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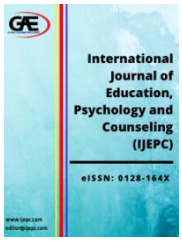

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EVOLVING TRENDS OF TECHNOLOGICAL INNOVATION IN EDUCATIONAL ASSESSMENT: A BIBLIOMETRIC ANALYSIS

Nurulhuda Hassan[1], Mohd Nazri Abd Rahman[2*], Bambang Sumintono[3]

[1] Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia
Email: nuhaone@gmail.com
[2] Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia
Email: mohdnazri_ar@um.edu.my
[3] Faculty of Education, Universitas Islam Internasional Indonesia, Indonesia
Email: bambang.sumintono@uiii.ac.id
[*] Corresponding Author

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Abstract:

This study is a bibliometric analysis investigating the incorporation of technology in educational assessment. This study aims to analyze the influence of these developments on assessment methods in schools, considering the increasing integration of technology due to the availability of digital tools and the emphasis on data-driven, individualized learning. This study examines the current patterns in academic research, identifies important topics, and investigates the impact of technological breakthroughs such as Artificial Intelligence (AI) on teaching methods and educational policies. The objective is to provide guidance for future educational strategies and assessments. We utilize a bibliometric methodology, utilizing the Scopus database to extract pertinent publications. The inclusion criteria pertain to works published from 2014 to 2023, with a specific focus on Technological Innovation in Educational Assessment. Analyzed are key bibliometric indicators, including publishing patterns, prolific authors, and subject distribution. The study utilizes visualization methods to depict co-authorship networks, citation patterns, and theme clusters. Co-authorship networks and citation patterns provide insights into collaborative efforts and the spread of impactful research. This bibliometric analysis sheds light on the changing scholarly landscape of Technological Innovation in Educational Assessment. The detected tendencies enhance our comprehension of the intricate and diverse characteristics of research in this sector. Given the ongoing importance of technology innovation in education, the findings of this study provide a basis for future research, policy development, and educational methods within a country.

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Keywords:

Technology, Measurement, Assessment, Evaluation, Educational

Introduction

The integration of technological advancements into Educational Assessment has emerged as a crucial topic of investigation and growth in the constantly changing field of education (Anon 2021; R. Balmes 2022) "Evolving Trends of Technological Innovation in Educational Assessment in Schools," a bibliometric analysis, attempts to map and investigate the trajectory of technological innovations and how they are methodically incorporated into educational evaluation. The main goal is to comprehend how these developments have changed how schools use assessment techniques, an important part of educational reform and efficacy.This research is necessary because of the speed at which technology is being incorporated into education, fueled by several variables. This includes the growing accessibility of digital tools, the trend towards data-driven instructional tactics, and the demand for more personalized and flexible learning methods (Gorgoretti 2019; Kalimullina, Tarman, and Stepanova 2021). The need for creative and efficient assessment instruments cannot be overstated, especially in educational environments where basic knowledge and skills are taught (Nathan et al. 2013). These resources help teachers better understand how students learn and improve their capacity to modify their lessons to fit a range of student needs (Dinçer and Çengel-Schoville 2022; Zhang 2022).

In this piece, the publications and research trends in the field of educational measuring technology are traced through a thorough bibliometric journey. This study uses bibliometric methodologies to determine research gaps and important themes, highlight the most influential publications, and determine the global distribution of research activities in this field. The investigation explores a variety of technology interventions, from cutting-edge innovations like Artificial Intelligence (AI), machine learning, and gamification in assessments to digital assessment platforms and learning analytics. The study also seeks to shed light on how these technological advancements affect instructional strategies, policymaking, and educational outcomes. It aims to comprehend how these tools have been accepted by teachers and students in equal measure, as well as how well they have enhanced the evaluation process (Contents and Board 2023; Ma, Wang, and Teng 2021). The ultimate objective is to offer a road map for the next studies and advancements in this important field of education, showing the way toward more inclusive, productive, and successful educational assessment methods.

By providing a thorough overview of the past, present, and possible future of technological integration in Educational Assessment, "Evolving Trends of Technological Innovation in Educational Assessment in Schools" hopes to make a significant contribution to the discourse on Educational Technology (EdTech) through this bibliometric analysis by focusing on four main research questions:

(a) The evolution and distribution of research on Technological Innovation in Educational Assessment. (b) The most productive and effective countries, institutions, and authors in Technological Innovation in Educational Assessment studies. (c) The common themes in Technological Innovation in Educational Assessment among scholars. (d) The most influential

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articles in the field of Technological Innovation in Educational Assessment studies. This paper extensively examines several subjects and variables pertaining to the research questions and offers detailed information on the study's methodology, findings, and interpretations.

