STATE OF RESEARCH ON E-ASSESSMENT IN EDUCATION: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

This study aimed to reveal the trend of research on e-assessment in the field of educational sciences through scientific mapping and bibliometric analyses. For this purpose, the numerical distribution of research on e-assessment, citation analysis, research themes and the change of trend topics were examined. The publications to be examined were selected from WoS database according to PRISMA model, and 911 studies were included in the analysis. VOSviewer, Biblioshiny, Smart Bibliometrics and Leximancer software were used in data analysis. Apparently, there has been a significant increase in the number of research since 2005, and publications have been mostly produced in form of articles and papers. The most cited and the most productive countries are the USA, the United Kingdom and Australia, while the most cited journals are Assessment & Evaluation in Higher Education and British Journal of Educational Technology. An analysis of the keyword map revealed that the themes of technology and motivation, blended learning and collaboration, interaction and innovative approaches, validity and reliability, higher education, quality, basic disciplines and Covid-19 were frequently emphasized in the studies on e-assessment. An analysis of trend topics by years showed that, between 2010 and 2021, the trend topic distribution changed to include topics such as Covid-19, academic integrity, engagement, cheating, case study, and higher education. All these findings reveal that e-evaluation activities have displayed a development and transformation over time with the effect of developing technology, the pandemic, the spread of e-learning, the expansion of communication opportunities and many other factors.

Keywords: E-assessment, online assessment, online evaluation, e-learning, bibliometric analysis.

INTRODUCTION

As a key component for effective learning with an essential role for all educational levels, the assessment process aims to identify students' knowledge, skills and understanding, as well as to promote learning and ensure achievement of intended learning outcomes. Assessment also has an influence over students' approaches to learning and study; assessment process is seen as one of the factors influencing students' perceptions of learning environments (Thomson & Falchikov 1998). It also strengthens the quality of education, facilitating the recognition of the education provided in different institutions. E-assessment is defined as the use of information and communication technologies (ICT) in all processes, from designing assignments to storing results, throughout the assessment process (Joint Information Systems Committee, 2007). Jordan (2013) also stated that the term e-assessment covers the use of computers as part of any assessment-related activity. With the acceleration of e-learning processes, e-assessment practices have become more and more widespread. The rising interest in e-assessment practices and the increasing volume of research on the topic are also associated with the changing nature of higher education and increasing expectations for e-assessment practices (Nicol, 2007).

E-assessment Processes

Besides their numerous advantages and conveniences, e-assessment processes may also cause some limitations and ethical problems due to the misperception-misuse of the process. Opportunity for immediate feedback (Rolim & Isaias, 2019), flexibility to provide different feedbacks (Nikou & Economides, 2018), advantages in terms of spatial access (Peytcheva-Forsyth et al., 2018) and the ability to increase opportunities for self-reflection (Whitelock et al., 2015) are some of the unique advantages offered by e-assessment. On the other hand, Peytcheva-Forsyth et al. (2018) stated that e-assessment practices also have some inherent challenges such as cheating, copying, plagiarism and fake identity, which may reduce the quality of online learning and assessment. Mellar et al. (2018) used student authentication and authorship checking systems in their study to address cheating, which is one of the major problems in e-assessment processes. They noted in their study that most of the teachers considered cheating as a big problem in e-assessment, while student authentication was not perceived as a big problem in well-controlled proctored assessments, and that author checking is important to prevent plagiarism. There have still been a lot of research on different topics in the field of e-assessment, such as effectiveness of assessment, fairness of exams, e-assessment procedure, quality assurance and pedagogical principles (Conn &Norris, 2005; Flavin, 2021; Fructuoso et al., 2018; St-Onge et al., 2022).

Bibliometric Analysis

Particularly in recent years, bibliometric analysis has gained great popularity in research (Khan et al., 2021); it is stated that this popularity is based on its contribution to handling large volumes of scientific data and creating high research impact (Donthu et al., 2021). Given the contribution of a critical view of the past to the progress of the future, systematic reviews of journals with an academic background are seen as a common practice in academia (Rialp et al., 2019). Bibliometric analysis is used to make sense of and decipher large quantities of unstructured data, providing researchers a single general point of view, and can build solid foundations to stimulate progress in a field in unique and meaningful ways (Donthu et al., 2021). The bibliometric method involves the application of quantitative techniques such as citation analysis on bibliometric data such as publication and citation units (Broadus, 1987). Like the bibliometric method, systematic literature searches are also used to provide an overview of research. However, systematic literature reviews are conducted manually by researchers and therefore require a narrow study scope; they include fewer articles for review (Snyder, 2019), and rely on qualitative techniques that can be impaired by the interpretation bias from academics with different academic backgrounds (MacCoun, 1998). Thus, the bibliometric analysis method, which is based on quantitative techniques and can provide a summary of a particular field by handling large quantities of literature, is often preferred especially when the dataset is too large for manual review.

Problem Situation

While e-assessment practices remain a topic for many academic studies with their advantages and limitations, studies aiming to provide an overview of research on e-assessment and to create a general map of research trends are extremely limited. Many reseachers have utilized systematic review method to measure distribution of trend topics, and research effectiveness. For example, in his research to provide an overview based on the articles in three scientific journals on e-assessment, Stodberg (2012) stated that there were generally small-scale studies containing closed-ended questions such as multiple choice questions, and that more longitudinal studies were needed on e-assessment. Gikandi et al. (2011) conducted a systematic qualitative review of the research literature on online formative assessment in higher education, emphasizing validity, reliability, and dishonesty as key issues of assessment upon their research, underscoring the importance of formative and immediate feedback, engagement with critical learning processes, and promoting equitable education. The bibliometric method was used only by Sudakova (2022) , who conducted a bibliometric research on online formative assessment in higher education, analyzing 898 studies searched in the Scopus database, and presented citation analyses, the most influential journals, authors, trend topics, and co-creation networks. Yet, he limited his work to higher education and formative assessment. There is no bibliometric study in the literature that will reveal the map of studies that examine e-assessment in all aspects and educational levels within a general context. As bibliometric analysis provides broader insight through quantitative synthesis of research topics in a particular discipline via citation mapping (Zupic & Cater, 2015), there is a gap in the literature for such studies in which research on e-assessment is examined from a holistic context with this method.

PURPOSE OF THE STUDY

This study aims to reveal the trend of research on e-assessment in the field of educational sciences through scientific mapping and bibliometric analyses. Answers were sought for the following questions in the field of educational sciences in line with this purpose:

1. How is the numerical distribution of research on e-assessment by year, type of publication and country?
2. Which journals, authors, institutions and countries are most cited in the research on e-assessment?
3. What are the themes of research on e-assessment?
4. How is the change of trend topics in the research on e-assessment by year?
5. How is the cluster distribution formed after the text analysis of titles- keywords and abstracts in studies on e-assessment?

METHOD

Data Collection Process

Web of Science (WoS) database was used for the selection of the papers to be examined in the scope of this research. This database was chosen as it has a wider historical scope than Scopus (Balstad & Berg, 2020). The publication review using logical operators and keywords was shaped according to the PRISMA model (Page et al., 2020). Figure 1 provides a summary of how the publication search was shaped.

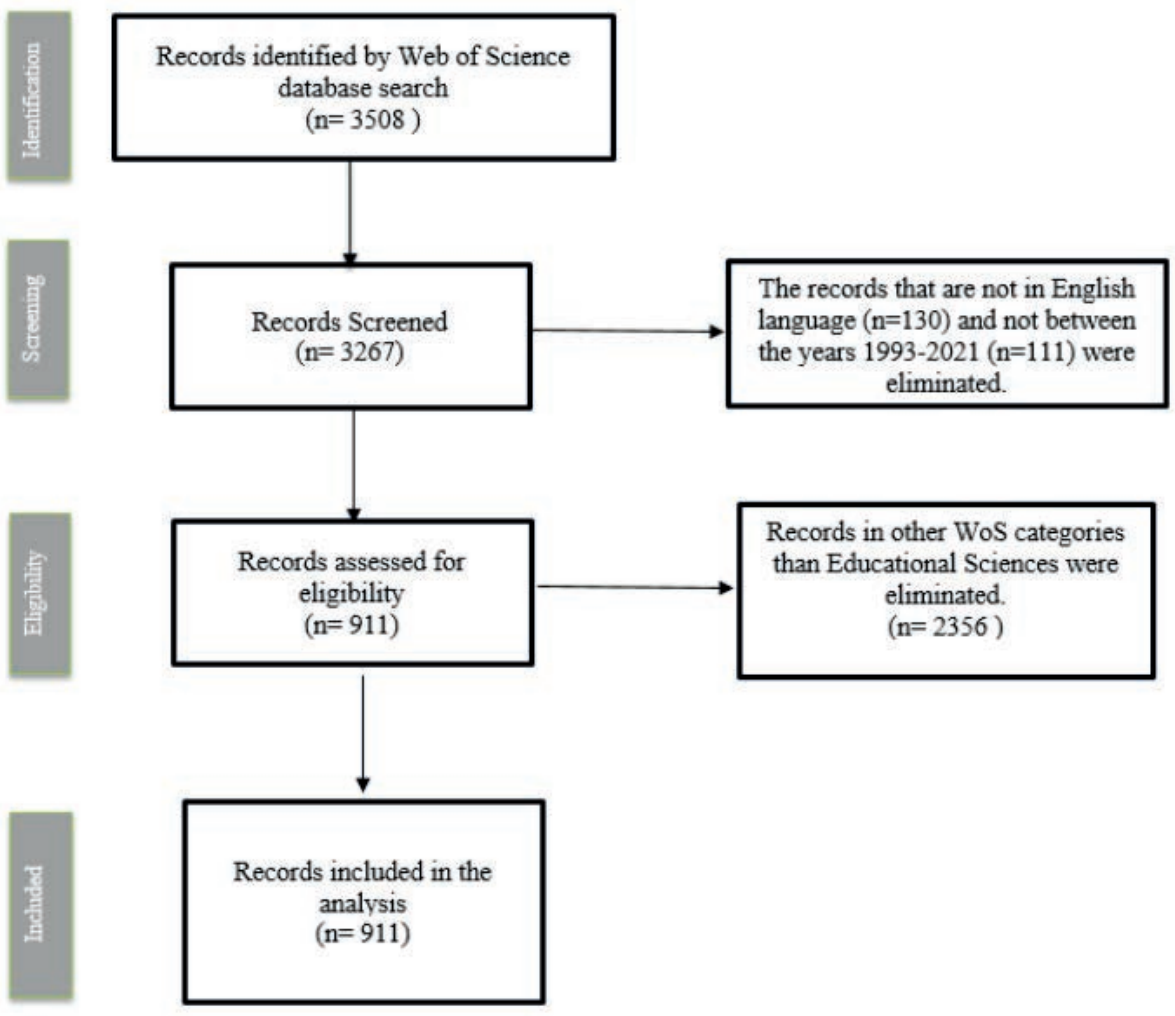

Figure 1. Selection of the publications included in the research by PRISMA method

A search was performed on WoS database on 26.05.2022. Studies in which the terms "online evaluation", "online assessment", "e-assessment" or "e-evaluation" were used in the title, keyword and abstract were searched using logical operators; 3508 records were found. After the records that are not in English language (n=130) and not between years 1993-2021 (n=111) were excluded, and the records in category of Educational Sciences were filtered, the remaining records (n=911) were included in the analysis.

Analysis of Data

VOSviewer, Biblioshiny, Smart Bibliometrics and Leximancer software were used for data analysis in the research. Distribution analyses of the examined publications were made on the information provided by the WoS database, and the worldwide scientific production map was produced by the Smart Bibliometrics software. Biblioshiny, Smart Bibliometrics and VOSviewer were collectively used in citation analysis, common word analysis and trend topic distribution analysis; Leximancer software was used for text analysis of abstracts-keywords and titles. VOSviewer is a free computer software for bibliometric mapping and visualization (Van Eck & Waltman, 2010). Smart Bibliometrics is a free or restricted access software that provides automatic visualization by uploading database files to designated drives (Pessin et al., 2022). Biblioshiny is software created in R, a programming language for statistical computing and graphics, and analyzing information in database files with dynamic graphic visualizations (Massimo & Cuccurullo, 2021). Leximancer is a text-mining program used for the analysis of qualitative data, providing visual display of information in the database in various forms such as concept maps and network clouds through statistics-based algorithms (Smith & Humphreys 2006). The described software were used for citation, distribution and text analyses in line with the questions of this research; the data were carefully reviewed before analysis, combining words with similar meanings and creating 'thesaurus files' of data such as institution-journal-country-author that are referred to in various ways for use in the analyses.

Limitations

This research is limited to e-assessment studies in English between the years 1993 and 2021, searched under the category of Educational Sciences in WoS database. E-assessment studies that are indexed in other databases and not in WoS are excluded from the scope, which constitutes one of the limitations of the research. Bibliometric analysis studies also have some limitations in the aspect that they examine social effects and take metadata into consideration rather than actual data of research (Mishra et al., 2021).

FINDINGS

911 studies covering the period 1993-2021 were analyzed under this research. The numerical distribution of the analyzed researches by year, publication type and countries, the most cited journals, authors, institutions and countries, the research themes of their studies, the change in trend topics and the cluster distribution resulting from text analysis will be presented in Findings section.

Distribution Analysis of Research on E-Assessment

The distribution of the number of publications included in the research by year is shown in Figure 2. There has been a significant increase in the number of studies on e-assessment since 2005, with the highest rank belonging to 2021 with 80 publications.

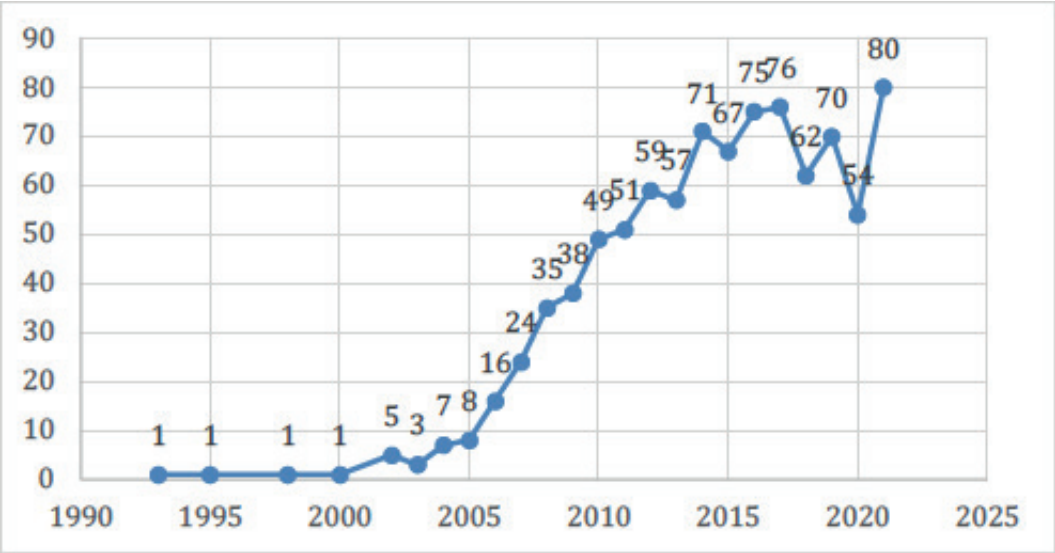

Figure 2. Distribution of the number of publications by year

Figure 3 presents the graphical representation of the distribution of studies by type of publication. As can be seen from Figure 3, research on e-assessment is mostly produced in article format with a rate of 52%, which is followed by conference proceedings with a rate of 41%. Book chapters ranked third with a rate of 4%, followed by early access publications, editorial materials and review papers that account for the remaining 3% altogether.

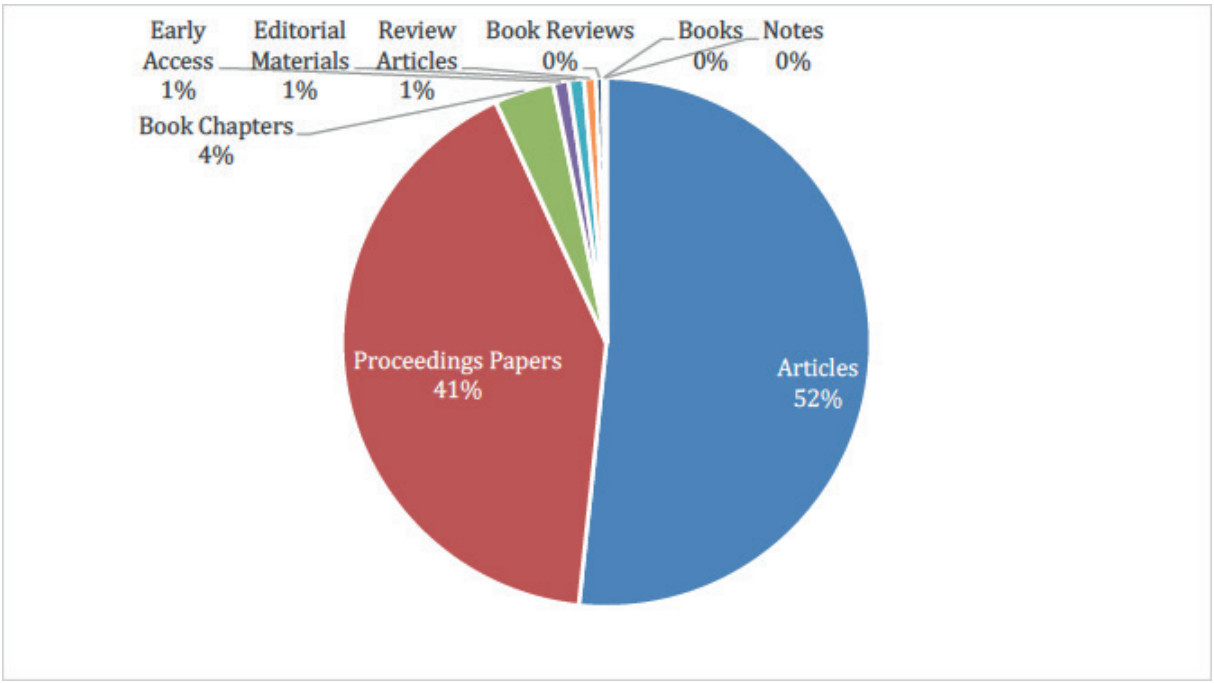

Figure 3. Distribution of studies by type of publication

The ranking of countries by publications produced in the field of e-assessment is shown in Figure 4. Figure 5 presents the worldwide scientific production map of studies on e-assessment. The most productive countries in the field are the USA (n=129), England (n=113), Australia (n=86) and Spain (n=86), as shown by Figure 4. Figure 5 reveals, on the other hand, that scientific production in the field of e-assessment is more prevalent across Europe, North America and Australia.

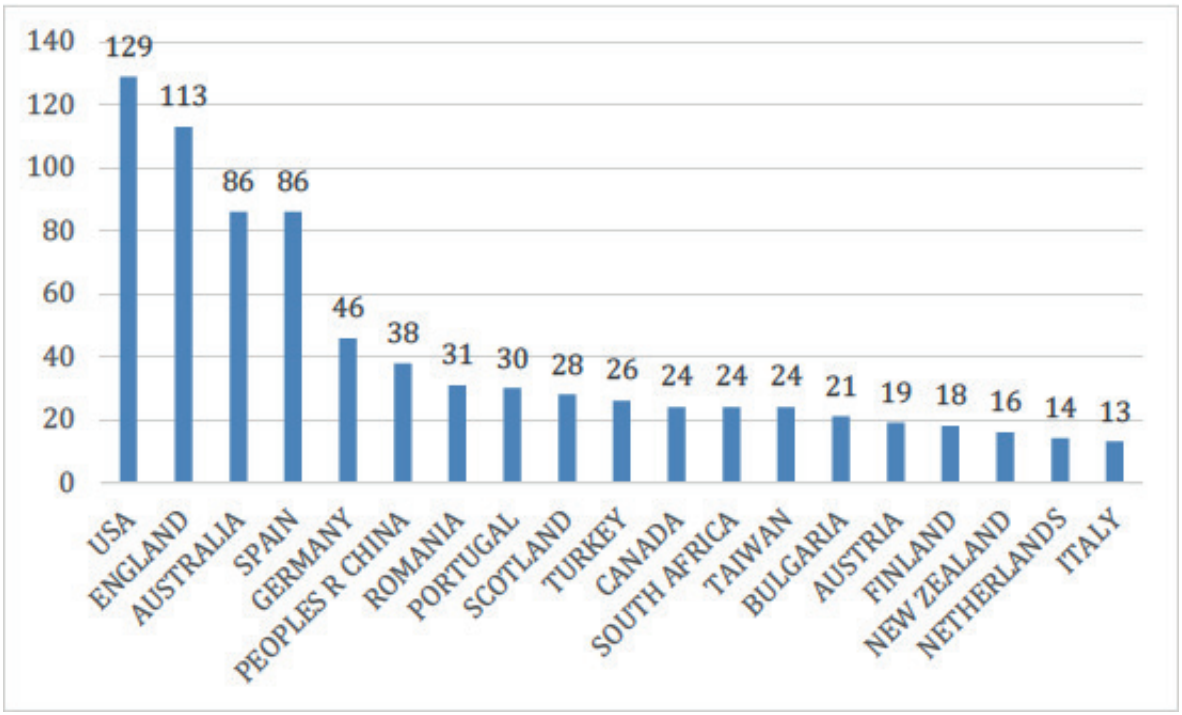

Figure 4. Ranking of countries by number of publications

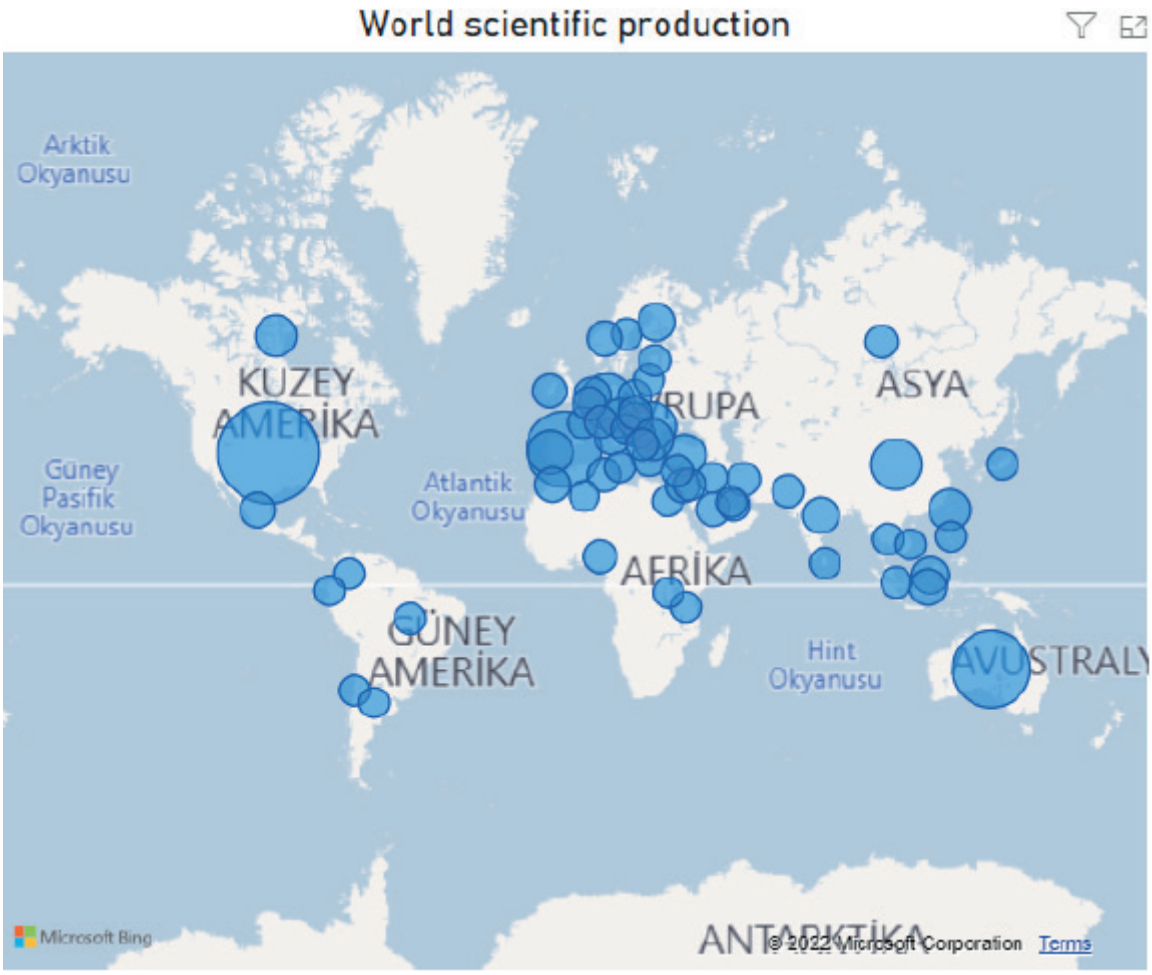

Figure 5. Scientific production map of e-assessment studies worldwide

Citation Analysis

Most Cited Journals and Most Productive Journals

The sources with the highest number of publications in terms of studies on e-assessment are shown in Figure 6. As seen from Figure 6, the International Journal of Emerging Technologies In Learning (n=31), Assessment & Evaluation In Higher Education (n=30) and British Journal of Educational Technology (n=28) are listed as the top sources with the highest number of publications in the field of e-assessment. It is concluded from Figure 6 that Edulearn conferences have an important position in terms of studies on e-assessment.

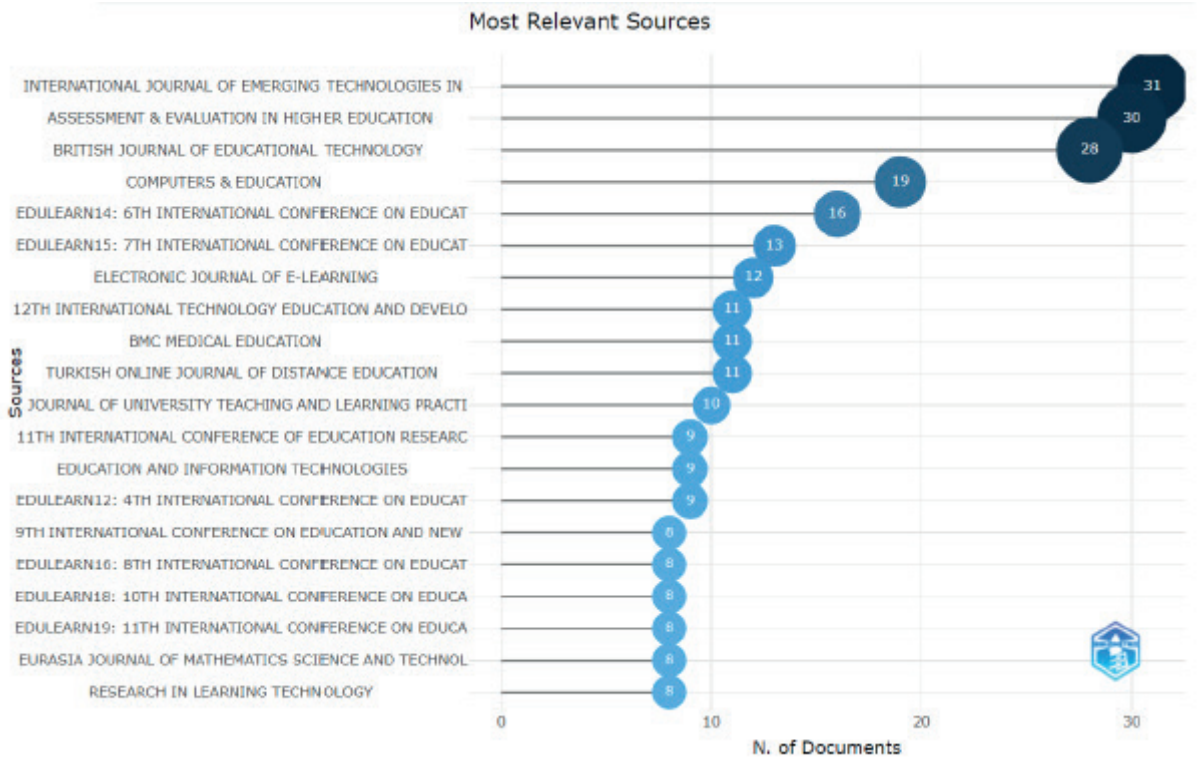

Figure 6. Sources with the highest number of publications in terms of research on e-assessment

The most cited journals in the field of e-assessment are listed in Figure 7 and Table 1. It is seen that Computers & Education (n=960), British Journal Of Educational Technology (n=740) and Assessment & Evaluation in Higher Education (n=554) are the most cited journals.

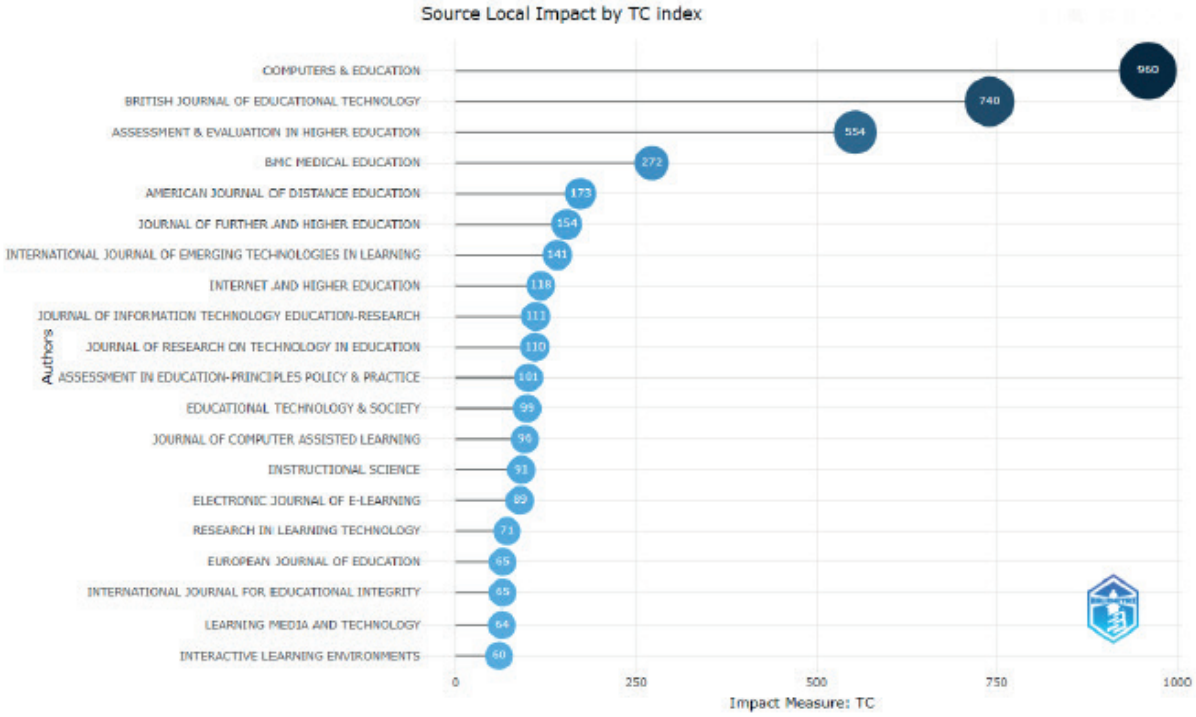

Figure 7. Most cited journals by research on e-assessment

Table 1. Most cited journals by research on e-assessment

Title of Journal	Number of Document	Citation Count	TLS
Computers & Education	19	960	59
British Journal Of Educational Technology	28	740	132
Assessment & Evaluation In Higher Education	30	554	134
Bmc Medical Education	11	272	3
American Journal Of Distance Education	3	173	16
Journal Of Further And Higher Education	2	154	21
International Journal Of Emerging Technologies In Learning	31	141	39
Internet And Higher Education	4	118	13
Journal Of Information Technology Education-Research	3	111	17
Journal Of Research On Technology In Education	1	110	7

TLS: Total Link Strength

In view of the Figure 7 and Table 1, the position of Computers & Education as the most cited journal despite ranking 4th in the list of highest number of publications can be considered as an indicator of the quality of the articles in this journal. British Journal of Educational Technology and Assessment & Evaluation in Higher Education both have the highest number of publications and the highest citation counts, which allows these journals to be considered as the leading sources in the field of e-assessment.

According to Garfield (1980), Bradford's Law claims that a substantial portion (1/3) of articles published on a particular subject or discipline is always composed of a small, core group of sources, while the other 1/3 is composed of a second group of more sources, and the remaining 1/3 comprises a large group that covers a lot more sources. Accordingly, it is suggested that there is a core group of sources in productivity ranking of the scientific journals publishing articles on a particular subject, and that the majority of articles are a part of that core group, arranged in order of decreasing productivity (Bradford, 1934). Figure 7 presents the core source distribution of publications in the field of e-assessment according to Bradford's Law.

