Innovation and Technology in Online Education: A Bibliometric Analysis

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Abstract. Online education is a teaching and learning environment over the internet. Hence, many educators and learners demonstrated using various innovations and technologies in delivering online education effectively during the outbreak of the COVID-19 pandemic. The purpose of this study is to analyse the status quo and the recent advancement of technology utilization in online education system either by e-learning, also known as, online learning since the introduction of internet in mid 1970s. A bibliometric analysis research approach was carried out using the Elsevier-Scopus database, analyzing a wide range of bibliometrics' key indicators such as total number of publications and citation analysis coupled with bibliometric networking analysis using visualization of similarities software, VOSViewer available in the public domain. It was an interesting find as the number of publications had increased significantly plus online education is a developing subject area among academic researchers utilizing innovation and technology in their teaching and learning pedagogy.

Keywords: Online teaching · Innovation · Technology · Online learning · E-learning

1 Introduction

The Internet has revolutionized the way humans interact with each other since its introduction on mid-1970s. From electronic mails, data sharing, forums, blogs, and lately with cloud computing, the Internet has transformed the traditional education system into an online based education system. Advancement in technology has also driven many network-based companies such as Google, Apple, Microsoft and many more to innovate in this space, giving rise to platform-based technologies such as Google Classroom, iTunes U and Microsoft Teams. These platforms are free web services which enables

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teachers and students to share their files in the cloud as part of their virtual classroom coupled with grading of assignments in a distance learning or online learning environment. Key distinctions exist between both type of learning modes either by online learning or e-learning as both are designed to provide a mixture of teaching methods supplementing traditional teaching methods and provide continuous learning opportunities to students accessible in any corner of the world.

Distance learning is solely the mode of delivering the instruction via online. Both learning methods are viable and found to be effective with distinctive advantage for teachers and students. The recent outbreak of infectious coronavirus disease (COVID-19) pandemic in almost all the countries around the world created a 'new' normal to the interaction among human beings where social distancing is indefinitely a must to prevent and contain the outbreak. This outbreak caused schools, learning institutions, and pre-schools centre to be closed for almost 3 months to-date. This impacted the economic and social sector mainly the education system in those affected countries hugely. The World's Health Organization (WHO) [1] reported the virus will stay with human being for long time as no vaccine had been successfully developed yet.

The pandemic had frightened educators and learners. However, the introduction of many innovations and utilization of latest technologies such as virtual classes showed that teaching and learning can be effectively and efficiently performed. This was reported based on registered downloads from the Google Play Store and the Apple iOS Store in April 2020 for YouTube Kids, with 10.6 million newly registered users followed by Google Classroom, with more than 28.2 million downloads, respectively [2]. Usefulness and easiness of Google Classroom (GC) were the main contributing factors for the high utilization rate of GC type of platform for blended learning in higher education adopt by most of the institutions, including Malaysia's Ministry of Education, as part of the learning management system (LMS) technology for supporting out of classroom pedagogical [3].

Furthermore, several research studies indicated that technology utilization in the classroom enables and unlocks greater participation and collaboration between the teachers and learners, which resulted in many great inventions and innovation [4, 5].

2 Literature Review

Analysis on the subject area of focus comprises online education or e-learning, a number of articles using a bibliometric analysis approach have been published in the following journal sources, namely the Journal of Education Sciences [6], the Journal of Test Engineering and Management [7], the British Journal of Education [8]. Other publications related to paper proceedings in annual conferences on the subject areas focusing on the field of computer sciences [9], mathematics modelling [10], nursing education [11, 12] as well as the recent discussion on Massive Online Open Courses (MOOC) provides indication on impact of innovation and technology in education [13].

3 Methodology

This study follows a structured bibliometric analysis method, as previously applied by numerous researchers on other subject areas [6]. The statistical analysis approach done on key sets indicators such as type of journals, authors, countries and institutions provides basic information on current status, development and future directions of a subject areas coupled with citation analysis on most cited and influential articles on the research field. As this study aims to understand the key trending on innovation and technology influential in online education, a period of 35 years was generally selected based on the evolution of internet and computing technology (see Fig. 1). Several tools were used in this study, namely Publish or Perish (PoP) software, easily assessable in the public domain in the author's blog of Anne-Wil Harzing enables retrieval of bibliography data and analyses academic citations.

