The Status and Hotspots of Smart Learning: Base on the Bibliometric Analysis and Knowledge Mapping

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Abstract. To reveal the status and hotspots on the area of smart learning, 303 related articles form the Web of Science (WOS) were analyzed by the visualization software CiteSpace. The results showed that: (1) the area of smart learning stared in 2002 and shows an upward trend year by year form 2010, and the number of articles reached the historical peak in 2016. Kinshuk, China and Lecture Notes in Educational Technology topped the lists of contributing authors, country and publication respectively. (2) “smart learning”, “smart learning ecosystem”, “learning analytics”, “embedded intelligence”, “mobile devices” and “smart-learning” are the top six largest clusters in the domain of smart learning.

1. Introduction
Modern information technology has profoundly changed the way people think, produce, live and learn. Smart education is in the ascendant, and the study of smart education must be smart learning that matches it. So, what kind of learning is smart learning? Although researchers have different definitions of smart learning, they generally have the following main understandings: (a) using multimedia, Internet, and agency technologies to enhance, enrich, and accelerate the learning process; (b) by means of open educational resources Intelligent information technology and international norms, flexible learning that enhances learners' ability to change behaviors; (c) learner self-directed, people-oriented learning methods; (d) use of smart devices and social networks, learners Develop a learning path for self-initiated creative learning [1-2]. Relevant literature has initially shown that South Korea, Malaysia, Australia, Japan, and IBM have paid more attention to “smart learning”, especially in South Korea. For example, IBM originally proposed the concept of Smart Planet in 2008, the E-Learning Week 2010 conference held in South Korea used “Smart Learning” as its key issue in 2010, Singapore's "i2015" program to maintain the concept of smart learning, and so on [3-5]. The current research on smart learning mainly involves the connotation of smart learning, the smart learning environment, the smart learning academic platform, the smart learning resources, the smart learning mode, intelligent learning analysis, smart learning experience, the smart learning service, the smart learning design, the smart learning space, etc. [6-8]. From the content of these studies, it has basically covered all the elements of smart learning. However, the development of smart learning and the specific content of the related research are still unclear. This study, therefore, set out to explore the status and hotspots in...
the domain of smart learning with the help of the visualization software Citespace.

2. Methodology

2.1 data sources
303 articles were yielded by the search conducted in the Web of Science core collection (WOS) under the topic of “smart learning”.

2.2 data processing
The RIS format of the 303 articles was carried out by the bibliometric analysis and visual analysis by the visualization software CiteSpace.5.5. R2 [9].

3. Results

3.1 Bibliometric analysis

3.1.1 Publishing trend. Fig.1 demonstrates the publishing trend of studies on in the domain of smart learning. The earliest research of smart learning started in 2002 while there were several pieces of research in the next seven years. There was an upward trend from 2010 and appeared at a historical peak in 2016 with 62 articles.

![Publishing trend](image)

3.1.2 Author statistics. As seen in Tab.1, all of the top 10 contributing authors have published more than three articles. Kinshuk tops the list, followed by Mikulecky and Giovannela, each of them published more than six articles.

| Rank | Author               | Frequency |
|------|----------------------|-----------|
| 1    | KINSHUK              | 9         |
| 2    | MIKULECKY P          | 8         |
| 3    | GIOVANNELLA C        | 7         |
| 4    | HUANG RH             | 6         |
| 5    | REHM M               | 6         |
| 6    | BOULANGER D          | 5         |
| 7    | SIMONOVA I           | 5         |
| 8    | BAKKEN JP            | 4         |
| 9    | JEMNI M              | 4         |
| 10   | LEE H                | 4         |
3.1.3 Country statistics. As shown in Tab.2, all of the top 10 countries have contributed more than twelve articles in the domain of smart learning. China was the best performer among the list, followed by South Korea and the USA, each of them contributed more than twenty-one articles.

Tab.2 Top 10 contributing countries

| Rank | Country                          | Frequency |
|------|----------------------------------|-----------|
| 1    | PEOPLES R CHINA                  | 43        |
| 2    | SOUTH KOREA                      | 41        |
| 3    | USA                              | 22        |
| 4    | INDIA                            | 20        |
| 5    | ITALY                            | 18        |
| 6    | SPAIN                            | 16        |
| 7    | CANADA                           | 15        |
| 8    | CZECH REPUBLIC                   | 15        |
| 9    | ENGLAND                          | 13        |
| 10   | U ARAB EMIRATES                  | 12        |

3.1.4 Source publication statistics. As seen in Tab.3, all of the top 10 source publications contributed more than seven articles in the domain of smart learning. