

Social Media in General Education: A Bibliometric Analysis of Web of Science from 2005-2021

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ABSTRACT

Social media plays an increasingly important role in school activities. The study analysed 2,122 eligibility bibliographic records from 2005 to 2021 were extracted from the Web of Science database. This study employs a bibliometric method to analyze the use of social media on K-12 education worldwide. We concerned the following issues: the annual publication of Social Media in General Education (SMGE), the main characteristics of the SMGE research community, the primary sources in the field, the leading research themes and the new research topics in the field of SMGE. The results represented an annual growth trend of 17.15%. Countries with the highest number of publications were the US, England, Australia, China, and Turkey. The research community consisted of small groups; and Valcke M from the University of Ghent (Belgium) was one of the leading authors with large number of publications and citations. Sources focused on four scopes: Language Education, Educational Technology, Teacher and Teaching Education, Science Education. Furthermore, six themes were developed: SMGE's environment, ICT integration, teachers' beliefs and teaching practice, students' learning, teachers' motivation and engagement, SMGE's learning approach. Two prominent topics were COVID-19-related, online and distance learning. The findings represent the basic information of the SMGE knowledge base considered as a source of reference for teachers, school managers, and policymakers interested in SMGE research and suggest further research directions.

Keywords: COVID-19, ICT integration, Teachers' beliefs, Online learning, Distance learning, Social media, General education.

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INTRODUCTION

Social media were first used for the first time more than 20 years ago, under the name of *Sixdegrees.com*, where users could create personal profiles, connect with other users to share problems and topics of mutual interest, and view others' connections.^[1] Therefore, it is changing the ways people access information across societies and worldwide. Some researchers considered social media platforms as "a group of internet-based applications that build on the ideological and technological foundations of Web 2.0 and that allow the creation and exchange of user-generated content".^[2] Others considered social media as a tool that increases our ability to share, co-operate with others, and take collective action outside traditional institutions and organizations. In short, these arguments describe social media networks as various forms of online sociality: collective action, communication,

communities, networking, collaboration, and the creative making of user-generated sociality.^[2]

Social Media in General Education

Social media in general education is an area of research that receives great attention, in which its publication volume has rapidly increased in the past decade and will be continued to expand in upcoming years.^[4,5] However, most studies still center around the topics of educational process and direct benefits of social media on students and teachers. For instance, according to Aloraini and Cardoso's,^[6] previous studies exemplified various benefits of social media to general education, that includes (1) it promotes interaction such as discussion and teamwork in the online environment;^[7] (2) it offers more opportunities to interact and communicate more efficiently which can lead to a better learning outcome;^[8,9] (3) it creates a collaborative learning environment based on Web 2.0 applications.^[10] A study by Greenhow *et al.*^[8] further shows the benefits of social media for both students and teachers. The authors pointed out three important social media affordances to students: cultivating active learning, enhancing students' collaboration, and increasing their community connections.



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The Benefits of Social Media on Education?

Social media platforms have become a tool regularly used for communication, sharing information, and discussions among teachers and students. They provide spaces where people can raise their voices, ask questions, and be in various classes. Research indicated that integrating social media into education could improve student examination outcomes.^[11,12] Others also found that using social media platforms in education could enhance students' communication skills, knowledge retention, and critical thinking skills.^[13,14] Teachers use digital technology in teaching as a powerful tool to master their teaching plans for better educational reforms, assessments, and for creating professional classroom environments.^[15] In many schools in the United Kingdom, the educators expressed their concerns on the issue of cyber security and that social networking sites should be used for the right purposes.^[16]

Social media has also been used as an increasingly popular and effective tool in the learning process,^[17,18] based on two fundamental theories: social constructivism and social connectivism.^[16,19,20] Social constructivists believe that learning is not only the construction of knowledge through individual experiences in a context of circumstances, activity, or culture, but the cooperation between learner-learner and learner-teacher also plays a crucial role.^[4,16,21] According to this theory, social media can be used as an educational tool to motivate learners to participate in an online social context, and knowledge becomes a "collective agreement" with its validity being endorsed by peer review in an engaged community.^[22] On another note, Siemens^[23] introduced connectivism as a network learning theory in the digital age based on the epistemology of connective knowledge.^[21] This theory suggests that learning is influenced by technology and socialization.^[23] Specifically, using Internet-based technologies, the learner will be a node in one or more networks to perform their learning outcomes. According to this theory, social media can be used as a communication, collaboration, and content creation network to share users' knowledge.^[4,24]

It can be said that social media is currently an effective tool in communication and knowledge sharing activities between students and teachers, and supports to create a positive, collaborative and effective learning environment.