Fig. 1. Number of relevant publications

PoP software provides basic bibliometric analysis capabilities and citation analysis using the following metrics such as the total number of publications and citations, average citations per paper, articles cited per author, papers per author, and annual average citations, Hirsch's h-index and its related parameters assessing the quality and quantity of the articles published, and Egghe's g-index. The network analysis was conducted using VOSViewer, a free software used to map and visualize bibliometric networks based on statistical method on parameters such as citation, bibliographic coupling, co-citation, or co-authorship relations developed by Van Eck and Waltman [14].

The Elsevier-Scopus is the primary data source used in this study, being one of the most influential scientific database collections, providing wide coverage from journals to conference proceeding papers which consists of basic built-in analytical tools on the search results. The number of papers published each year indicates the subject area is a major interest of today's researchers based on the exponential growth since evolution of computer technology and accessible of its auxiliary technologies such as internet, network cable and bandwidth both globally and locally within the scale of the classroom in early 2000's [15].

A systematic approach had been taken as per Fig. 2 to obtain final number of papers (N = 798) as of 29th May 2020. The following keywords were used in this study comprises "online teaching", "innovation", technology", "education", "online learning", and "e-learning" with connectors used are "AND" and "OR" to provide more focused and productive results based on the article title, abstracts and keywords. A comprehensive results criterion was developed focusing on the scope of the subject area and those out of scope from the subject area to finalize on the final search results as illustrated in Fig. 2 using a PRISMA flow diagram.

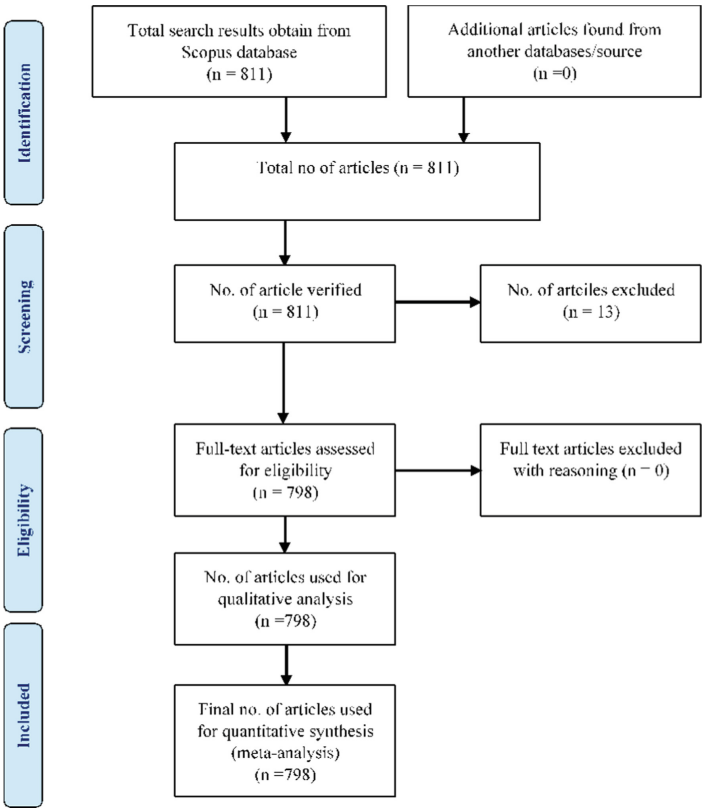

Fig. 2. Adoption of PRISMA flow diagram (Source: Moher et al. [16])

4 Results

The results of the bibliometric analysis conducted based on type of document and sources, evolution of published studies, primary language used in the documents, most active subject area of research and source title in the field of online education, etc. are presented next.

