the thematic map.

Figure 29

Network Map Based on Author's Keywords

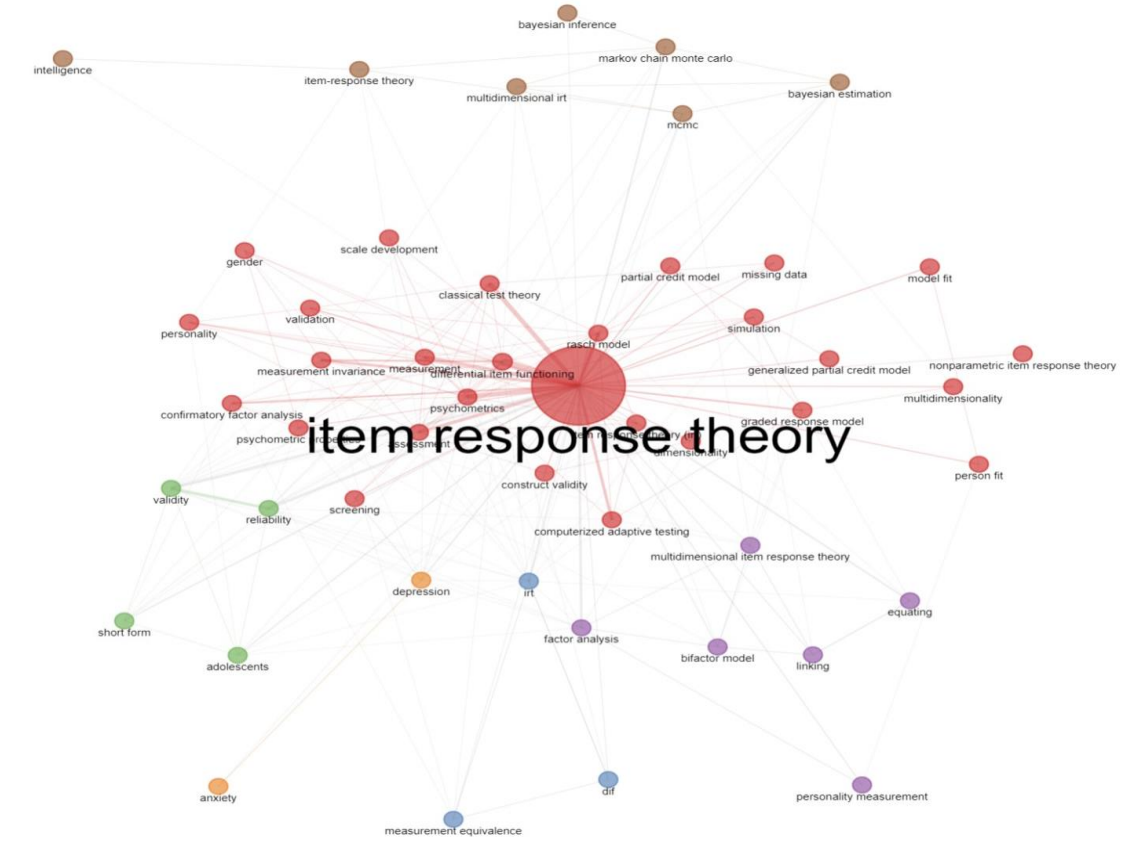
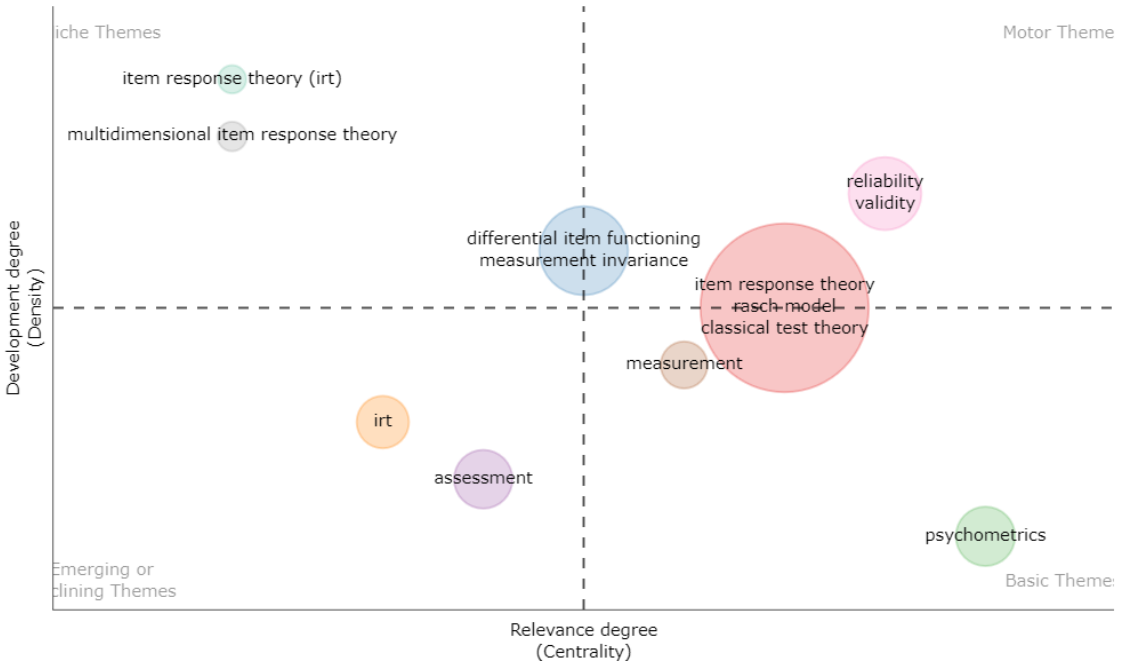