The bibliometric analysis examined the literature on Technological Innovation in Educational Assessment to address these four issues, taking into account the following aspects:

(a) What is the evolution and distribution of technological innovation in Educational Assessment research? The metrics that are commonly used to evaluate research impact include the annual number of published studies, the annual number of cited publications, the total number of citations per year, the average number of citations per publication for each year, the average number of citations per cited publication for each year, the h-index, and the g-index. • The sorts of papers • The languages of the documents • The subject area

(b) Which countries, institutions, and authors demonstrate the highest level of productivity and effectiveness in the field of Technological Innovation in Educational Assessment studies? • Titles with the highest level of activity • Publishers with the highest level of activity • Countries with the highest level of activity • Institutions with the most impact • Examination of Citation Metrics

(c) What are the predominant themes in Technological Innovation in Educational Assessment as identified by scholars? • Analysis of Keywords • Analysis of Text

(d) Which articles have had the greatest impact on the subject of Technological Innovation in Educational Assessment studies? • Analysis of authorship and co-authorship. This study aimed to gain a comprehensive understanding of the global impact and collaborative nature of Technological Innovation in Educational Assessment phenomena. Examining the latest data was crucial in furnishing researchers with the necessary knowledge to propose further inquiries into the development of Technological Innovation in Educational Assessment.

Literature Review

The convergence of AI and machine learning is leading to a dramatic revolution in the field of Educational Measurement and Assessment. These technologies, which were first applied to credit risk management in industries such as banking, are already transforming education. By tailoring instructional materials according to an in-depth understanding of student performance and learning requirements, they improve educational data analysis and enable personalized learning experiences (Almustafa, Assaf, and Allahham 2023; Liang 2023; Thambusamy and Singh 2021). Additionally, by automating tedious processes, AI and machine learning help to improve assessment accuracy and dependability while freeing up teachers to concentrate more on essential teaching activities (Almustafa et al. 2023; Monib 2021). Novel instruments, like in-the-moment attention-tracking devices, have been created to comprehensively understand student involvement (Thambusamy and Singh 2021).

Alongside these technological developments, the evolution of online assessment platforms has been essential. These platforms, essential to remote learning environments, differ in usability, security, and platform support, affecting how effective they are in various learning environments (Topuz et al. 2022). There is ongoing discussion on the suitability and extent of online exams, particularly in higher education. This underscores the need to make well-

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informed choices when using digital assessment instruments (Ali, Barhom, and Duggal 2023; Thambusamy and Singh 2021). These platforms could benefit from the incorporation of AI, but there are also questions about dependability and academic integrity raised by this development (Buckingham Shum 2023). Moreover, there is a growing movement in favour of authentic assessment, which argues for a change from conventional to more useful and real-world assessment techniques (Karadağ 2023).

Digital technologies for formative assessment are changing the face of educational evaluation in the field of EdTech. These resources complement ongoing observation and criticism and are consistent with cutting-edge pedagogical ideas such as the New Ukrainian School (Ukashatu 2021). Several factors are considered when evaluating digital assessment platforms, such as features, cost-effectiveness, and psychometrics, underscoring the significance of making well-informed decisions (Ali et al. 2023). According to research, professional development techniques are crucial for establishing trust and promoting teachers' acceptance of AI-powered EdTech (Nazaretsky et al. 2022).

Data analytics is having a big impact on educational assessment since it allows educators to make data-driven decisions, as demonstrated by technologies like the Visualisation Literacy Assessment Tests (VLAT) (Almustafa et al. 2023; Zhorova et al. 2022). New modes of assessment, including monitoring, feedback, and intervention, are being introduced in higher education through the use of learning analytics (Lee, Kim, and Kwon 2017). Notwithstanding their advantages, the scalability and acceptance of these analytical tools pose certain difficulties. Issues of trust, sustainability, and the requirement for a balanced approach to AI integration in educational contexts are brought to light by the growing acknowledgment of AI's ability to improve the effectiveness and accuracy of educational assessments (Buckingham Shum 2023; Caspari-Sadeghi 2023; Owan et al. 2023). In order to ensure the efficient and responsible use of emerging technologies in educational contexts, this era of transformative innovation in educational assessment necessitates constant adaptation and critical review.

Methodology

Bibliometrics refers to the integration, organization, and analysis of bibliographic data derived from scientific publications (Alves, Borges, and De Nadae 2021; Assyakur and Rosa 2022; Verbeek et al. 2002). In addition to basic descriptive information such as publishing journals, publication year, and major author classification (Wu and Wu 2017), it also includes advanced approaches like document co-citation analysis. To achieve a successful literature review, it is essential to follow a systematic procedure that includes identifying relevant keywords, conducting a thorough literature search, and analyzing the collected information. This iterative approach helps create a full bibliography and obtain reliable results (Fahimnia, Sarkis, and Davarzani 2015). Given this, the study aimed to concentrate on high-quality publications since they provide useful insights into the theoretical viewpoints that influence the development of the research field. In order to guarantee the accuracy of the data, the study utilized the Scopus database for data collecting (Al-Khoury et al. 2022; Khiste and Paithankar 2017; di Stefano, Peteraf, and Veronay 2010). Furthermore, to guarantee the incorporation of top-notch publications, only articles published in meticulously peer-reviewed scholarly journals were considered, deliberately excluding books and lecture notes (Liu et al. 2015). Significantly, Scopus, a renowned database maintained by Elsevier, enabled the gathering of papers from 2019 to December 2023 for further research due to its comprehensive coverage.

