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# Bibliometric Analysis of the Research on Seamless Learning

**Tarik Talan**
Gaziantep Islam Science and Technology University, Turkey

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## Abstract

Seamless learning has a significance that has been increasing in recent years, and an increasing number of studies on the subject in the literature draws attention. This study aimed to examine the research on seamless learning between 1996 and 2020 with the bibliometric analysis method. The Scopus database was used in the collection of the data. After various screening processes, a total of 389 publications were included in the analysis. Descriptive analysis and bibliometric analysis were used in the analysis of the data. The distribution of publications by years, types of publications, sources, and languages were analyzed in the research. Additionally, visual maps were created with analyses of co-author, co-citation, and co-word. At the end of the study, it was seen that there has been an increase in the number of publications from the past to the present, articles and papers were predominant, and that most of the studies were carried out in English. As a result of bibliometric analysis, it was concluded that the most efficient countries in seamless learning were the United Kingdom, the United States, and Singapore. Also, it has been determined that the National Institute of Education, Center for International Education and Exchange, and Kyushu University institutions are dominant. The most frequently mentioned authors cited in studies in many different fields are M. Sharples, L.-H. Wong, and H. Ogata. According to the co-word analysis, the keywords seamless learning, mobile learning, ubiquitous learning, and mobile-assisted language learning stand out in the field of seamless learning.

## Introduction

One of the main reasons for the emergence of innovative methods and approaches in education in recent years is the developments in technology. Technological developments such as smartphones, tablets, wireless internet connection, and cloud computing have found their place in education as well as in all other fields. Especially the fact that mobile technologies are portable eliminates the time and space limitations such as classroom walls or school bells, as well as facilitates information exchange between individuals and changes learning styles. Supporting or developing learning environments with mobile platforms has added a new dimension to the concept of learning. One of the methods in which mobile devices are actively used in learning-teaching processes is the seamless learning approach, which has been the subject of many studies in recent years. Seamless learning, which is generally seen as a continuation of mobile learning and informal learning concepts,

is based on the logic that individuals' learning experiences continue uninterrupted without allowing any disconnection (Wong & Looi, 2011). Seamless learning was first defined by Kuh (1996) to emphasize the continuity between formal and informal learning environments. However, in this definition by Kuh (1996) that does not include technology, Chan et al. (2006) included digital devices to achieve a continuous learning process with the popularization of mobile technologies (Bayram, 2019). With the spread of mobile and informal learning technologies, seamless learning has become a practice and research subject in great demand (Şad, İlhan & Poçan, 2016).

Seamless learning is a learning approach in which the learner can access the right information at the right time, in the right place, with one or more personal devices, and which enables the transition from various learning scenarios to another easily and quickly (Yetik & Keskin, 2016). In a different definition, seamless learning is the uninterrupted learning of individuals by communicating directly with their environment with the help of mobile, wireless and online devices without any limitation of space or time, providing natural and fast access to learning resources, combining their formal learning experiences at school with their daily experiences outside of school without any disconnection (Şad, İlhan, & Poçan, 2016). Wong and Looi (2011) define the concept of seamless learning as the seamless integration of learning experiences into formal and informal learning contexts, individual and social learning processes, real and virtual environments. Therefore, this learning approach serves as a bridge that connects the private and general learning areas where learning takes place through individual or collective efforts in various contexts such as formal or informal, in-school or out-of-school (Looi et al., 2010; Şad, İlhan, & Poçan, 2016). Accordingly, the most important feature of seamless learning is that it provides an uninterrupted flow of learning between different contexts (Wong & Looi, 2011). Chiu et al. (2008) stated that everywhere and anytime learning environments provide seamless learning, making it possible for students to learn without interruption while traveling from one place to another. Although there are many definitions of seamless learning in the literature, the features emphasized in this learning are that it creates a bridge between formal and informal learning; learning is actualized independent from time and place, it enables individual and social learning, combines classroom and out-of-class learning environments, and socialization (Poçan, 2019). This learning approach encourages students to apply the knowledge they learn at school to daily life (Safiah, Degeng, Setyosari, & Ulfa, 2020).

Seamless learning is used more and more every day with different applications in different countries. However, as in every approach, some difficulties in the practice of seamless learning have been stated by the researchers (Yakar, 2019). In the relevant literature, it was stated that the lack of expertise is a limiting factor in the process of including seamless learning practices in education (Baran, 2014; Malandrino et al., 2015). In addition, the problem of accessing digital tools by students with limited financial means stands out as another challenge (Baran, 2014; Aburezaq & Isthaiwa, 2013). Other difficulties in seamless learning are the extra workload for the teacher and the low level of determination of students to participate in activities (Aburezaq & Isthaiwa, 2013; Yakar, 2019).

Despite having rich literature, seamless learning is generally defined as technology-enhanced learning or a special form of mobile and accessible learning (Yetik & Keskin, 2016). However, seamless learning is a

student-centered uninterrupted learning approach that includes mobile devices, is intertwined with technology and social environments, and takes place in formal-informal environments regardless of time and space (Looi et al., 2010; Wong & Looi, 2011; Yetik & Keskin, 2016). Unlike mobile learning, seamless learning emphasizes the use of all available technologies in addition to mobile or stationary technologies to learn in any situation (Chin et al. 2016). In addition, Wong, Chen & Jan (2012) stated that seamless learning can be one of the most complex forms of learning since it includes the versatility of learners' daily lives and has the potential to integrate many of the models such as digital learning, e-learning, mobile learning, and informal learning.