Systematic Reviews on Social Media in Education

As aforementioned, a bulk of literature has focused on the use of social media in general education. As a result, many researchers have systematically reviewed relevant literature on specific topics under this research area. Critical synthesis, meta-analysis, and bibliometric analysis are the main approaches to performing literature reviews.^[25] A critical analysis is a type of systematic review based on a qualitative approach,^[26,27] while meta-analysis is used to analyze quantitative data.^[28,29] According to Barrot,^[30]

the majority of systematic reviews on the topic of social media in education are either critical analyses^[5,31,32] or meta-analyses.^[33,34]

In recent years, bibliometric analysis has emerged as an approach that quantitatively assesses the academic quality of journals or authors using statistical methods such as citation rates.^[35] This approach is believed to have a pivotal role in the evaluation of education research; however, because this is still a new literature review, there have only been a few papers using this analysis to evaluate the use of social media in general education. One of the most outstanding ones is conducted by Barrot,^[4] which focused on using social media for educational purposes to show steady scientific output growth and citations on this topic. Another systematic review by Barrot^[30] also used bibliometric analysis as one of the two methods to evaluate the scientific literature on social media in education published between 2008 and 2019 based on the Scopus database. The main difference between the two studies is that the latter focuses on published research on the use of social media for language learning and teaching. The study results indicated that research on the impacts of social media on language education increased exponentially and will continue to rise in the future. The data also demonstrates a broad geographical distribution of publications on such topics (e.g., the United States, Australia, Malaysia, and Taiwan). Another systematic review by Hashim *et al.*^[36] using Google Scholar database found 1,373 manuscripts related to the use of social media for teaching and learning in higher education. Out of these papers, only 94 were chosen for analysis. The findings have shown the trends, topics, and challenges addressed by previous research for the past ten years, from 2008 to 2018. Specifically, the review concludes that social media is a tool with great potential to support teaching and learning that can take place anytime, anywhere, and universally for all students. Therefore, it is suggested that higher education institutions use social media sites to transform the learning and teaching processes, accommodating the needs of a new generation of students. This new generation is often known as digital natives, who have been using social media from an early age and thus are familiar with the functionality of social media as well as are comfortable with the use of digital technology in classroom settings. Manca^[20] used the bibliometric method to examine the scientific literature on the impacts of four social media platforms (Instagram, Pinterest, Snapchat, and WhatsApp) on students' learning outcomes at the higher education level. The findings illustrated that WhatsApp was the social media platform receiving the most interest from education scholars, while the other three platforms were barely explored. Another important finding of this study indicates that the use of the pedagogical function of social media is still only partially implemented. Meanwhile, the study by Lopes *et al.*^[37] delved into a review of the scientific literature on one social media platform only - Facebook. 260 articles from 2008 to 2016 in Web of Science were selected through screening and filtering. The study's findings revealed the leading countries in terms of research output on this

topic, including the United States, Australia, Turkey, the United Kingdom, and Taiwan; Computers and Education was found the most preferred publication platform. The literature review, therefore, confirms the importance of Facebook in facilitating learning and teaching activities.

Indeed, the above reviews have demonstrated that there have been some literature reviews on social media at different levels (e.g., higher education, general education) and aspects of education (e.g., language learning). However, it is noted that there is a lack of studies on the use of social media for K-12 (kindergarten to grade 12) using the bibliometric analysis. This study, therefore, employs a bibliometric method to analyze the use of social media on K-12 education worldwide. Specifically, this paper seeks to answer these research questions as follows:

RQ1: How was the annual publication of social media in general education (SMGE) from 2005 to 2021? Which nation has dominant in this field?

RQ2: What were the main characteristics of the SMGE research community from 2005 to 2021? Which are the most relevant authors?

RQ3: What are the primary sources in the field of SMGE from 2005 to 2021?

RQ4: What are the leading research themes in the field of SMGE from 2005 to 2021?

RQ5: What are the new research topics in the field of SMGE?

METHODOLOGY

Since being proposed for the first time by Pritchard,^[38] bibliometrics has been used to explore the knowledge base on a field of study. In the field of education, this method is employed at many levels of learning, i.e., preschool,^[39] high school,^[40] higher education,^[41,42] and lifelong learning.^[43] These studies often referred to either source of databases, Scopus and Web of Sciences. Compared to Scopus, the Web of Sciences provides more detailed information.^[44] Therefore, this study used the Web of Sciences database as the primary data collection source.

The data collection process was conducted in three steps. First, the research team identified keywords based on the research purpose. The topics of the searched papers should satisfy three conditions simultaneously: i) “social media” or internet-based applications, ii) “general education” or keywords related to this level of study and not contain other grade-related keywords, iii) related to school activities (see operations 1-4 in Figure 1). Second, the research team needed to narrow the search dataset based on the search results collected from the first step. Data was limited regarding collections, research areas, types of documents, languages, and published years (see operations 5-10 in Figure 1). The timing of data collection was 16h00 on the 13th

of June 2022. Then, the document content was validated. Each record was reviewed based on its title and summary information, which determined the paper’s eligibility. After the data collection process, the dataset containing 2,122 records related to SMGE for 2005-2021 was formed.

The authors used two analytical methods to answer the research questions: descriptive statistical analysis and science mapping analysis. The information needed for the analysis included the year of publication of the paper, the author’s name, the author’s affiliation, the paper’s title, the paper’s keywords, the publication source, and the references. Descriptive statistical analysis was used to determine the number of annual publications, the most prominent authors, the most relevant sources, the most cited papers, and topical topics based on the frequency of author keywords. Science mapping analyses were conducted to visualize the collaboration of countries, the researcher community, the scopes of sources, the themes of the knowledge base, and the topical topics. All the analyses were supported by Microsoft Excel, VOSviewer (<https://www.vosviewer.com/>), and R application with Biblioshiny package (<https://www.bibliometrix.org/home/>).

RESULTS

Annual publications on SMGE for 2005-2021

There were 2,122 SMGE papers in the period between 2005 and 2021, including 2,090 articles (98.49%), 30 proceedings papers (1.41%), and two book chapters (0.09%). Figure 2 showed the tendency of SMGE papers over time between 2005 and 2021. The data draw a growth tendency in the number of publications for the whole period, with a significant increase in the two years, 2020-2021. The average annual growth rate was 17.15% per year.

According to the authors’ nationality information, co-authoring analysis was conducted to explore the science mapping of country collaboration in SMGE between 2005 and 2021. There

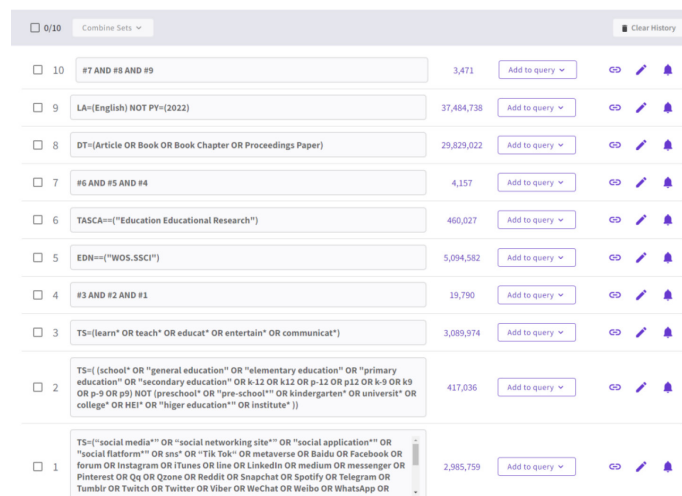


Figure 1: Data search operations on the Web of Sciences.

were 94 countries involved in the research of this field, of which 74 countries were shown in Figure 3, and 20 countries left were the isolated ones (not shown in Figure 3). Based on the size of the nodes, the United States was the biggest node, with 590 papers published (27.80%), followed by England (201 papers, 9.47%), Australia (200 papers, 9.43%), China (163 papers, 7.68%), Turkey (140 papers, 6.60%), Taiwan (128 papers, 6.03%). The thickness of the links among nodes represented the strength of collaboration between them. The United States and China had the strongest link with 17 papers. The second strongest link was between the United States and Germany with 13 papers, England and Spain (13 papers), the United States and Canada (12 papers), the United States and Australia (11 papers), Australia and China (09 papers), England and Australia (09 papers).

The color of the nodes showed the average published year of countries. The traditional countries in SMGE were the grey nodes, including the United States, England, Australia, Turkey, and Canada. The countries new to the field were the yellow nodes, including Hungary, Palestine, Mozambique, Peru, Saudi Arabia, and Bolivia. These countries were linked to the former countries.

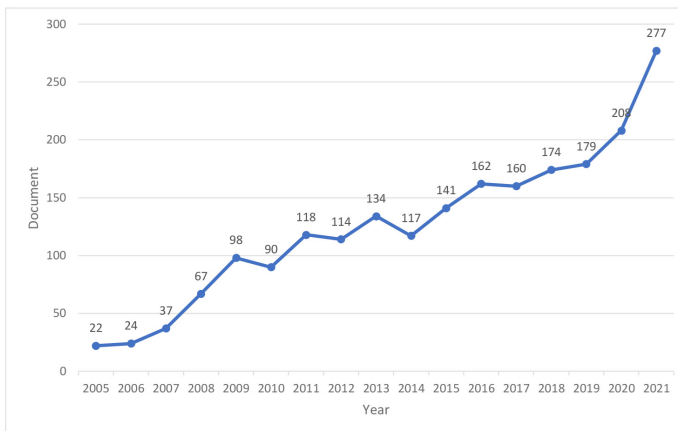


Figure 2: Annual scientific production of SMGE between 2005-2021.

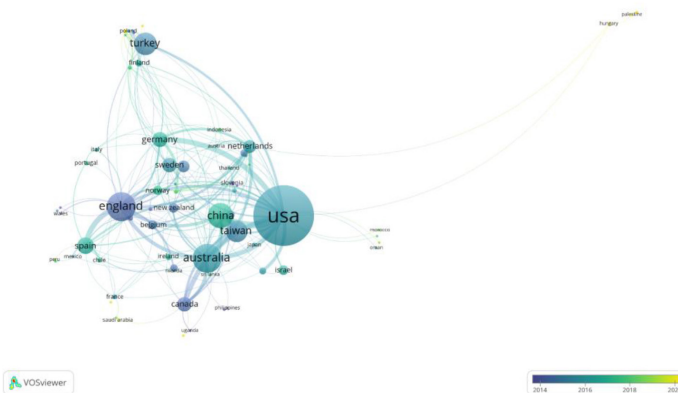


Figure 3: Countries' collaboration in the field of SMGE between 2005-2021 (74 countries).