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Data Search Strategy

The study utilized a screening process to identify the specific search phrases for retrieving articles. The study began by searching the Scopus database using the search terms "technology" AND "assessment" OR "measurement" OR "evaluation" AND "education" in the "Article title, abstract and keywords" box. This resulted in a total of 54,763 articles being gathered. Subsequently, the query string was modified to prioritize the search phrases "technology" AND "assessment" OR "measurement" OR "evaluation" AND "teacher" specifically for instructors. A total of 4091 results were obtained using this method. Subsequently, only research publications written in English were considered, whereas article reviews were deliberately eliminated. The ultimate process of refining the search string resulted in a total of 1006 publications, which were subsequently utilized for bibliometric analysis (Table 1). Furthermore, the publications were carefully evaluated based on the study's specific criteria for inclusion and exclusion, as outlined in Table 2. Incorporated in the study were all papers from the Scopus database pertaining to technology and assessment with a specific focus on teachers as of December 2023).

Table 1: The Search String

Scopus
TITLE-ABS-KEY (technology AND education AND (assessment OR measurement OR evaluation) AND teacher AND school) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "NURS") OR EXCLUDE (SUBJAREA , "PHAR") OR EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "NEUR") OR EXCLUDE (SUBJAREA , "BIOC")) AND (LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023)) AND (EXCLUDE (EXACTKEYWORD , "Austria") OR EXCLUDE (EXACTKEYWORD , "Cervical Spinal Cord Injury") OR EXCLUDE (EXACTKEYWORD , "Animal Parasitosis") OR EXCLUDE (EXACTKEYWORD , "University") OR EXCLUDE (EXACTKEYWORD , "Nursing Education") OR EXCLUDE (EXACTKEYWORD , "Major Clinical Study") OR EXCLUDE (EXACTKEYWORD , "Clinical Article") OR EXCLUDE (EXACTKEYWORD , "Medical Profession") OR EXCLUDE (EXACTKEYWORD , "Cerebral Palsy") OR EXCLUDE (EXACTKEYWORD , "Higher Education") OR EXCLUDE (EXACTKEYWORD , "Colleges And Universities") OR EXCLUDE (EXACTKEYWORD , "Sustainable Development"))

Table 2: The Selection Criterion of Searching

Criterion	**Inclusion**	**Exclusion**
Language	English	Non-English
Timeline	2014 – 2023	< 2013
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

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Data Cleaning and Harmonization

After identifying the bibliometric data, the authors exported the data from the Scopus database into a file formatted with comma-separated values (.csv). By applying filters to the retrieved data records from Scopus, the researchers found 4091 original research papers, taking into account the nature of publication and duplication. Afterward, the researchers performed data cleansing and verification on the pertinent study publications. Data purification procedures were performed to identify any missing or erroneous input entries by carefully inspecting the field columns to ensure that no important data was omitted. Furthermore, it was confirmed that the data in each field was properly matched with its corresponding field title. The researchers examined the title, abstract, and keywords of the papers in order to selectively identify pertinent articles on Technological Innovation in Educational Assessement. The researchers ultimately incorporated 1006 authentic research publications for bibliometric analysis.

Data Analysis

VOSviewer, created by Nees Jan van Eck and Ludo Waltman at Leiden University, is a user-friendly bibliometric programme that is highly regarded for its capacity to convert intricate bibliometric data into easily understandable visual network representations, clusters, and density maps (van Eck and Waltman 2010, 2017). It provides a dynamic method for examining scientific literature, with a special focus on visualizing networks of co-authorship, co-citation, and keyword co-occurrence. This enables researchers to understand research fields, assisting them in analyzing complex research topics. The software's regular updates guarantee its status as a top tool in bibliometric analysis.

The analysis was conducted using VOSviewer version 1.6.19, utilizing datasets obtained from Scopus. The datasets encompassed publications from 2014 to December 2023. The programme utilizes VOS clustering and mapping algorithms as an alternative to Multidimensional Scaling (MDS) (Appio, Cesaroni, and Di Minin 2014). It accurately represents the relationship between items by calculating the Association Strength (ASij) using the formula (Van Eck and Waltman 2007):

$$AS_{ij} = \frac{c_{ij}}{w_i w_j}.$$

This approach efficiently places objects on a map by minimizing the squared distances between them, taking into account the LinLog/modularity normalization (Appio et al. 2016).