### Objectives of the Study

The fact that mobile devices and applications find a place in our lives and that human beings become individuals who are constantly learning has laid the groundwork for seamless learning environments by bringing the continuity of learning to the forefront. Considering that it is difficult to limit learning to a specific place or time especially in recent years, the practicality and importance of this concept in teaching processes have increased even more. It is seen that research and development studies on seamless learning continue in the literature. The increasing number of scientific studies makes it necessary to interpret and summarize the accumulated knowledge. Therefore, this situation reveals the need for bibliometric research in the field of seamless learning. For this reason, it is crucial to examine the studies on seamless learning in the world up to now. Thus, this study aimed to determine the scientific research on seamless learning and evaluate them by examining their bibliometric properties. In other words, the study aims to determine how the studies on seamless learning have progressed from the past to the present. By this means, it is aimed to contribute to the field at the point of development of studies on this subject and prevent the studies from being repetitive. In line with the determined purpose, 389 studies on seamless learning, published in the Scopus database between 1996 and 2020, were examined in terms of bibliometrics, and the trends in the field were tried to be revealed. With this aspect, the research is thought to bring an important and new perspective to the literature.

## Method

In this study, studies on seamless learning have been examined using the bibliometric analysis method. Bibliometrics is a method in which mathematical and statistical methods are used to measure and analyze scientific publications (Pritchard, 1969). Bibliometric analysis is a type of scientific publication analysis that evaluates the developments on a particular subject, scientific quality, and the impact of works and sources (Bouyssou & Marchant, 2011). The most important data used in bibliometrics are the journal titles, authors, institutions, references, document type, title, terms, keywords, abstract, subject headings, and acknowledgment sections (Glänzel, 2003).

### Data Collection

In this study, the Scopus database was used to obtain the bibliometric data examined. Below are the codes written on how the content is scanned in Scopus' search engine (Article title, abstract, keywords) in the subject

area:

*TITLE-ABS-KEY ("seamless learn*" OR "seamless teach*" OR "seamless study*" OR "seamless co-read*" OR "seamless language learn*" OR "seamless educat*" OR "seamless-learn*" OR "seamless flipped learn*" OR "seamless, ubiquitous" OR "seamless collaborative" OR "seamless science" OR "seamless online learn*" OR "seamless mobile learn*" OR "seamless connection between learn*" OR "seamless integration of formal" OR "seamless read*" ) AND PUBYEAR > 1995 AND PUBYEAR < 2021*

The search results were filtered to cover the years 1996 and 2020. Since Kuh's (1996) study on the subject, published in 1996, is a pioneering publication that contributed to the development of discussions in this field, studies scanned by Scopus since 1996 were evaluated in this research. There was no filtering in the language of the publications. The last screening was conducted in January 2021 and a total of 389 studies were reached. The bibliographic data of these publications (such as publication years, publication types, publication languages, titles, author names, countries of the authors, citation numbers, abstract, keywords, and bibliography information) were found.

**Data Analysis**

Bibliometric and descriptive content analyses were used in the analysis of the data in the study. The system of the Scopus database was used within the scope of content analysis. VOSviewer (Version 1.6.16, Centre for Science and Technology Studies of Leiden University), a mapping and visualization software tool, was used for bibliometric analyses. Among all the data obtained at the end of the data collection process, the distribution of the studies by years and the publication types and languages were examined first. Then, the sources the studies were indexed in and the number of citations received by the studies was included in the content analysis process. In the process of bibliometric analysis of the studies on the subject, co-author (countries, institution), co-citation (author), and co-word analyses were made.

## Results

Within the framework of the purpose of the research, the following findings were reached. The findings of the research are presented in tables and figures.

**Descriptive Findings**

*Distribution of Publications by Years*

In the study, the distribution of the studies published in the Scopus database by years was examined first. The findings obtained are presented in Figure 1.