4.1 Document and Source Types

The distribution of the type of scientific publication produced through the research span in Table 1 shows that majority of the publications were scientific articles, comprises 46.37% of the total publications, followed by conference papers (39.22%). The remaining minority can be considered as not representative to this field of research which are below 5% as mainly books, editorial and speaker's keynote.

Table 1. Type of documents in the search result.

Type of document	Frequency	% (N = 798)
Article	370	46.37
Conference paper	313	39.22
Book chapter	62	7.77
Review	37	4.64
Book	14	1.75
Editorial	1	0.13
Note	1	0.13
Total	**798**	**100.00**

4.2 Source Type

A balance source type shown in Table 2 indicates a much-debated subject area of focus among academic researchers based on number of journals and conference proceedings published whereby both constitute more than 85% of total source type.

Table 2. Source type.

Source type	Frequency	% (N = 798)
Journals	403	50.50
Conference proceedings	276	34.59
Book	73	9.15
Book series	44	5.51
Trade journal	2	0.25

4.3 Year of Publications – Evolution of Published Studies

The exponential growth in the publication with cumulative average growth about 6.5% per year taken from 2008 indicates traction in the subject area which paces up with

educational technology. As shown in Table 3, it gained a lot of momentum for the past 6 months since Covid-19 outbreak in 2019.

Table 3. Year of publications.

Year	Frequency	% (N = 798)	Percent of cumulative
1986	1	0.12	0.12
1998	1	0.12	0.25
1999	3	0.37	0.62
2000	5	0.62	1.24
2001	5	0.62	1.87
2002	17	2.12	3.99
2003	12	1.50	5.48
2004	15	1.87	7.35
2005	35	4.37	11.72
2006	27	3.37	15.10
2007	23	2.87	17.97
2008	28	3.50	21.47
2009	38	4.75	26.22
2010	53	6.63	32.86
2011	50	6.26	39.12
2012	41	5.14	44.25
2013	59	7.39	51.65
2014	54	6.77	58.42
2015	35	4.39	62.81
2016	59	7.41	70.22
2017	58	7.28	77.50
2018	70	8.80	86.30
2019	79	9.93	96.23
2020	30	3.77	100.00

4.4 Languages of Documents

English has been the primary language of choice for researchers to convey their ideas, findings and probabilities to create collaboration work around the globe, accounting more than 97% (see Table 4).

Table 4. Top 5 types of language usages in the publications.

Language	Frequency	% (N = 803)
English	782	97.5
Spanish	8	1.0
Chinese	4	0.5
German	3	0.4
Portuguese	2	0.2

Table 5. Documents by subject area.

Subject area	Frequency	% (N = 1205)
Social Science	500	41.49
Computer Science	373	30.95
Engineering	45	3.73
Business, Management & Accounting	36	2.99
Arts & Humanities	36	2.99
Medicine	35	2.90
Mathematics	32	2.66
Nursing	27	2.24
Decision Sciences	18	1.49
Psychology	18	1.49
Health Professions	13	1.08
Biochemistry, Genetics & Molecular Biology	12	1.00
Material Science	11	0.91
Physics & Astronomy	11	0.91
Chemistry	8	0.66
Environmental Sciences	7	0.58
Chemical Engineering	5	0.41
Energy	5	0.41
Agricultural & Biological Sciences	3	0.25
Dentistry	3	0.25
Earth & Planetary Sciences	2	0.17
Economics, Econometrics & Finance	2	0.17
Pharmacology, Toxicology & Pharmaceutics	2	0.17
Immunology & Microbiology	1	0.08

4.5 Subject Area

The majority of the publications concentrates on Social Sciences and Computer Science subjects covering more than 70% of the total publications. Other subjects also geared up with interdisciplinary focuses are shown in the number of publications obtained, 1205 documents (see Table 5).

Table 6. Most active source title.