VOSviewer demonstrates its analytical capabilities through its keyword co-occurrence analysis, which uncovers the development and dominant themes in study areas. Additionally, citation analysis shows important research patterns and approaches. Document co-citation analysis uses network theory to identify the essential structure inside datasets (Allahverdiyev and Yucesoy 2017). The utilization of these techniques in VOSviewer not only streamlines the examination of bibliometric intricacies but also emphasizes the historical and thematic importance of research fields, rendering it an essential instrument for academic inquiry and knowledge development (Li et al. 2016; Zhao 2017).

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Results and Findings

What is the Evolution and Distribution of Technological Innovation in Educational Assessment Research?

The analysis of 1006 articles retrieved from the Scopus database, covering the period from 2014 to 2023, offers significant insights into the domain of Technological Innovation in Educational Assessment (Table 3). Throughout the past ten years, a significant amount of research has been produced, involving 3100 contributors and resulting in 759 referenced articles. These contributions have received a significant number of citations, specifically 10,098 citations in total. On average, each manuscript received 10.04 citations, and each cited work received an even higher average of 13.30 citations. These numbers demonstrate the importance of the field and the relevance of its research. Each year, the work on this topic has garnered around 1122 citations, with an average of 3.26 citations per author, demonstrating the active involvement of the academic community. The mean number of authors per manuscript is 3.08, highlighting a cooperative research approach. The h-index of 44, g-index of 70, and m-index of 4.00 demonstrate the substantial impact and consistent academic contribution in the central areas of this field. The h-core papers have accumulated 6,840 citations, underscoring the fundamental and continuous progress in educational assessment technology.

Table 3: Main Information of Data Analysis

Information	Data
Publication Years	2014 – 2023
Total Publications	1006
Citable Year	11
Number of Contributing Authors	3100
Number of Cited Papers	759
Total Citations	10,098
Citation per Paper	10.04
Citation per Cited Paper	13.30
Citation per Year	1122.00
Citation per Author	3.26
Author per Paper	3.08
Citation sum within h-Core	6,840
h-index	44
g-index	70
m-index	4.00

Between 2014 and 2023, a comprehensive analysis was conducted on a total of 1006 publications. The annual output showed a steady increase over time, reaching its highest point in the later years, as indicated in Table 4. The percentage of cited publications (NCP) closely mirrors the trend in Total Publications (TP). However, the Total Citations (TC) reached its highest point around 2016, with a higher average Citation rate per Publication (C/P) and per Cited Publication (C/CP) in earlier years. This indicates that the field has matured, with significant and influential work taking place in the mid-2010s. The data from recent years suggests a decrease in the average number of citations, which could be a result of either the field becoming saturated or the natural reduction in citations for newer papers. The h-index for this period is 154, signifying that 154 articles have been mentioned at least 154 times, significantly influencing the subject. The g-index of 268 indicates that the most highly cited

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papers possess significant influence. The field has substantial academic activity with differing levels of influence and involvement over time.

Table 4: Total Publication by Year

Year	TP	%	NCP	TC	C/P	C/CP	h-index	g-index
2014	45	4.47%	39	667	14.82	17.10	13	25
2015	61	6.06%	55	1303	21.36	23.69	17	35
2016	72	7.16%	64	1663	23.10	25.98	19	39
2017	83	8.25%	76	1490	17.95	19.61	21	36
2018	73	7.26%	65	995	13.63	15.31	15	29
2019	105	10.44%	93	1112	10.59	11.96	19	28
2020	124	12.33%	106	1207	9.73	11.39	20	28
2021	137	13.62%	114	1096	8.00	9.61	16	26
2022	152	15.11%	106	456	3.00	4.30	10	15
2023	154	15.31%	41	109	0.71	2.66	4	7
Grand Total	**1006**	**100.00 %**	**759**	**10098**	**10.04**	**13.30**	**154**	**268**

Notes: TP=Total number of Publications; NCP=Number of Cited Publications; TC=Total Citations; C/P=average Citations per Publication; C/CP=average Citations per Cited Publication; h=h-index; and g=g-index

Figure 1 displays a bar and line chart that analyses the trend over a period of ten years for a collection of 1006 publications in this field of study. The data depicts an initial surge in overall publications starting from 2014, reaching a pinnacle in 2021, followed by a small decrease in 2022 and subsequent stabilization in 2023. The number of citations exhibits a distinct pattern, reaching its highest point in 2016 and subsequently decreasing gradually. The surge of 1663 citations in 2016, compared to the peak number of publications in 2021 and 2023, indicates that earlier works had a more significant impact in terms of citations. This suggests that the research in question is progressing and evolving, with influential publications published in the mid-2010s continuing to have a lasting impact in the following years. The recent decline in citation numbers could be attributed to the insufficient time for newer papers to accumulate citations or a change in research emphasis within the area. Overall, the statistics illustrate a dynamic field with evolving citation patterns throughout time.