Figure 30

Thematic Map



The thematic map had eight clusters. When the author's keywords were considered, niche themes were item response theory (IRT) and multidimensional item response theory. Emerging themes were IRT and assessment. The Basic (developing) theme was measurement and psychometrics. Motor (developed) themes were reliability and validity. Differential item functioning and measurement invariance cluster was located between two quadrants such as item response theory, Rasch model, and classical test theory cluster.

Conclusion and Discussion

This research aimed to introduce the *biblioshiny* interface opened with the *bibliometrix* package in R programming language and to perform a bibliometric analysis. Publications related to IRT in education and psychology were handled in this research. Between 2001 and 2021, 3388 articles searched in WoS were taken into consideration.

It had been observed that the IRT-related articles included in this research in the field of education and psychology were mostly published in Applied Psychological Measurement, Educational and Psychological Measurement, Psychological Assessment, Psychometrika, and Journal of Educational Measurement, respectively. There were 33 articles on IRT included in this research in the 14th-ranked Journal of Measurement and Evaluation in Education and Psychology (JMEEP). The most cited journals for IRT-related articles were Psychometrika, Applied Psychological Measurement, Journal of Educational Measurement, Educational Psychological Measurement, and Psychological Assessment, respectively. Aksu and Güzeller (2019) conducted a bibliometric analysis of 1367 IRT-related studies searched in WoS between 1980 and 2018 with Citespace II. They found similar results in this research.

According to the determined criteria, when the authors who have published the most articles on IRT was examined, Ferrando PJ had the most publications. When the institutions of the authors who published the most articles on IRT were examined, the most relevant articles were written by authors from the University of Illinois Urbana-Champaign in the USA. It has been observed that employees in institutions in Turkey publish fewer articles. However, the number of corresponding author's articles in Turkey was in the top 10. Increasing the quantity and improving the quality of IRT-related publications is only possible with good cooperation. It was seen that only nine of the articles included in this research were in cooperation with other countries in Turkey. Collaboration with authors from other countries should be increased to improve studies in Turkey. When the total number of citations was examined, it was noteworthy that the number of citations of the articles written in institutions in the USA was approximately 100 times more than the number of articles written from institutions in Turkey. Gómez Benito et al. (2005), in their bibliometric research on 271 articles containing the terms "differential item functioning," "DIF," or "item bias" between 1975 and 2000, published in USA, Holland, Spain, and Canada mostly. They found that authors from these countries were the most productive. Consistent with this research in the article of Gómez Benito et al. (2005), the USA was the most productive corresponding author's country at a rate of 64.5%. Aksu and Güzeller (2019) found that the corresponding author's countries making the biggest contribution to IRT literature were USA, Netherland, Canada, Spain, and China, respectively. When corresponding authors' country and most cited countries were examined, most studies were conducted by authors in the USA. The reason for this situation can be explained by the fact that the USA is a pioneer in the world in the number and quality of universities. According to the Fall 2020 National Center for Education Statistics data, there were approximately 3773 degree-granting postsecondary institutions in the US (see National Center for Education Statistics (NCES), 2020). When these colleges and universities were taken into consideration, it was seen that most of them were research universities where a high number of research was conducted (see NCES, 2020). Authors in Turkey can conduct their research by collaborating with authors from the USA, Canada, and the Netherlands, which are the most cited countries.