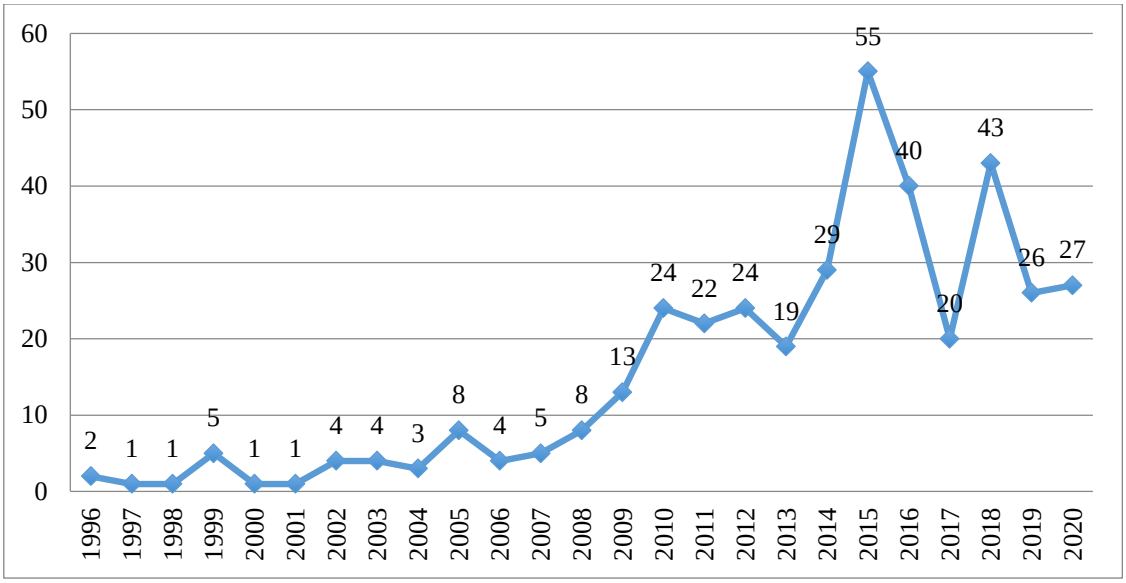


Figure 1. Distribution of Publications by Years

When Figure 1 is examined, it is seen that the first study was conducted in 1996. For this reason, studies conducted between 1996 and 2020 were included in the scope of bibliometric analysis. Besides, while an increase in the studies is observed from the past to the present, it is understood that this increase is not regular. With 55 studies, 2015 was the year with the most publishing. It is seen that there has been a decrease in the number of studies since this year.

*Distribution of the Publications by Types and Language*

The distribution of 389 studies published on the subject by publication types and languages are given in Table 1.

Table 1. Distribution of the Publications by Types and Language

| **Document Types** | | **f** | **%** |
|---|---|---|---|
| 1 | Proceedings paper | 146 | 37.5 |
| 2 | Article | 145 | 37.3 |
| 3 | Book Chapter | 60 | 15.4 |
| 4 | Conference Review | 16 | 4.1 |
| 5 | Review | 12 | 3.1 |
| 6 | Book | 6 | 1.5 |
| 7 | Editorial | 4 | 1.0 |
| **Document Languages** | | | |
| 1 | English | 386 | 99.2 |
| 2 | Chinese | 2 | 0.5 |
| 3 | Japanese | 1 | 0.3 |

When Table 1 was examined, it was understood that the studies on the subject published in the Scopus database

were made in different types of publications. When the publication type of the studies published between 1996 and 2020 are examined, it is seen that the articles (f=145; 37.3%) and proceedings paper (f=146; 37.5%) are predominant and the ratio of these in the total is 74.8%. According to these results, it can be said that journals and scientific congresses in the fieldwork actively. Besides, most of the publications were published in English (f=386; 99.2%).

*Distribution of Publications by Sources*

The sources indexing the studies on the subject in the Scopus database were also examined. The relevant data are presented in Table 2.

Table 2. The Top 10 Productive Sources on Seamless Learning

| **Source** | **f** | **CiteScore 2020** | **Scopus coverage years** | **Publisher** |
|---|---|---|---|---|
| Lecture Notes in Computer Science | 17 | 1.8 | 1973 | Springer Nature |
| Educational Technology and Society | 14 | 7.4 | 1998 | National Taiwan Normal University |
| Lecture Notes in Educational Technology | 12 | 0.9 | 2014 | Springer Nature |
| British Journal of Educational Technology | 7 | 7.4 | 1970 | Wiley-Blackwell |
| International Journal of Mobile Learning and Organisation | 7 | 5.0 | 2007 | Inderscience |
| IEEE Transactions on Learning Technologies | 6 | 7.1 | 2008 | IEEE |
| Ceur Workshop Proceedings | 5 | 0.8 | 2000 | - |
| Communications in Computer And Information Science | 5 | 0.8 | 2007 | Springer Nature |
| ACM International Conference Proceeding Series | 4 | 1.1 | 1999 | - |
| Computers and Education | 4 | 13.9 | 1976 | Elsevier |

When the studies on seamless learning are examined, it is seen that Lecture Notes in Computer Science (f=17; CiteScore: 1.8) is one of the sources with the most publishing. It is followed by Educational Technology and Society (f=14; CiteScore: 7.4) and Lecture Notes in Educational Technology (f=12; CiteScore: 0.9), respectively.

*Distribution of the Publications According to the Number of Citations*

While citation analysis studies are evaluated within bibliometric studies, they provide a lot of valuable data to researchers. Table 3 presents the distribution of the examined studies according to the number of citations they received.

Table 3. Distribution of the Publications According to the Number of Citations

| **Number of Citations** | **f** | **%** |
|---|---|---|
| 0 Citation | 110 | 28.3 |
| 1-10 Citation | 194 | 49.9 |
| 11-24 Citation | 44 | 11.3 |
| 25-49 Citation | 21 | 5.4 |
| 50-99 Citation | 8 | 2.1 |
| 100-250 Citation | 9 | 2.3 |
| >250 Citation | 3 | 0.8 |
| **SUM** | **389** | **100** |

279 (71.7%) of the 389 studies examined were cited by other publications. On the other hand, it was seen that 28.3% (f=110) of the studies were not cited at all. In addition, within the scope of the research, the data obtained by examining the most cited publications on the subject are presented below (see Table 4).