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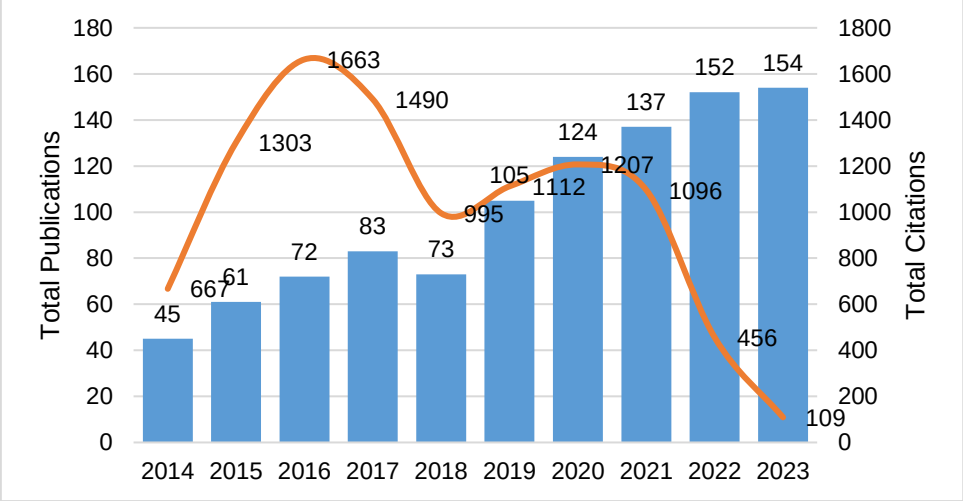

Figure 1: Total Publications and Citations by Year

Which Countries, Institutions, and Authors are the most Prolific and Efficient in Conducting Studies on Technological Innovation in Educational Assessment?

Table 5 displays the top 10 countries that significantly contribute to technical innovation in Educational Assessment. The United States is the top country in terms of publications, with a total of 151. It also has the biggest number of citations, totalling 1785. The United States maintains a significant impact in terms of citations, as indicated by an h-index of 18 and a g-index of 42. Spain, China, and the Russian Federation are ranked next, exhibiting noteworthy publication counts and citation rates demonstrating their substantial contributions to the area. Turkey is notable for its elevated rate of Citations per Publication (C/P). Despite being lower on the list, Indonesia and Malaysia exhibit significant engagement, while Taiwan, the United Kingdom, and Australia are in the top ten, each displaying noteworthy citation metrics. These countries demonstrate a strong and active involvement in researching EdTech, with different levels of influence and academic impact, as shown by their bibliometric indicators, such as the h-index and g-index.

Table 5: Top 10 Countries that Contributed to Technological Innovation in Educational Assessment

Country	TP	TC	NCP	C/P	C/CP	h-index	g-index
United States	151	1785	110	11.82	16.23	18	42
Spain	87	701	67	8.06	10.46	14	26
China	80	639	61	7.99	10.48	13	25
Russian Federation	79	734	55	9.29	13.35	15	27
Turkey	68	813	50	11.96	16.26	12	28
Indonesia	51	415	42	8.14	9.88	11	20
Malaysia	45	482	38	10.71	12.68	13	21
Taiwan	43	379	34	8.81	11.15	10	19
United Kingdom	35	330	24	9.43	13.75	11	18
Australia	30	138	24	4.60	5.75	7	11

Notes: TP=Total number of Publications; NCP=Number of Cited Publications; TC=Total Citations; C/P=average Citations per Publication; C/CP=average Citations per Cited Publication; h=h-index; and g=g-index

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Table 6 displays the contributions made by the top 10 writers on the subject of technical innovation in Educational Assessment. Hwang, Gwo-Jen has achieved a remarkable feat with a total of 234 citations from 5 articles, demonstrating a significant influence with an average of 46.80 citations per publication. Hartell, Eva has a relatively low total citation count of 26, which is spread across four publications. Walden, Emily D., Yunus, Melor Md, Terrazas-Arellanes, Fatima E., and Strycker, Lisa A. are highly influential authors who have each contributed three papers, all of which have consistently had a substantial influence in terms of citations. Thannimalai, Raamani has an impressive citation average of 18.33 per publication, indicating highly significant work. Soboleva, Elena V., Prendes Espinosa, Ma Paz, and Rogach, O.V. exhibit significant involvement in the field while having fewer overall citations. The h-index and g-index of these authors indicate their different degrees of impact and acknowledgement within the academic world.