Source title	No. of documents	%
TechTrends	10	1.25
British Journal of Educational Technology	10	1.25
Turkish Online Journal of Distance Education	9	1.13
International Journal of Emerging Technologies in Learning	8	1.00
Computers and Education	8	1.00
Internet and Higher Education	7	0.88
Australasian Journal of Educational Technology	7	0.88
Journal of Asynchronous Learning Network	7	0.88
Online Learning Journal	6	0.75
Distance Education	6	0.75
Education and Information Technologies	6	0.75
Teacher Training and Professional Development: Concepts, Methodologies, Tools, and Applications	5	0.63
Nurse Education Today	5	0.63
International Review of Research in Open and Distance Learning	5	0.63
13th European Conference on e-Learning, ECEL 2014	4	0.50
25th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education - ""Hello? Where are you in the landscape of educational technology?"", ASCILITE 2008	4	0.50
Educational Technology and Society	4	0.50
Educational Technology Research and Development	4	0.50
Innovations in Education and Teaching International	4	0.50
International Journal of Innovation and Learning	4	0.50
Journal of Educators Online	4	0.50
Turkish Online Journal of Educational Technology	4	0.50
Others	667	83.58

4.6 Most Active Source Titles

Most of the publications, mostly articles are contained in many international or local journals. Table 6 presents the overview of the most active source based on the Elsevier-Scopus database with the keywords used, which represents 1.25% of the total publications. The three journals found with the most articles on the subject were TechTrends by Springer (10), British Journal of Educational Technology (10), and Turkish Online Journal of Distance Education (9). Since the subject area covers a broad spectrum with overlapping field of studies, it generates a lot of publications in various source title.

4.7 Keywords Analysis

The keyword analysis is extracted from VOSViewer which enabled identification of the most popular keywords used by the authors in their publications. This so-called network map illustrates on the leading themes studied as shown in Fig. 3. The larger the keyword, the more frequently the word was used, and vice versa. The objective of this study had been met based on the frequency of the keyword "online teaching" emerged as the most frequent used word among researchers which indicates this subject area is gaining a lot of

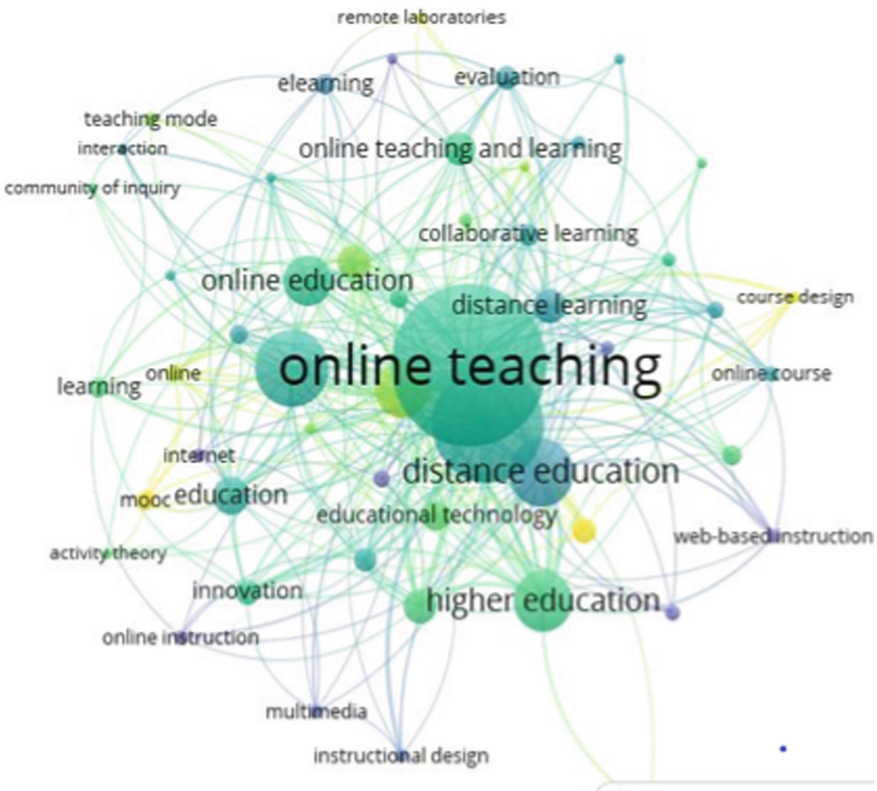

Fig. 3. Network visualization map of the author keywords

interest complimenting traditional teaching methods. In the education system, teaching and learning is the essential part for development of individual's knowledge for their profession gains and most of the authors used keywords such as eLearning and distance education, with interchangeable keywords such as MOOC, which is the abbreviation for massive open online courses.