Characteristics of SMGE community from 2005-2021

The most productive authors in SMGE between 2005 and 2021 were listed in Table 1. Valcke M (Ghent University, Belgium) and Lin CH (Michigan State University, USA) were at the top of the list with 08 papers. Six authors published seven documents, including Hwang GJ (National Taiwan University of Science and Technology, Taiwan), Tsai CC (National Taiwan Normal University, Taiwan), Chen CH (National Taiwan University of Science and Technology, Taiwan), Chen NS (National Sun Yat-Sen University, Taiwan), She HC (National Chiao Tung University, Taiwan), Chu SKW (University of Hong Kong, People's Republic of China). Each top author had at least five SMGE publications between 2005 and 2021.

Based on the citation index, three of the top 10 most cited authors included Valcke M (citation ranking #1, 891 citations), Tondeur J (#3, 765), Van Braak J (#4, 622). Their affiliation was the University of Ghent (Belgium), and they collaborated on three publications. The authors' affiliations included 06 Taiwanese institutions, 04 Belgian institutions, 04 American institutions, 03 Chinese institutions, 02 Australian institutions, and 01 English institution.

SMGE community witnessed 1,000 authors' collaborations between 2005 and 2021 (see Figure 4). The community was formed by 206 groups in which Tsai CC's group and Lane R's group were the biggest ones with 19 authors. Fourteen other groups had from 10 to 20 authors. One hundred and ninety-two others had less than ten authors per group. In addition, the degree of cooperation between authors was weak. The highest link strength recorded was five times, between Lin CH and Zhang YN, Valcke M and Schellens T, and between Tondeur J and Van Braak J. Based on the color of the nodes, representing the average published year, the groups with long tradition of researching SMGE were colored blue, e.g., Valcke M's group, Chu SKW's group, She HC's group, Keddia A's group, and Dede C's group. In addition, some traditional research groups with the participation of new authors (yellow nodes) include Lin CH's group, Hu SH's group, Carpenter JP's group, Lubienski C' group, Rodriguez C's group.

Moreover, some new research groups joined the SMGE community, e.g., Lane R's, Condon L's, Wren H's, and Connell J's. It is noted that the development of the research community was mainly associated with the participation of new research groups. Until now, no essential research group has appeared despite the expansion of traditional research groups.

The primary sources in SMGE from 2005 to 2021

Table 2 listed the top 20 primary sources in the field of SMGE with the most active ones from 2005 to 2021. The data showed that the found sources are all high-quality journals, with 19 ranked Q1 and one ranked Q2 according to Scimagojr ranking in 2021. By publication scope, the main subject areas were *education*

Table 1: List of relevant authors in SMGE from 2005 to 2021 (sorted by the number of publications).

ID	Author	Affiliation	h_index	TC (Ranking)	NP	PY
1-2	Valcke M	Univ Ghent, Belgium	7	891 (1)	8	2008
1-2	Lin CH	Michigan State Univ, USA	5	131 (93)	8	2011
3-8	Hwang GJ	Natl Taiwan Univ Sci & Technol, Taiwan	6	209 (53)	7	2012
3-8	Tsai CC	Natl Taiwan Normal Univ, Taiwan	6	200 (59)	7	2006
3-8	Chen CH	Natl Taiwan Univ Sci & Technol, Taiwan	6	179 (67)	7	2011
3-8	Chen NS	Natl Sun Yat Sen Univ, Taiwan	6	166 (72)	7	2011
3-8	She HC	Natl Chiao Tung Univ, Taiwan	5	164 (78)	7	2009
3-8	Chu SKW	Univ Hong Kong, Peoples R China	6	136 (89)	7	2012
9-15	Tondeur J	Univ Ghent, Belgium	6	675 (3)	6	2008
9-15	Carpenter JP	Elon Univ, USA	6	342 (19)	6	2015
9-15	Lingard B	Univ Queensland, Australia	6	327 (22)	6	2013
9-15	Azzarito L	Univ Loughborough, England	6	191 (60)	6	2006
9-15	Selwyn N	Monash Univ, Australia	5	165 (74)	6	2015
9-15	Lubienski C	Univ Illinois, USA	3	86 (171)	6	2014
9-15	Hu SH	Northwestern Univ, USA	3	18 (1318)	6	2008
16-19	Van Braak J	Univ Ghent, Belgium	5	662 (4)	5	2008
16-19	Schellens T	Univ Ghent, Belgium	5	328 (21)	5	2010
16-19	Li XX	Univ Hong Kong, Peoples R China	5	166 (72)	5	2011
16-19	Lo YY	Univ Hong Kong, Peoples R China	5	130 (96)	5	2012
20	Hong HY	Natl Chengchi Univ, Taiwan	4	118 (106)	5	2011

Note: TC: total citation, NP: number of publications, PY: the first year of publication.