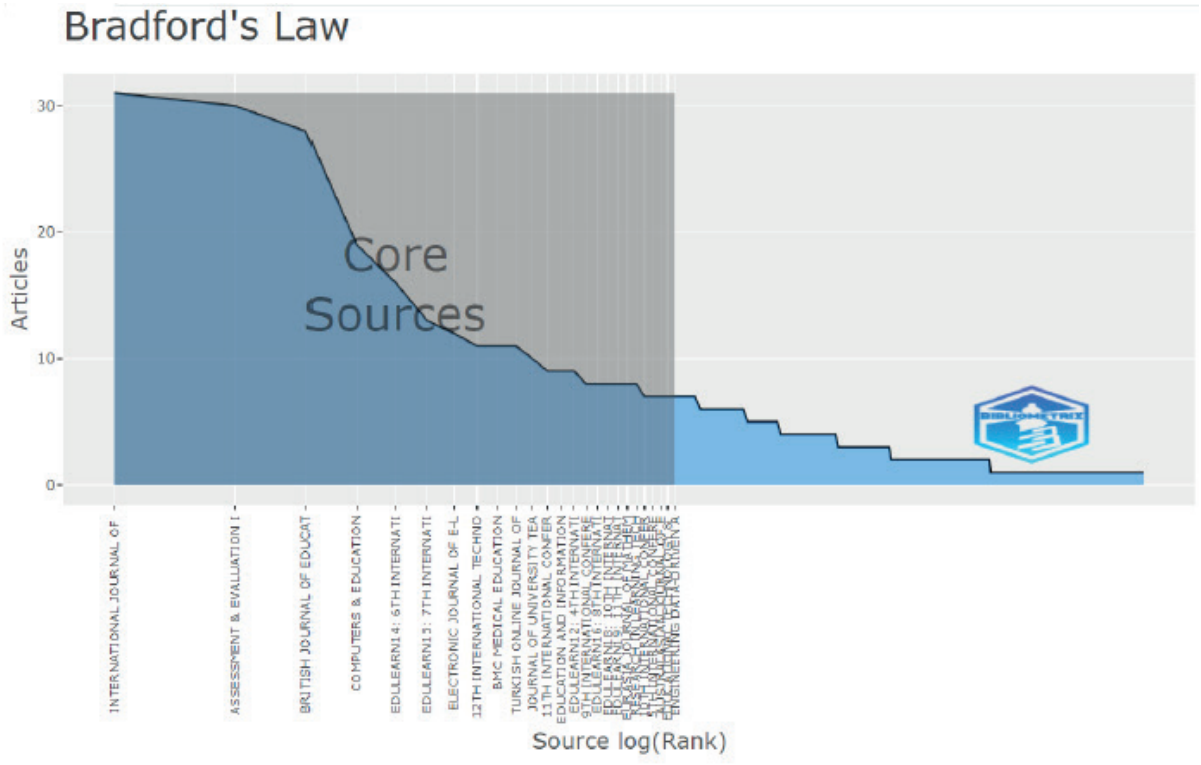

Figure 8. Core group of sources as per Bradford's Law

The findings given in Figure 7 are in parallel with Figure 6, which presents the ranking of the sources with the highest number of publications. It is understood that the International Journal of Emerging Technologies In Learning, Assessment & Evaluation In Higher Education, British Journal of Educational Technology and Computers & Education journals, which represent a significant portion of the core group of journals, are also listed as the journals with the highest number of publications.

Most Cited Authors and Collaboration of Authors

The authors with the highest citation count for research on e-assessment are listed in Figure 9. As shown by Figure 9, Martin Ebner Andreas Holzinger, David Nicol and Gavin Brown are among the top-cited authors.

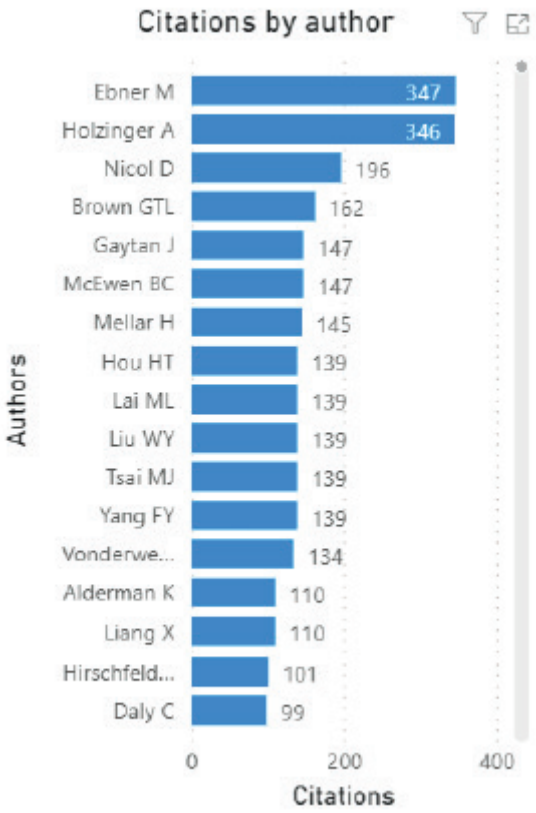

Figure 9. Most cited authors by research on e-assessment

The topics mostly addressed in publications by the most cited authors are seen to include the use of e-assessment in game-based learning, e-assessment design, students' perceptions of assessment, e-assessment strategies, formative assessment, and test reliability methods such as student authentication and authorship checking systems.

Figure 10 presents the distribution of corresponding authors in publications on e-assessment by country. A corresponding author is the person who submits the publication to the journal editor, manages all communicative processes, and has an e-mail address on the first page of the article as a contact person for other researchers (Mattsson et al., 2011). Accordingly, there are a total of 116 articles in which the corresponding author is based in the USA, with the USA ranking the top place. The UK ranks 2nd with 115 articles, Australia 3rd with 68 articles, and Spain 4th with 67 articles in the country ranking of the corresponding authors.

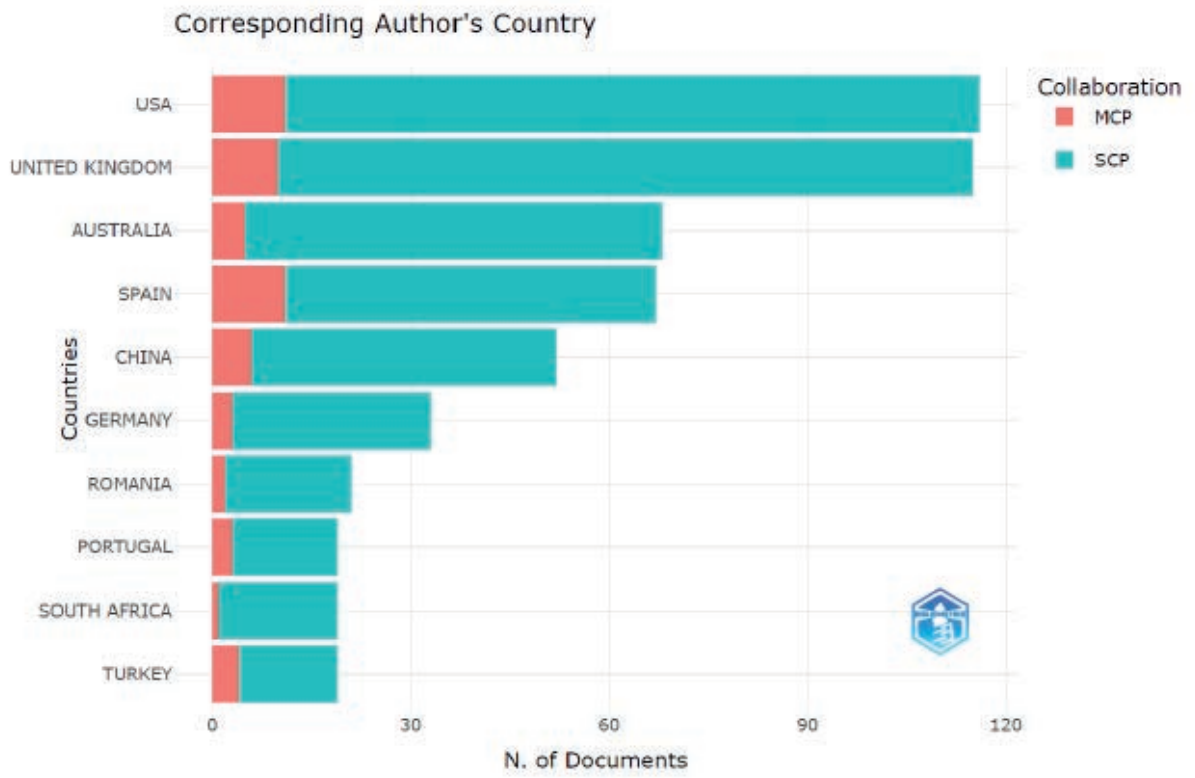

Figure 10. Distribution of corresponding authors by country. (Corresponding author's country. Intra-country (SCP) and inter-country (MCP) collaboration)

Figure 10 also shows the levels of intra-country (SCP) and inter-country (MCP) collaboration in different colors; the numerical equivalent of these representations is presented in Table 2. Table 2 shows the portion of intra-country (SCP) and inter-country (MCP) collaborations in the chart of country distribution of the corresponding authors (Figure 10).

Table 2. The intra-country (SCP) and inter-country (MCP) collaboration

Country	Articles	Freq	SCP	MCP	MCP_Ratio
USA	116	0,14518	105	11	0,0948
UNITED KINGDOM	115	0,14393	105	10	0,087
AUSTRALIA	68	0,08511	63	5	0,0735
SPAIN	67	0,08385	56	11	0,1642
CHINA	52	0,06508	46	6	0,1154
GERMANY	33	0,0413	30	3	0,0909
ROMANIA	21	0,02628	19	2	0,0952
PORTUGAL	19	0,02378	16	3	0,1579
SOUTH AFRICA	19	0,02378	18	1	0,0526
TURKIYE	19	0,02378	15	4	0,2105

According to Table 2, the rate of intra-country collaborations is higher than that of inter-country collaborations in many countries. The countries with the highest inter-country (MCP) collaborations are the USA, the UK and Spain. As for the MCP rate, Turkiye has the highest rate of inter-country collaboration, while Spain, Portugal and China are among the countries with a high rate of inter-country collaboration.

Most Cited Institutions

The list of most cited institutions in research on e-assessment is presented in Table 3. According to Table 3, Graz University of Technology, one of the five universities in Styria, Austria, and the oldest institute of science and technology research-training in Austria, is among the leading institutions in the field of e-assessment with 9 documents and 393 citations. It is followed by the University of Strathclyde in Scotland and the National Taiwan University of Science and Technology in Taiwan.

Table 3. Most Cited Institutions

Institution	Number of Document	Citation Count	TLS
Graz University of Technology	9	393	20
University of Strathclyde	6	232	40
National Taiwan University of Science and Technology	3	193	4
The University of Auckland	7	168	11
National Taiwan Normal University	3	156	2
North Carolina A&T State University	1	147	13
University of West Georgia	1	147	13
Cleveland State University	3	143	13
The University of Hong Kong	4	135	14
The Open University	17	124	77

TLS: Total Link Strength

It is seen that other top ranking institutions by productivity in the field of e-assessment are universities in New Zealand, Taiwan, USA, China and the UK. Also, it is understood that The Open University, an open education institution providing non-formal education at undergraduate level in the United Kingdom, has the highest number of publications in terms of research on e-assessment.

Most Cited Countries

The most cited countries in the field of e-assessment are listed in Figure 11 and the network map is shown in Table 12. The UK with 1443 citations and the USA with 1198 citations are the top ranking countries by a large margin in this field. They are followed by Australia (n: 621) and China (n:541).