Table 6: Top 10 Authors Who Contributed to Technological Innovation in Educational Assessment

Author's Name	Affiliation	TP	NCP	TC	C/P	C/CP	h-index	g-index
Hwang, Gwo-Jen	National University of Taiwan	5	5	234	46.80	46.80	4	5
Hartell, Eva	KTH Royal Institute of Sweden	4	4	26	6.50	6.50	3	4
Walden, Emily D.	University of Oregon, United States	3	3	24	8.00	8.00	3	3
Yunus, Melor Md	University Kebangsaan Malaysia	3	3	11	3.67	3.67	2	3
Terrazas-Arellanes, Fatima E.	University of Oregon, United States	3	3	24	8.00	8.00	3	3
Strycker, Lisa A.	University of Oregon, United States	3	3	24	8.00	8.00	3	3
Thannimalai, Raamani	Secondary School Kepala Batas, Malaysia	3	3	55	18.33	18.33	3	3
Soboleva, Elena V.	Vyatka Sataes University of Russia	3	2	10	3.33	5.00	1	3
Prendes Espinosa, Ma Paz	De Murcia University, Spain	3	3	12	4.00	4.00	2	3
Rogach, O.V.	Russian States Sosial University	3	3	38	12.67	12.67	2	3

Notes: TP=Total number of Publications; NCP=Number of Cited Publications; TC=Total Citations; C/P=average Citations per Publication; C/CP=average Citations per Cited Publication; h=h-index; and g=g-index

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Table 7 displays the top 10 institutions that have made noteworthy contributions to technical innovation in the field of Educational Assessment. Universiti Utara Malaysia is at the forefront with 12 publications and a total of 97 citations, demonstrating a commendable citation rate per publication. National Taiwan Normal University has a higher number of publications, specifically 11, compared to The Education University of Hong Kong, which has eight publications. However, despite the lower number of publications, The Education University of Hong Kong has a lower citation impact. Purdue University and Near East University, both with seven publications, exhibit moderate citation counts, suggesting a growing impact on the subject. The National Taiwan University of Science and Technology stands out with its excellent citation effect, as evidenced by its six publications. The Chinese University of Hong Kong, The University of Hong Kong, and Universiti Kebangsaan Malaysia are other universities that make substantial contributions with greater citation rates per publication, indicating the superior quality and impact of their research. New York University completes the list, demonstrating the worldwide reach of influential research in this field. The h-index and g-index reflect the academic reputation and reach of the intellectual output of these institutions.

Table 7: Top 10 Institutions Most Influenced by Technological Innovation in Educational Assessment

Institution	Country	TP	TC	NCP	C/P	C/CP	h-index	g-index
Universiti Utara Malaysia	Malaysia	12	97	8	8.08	12.13	5	9
National Taiwan Normal University	China	11	106	9	9.64	11.78	5	10
The Education University of Hong Kong	Hong Kong	8	19	6	2.38	3.17	3	4
Purdue University	United States	7	16	3	2.29	5.33	3	4
Near East University	Cyprus	7	8	4	1.14	2.00	2	2
National Taiwan University of Science and Technology	China	6	116	4	19.33	29.00	3	6
The Chinese University of Hong Kong	Hong Kong	6	25	5	4.17	5.00	3	5
The University of Hong Kong	Hong Kong	6	59	6	9.83	9.83	4	6
Universiti Kebangsaan Malaysia	Malaysia	6	24	6	4.00	4.00	3	4
New York University	United States	5	31	4	6.20	7.75	3	5

Notes: TP=Total number of Publications; NCP=Number of Cited Publications; TC=Total Citations; C/P=average Citations per Publication; C/CP=average Citations per Cited Publication; h=h-index; and g=g-index

What are the Prevailing Topics in the Subject of Technological Innovation in Educational Assessment as Identified by Scholars?

Table 8 presents a compilation of the 10 most often referenced works on technological innovation in Educational Assessment. These articles provide valuable insights and have had significant effects on the field. Kokotsaki, Menzies, and Wiggins (2016) conducted a

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 9 Issue 53 (March 2024) PP. 83-100
DOI 10.35631/IJEPC.953009

comprehensive literature evaluation on project-based learning, which has received 484 citations at an average rate of 53.78 per year. Han, Capraro, and Capraro's (2015) study on the distinct impacts of project-based learning in STEM fields is ranked second, with 266 citations. The systematic review conducted by Fu and Hwang (2018) on mobile collaborative learning and the research conducted by Schelly et al. (2015) on 3-D printing in education demonstrates the wide range of ways technology is used in learning. These studies have received significant annual citation rates. Tondeur et al. (2016) and Smeda, Dakich, and Sharda (2014) provide valuable information on teacher training for technology integration and the efficacy of digital storytelling, respectively. Fatani's (2020) study on videoconferencing during the COVID-19 pandemic and Sun, Anbarasan, and Kumar's (2021) research on AI-based English teaching platforms emphasize how EdTech effectively addresses present difficulties. Finally, the inclusion of Roberts-Holmes' (2015) analysis of datafication and Drossel, Eickelmann, and Gerick's (2017) investigation on predictors of ICT use in education completes the list, showcasing the dynamic nature of educational measuring tools. These publications are considered fundamental in academic discussions, as indicated by their citation counts and impact on future studies.