When the collaboration network was examined, there were five clusters. USA, China, Canada, Australia, Turkey, Korea, Norway, New Zealand, Singapore, Russia, Saudi Arabia, and Cyprus belong to the first cluster. When the centrality levels were examined, it was seen that the studies included in the research

were mostly from the USA. The reason for the most cited and relevant articles on IRT in the USA may be due to the high number of qualified higher educational institutions (see NCES, 2020). Turkey needs to increase the number of publications to reach a central position. The policies and incentives of institutions such as the Higher Education Institution and The Scientific and Technological Research Council of Turkey (TÜBİTAK) are important in increasing the quality and number of publications. The motivation of the authors in Turkey to make quality publications in journals with high impact factors should be increased with incentives. In bibliometric studies conducted in different countries, it has been stated that researchers working in western countries have difficulties in producing quality publications due to project support, course load, and language deficiencies (Gümüş et al., 2019; Hallinger & Hammad, 2019). Hallinger and Hammad (2019) similarly stated that collaborations and scholarship opportunities are important factors for researchers to produce. Gülmez et al. (2020), in their bibliometric research on educational research, revealed that the visibility of Turkish-based research in foreign-sourced journals was low. They mentioned the limitations in the time, language, and funding resources allocated to the research as the reason for this. In order to overcome these limitations, researchers should be supported in foreign language education, translation, and academic writing. They stated that policymakers and university representatives should support researchers to make international collaborations. On the other hand, Rey-Rocha et al. (2002) indicated that it should not be overlooked that an excess of quantity does not mean an increase in the quality of studies.

In the research included in this bibliometric research, the highest number of references were given to Embretson, S. E., & Reise, S. P.'s (2013) Item Response Theory book. Aksu and Güzeller (2019) found that the most cited authors in the field of IRT were De Ayala, Embretson, Reckase, Reise, and Chalmers, respectively. This finding is partially consistent with this research. When the articles searched in WoS in the field of education and psychology related to IRT were examined, it was seen that keywords such as model, validity, performance, validation, reliability, scale, ability, and parameters were used. Concepts such as validity, performance, validation, and reliability were seen to stand out in the articles included in the analysis. When trending topics based on keywords plus were examined, it was seen that the most bi-factor models have been trending topics in recent years. Trending topics based on the author's keywords plot have shown that COVID-19 has been a trending topic in recent years. When the conceptual structure map was examined, scale, reliability, and validity were included in a separate dimension. When the network map was examined, item response theory, differential item functioning, psychometrics, assessment, measurement, Rasch model, measurement invariance, item response theory (IRT), classical test theory, computerized adaptive testing, graded response model, confirmatory factor analysis, validation, personality, partial credit model, psychometric properties, missing data, scale development, simulation, dimensionality, nonparametric response item theory, construct validity, validity concepts, multidimensionality, screening, gender, generalized partial credit model, person fit, model fit keywords were in one cluster. The keyword network map had 50 concepts and 6 clusters. Word analysis conducted in Aksu and Güzeller's (2019, p. 61) research found that the most repeated words were "item response theory, classical test theory, model, validating, reliability, validity, and Rasch model," with overlapping this research.

There were some limitations to the research. The study had five criteria. The first criterion was related to the research topic. It is a criterion to have the expressions "item response theory" (IRT) or "item response modeling," or "item response model" in the abstract. Terms in the abstract could be searched by adding synonyms (for example, latent trait models). Only articles were included in the research. Publications such as book chapters and conference papers could be included in bibliometric analysis. Publications related to education and psychology were discussed in the research. There were also publications in the field of health-related to IRT. Research could be carried out by including other research areas. The research focused on publications between 2001 and 2021 and did not include articles published in other years. Similar research can be conducted by expanding the year range. Searching all articles in SSCI or ESCI or SCI-E or A&HCI was one of the inclusion criteria. However, there were many IRT related articles searched in other sources. More extensive research can be done on different datasets (e.g., Scopus). Finally, it should be noted that bibliometric research will guide researchers and reveal gaps in the field.

Declaration

Author Contribution: SB wrote all sections including "abstract, introduction, method, findings, conclusion and discussion". SB had roles in the conceptualization, resources, data analysis, reporting, drafting, reviewing, and editing.

Conflict of Interest: There is no conflict of interest.

Ethical Approval: Ethical rules were followed in this research. Ethical approval is not required, because data from WoS was used in this research.

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