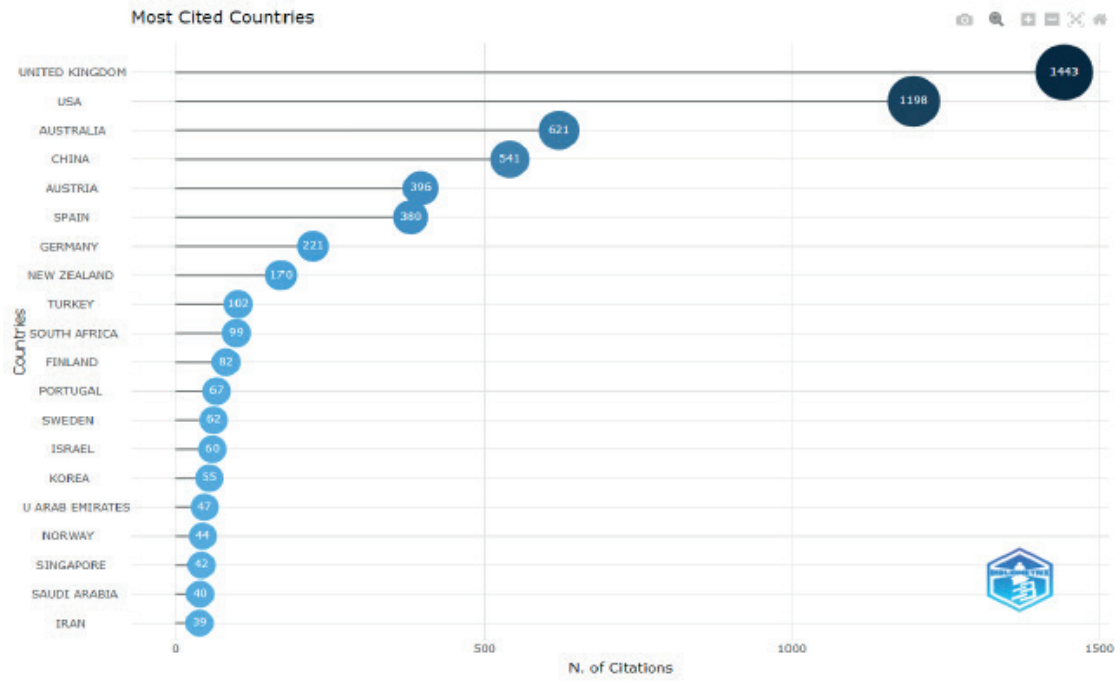

Figure 11. Most cited countries

The circles in the network map of the most cited countries in Figure 12 show the citation frequency, association and influence of that country according to their respective size. As can be understood from this figure, the most cited countries such as the UK (England), USA, Australia, and Spain are represented in a more central position with larger circles, which also confirms Figure 11. On the other hand, countries with weaker citation frequency and link strength are at the far ends of the map.

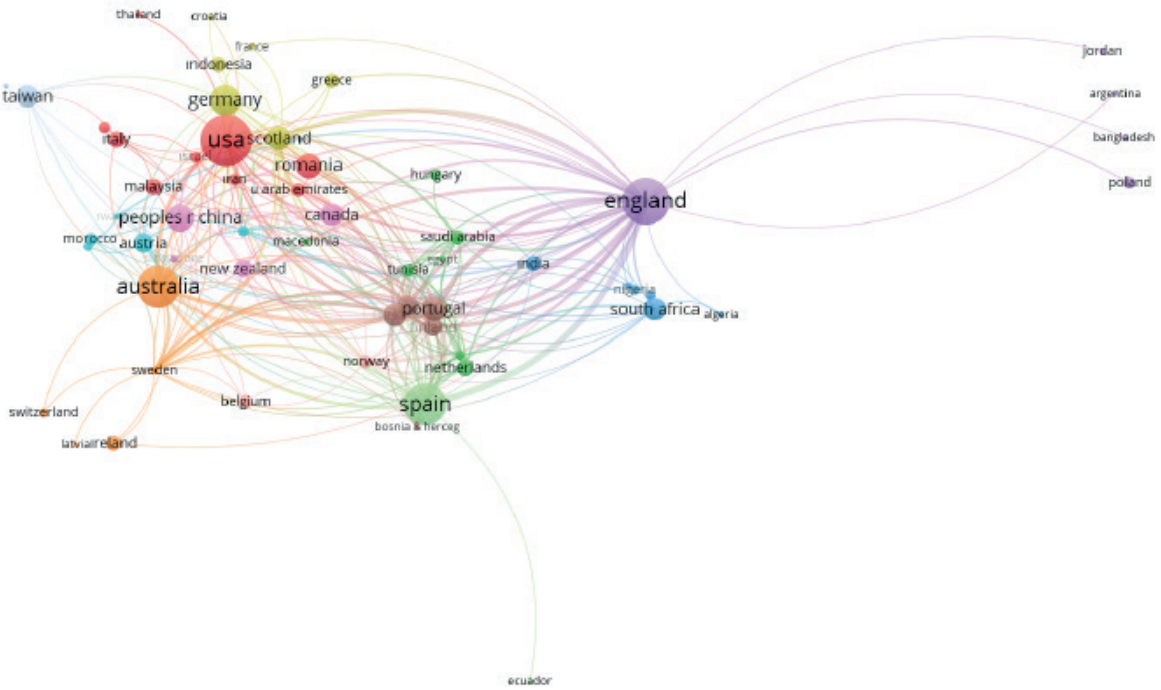

Figure 12. Network map of most cited countries

The 3-field plot in Figure 13 presents the keyword-source-country matching of the reviewed publications. Starting with the keyword and followed by the source, these three items are linked to the country of their publications via gray links. The size of the rectangles in each list indicates the number of publications associated with that item.

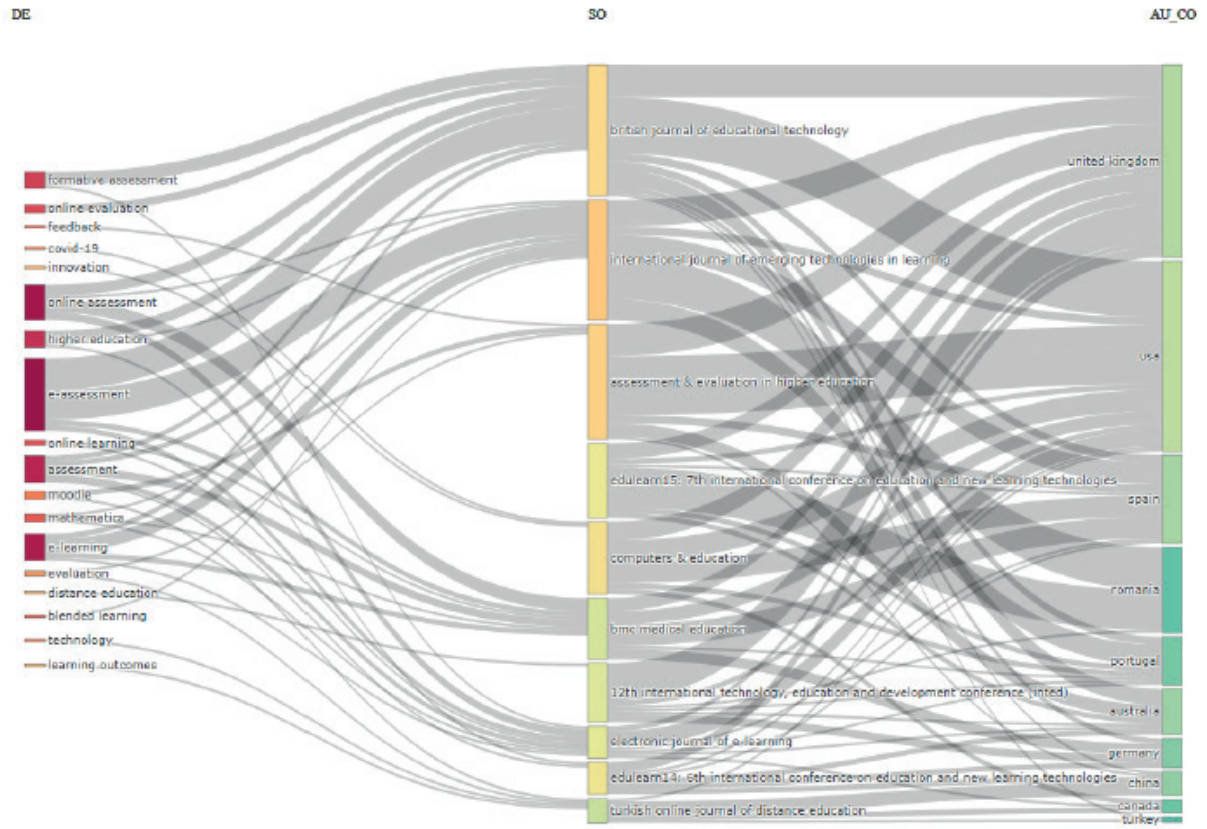

Figure 13. 3-field plot of keyword-source-country matching

When Figure 13 is examined, it is seen that the keywords "online evaluation, e-assessment, assessment, e-learning, higher education and formative assessment" are the most frequently repeated keywords. It is understood that the journals with the highest links for these keywords are British Journal Of Educational Technology, International Journal of Emerging Technologies In Learning and Assessment & Evaluation In Higher Education, and the publications in these journals are also mostly from the UK and the USA, as verified by the information in Figure 6. This supports the dominant position of the UK and the USA regarding publications in this field.

Common Word Analysis (Keyword)

Thematic clustering analysis based on keywords was conducted to explore the key concepts in the publications analyzed. The purpose of keyword analysis is to highlight the direction and main trends of research. Figure 14 provides a network visualization based on the co-occurrence of keywords identified by the authors. VOSviewer was used to visualize the co-occurrence of keywords. VOSviewer is a software that helps to create a bibliometric network and visualize its information. As shown in Figure 6, the larger the size of the circles, the stronger the frequency of occurrence of their keywords. The similar color of the circles indicates the cluster of keywords, and the lines between the circles indicate the link between the keywords (Xie et al., 2020). The minimum number of occurrences of keywords is set to 7. Out of 2116 keywords, 34 met the occurrence threshold of 7. As given in Figure 3, those keywords were divided into clusters based on their co-occurrence with other key words and their total link strength. There are 9 clusters formed.