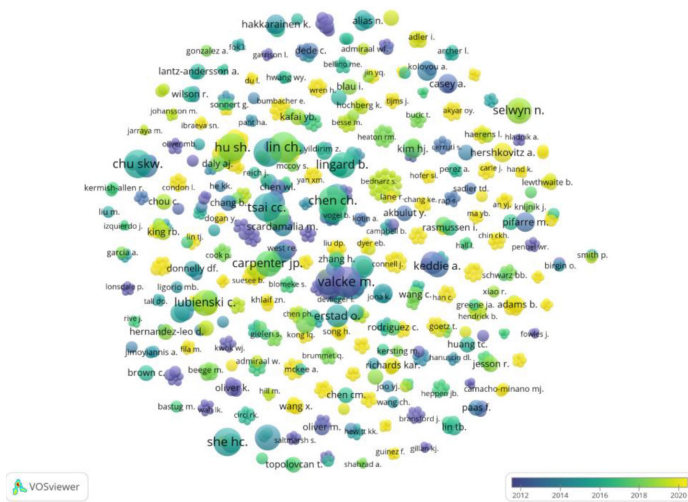


Figure 4: SMGE community over time between 2005 and 2021 (1,000 authors).

(20/20 sources), *e-learning* (5/20), and *computer science* (5/20). Some subject areas are related to SMGE, that is, *media technology*, and *information systems*, and *communication*. According to the number of publications, *Computer Sciences* and *Education* were in the first place with 173 papers (Figure 2). The following journals had a large difference in the number of publications compared

to the former, namely *International Journal of Science Education* (44), *Educational Technology and Society* (41), *Teachers College Record* (39), and *Education and Information Technologies* (33). Regarding the citation index, *computers and Education* was still in first place with 8254 citations, followed by the *Journal of Science Education and Technology* (1,637 citations), *British Journal of Educational Technology* (920), *Educational Technology and Society* (782), *Learning Media and Technology* (773), and *Journal of Computer Assisted Learning* (754). Highly cited journals are likely to be relevant to educational technology.

Figure 5 visualized the relationships between 100 publications rendered bibliographic coupling analysis. Based on the color of the nodes, there were four scopes that SMGE publishers were interested in from 2005 to 2021. The first scope was Language Education, with 45 publications (red cluster). Major publication sources included *Learning Media and Technology* (31 papers, 2332 link strength), *International Journal of Bilingual Education and Bilingualism* (27 citations, 1634 link strength), and *English Teaching: Practice and Critique* (19 citations, 1036 link strength). The second scope was Educational Technology, with 19 publications (green cluster). Prominent in this group were *Computer and Education* (174 citations, 20284 link strength), followed by *Educational Technology and Society* (43 citations,

Table 2: Top 20 sources in SMGE between 2005 and 2021 (sorted by number of publications).

ID	Source	Scope	h_index	TC (ranking)	NP	PY
1	Computers and Education	Computer Science (miscellaneous) (Q1) Education (Q1) E-learning (Q1)	52	8354 (1)	173	2005
2	International Journal of Science Education	Education (Q1)	15	697 (8)	44	2006
3	Educational Technology and Society	Engineering (miscellaneous) (Q1) Education (Q1) E-learning (Q1) Sociology and Political Science (Q1)	16	782 (4)	41	2005
4	Teachers College Record	Education (Q1)	13	523 (11)	39	2006
5	Education and Information Technologies	Education (Q1) E-learning (Q1) Library and Information Sciences (Q1)	9	216 (41)	33	2018
6-7	Journal of Science Education and Technology	Engineering (miscellaneous) (Q1) Education (Q1)	15	1637 (2)	31	2008
6-7	Learning Media and Technology	Media Technology (Q1) Education (Q1)	13	773 (5)	31	2008
8	Educational Technology Research and Development	Education (Q1)	10	446 (14)	31	2006
9	Journal of Computer Assisted Learning	Computer Science Applications (Q1) Education (Q1) E-learning (Q1)	12	754 (6)	30	2005
10-12	Journal of Education Policy	Education (Q1)	14	598 (9)	28	2007
10-12	Technology Pedagogy and Education	Computer Science Applications (Q1) Information Systems (Q1) Communication (Q1) Education (Q1)	13	373 (18)	28	2010
10-12	Eurasia Journal of Mathematics Science and Technology Education	Applied Mathematics (Q2) Education (Q2)	9	268 (28)	28	2012
13-14	Teaching and Teacher Education	Education (Q1)	15	540 (10)	26	2005
13-14	Interactive Learning Environments	Computer Science Applications (Q1) Education (Q1) E-learning (Q1)	10	308 (25)	26	2014
15-18	British Journal of Educational Technology	Education (Q1) E-learning (Q1)	14	920 (3)	25	2006
15-18	International Journal of Bilingual Education and Bilingualism	Education (Q1) Linguistics and Language (Q1)	11	474 (12)	25	2009
15-18	Sport Education and Society	Physical Therapy, Sports Therapy and Rehabilitation (Q1) Sports Science (Q1) Orthopedics and Sports Medicine (Q1) Education (Q1)	12	470 (13)	25	2006
15-18	Research in Science Education	Education (Q1)	11	343 (22)	25	2005
19	Journal of Curriculum Studies	Education (Q1)	10	262 (33)	20	2006
20	Journal of Educational Computing Research	Computer Science Applications (Q1) Education (Q1)	10	343 (23)	19	2008

Note: TC: total citations, NP: number of publications, PY: the year of the first SMGE publication, Scopes of sources were referred in <https://www.scimagojr.com/> at 16:00 July 15, 2022.