Table 4. The Top 10 Most Cited Publications on Seamless Learning

| **Document title** | **Authors** | **Year** | **Source** | **Cited by** |
|---|---|---|---|---|
| What seams do we remove in mobile-assisted seamless learning? A critical review of the literature | Wong, L.-H., Looi, C.-K. | 2011 | Computers and Education | 310 |
| Leveraging mobile technology for sustainable seamless learning: A research agenda | Looi, C.-K., Seow, P., Zhang, B., (...), Chen, W., Wong, L.-H. | 2010 | British Journal of Educational Technology | 290 |
| Context aware ubiquitous learning environments for peer-to-peer collaborative learning | Yang, S.J.H. | 2006 | Educational Technology and Society | 283 |
| Definition, framework and research issues of smart learning environments - a context-aware ubiquitous learning perspective | Hwang, G.-J. | 2014 | Smart Learning Environments | 197 |
| Applications, impacts and trends of mobile technology-enhanced learning: A review of 2008-2012 publications in selected SSCI journals | Hwang, G.-J., Wu, P.-H. | 2014 | International Journal of Mobile Learning and Organisation | 161 |
| A learner-centric view of mobile seamless learning | Wong, L.-H. | 2012 | British Journal of Educational Technology | 138 |
| A research framework of smart education | Zhu, Z.-T., Yu, M.-H., Riezebos, P. | 2016 | Smart Learning Environments | 123 |
| "Bring Your Own Device (BYOD)" for seamless science inquiry in a primary school | Song, Y. | 2014 | Computers and Education | 123 |
| Guiding Principles for Creating Seamless Learning Environments for Undergraduates | Kuh, G.D. | 1996 | Journal of College Student Development | 117 |
| Students' personal and social meaning making in a Chinese idiom mobile learning environment | Wong, L.-H., Chin, C.-K., Tan, C.-L., Liu, M. | 2010 | Educational Technology and Society | 115 |

Table 4 gives information about the authors and citation numbers of the most frequently cited publications in the Scopus database. According to these data, the most frequently cited publication with 310 citations belongs to Wong, L.-H. & Looi, C.-K. (2011) and then follows Looi, C.-K., et al. (2010); Yang, S. J. H. (2006) and Hwang, G.-J. (2014), respectively.

**Bibliometric Findings**

*Co-author Analysis (Countries)*

The network structure between the countries of the authors of the publications within the scope of the research is given in Figure 2. Figure 2 shows that the closer the two countries are, the stronger and wider the connections of these countries.