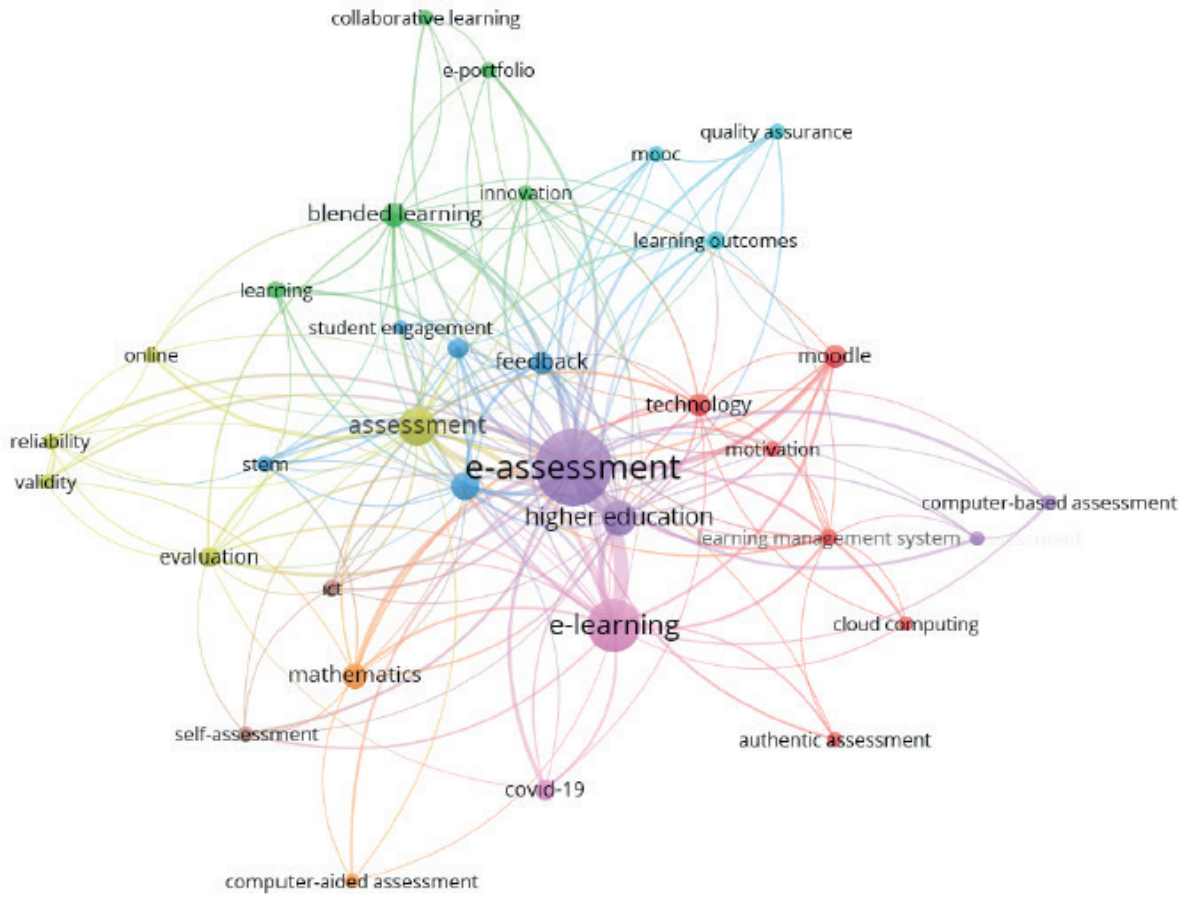

Figure 14. Keyword clustering generated in VOSviewer

Technology and Motivation: The red cluster consists of the words authentic assessment, cloud computing, learning management system, motivation, technology and moodle. Within this cluster, there is notable emphasis on learning management systems, which is one of the technologies used in e-assessment processes, with 3 different words. Moreover, it is seen that motivation and authentic assessment are frequently emphasized in the studies in this cluster.

Blended Learning and Collaboration: The green cluster consists of the words blended learning, collaborative learning, e-portfolio, innovation and learning. The concept of blended learning in this cluster is larger, which indicates that it is repeated more frequently compared to other concepts. The concepts of collaborative learning and e-portfolio are positioned in proximity of each other, which shows that these terms are often studied together.

Interaction and Innovative Approaches: The blue cluster covers the concepts of feedback, formative assessment, learning analytics, stem and student engagement. The concepts of feedback, formative assessment and student engagement, which point out the student interaction with the instructor or with the technical device in the e-assessment process, are gathered in the same cluster, which indicates that these topics related to interaction are frequently studied together. Innovative approaches such as stem and learning analytics have also been frequently associated with these concepts that point to interaction. The concepts of formative assessment and feedback are close to the center and larger than the other terms in the cluster, which indicates that these concepts are frequently studied in other clusters and their frequency of occurrence is high.

Validity and Reliability: The yellow cluster contains the terms assessment, online, validity and reliability. It is understood that the validity and reliability of online evaluation activities are questioned in this cluster. The central position and large structure of the term assessment in the cluster indicates that the term is both frequently repeated and frequently studied.

Higher Education Studies: The purple cluster covers the terms e-assessment, higher education, summative assessment and computer-based assessment. The most repeated word in this cluster is e-assessment, which is positioned at the center of the map, and followed by higher education. This indicates that studies on e-assessment have mostly been conducted at higher education level. It is understood that computer-based and summative assessments are also frequently addressed in e-assessment studies in higher education.

Quality: The turquoise cluster represents studies on learning outcomes, quality and moocs. It is understood from this cluster that the topic of quality is questioned particularly in moocs and learning outcomes.

Basic Disciplines: The terms mathematics, information technologies, computer-aided assessment and self-assessment are seen in the brown and orange clusters, which are two nested clusters. It can be deduced from this data that the two disciplines based on e-assessment studies are information technologies and mathematics, and that studies on self-assessment and computer-aided assessment are mostly related to these two fields.

Covid-19 Process: The pink cluster includes the terms e-learning and Covid-19. It can be understood that this cluster points to research on e-assessment processes in the studies on e-learning, which gained momentum during the Covid-19 pandemic.

Thematic Mapping

Figure 15 shows a thematic map divided into four topological regions based on density and centrality. This map was created by a semi-automatic algorithm with reference to the titles and keywords of all studies analyzed using Biblioshiny, and explains the research themes obtained from the conceptual structure of the documents included in the bibliometric analysis. The clusters in the graph indicate the subjects of the research, and the size of the clusters stands out in proportion to the number of keywords. Each quadrant in the figure represents a different theme. The right upper quadrant of the figure shows motor themes characterized by both high centrality and density. The left lower quadrant contains the subjects that have been used but showing a downtrend, indicated by low centrality and density. The themes placed in the right lower quadrant of the thematic map are known as core themes, while the left lower quadrant represents the themes that appear with low centrality and density.

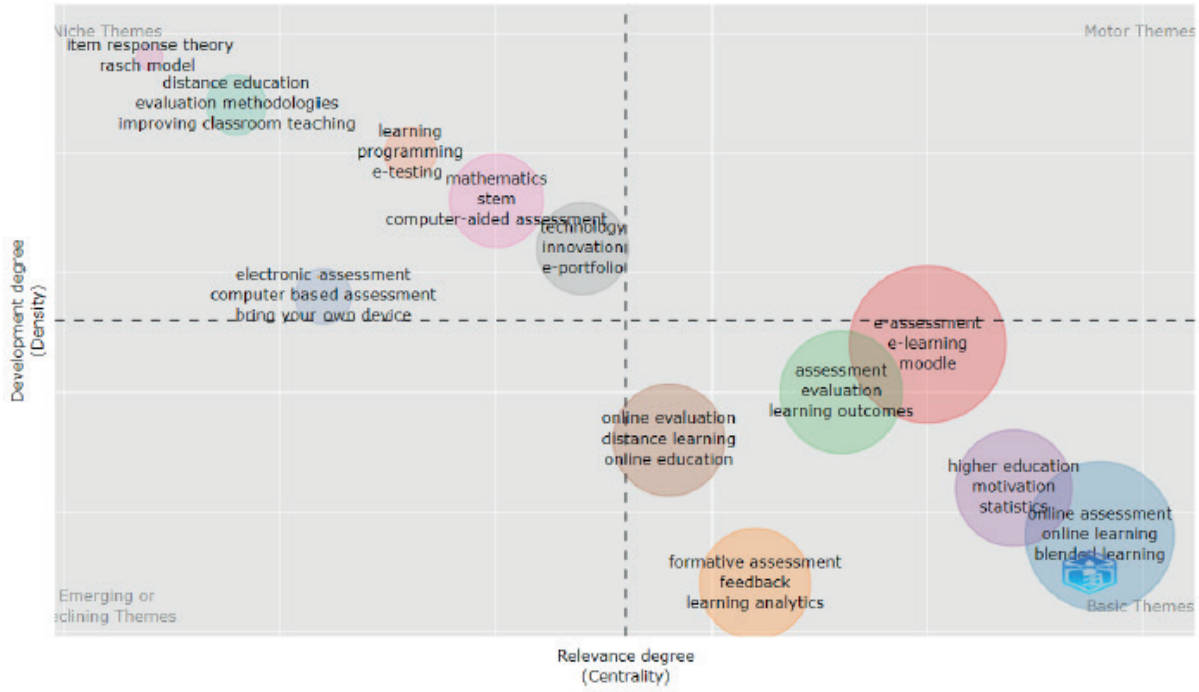

Figure 15. Thematic Map

The right upper quadrant is the area marked by high density and centrality, with e-assessment, e-learning and moodle clusters partially falling under this area. These topics need to be further developed given their importance for future research. The left upper quadrant shows underrepresented topics such as "item response theory", "stem" and "evaluation methodologies" with high density but low centrality, and with the potential to show rapid development. Whereas, the main themes with high centrality but low intensity in the right lower quadrant include topics such as formative assessment, higher education, online learning, and motivation. These are important for research as general topics, and are part of the topic of e-assessment.

Change in Trend Topics by Year

While some topics in the field of e-assessment have become trend topics over the years, others may end up becoming outdated. The changes in trend topics over the years are shown in Figure 16 for the period 1993-2010, and in Figure 17 for 2010- 2021.

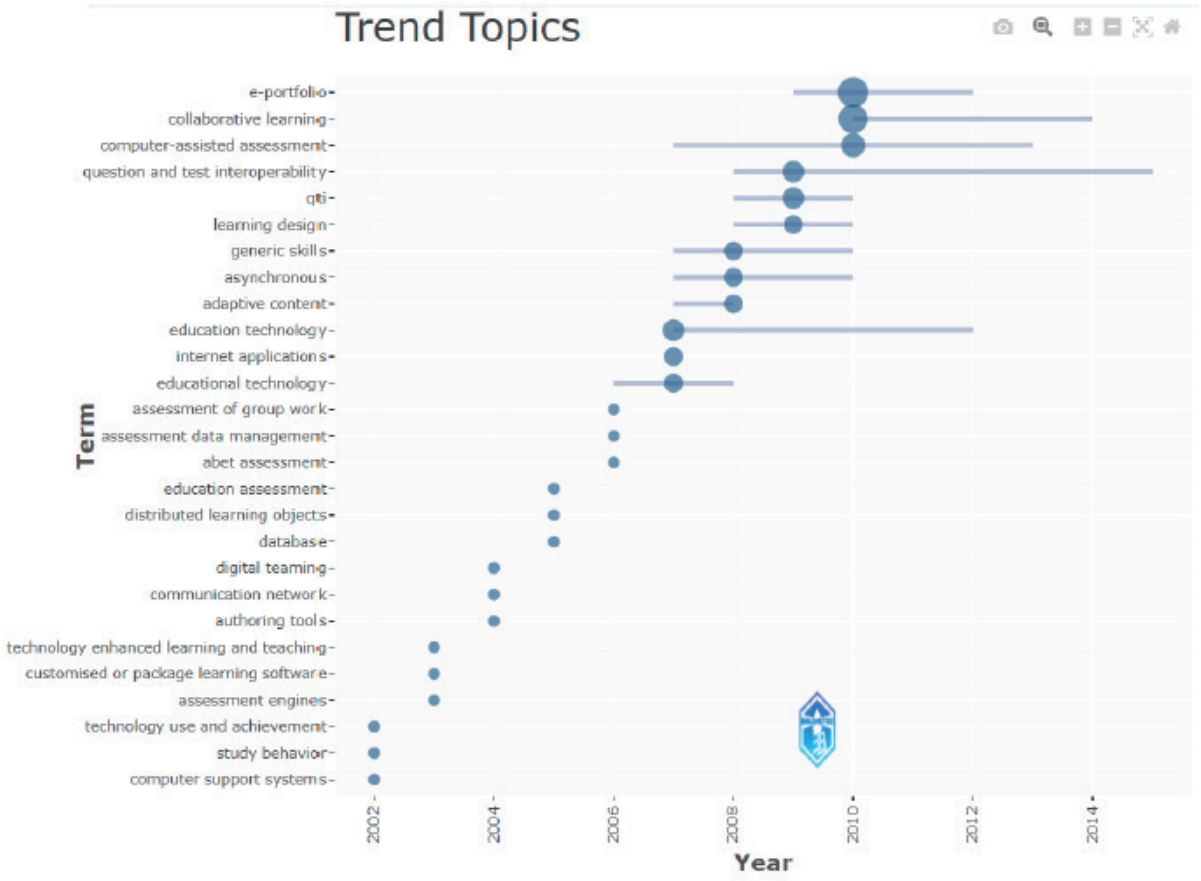

Figure 16. Change in Trend Topics by Year: 1993-2010

It is seen from Figure 16 that the studies on e-assessment in the period 1993-2010 were mostly concentrated on the year 2010, and that the topics of e-portfolio, collaborative learning and computer-aided assessment were the trend topics in the field of e-assessment. Also, Question and Test Interoperability (QTI), educational technologies, asynchronous technologies and adaptive content are among the topics studied frequently.