4297 link strength), Educational Technology Research and Development (37 citations, 4160 link strength), and Educational and Information Technologies (2638 citations, 36 link strength). The third scope was Teacher and Teaching Education, with 19 publications (blue cluster). The most relevant journals were Teaching and Teacher Education (26 citations, 5093 link strength), Egitim ve Bilim-Education and Science (26 citations, 1186 link strength), and South African Journal of Education (25 citations, 1148 link strength). The fourth scope was Science Education, with 13 published sources (yellow cluster). Important publications in this cluster were International Journal of Science Education (45 citations, 4946 link strength), Journal of Science Education and Technology (32 citations, 4878 link strength), and Research in Science Education (27 citations, 4007 link strength). Computer and Education was at the heart of the research network, and this source was closely linked to relevant sources of the other clusters within the SMGE.

SMGE themes from 2005-2021

The top 10 SMGE papers by citation index for 2005-2021 were listed in Table 3. The topics covered in this list are: the virtual environment in teaching,^[45,46,47] using video games in teaching and,^[48,49] teachers' intentions of using technology,^[51] teachers' beliefs,^[52] and teaching methods.^[53] These papers were published in Computers and Education (06 articles), Journal of Science Education and Technology (03 articles), and Journal of Research in Science Teaching (01 article).

Figure 6 represented the relationships between 300 references determined by bibliographic coupling analysis. Six SMGE themes were developed, corresponding to six different color clusters, in which the link strength index represented the number of citations of the papers. First, *SMGE's environment* was the biggest theme, with 77 red nodes. Research by Adler *et al.*^[54] was the most prominent, 306 link strength, which studied how teachers facilitated students' motivation in an online environment. Racionero and Padros's research,^[55] 229 link strength concerned

intersubjectivity and communication as primary factors in online learning. Seah and Toh-Heng's study,^[56] 227 link strengths explored learning environments which are accessible to all learners.

The second theme was *ICT integration* with 59 green nodes. Hermans *et al.*'s study,^[52] 396 link strengths, was the most relevant paper, investigating the impacts of educators' beliefs on the classroom use of computers. Chan and Chan's study,^[57] 367 link strengths, discussed students' views of collaboration and online participation in knowledge forums. Lastly, Eteokleous's research,^[58] 348 link strength, investigated how to integrate computer technology into a centralized school system.

Third, *teachers' beliefs and teaching practice* theme had 52 blue nodes. The biggest node was De Vries, Jansen and De Grift's study,^[59] 881 link strength, which demonstrated the relationships between teachers' beliefs on their teaching and students' learning; followed by Chai and Tan's paper,^[60] 645 link strength, which explored teachers' learning in their knowledge-building community. Last but not least, Van Den Bergh, Ros and Beijaard's paper,^[61] 376 link strength suggested the directions for the teacher to improve their feedback during active learning.

Fourth, *the students' learning* theme had 51 yellow nodes. The most relevant paper was by Oortwijn, Boekaerts and Vedder,^[62] 396 link strength, discussing the effectiveness of cooperative learning in multiethnic classrooms. Lawton *et al.*'s paper,^[63] 325 link strengths, explored the relationship between students' learning outcomes and online course design. Lastly, Song's paper,^[64] 296 link strengths, investigated the effects of ESL learning tasks in an online environment.

The fifth theme was *teachers' motivation and engagement* with 32 purple nodes. Hashim and Carpenter's study^[65] had 325 link strengths, studying teachers' motivation in using social media. The second most prominent paper in this category was by Carpenter and Green,^[66] 317 link strength, explored the roles of Voxer application to communication among educators. The paper follows this by Fischer, Fishman and Schoenebeck,^[67] 317 link strength, which sought teachers' engagement in using Twitter.

The last theme was so-called *SMGE's learning approach* with 29 grey nodes. The biggest node was the paper by Yang *et al.*,^[68] 287 link strengths, presented the relationships between students' online learning approaches, e.g., group and individual, and their learning performances on certain topics. The second noticeable paper of this theme was by Weng, Lin and She,^[69] 231 link strengths, researching students' online argumentation on learning biology between theoretical and hypothetical concepts. The study by Evagorou, Jimenez-Aleixandre and Osborne^[70] with 178 link strength was the last prominent paper in this category, which addressed the differences among students' decisions in socioscientific problems based on evidence from the learning environment.

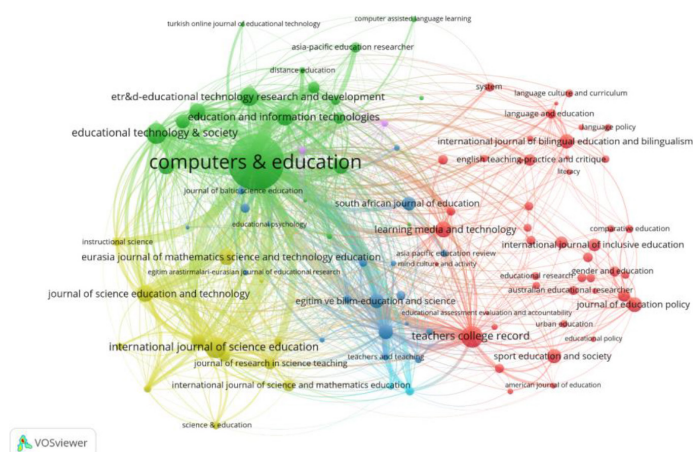


Figure 5: Scopes of SMGE sources between 2005-2021 (100 sources).