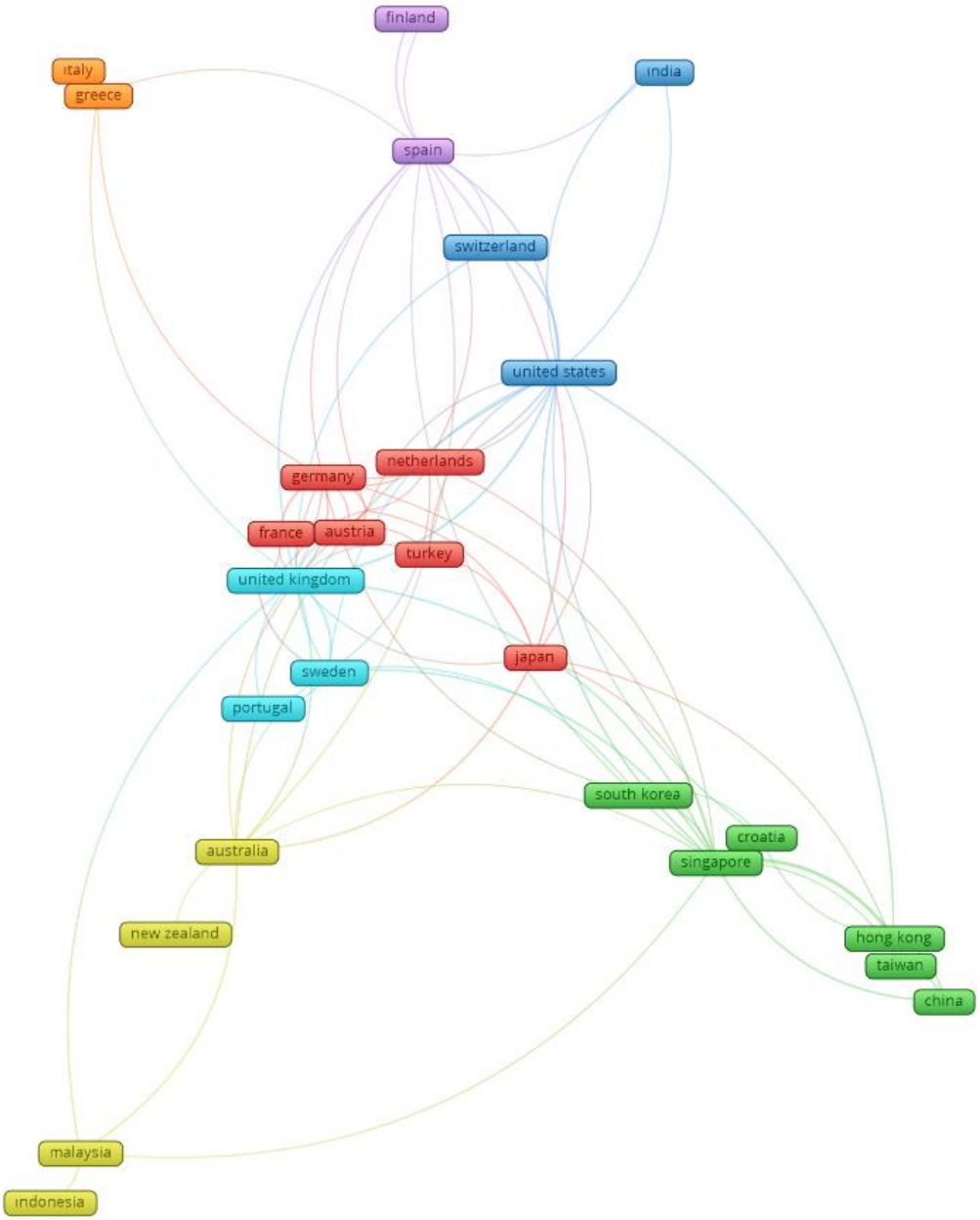


Figure 2. Cooperation Network between the Countries

According to the findings obtained, it was determined that the United Kingdom and the United States work with 15 countries. Singapore (14 links), Spain (13 links), Germany (12 links), and others followed the list. However, for publishing articles on seamless learning, only the researchers in New Zealand, Italy, Indonesia, Finland, and South Africa were associated with only one country.

*Co-author Analysis (Institution)*

When the institutions of the co-authors were examined, it was seen that the network structure was very complex, and there was no significantly prominent association structure. For this reason, an interpretation was made about the institutions of the co-authors using a heat map. Co-author analysis for inter-institutional cooperation is presented in Figure 3.