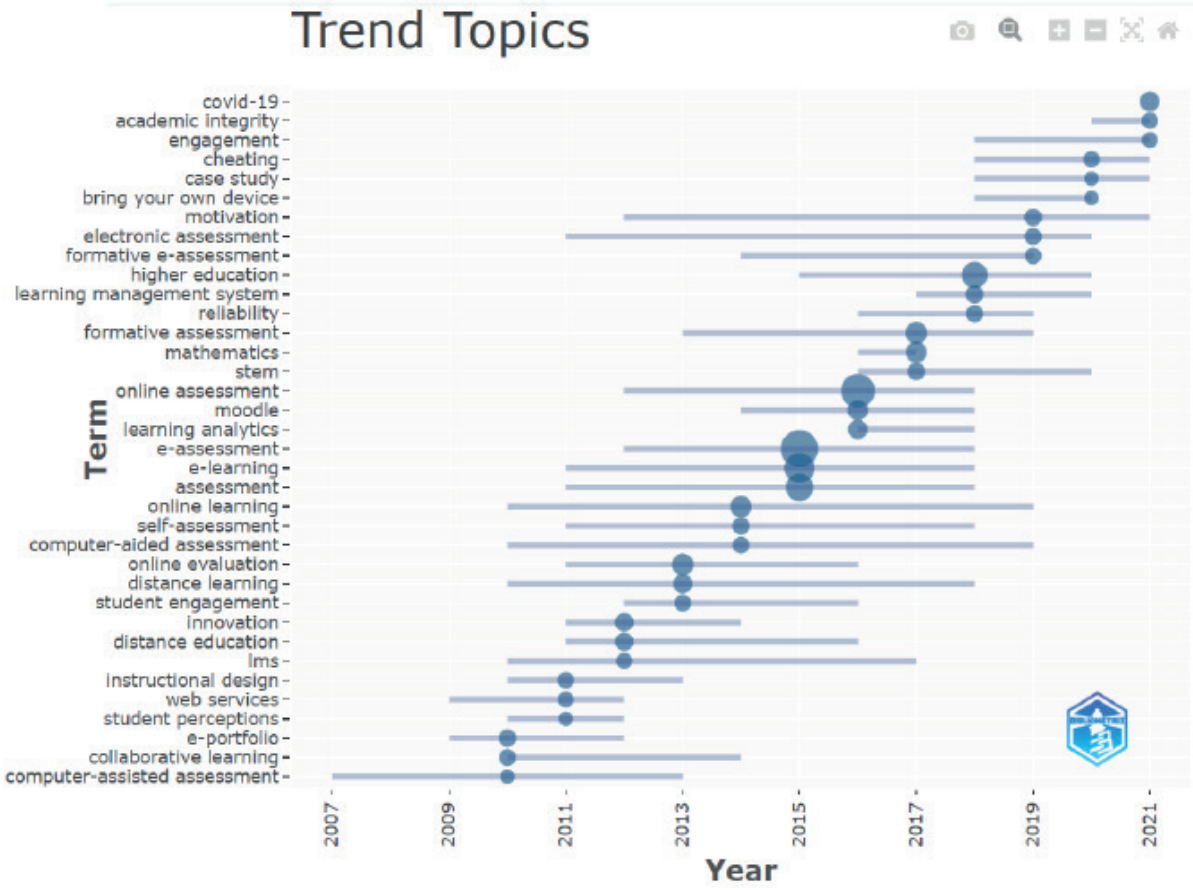

Figure 17. Change in Trend Topics by Year: 2010- 2021

Figure 17 shows that the studies on e-assessment in the period 2010-2021 were mostly concentrated on the period 2015-2018, in which e-assessment, e-learning, online learning, formative assessment, learning management systems, reliability, moodle and learning analytics were the trend topics in this period. A change is observed in the trend topics after the year 2019; it is noteworthy that Covid-19, academic integrity, engagement, cheating, case study, bring your own device and motivation appear as the trend topics in the field of e-evaluation. It is considered that the sudden transition to online education and e-assessment processes in many educational institutions during the Covid-19 pandemic has an impact on this change in trend topics.

Text Analysis of Abstract-Keywords and Titles

Figure 18 presents the thematic concept map created by text analysis via Leximancer software of the abstract-keywords and titles of the studies on e-assessment, which are examined in the scope of this research. Leximancer helps visualize the relationships between concepts based on the frequency of co-occurrence of the words in the analyzed text, enabling identification of thematic regions with colored circles of prominent concepts (Zawacki-Richter & Latchem, 2018). Figure 18 shows that the 8 themes obtained from the text analysis of the abstracts-keywords and titles of the analyzed studies are titled as Assessment, Student, Use, E-Assessment, Education, Feedback, Data, and Problem. These themes demonstrate that studies on e-assessment focus on many different elements related to students, such as performance, difference, group work, tasks, time and level, that feedback, data set and problems cover an important area in the studies on e-assessment, and that the systems, applications, platforms, tools, processes, etc. used in e-assessment mechanisms are of importance. Moreover, it is seen that higher education, technology education, learning outcomes, learning environment and learning support are frequently emphasized within the context of education in the studies on e-assessment, and that formative assessment, assessment methods and approaches are among the frequently studied topics.

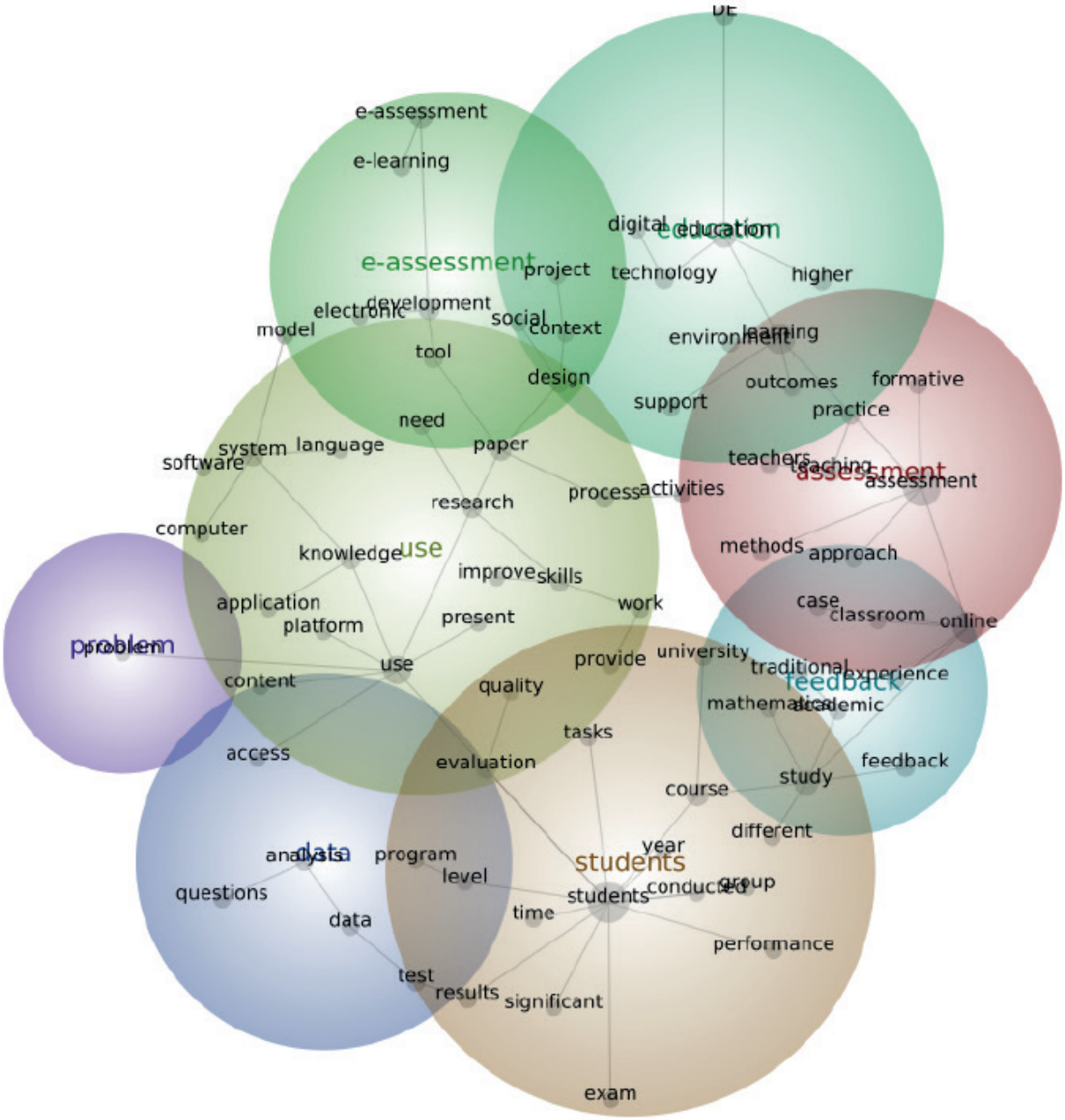

Figure 18. Thematic concept map providing text analysis of keywords, titles and abstracts

The themes presented in the thematic concept maps created by Leximancer are ranked by level of importance in Figure 19, and the concepts that are prominent in terms of count and relevance are presented in Figure 20.