4.8 Geographical Distribution of Publications

Table 7 details that the United Sates had been reported with the highest number of publications followed by Australia and China and normalizing per capita, Finland had the best performance among the Scandinavian countries obtained and trailed by English-speaking countries such as India, China, New Zealand, Malaysia and Hong Kong appears in the top 20 list.

Table 7. Top 20 countries with number of publications.

Country	Frequency	% (N = 747)
United States	281	37.62
Australia	105	14.06
China	108	14.46
United Kingdom	45	6.02
Canada	45	6.02
Spain	32	4.28
Taiwan	27	3.61
Malaysia	12	1.61
Germany	11	1.47
India	11	1.47
New Zealand	10	1.34
Finland	10	1.34
Turkey	8	1.07
Sweden	7	0.94
Italy	7	0.94
Croatia	6	0.80
Hong Kong	6	0.80
Portugal	6	0.80
Mexico	5	0.67
Greece	5	0.67

4.9 Most Influential Institutions

A close analysis on the most outstanding institutions with their scientific production shown in Table 8 shows that Deakin University, Australia leading with 4 documents, followed by University of Central Florida, US with 4 and Athabasca University, Canada with 3 in the field of online education utilizing innovation and technology in their teaching and learning approaches.

Table 8. Top 5 most influential institutions with minimum of two publications.

Institution	Frequency	% (N = 46)
Deakin University, Australia	4	8.70
University of Central Florida, US	4	8.70
Athabasca University, Canada	3	6.52
Australian Catholic University, Australia	2	4.35
Avondale College, Australia	2	4.35

4.10 Citation Analysis

Papers on innovations and technologies in online education received fair citation in general. The average number of citations based on the publication number of 798 papers is 5.54. The highest citation number is 216 on Shea et al. [17]. Table 9 provides the most cited papers based on the total publication number obtained.

Table 9. Highly cited articles and most influential papers.

No.	Authors	Title	Year	Cites	Cites per year
1	P. Shea, T. Bidjerano	"Community of inquiry as a theoretical framework to foster epistemic engagement and cognitive presence in online education"	2009	216	19.64
2	L. Harasim	"Learning theory and online technologies"	2012	144	18
3	E. Baran, A.-P. Correia, A. Thompson	"Transforming online teaching practice: Critical analysis of the literature on the roles and competencies of online teachers"	2011	134	14.89

(*continued*)

Table 9. (*continued*)

No.	Authors	Title	Year	Cites	Cites per year
4	R. Hampel, U. Stickler	"New skills for new classrooms: Training tutors to teach languages online"	2005	125	8.33
5	L. Stefani, R. Mason, C. Pegler	"The educational potential of e-portfolios: Supporting personal development and reflective learning"	2007	118	9.08
6	A. Carr-Chellman, P. Duchastel	"The ideal online course"	2000	102	5.1
7	L. Schrum, S. Hong	"Dimensions and strategies for online success: Voices from experienced educators"	2002	88	4.89
8	S. Bennett, L. Lockyer	"Becoming an online teacher: Adapting to a changed environment for teaching and learning in higher education"	2004	66	4.13
9	R. Sims, G. Dobbs, T. Hand	"Enhancing quality in online learning: Scaffolding planning and design through proactive evaluation"	2002	64	3.56
10	J.W.H. Sit, J.W.Y. Chung, M.C.M. Chow, T.K.S. Wong	"Experiences of online learning: Students' perspective"	2005	59	3.93
11	J. Lu	"A personalized e-learning material recommender system"	2004	58	3.63
12	P. Shea, A. Pickett, C.S. Li	"Increasing access to higher education: A study of the diffusion of online teaching among 913 college faculty"	2005	56	3.73
13	G. Motteram, G. Forrester	"Becoming an online distance learner: What can be learned from students' experiences of induction to distance programmes?"	2005	51	3.4
14	S.-J. Jang	"The effects of integrating technology, observation and writing into a teacher education method course"	2008	50	4.17