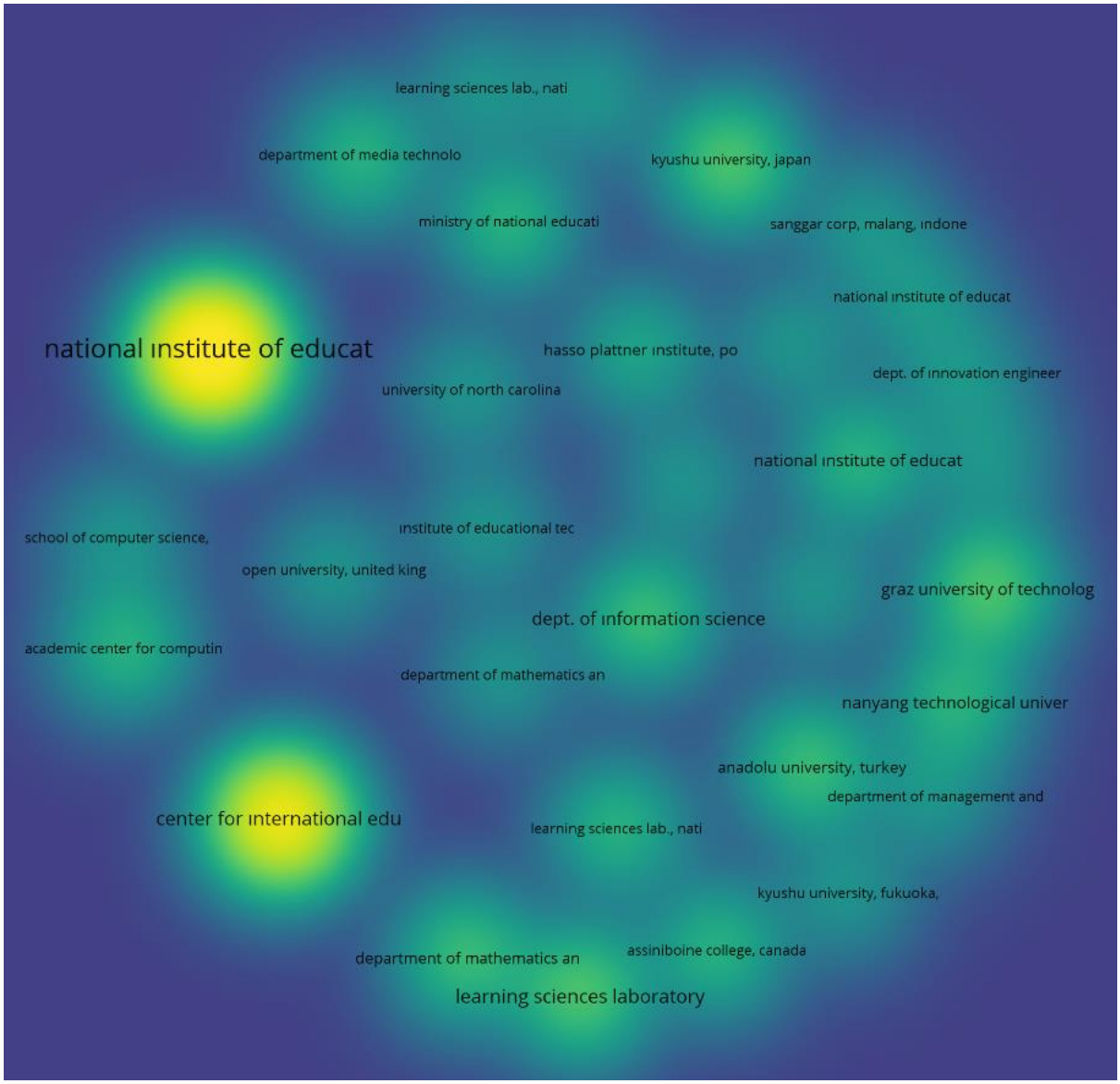


Figure 3. Institutional Cooperation Network

As can be seen in Figure 3, it is seen that the institutions National Institute of Education, Center for International

Education and Exchange, Kyushu University, Singapore Centre for Chinese Language, Universitat Pompeu Fabra, and University of Sydney are dominant on the map.

*Co-citation Analysis (Author)*

The network structure of the co-citation analysis of the publications on the subject is given in Figure 4.