Table 3: Top 10 SMGE papers between 2005-2021 (sorted by number of citations).

ID	Author(s)	Title	Source	PY	TC
1	Dunleavy M; Dede C; Mitchell R	Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning	Journal of Science Education and Technology	2009	525
2	Weintrop D; Beheshti E; Horn M; Orton K; Jona K; Trouille L; Wilensky U	Defining Computational Thinking for Mathematics and Science Classrooms	Journal of Science Education and Technology	2016	376
3	Liu IF; Chen MC; Sun YLS; Wible D; Kuo CH	Extending the TAM Model to Explore the Factors that Affect Intention to Use an Online Learning Community	Computers and Education	2010	347
4	Annetta LA; Minogue J; Holmes SY; Cheng MT	Investigating the Impact of Video Games on High School Students' Engagement and Learning about Genetics	Computers and Education	2009	326
5	Hermans R; Tondeur J; Van Braak J; Valcke M	The Impact of Primary School Teachers' Educational Beliefs on the Classroom Use of Computers	Computers and Education	2008	294
6	Albirini A	Teachers' Attitudes Toward Information and Communication Technologies: the Case of Syrian EFL Teachers	Computers and Education	2006	270
7	Bourgonjon J; Valcke M; Soetaert R; Schellens T	Students' Perceptions About the Use of Video Games in the Classroom	Computers and Education	2010	242
8	Steinkuehler C; Duncan S	Scientific Habits of Mind in Virtual Worlds	Journal of Science Education and Technology	2008	227
9	Chin C	Teacher Questioning in Science Classrooms: Approaches that Stimulate Productive Thinking	Journal of Research in Science Teaching	2007	225
10	Kamarainen AM; Metcalf S; Grotzer T; Browne A; Mazzuca D; Tutwiler MS; Dede C	Ecomobile: Integrating Augmented Reality and Probreware with Environmental Education Field Trips	Computers and Education	2013	213

Note: TC: total citations; PY: published year.

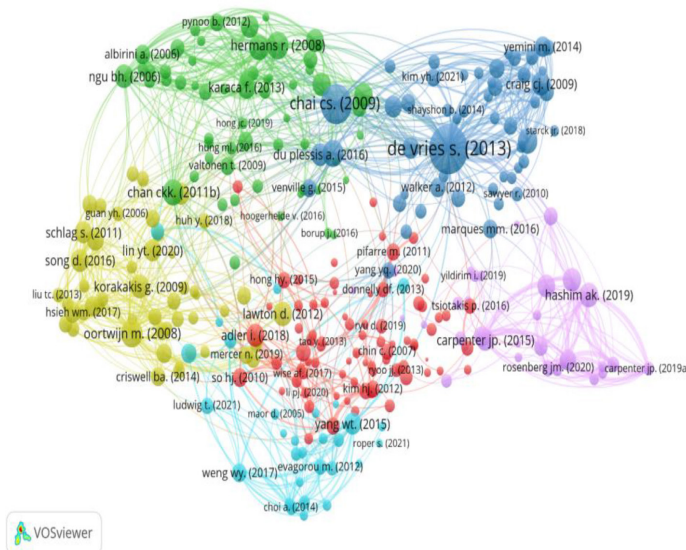


Figure 6: SMGE themes between 2005-2021 (300 documents).

SMGE's topical topics

Figure 7 listed the SMGE keywords that appeared the most each year from 2005 to 2021. Two new keywords appeared in 2021, e.g., *COVID-19* (29 times), *distance education and online learning* (09 times). On the other hand, the topics shown in Figure 8 were based on the co-occurrence analysis of 100 keywords. The two keywords *COVID-19* and *distance education and online learning* were colored yellow. The data demonstrated that the keyword *COVID-19* appeared together with online learning (7 co-occurrence), distance education (2), teacher professional development (2), social media (1), teacher education (1), education policy (1), curriculum (1), assessment (1), and motivation (1). For the keyword *distance education and online learning*, the related keywords were media in education (3), pedagogical issues (3), teacher professional development (3), cooperative/collaborative learning (2), improve classroom teaching (2), teaching/learning strategies (1), mobile learning (1), human-computer interface (1).