Table 8: Top 10 Highly Cited Articles in Technological Innovation in Educational Assessment

Author(s)	Title	Source Title	Total Citation	Citation per Year
Kokotsaki D., Menzies V.,& Wiggins A. (2016)	Project-based learning: A review of the literature	Improving Schools	484	53.78
Han S., Capraro R.,& Capraro M.M. (2015)	How Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) affects high, middle, and low achievers differently: the impact of student factors on achievement	International Journal of Science and Mathematics Education	266	26.60
Fu Q.-K.,& Hwang G.-J. (2018)	Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016	Computers and Education	196	28.00
Schelly C., Anzalone G., Wijnen B.,& Pearce J.M. (2015)	Open-source 3-D printing technologies for education: Bringing additive manufacturing to the classroom	Journal of Visual Languages and Computing	146	14.60
Tondeur J., Van Braak J., Siddiq F.,& Scherer R. (2016)	Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement	Computers and Education	128	14.22

International Journal of Education, Psychology and Counseling
IJEPC
EISSN : 0128-164X
Volume 9 Issue 53 (March 2024) PP. 83-100
DOI 10.35631/IJEPC.953009

Smeda N., Dakich E.,& Sharda N. (2014)	The effectiveness of digital storytelling in the classrooms: a comprehensive study	Smart Learning Environments	127	11.55
Fatani T.H. (2020)	Student satisfaction with videoconferencing teaching quality during the COVID-19 pandemic	BMC Medical Education	121	24.20
Sun Z., Anbarasan M.,& Praveen Kumar D. (2021)	Design of an online intelligent English teaching platform based on artificial intelligence techniques	Computational Intelligence	119	29.75
Roberts-Holmes G. (2015)	The 'datafication' of early years pedagogy: 'if the teaching is good, the data should be good, and if there's bad teaching, there is bad data'	Journal of Education Policy	118	11.80
Drossel K.,& Eickelmann B.; Gerick J. (2017)	Predictors of teachers' use of ICT in school – the relevance of school characteristics, teachers' attitudes, and teacher collaboration	Education and Information Technologies	112	14.00

Which articles have had the greatest impact on the topic of Technological Innovation in Educational Assessment studies?

Figure 2 of the VOSviewer visualization illustrates a network of co-authorship among scholars on the subject of Technological Innovation in Educational Assessment. The graph illustrates clusters of collaboration, with authors Huang X., Hu X., and Craig S.D. forming a prominent group, indicating a significant level of collaborative work, potentially within comparable subtopics or approaches. Another clearly identifiable group was formed by Martin W.B., Yu J., and Du X., indicating the presence of another active collaborative network. The interconnections among various authors within the network underscore the multidisciplinary and collaborative essence of research in this field, presenting the opportunity to exchange ideas and disseminate novel methodologies. The map indicates that although there are key individuals in the scientific community, a wide range of collaboration propels the field's progress.

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IJEPC
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DOI 10.35631/IJEPC.953009

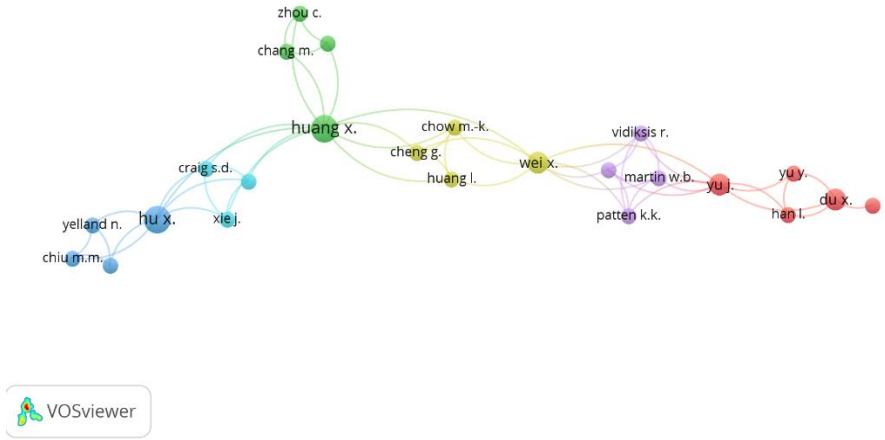

Figure 2: Network of Co-Authorship among Researchers in the Field of Technological Innovation in Educational Assessment

The VOSviewer map demonstrates the interconnections between important subjects in Technological Innovation in Educational Assessment, highlighting "teaching," "e-learning," and "digital devices" as essential nodes in the discussion (Figure 3). These crucial terms connect to fundamental notions like "students" and "teachers" as well as innovative components such as "interactive learning environments" and "computer-aided instruction." The visualization also demonstrates the recent emphasis on "COVID-19," illustrating the impact of the epidemic on instructional technologies. The clusters depicted on the map demonstrate the incorporation of technology in different educational tiers, ranging from elementary education to medical school. This highlights the extensive influence of technological progress throughout the entire educational continuum.