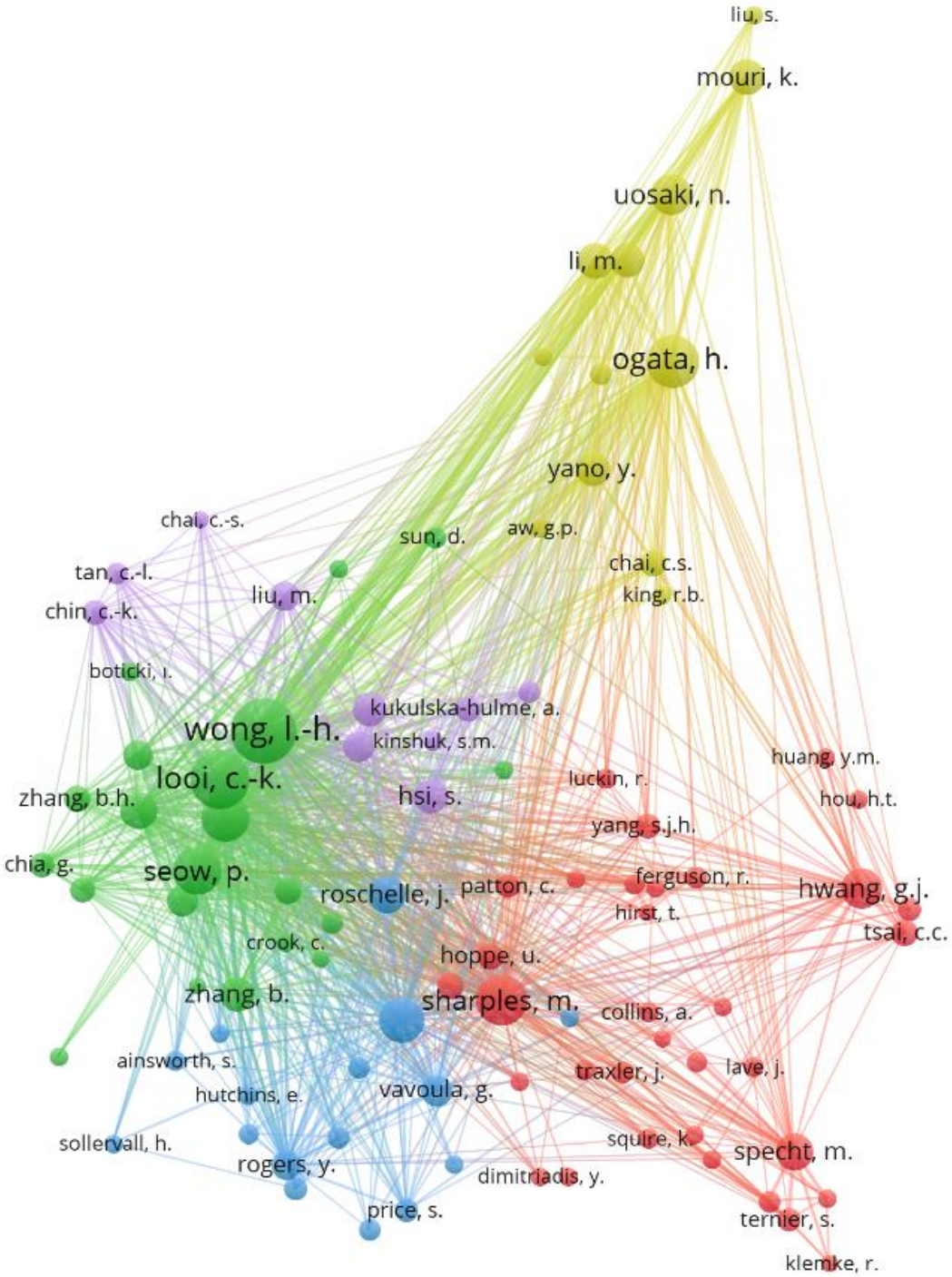


Figure 4. Co-citation (author) Network

Each round figure in Figure 4 indicates an author. The large size of these figures indicates that the name of the relevant author is mentioned more frequently in the publications during the relevant period. If there is a line between two author names, it states that these two authors work together. It shows that the thicker this line is, the more the two authors worked together. Besides, it is observed that several different clusters are formed in the network structure. Authors who receive many citations together are gathered in the same cluster. Of these clusters, the red, green, yellow, blue, and purple clusters are larger and more prominent than others. When the entire Figure 4 is examined, M. Sharples, L.-H. Wong, and H. Ogata appear to be relatively central and associated with many different clusters. In this case, it can be said that the most mentioned authors who are cited in studies in various fields are M. Sharples, L.-H. Wong, and H. Ogata.

*Co-word Analysis*

Relationships between keywords used in the publications within the scope of the research were examined. The network structure that formed the said relationship is given in Figure 5. The circle size shows the most discussed subject, while the yellow areas show current subjects.

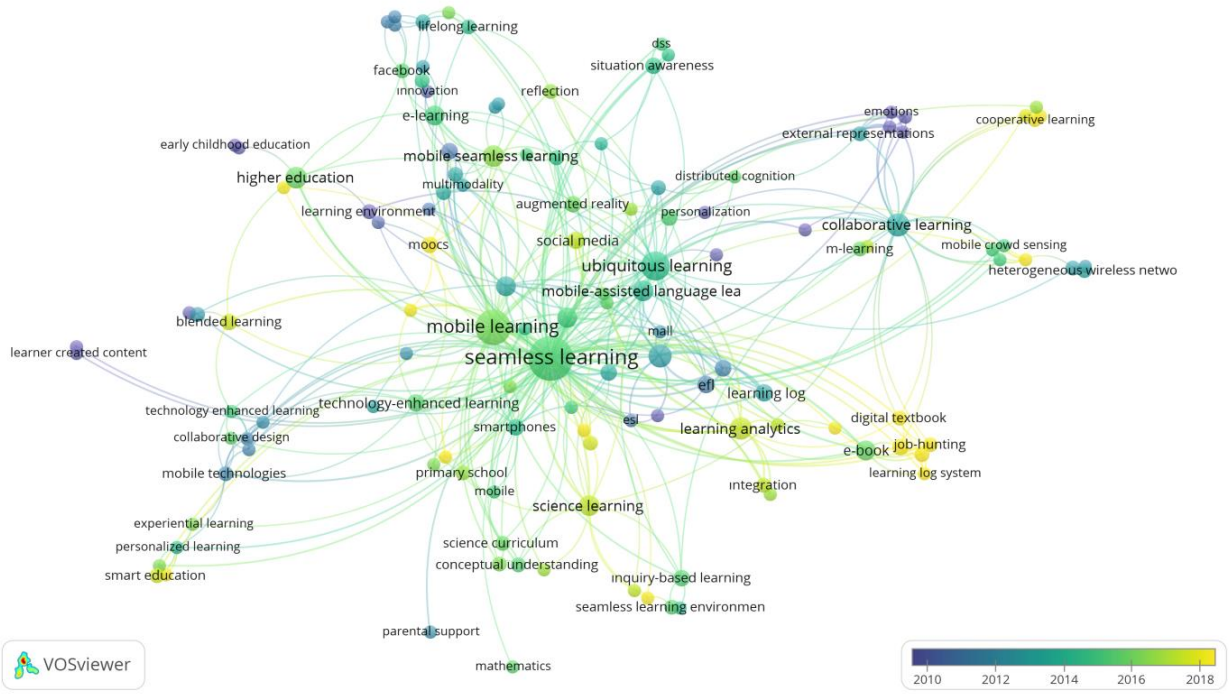


Figure 5. Analysis of the Keywords

As can be seen in Figure 5, the words seamless learning, mobile learning, ubiquitous learning, and mobile-assisted language learning are on the center of the map. These words are concepts that have been studied in conjunction with other clusters. It stands out that current issues are subjects like MOOCs, smart education, learning analytics, science learning, mobile technology, and social media.

## Discussion

In this study, the publications on seamless learning in the Scopus database were revealed by using content analysis and bibliometric analysis methods. In this context, the distribution of the studies by years, publication types, and sources was examined first. Then, information about the authors of the most frequently cited publications in the relevant literature and the number of citations were given. Also, co-author analysis (institution, countries), co-citation analysis (author), and co-word analyses of the publications were performed by using bibliometric analysis methods. When the literature was examined, no bibliometrics study on seamless learning was found. However, content analysis studies (Durak & Çankaya, 2018; Şad, İlhan & Poçan, 2016; Wong & Looi, 2011) on the subject stand out.

According to the results obtained from the research, we see that there has been an increase from the past to the present in the studies on the subject, but that this increase is not regular. On the other hand, Durak and Çankaya (2018) analyzed the studies conducted in the field of seamless learning between 2009 and 2018 with content analysis and revealed in their research that the number of studies on the subject increased every year. In another study, Şad, İlhan, and Poçan (2016) examined the distribution of studies on seamless learning by years. As a result of the research, it was stated that the increase in the number of studies on seamless learning between 2013 and 2016 drew attention.