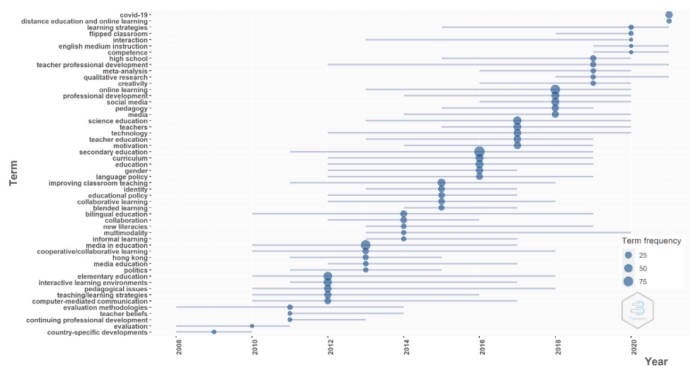


Figure 7: Relevant SMGE keywords between 2005-2021.

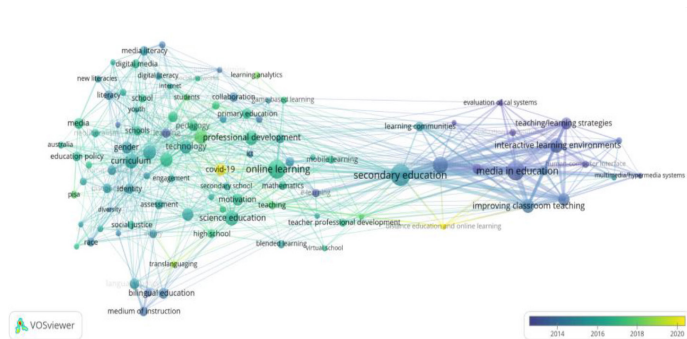


Figure 8: Topical SMGE topics over time between 2005-2021 (100 author keywords, each has at least five occurrences).

DISCUSSION

This study used the bibliometrics analysis to the dataset of 2,122 records extracted from the Web of Science to explore the knowledge base of SMGE from 2005 to 2021. In general, the results show the annual published growth of the research field and the development of this research community. Detailed findings are discussed as follows.

First, the noticeable annual growth of SMGE research publications showed the increasingly important role of social media in education. The emergence of social networking platforms is considered a new research topic in this field, e.g., Facebook,^[71] Twitter,^[72] Youtube,^[73] and MOOCs.^[74] Therefore, with the development of social networking sites, the trend of publishing SMGE research is likely to continue growing.

Second, based on the number of publications, the United States, England, China, Australia, and Turkey were the countries with the most publications in the SMGE research. Research results of Barrot^[75] and Do *et al.*^[76] on social media also showed similar results. It is argued that these countries have had sufficient technological development, economic advantages and are thus interested in this topic of research.^[43] On the other hand, new research groups were formed due to the emergence of new technologies that assisted the research community's development. However, it is noted that the rapid development of technology also limited the cooperation between research groups to conduct longitudinal studies.

Third, publishing sources were interested in four scopes, in which *educational technology* was the most noticeable journal with the center being the *computer and education* theme. This journal was notable for the number of papers as well as its citations and was most closely related to relevant sources of other scopes. The reason could be its priority in pedagogical research using digital technology for the community of educators.^[77]

Fourth, SMGE's knowledge base consists of six themes, in which *teachers' motivation and engagement* was the latest when examining the publication year of the papers. Research on

this theme focused on proposing a conceptual framework of teacher motivation in using social media,^[65] exploring teacher perineural behaviors in social media,^[78] investigating teacher identity,^[79] teacher engagement for professional learning using Twitter,^[67,80,81] Facebook,^[82,83] proposing a model for managing teaching resources on social networks,^[78] challenges in the use of social media in professional development.^[84] With the diversity in research issues, it can be seen that the role of teachers in SMGE is increasingly interesting and considered an important factor in the effectiveness of teaching and learning on online platforms.

Fifth, SMGE's topical topics in recent years were not found relevant to the emergence of new technology but rather the COVID-19 pandemic. Research contents revolved around improving the quality of online teaching in the context of the pandemic, such as curriculum,^[85] assessment,^[86,87] teacher professional development,^[87,88] improving classroom teaching,^[89] teaching and learning strategies,^[90,91] cooperative and collaborative learning,^[92] mobile learning,^[90] human-computer interface.^[92]

Last, it is noted that this study has several limitations. The first limitation is the search scope, in which papers were extracted from a single data source under time constraints, and keywords that did not fully capture all existing social media applications. Next, the analysis results have not mentioned the paper's actual content but rather the paper's bibliography information. Therefore, further research should be conducted on other data sources such as Google Scholar, Scopus, Lens, and PubMed, and at the same time, implement a systematic review to view this research area comprehensively.

CONCLUSION

This study explores the knowledge base of SMGE by applying bibliometrics analysis to 2,122 Web of Science indexed papers. The main findings showed the annual growth trend and the SMGE research community's development from 2005-2021. In this period, the United States, England, Australia, China, and Turkey were countries with the highest number of publications, and Valcke M. (University of Ghent, Belgium), was the most

cited author. Besides, the most cited theme was Educational Technology, and the latest research theme was *teachers' motivation and engagement*. In recent years, the SMGE community focused on online and distance learning due to the impacts of the COVID-19 pandemic. Although the study has some limitations, the findings are considered a source of reference for teachers, school managers, and policymakers interested in SMGE research and suggest further research directions.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY

Dataset file is available from the Harvard Dataverse at <https://doi.org/10.7910/DVN/9NQNJV>.

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