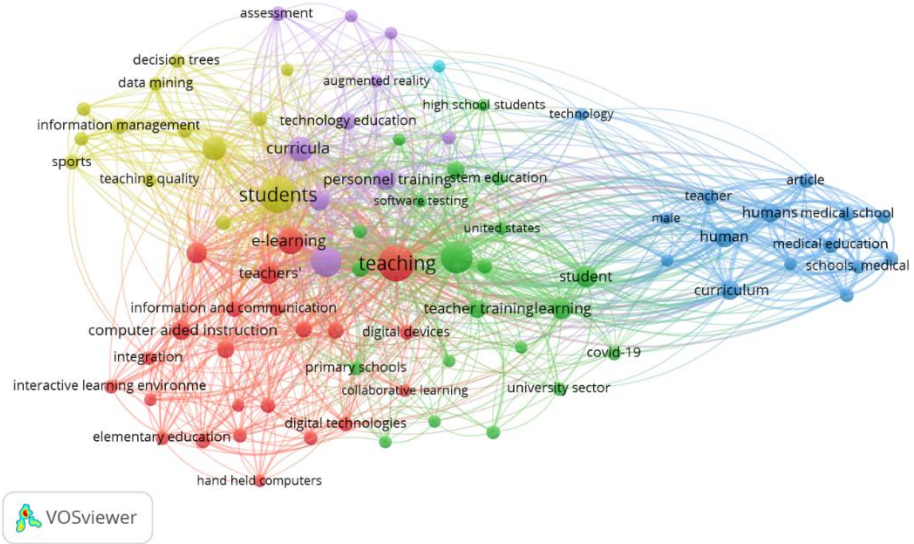

Figure 3: Interconnectedness of key themes within Technological Innovation in Educational Assessment

International Journal of Education, Psychology and Counseling
IJEPC
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Volume 9 Issue 53 (March 2024) PP. 83-100
DOI 10.35631/IJEPC.953009

Discussion and Conclusion

From 2014 to 2023, this study includes 1006 publications, which demonstrate the dynamic and developing nature of this topic. The research contributes substantially to our understanding of how technological advancements are changing how educational evaluation is done. This is an important part of educational reform and effectiveness. The study demonstrates a rising inclination in the quantity of research conducted on technological innovation in the field of Educational Assessment. The increasing number of papers and citations each year demonstrates a growing interest in and acknowledgment of the field's significance. The noticeable increase in total citations around 2016, followed by a steady decrease, indicates that the field has reached a stage of maturity, where influential works from the mid-2010s continue to have an impact in recent years.

The bibliometric study emphasizes the worldwide scope of research in this field, with significant contributions from nations such as the United States, Spain, China, and the Russian Federation. These countries and esteemed institutions like Universiti Utara Malaysia and National Taiwan Normal University have shown substantial academic influence, as indicated by impressive citation metrics and prominent publications. Many geographical locations highlight the widespread importance and utilization of technical advancements in educational evaluation. The topic is distinguished by the influential contributions of prominent authors such as Hwang, Gwo-Jen, and Hartell, Eva, whose works have substantially impacted EdTech research. A network of co-authorship among researchers indicates a lively academic community that encourages multidisciplinary and cooperative investigation.

Examining primary themes demonstrates a concentration on topics such as e-learning, digital devices, and interactive learning settings, indicating the field's reaction to current educational difficulties, particularly the COVID-19 pandemic. This signifies a transition towards learning and assessment approaches that are more tailored to individual needs, adaptable, and incorporate technology. The increasing focus on subjects such as AI-based teaching platforms and the influence of technology on teacher training and classroom techniques underscores the dynamic character of educational evaluation. Incorporating technology throughout several educational tiers, from primary to medical institutions, illustrates its extensive versatility.

The bibliometric analysis of "Evolving Trends of Technological Innovation in Educational Assessment" provides useful insights into the direction and influence of technology in education. The statement emphasizes the need for ongoing innovation and adjustment in educational methods to match technological progress. The study not only charts the present state of affairs but also lays the groundwork for future investigations and advancements in EdTech. By illuminating the main works, essential issues, and worldwide dissemination of research activities, it offers a guide for progressing toward more comprehensive, efficient, and prosperous educational assessment methods. Consequently, it makes a substantial contribution to the discussion on EdTech.

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