Lecture Notes in Computer Science is one of the most published sources. It is followed by Educational Technology and Society and Lecture Notes in Educational Technology, respectively. However, when other sources were examined, it was determined that there were relatively few publications in journals with high impact values. This situation is thought to be related to the problems experienced by researchers such as language deficiency, excessive course load, and limitations in project funding (Gülmez, Özteke & Gümüş, 2020; Gümüş et al., 2018; Hallinger & Hammad, 2019; Mertkan et al., 2017). In another study revealing the trends of studies on seamless learning, journals in which articles on the subject were published were examined. Accordingly, the top three journals in which the articles were published the most are Educational Technology and Society, International Journal of Mobile Learning and Organization, and IEEE Transactions on Learning Technologies (Durak & Çankaya, 2018). In the study on mobile learning, on the other hand, the journals Computers & Education, British Journal of Educational Technology, and Educational Technology & Society were the most contributing ones (Goksu, 2021).

It was concluded that the most cited publications belonged to Wong, L.-H. & Looi, C.-K. (2011), Looi, C.-K., et al. (2010), Yang, S. J. H. (2006), and Hwang, G.-J. (2014). On the other hand, while most of the studies were cited by other publications, it was found that some studies were not cited at all. It is thought that this may be due to the quality of the relevant publications or the fact that they were newly published.

In terms of co-authors' countries, it was determined that the United Kingdom, the United States, and Singapore are leading countries in seamless learning. Similarly, the fact that Singapore is among the leading countries is consistent with the result reported by Durak & Çankaya (2018) and Şad, İlhan & Poçan (2016). However, as a

result of the bibliometric analysis conducted on mobile learning, it was concluded that the most efficient countries were Taiwan, the USA, China, and England (Goksu, 2021). Similarly, in another study (Chee et al., 2017), Taiwan was found to be the most dominant country contributing to research on mobile learning. Looking at the increase in the number of mobile phone connection, there seems an increase of 5.6% in Africa, 0.7% in the USA, 3.5% in Asia-Pacific countries, 1.8% in the Middle East, and a decrease of 0.5% in Europe during the one year period from January 2019 to January 2020 (We are Social, 2020). It is thought that the increase in the use of mobile devices in Asia-Pacific countries such as China, Taiwan, and Singapore encourages students to choose seamless learning and researchers to conduct studies on this subject (Goksu, 2021).

When the institutions of the co-authors were examined, it was seen that the network structure was very complex, and there was no significantly prominent association structure. It was determined that cooperation networks were formed especially around a few universities, but that cooperation of some universities was quite limited. As a result of the co-author analysis for inter-institutional cooperation, it was determined that the National Institute of Education, Center for International Education and Exchange, Kyushu University, Singapore Centre for Chinese Language, Universitat Pompeu Fabra, and the University of Sydney were generally the dominant institutions. In the bibliometric analysis on mobile learning, the National Taiwan University of Science and Technology, National Central University, and the National University of Tainan were the most efficient universities (Goksu, 2021). When the network structure of the co-citation analysis of the publications on the subject was examined, it was concluded that the most frequently mentioned authors who were cited in studies in various fields were L.-H. Wong and C. -K. Looi. It is noteworthy that the most efficient researchers on seamless learning are usually working at universities in Asia-Pacific countries.

Co-word analysis reflects the content analysis of the examined studies and enables the reveal of common repeated concepts (Gülmez, Özteke & Gümüş, 2020). Therefore, the relationships between the keywords used in the publications within the scope of the research were also examined. At the end of the research, the words of seamless learning, mobile learning, ubiquitous learning, and mobile-assisted language learning were the most discussed topics. It was observed that MOOCs, smart education, learning analytics, science learning, mobile technology, and social media came to the fore in current subjects. Therefore, it can be said that these keywords are among the basic concepts in this field and that they will present important findings in terms of determining trend research topics. On the other hand, Durak & Çankaya (2018) examined the frequencies of keywords in the articles on the subject and determined that concepts such as student, learning, seamless learning environment came to the fore. In mobile learning studies, on the other hand, the keywords mobile devices/technologies, smartphone, higher education, and tablet stand out (Goksu, 2021). In addition, trending topics in mobile learning are MOOCs, tablets, learning strategies, and mobile phones (Goksu, 2021).

## Recommendations

This research has provided an overview of the developments in the research on the concept of seamless learning in the Scopus database. In this way, it aimed to reveal the map of the seamless learning area in terms of bibliometrics and present a study that researchers can turn to for new studies on this subject. In future studies,

various studies can be carried out by using different bibliometric and systematic review methods together, and by including the studies in the Web of Science. Especially the studies to be conducted in journals with high impact factors may be among the research topics. As the digital era in education has begun, more research is needed in this field to take more concrete steps in educational institutions. This research is thought to guide subject experts on specifying different research subjects.

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## Author Information

**Tarik Talan**

https://orcid.org/0000-0002-5371-4520

Gaziantep Islam Science and Technology University

Turkey

Contact e-mail: *ttalan46@hotmail.com*