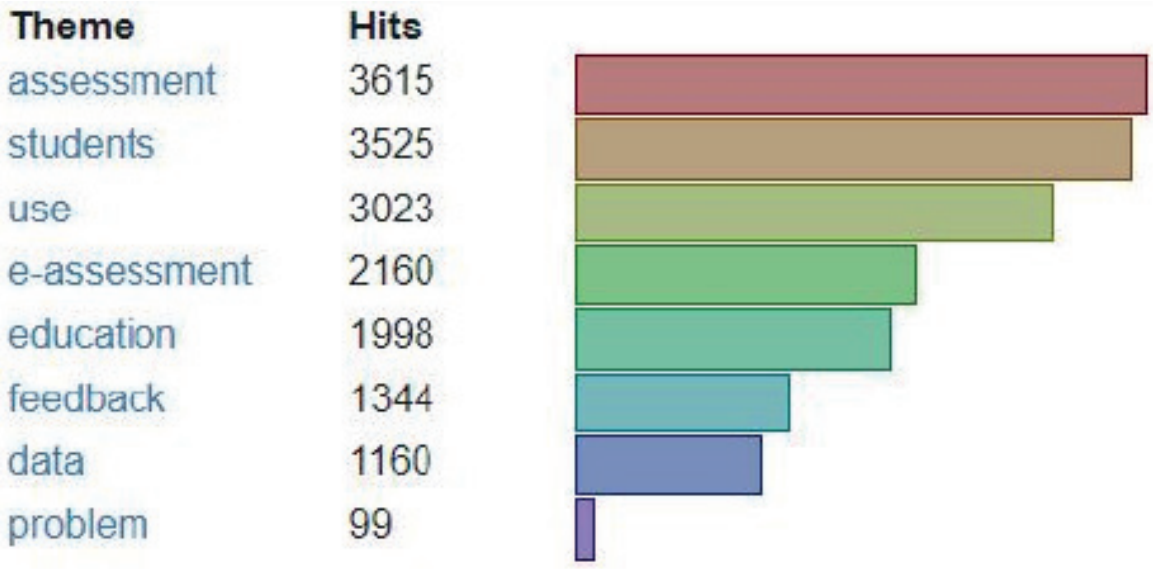

Figure 19. Levels of importance of the themes in the thematic concept map created by Leximancer

Ranked Concepts

Export

	Count	Relevance
students	2530	100%
assessment	2156	85%
online	1518	60%
learning	1364	54%
use	1156	46%
education	974	38%
study	797	32%
e-assessment	790	31%
system	670	26%
course	634	25%
paper	542	21%
development	534	21%
evaluation	463	18%
tool	452	18%
knowledge	444	18%
teaching	443	18%
results	415	16%
test	403	16%
feedback	380	15%
process	379	15%
technology	373	15%
research	369	15%
design	325	13%
data	323	13%
experience	317	13%
higher	311	12%
teachers	307	12%
analysis	286	11%
practice	285	11%
skills	281	11%
e-learning	273	11%
performance	256	10%
questions	251	10%
different	243	10%
formative	236	9%

Figure 20. Major concepts in the thematic concept map created by Leximancer

As can be seen from Figure 19 and Figure 20, the most dominant themes in the studies on e-assessment are Assessment, Student and Use, which leads to the inference that most of the studies focus on students and are concentrated on subjects related to use. An examination of the set of concepts in Figure 20 reveals that, apart from the concepts that stand out as themes, the system, courses, development, tools, teaching and feedback are frequently emphasized in the studies on e-assessment, and given importance in many studies.

DISCUSSION

The distribution of the publications included in the research by year, type of publication and country displayed an increase in studies on e-assessment starting from 2005, and it is seen that the highest number of studies belong to the year 2021. This finding is in parallel to the thesis advocated by studies (Crisp & Ward, 2008; Van der Pol et al., 2008; Wang, 2008) suggesting that effective use of e-assessment can provide meaningful educational experience for teachers and students; more and more studies have been produced on the use of e-assessment. It is understood that the studies produced are mostly published in the form of articles and proceedings. In their study analyzing the research on online formative assessment using the bibliometric method, Sudakova et al. (2022) reported that most of the publications were in article format, which was attributed to the fact that academic journals were indexed at a higher rate in databases.

The top most productive countries in terms of the research on e-assessment are seen to include the USA, England, Australia and Spain; the same ranking is observed in the countries of corresponding authors. The most cited countries are the UK, the USA, Australia and China. Besides these findings, Sudakova et al. (2022) also found that the USA and the UK are the two main centers for studies on e-assessment, and that the USA, the UK, Australia and Spain are also listed in the distribution of the countries of corresponding authors. The fact that studies published in languages other than English and indexed in other databases are not included in the analysis, as well as the fact that journals published in English are mostly indexed in international databases can be shown as the factors that affect this ranking (Tight, 2019).

The sources with the highest number of publications in the field of e-assessment are International Journal of Emerging Technologies In Learning, Assessment & Evaluation In Higher Education and British Journal Of Educational Technology, while the most cited journals are Computers & Education, British Journal Of Educational Technology and Assessment & Evaluation in Higher Education. It is understood that these journals, which represent the core group of journal according to Bradford's Law, are the most effective sources in this field. The top 3 most cited journals in the study conducted by Sudakova et al. (2022) overlap the top 3 most cited journals mentioned in this study, which confirms the leading position of these journals in the field of e-assessment.

The finding that the studies by the most cited authors focus on the use of e-assessment in game-based learning, e-assessment design, students' perceptions of assessment, e-assessment strategies, formative assessment and test reliability methods leads us to the conclusion that these topics are of interest in the field of e-assessment. Furthermore, it is observed that the rate of intra-country collaboration is higher than inter-country collaboration in many countries, and the countries with the highest rate of inter-country collaboration are the USA, the UK and Spain. In parallel with the findings of this study, Sudakova et al. (2022) also indicate that some countries have collaborated solely with the geographical regions in their proximity for studies on e-assessment, while some countries such as the USA and the UK have played a central role in collaboration. The top institutions in the field of e-assessment were found to be the Graz University of Technology in Austria, the University of Strathclyde in Scotland and the National Taiwan University of Science and Technology in Taiwan. Although Taiwan was not listed in the top ten most cited countries, it is worthy of note that two institutions in Taiwan were among the top ten in the list of most cited institutions. It is thought that this may be attributable to the difference in institution-country matching in the articles written via inter-country collaboration.

An examination of keyword clusters in the studies reveals the clusters of technology, motivation, blended learning, collaboration, interaction, innovative approaches, validity and reliability, higher education, quality, basic disciplines of information technologies and mathematics, and Covid-19 process. Cluster analysis of these keywords in publications is important to better understand the direction and research trends of studies on e-assessment. It is similarly reported in the study by Sudakova et al. (2022) that the term blended learning

gained widespread popularity in studies on e-assessment between the years 2010 and 2020, and the term COVID was widely used in publications on e-assessment in 2020. The use of hints, guiding questions and feedbacks in e-assessment processes can have a positive effect on learner motivation (Nicol & Macfarlane, 2006). The validity and reliability of e-assessment processes is among the topics addressed and frequently emphasized in various studies. Gikandi et al. (2011) indicated that the validity of online formative assessment is related to (1) the reality of assessment activities, (2) effective formative feedback, (3) multidimensional perspectives, and (4) student support. The topics of cheating, authentication and authorship checking have been among the frequently addressed key topics in many different studies on e-assessment (Karim & Shukur, 2015; Kocdar et al., 2018; Okada et al., 2019; Peytcheva-Forsyth et al., 2018).

Different mapping techniques were also used in this research in order to better understand the topics of focus in the publications. Given the importance of e-learning and moodle for future research in thematic mapping, there are areas that need further development, that topics such as "item response theory", "stem" and "evaluation methodologies" are the areas of rapid development and yet are underrepresented, and that formative assessment, higher education and motivation are of importance for research as the general topics. Sources indicate that Moodle, the world's leading open source LMS, is used by various academic disciplines as well as in STEM education (Gamage et al., 2022) and the number of Moodle users increased from 78 million in 2015 (Singh, 2015) to over 333 million in 2022 (Moodle Project, 2022), which points to the importance of Moodle in line with the findings of this research. It is stated that learner motivation is one of the main aspects that need to be addressed for a successful learning process, and that evaluation and assessment of learner motivation has been the subject of many studies in the field of e-learning (Ghergulescu & Muntean, 2014). The use of different assessment methodologies by instructors providing online education is considered significant in terms of facilitating interactions and developing effective learning communities, particularly in online and mixed environments (Akyol et al., 2009). The themes obtained from the text analysis of the abstracts, keywords and titles of the studies reveal that the studies on e-assessment focus on the main topics of Student, Use, Education, Feedback, Data, and Problem, and that differences regarding students, feedback, data set, systems used and problems are frequently addressed in the studies. Gikandi et al. (2011) also stated that student progress should be tracked and evaluated so as to ensure the acquisition of meaningful information, and noted the importance of feedback and student engagement in online formative assessment.

When the change in trend topics over the years is examined, it is seen that the topics such as e-portfolio, collaborative learning and computer-aided assessment, which were the trend topics between 1993 and 2010, were then replaced by topics such as formative assessment, learning management systems, reliability and learning analytics between 2010 and 2021, and that topics such as Covid-19, academic integrity, engagement, cheating, case study, motivation have come to the fore in the field of e-assessment after 2019. The listing of formative assessment, assessment methods and approaches, and reliability among the frequently studied topics in all types of analysis points to the importance of these topics in studies on e-assessment. Studies that describe formative assessment as "assessment for learning" and (Akiri et al., 2021; Na et al., 2021) underscore the role of formative assessment in providing feedbacks to enable better learning of students (Cong et al., 2020) similarly emphasize the importance of this type of assessment.

CONCLUSION AND SUGGESTIONS

This study aims to reveal the trend of research on e-assessment in the field of educational sciences through bibliometric analysis. For this purpose, 911 publications between 1993-2021 from the WoS database were included in the research using PRISMA method, and their distribution and citation analyses, research themes, changes in trend topics and text analyses were examined. VOSviewer, Biblioshiny, Smart Bibliometrics and Leximancer were used for the analysis of data.

As revealed by the results of the research, the development of research on e-assessment has followed an upward trend in the literature over time; the USA, the UK and Australia have been the top ranking countries in terms of research on e-assessment, and majority of the studies in the literature have been published in the form of articles and conference papers. The British Journal of Educational Technology and Assessment & Evaluation in Higher Education, the journals with the highest publication and citation counts, have been among the most notable sources in the field of e-assessment. The topics of the most cited authors' publications

particularly reveal the focus on the importance of the game-based approach, assessment design, student perceptions of assessment, assessment strategies, and test reliability in the field of e-assessment. It is observed that the rate of intra-country collaboration is higher than inter-country collaboration in many countries, and the countries with the highest rate of inter-country collaboration are the USA, the UK and Spain. On the basis of keyword analysis, we can conclude that technology, motivation, blended learning, collaboration, interaction, innovative approaches, validity and reliability, higher education studies, quality and the Covid-19 are frequently emphasized in the field of e-assessment. Furthermore, differences regarding students, feedback, data set, systems used and problems are among the most commonly addressed topics in e-assessment process. As for the change in trend topics, it is seen that the topics such as e-portfolio, collaborative learning and computer-aided assessment were then replaced by topics such as formative assessment, learning management systems, reliability and learning analytics, and that topics such as academic integrity, engagement, cheating, case study, and motivation have come to the fore in the literature after the Covid pandemic.

The results of this research, which aims to provide an understanding of the general trend of studies on e-assessment in the field of education, demonstrate how e-assessment practices have been developed and transformed in parallel with the development of technology, the pandemic, the development of e-learning practices and systemic differences in use, and present the current situation of the literature from a broad perspective. Further research to examine the developments in the field of e-assessment with supporting studies in different databases and languages can provide a better analysis of trends in this field, rapidly developing areas, areas with inadequate research coverage, and current trends, and help offer a more holistic view to the literature. Also, it is anticipated that articles that will reveal the scientific maps of the studies on the practice of formative and summative e-assessment at different levels will enrich the field. The systematic analysis of the literature within the context of validity-reliability, academic integrity and cheating, which are commonly addressed topics on e-assessment after the period of Covid pandemic, is considered important for providing a clearer picture of the developments in this field and identifying the gaps in the literature.

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