(*continued*)

Table 9. (*continued*)

No.	Authors	Title	Year	Cites	Cites per year
15	N. Guichon	"Training future language teachers to develop online tutors competence through reflective analysis"	2009	50	4.55
16	M. Ryan, K.H. Carlton, N.S. Ali	"Reflections on the role of faculty in distance learning and changing pedagogies"	2004	45	2.81
17	F. Zhao	"Enhancing the quality of online higher education through measurement"	2003	43	2.53
18	E. Murphy, M.A. RodrÃguez-Manzanares, M. Barbour	"Asynchronous and synchronous online teaching: Perspectives of Canadian high school distance education teachers"	2011	42	4.67
19	K. Kear, F. Chetwynd, J. Williams, H. Donelan	"Web conferencing for synchronous online tutorials: Perspectives of tutors using a new medium"	2012	42	5.25
20	S.F. Tello	"An Analysis of Student Persistence in Online Education"	2007	41	3.15
21	S. Bennett, D. Marsh	"Are we expecting online tutors to run before they can walk?"	2002	39	2.17
22	J.R. Reilly, C. Vandenhouten, S. Gallagher-Lepak, P. Ralston-Berg	"Faculty development for e-learning: A multi-campus community of practice (COP) approach"	2012	35	4.38
23	J.E. Sieber	"Misconceptions and realities about teaching online"	2005	33	2.2
24	C.-B. Lin, S.S.-C. Young, T.-W. Chan, Y.-H. Chan	"Teacher-oriented adaptive Web-based environment for supporting practical teaching models: A case study of school for all"	2005	33	2.2
25	E. Baran, A.-P. Correia	"A professional development framework for online teaching"	2014	33	5.5

(*continued*)

Table 9. (*continued*)

No.	Authors	Title	Year	Cites	Cites per year
26	S.-J. Jang	"Exploration of secondary students' creativity by integrating web-based technology into an innovative science curriculum"	2009	29	2.64
27	A. Sun, X. Chen	"Online education and its effective practice: A research review"	2016	29	7.25
28	C. Kamin, K.H. Souza, D. Heestand, A. Moses, P. O'sullivan	"Educational technology infrastructure and services in North American medical schools"	2006	27	1.93
29	C.E. Shepherd, D.U. Bolliger, T.A. Dousay, K. Persichitte	"Preparing Teachers for Online Instruction with a Graduate Certificate Program"	2016	9	2.25

5 Discussion

This study was able to provide the elucidation of the subject area related to scientific production on the evolvement of innovations and technologies in online education since the first publication on 1986. This exponential growth provides good correlation on impact of fast technological change influencing online education predominately starting from computer simulations with remote access capability. It was highly relevant since the outbreak of the pandemic virus as shown in the increase of publications from China and effected countries. With regards to the type of publications in this subject area, with notably "article" type of documents prevailed with more than 45% published. Therefore, it can be predicted that more articles will be published in near future. The keyword analysis also indicates that "online teaching" will be more substantial in future research interest as well highly anticipated by the learning communities complementing traditional teaching pedagogies.

6 Conclusion

The data above-mentioned data demonstrated that innovation and technology has been utilized in online education extensively and will continue to be a research subject of interest due to technological advancement. However, as this study does not reveal the impact of innovation and technology in online education especially on the teaching and learning outcome. As this study provides significant evidence based on emergence of the keyword of needs of online teaching for current generation, it led to rethinking of all teaching pedagogy been used to date. It is crucial for both technology and education to go

in hand in order to provide the right experience and knowledge to the users and a universal methodology can be easily emulated by others without restrictions as knowledge is wealth.

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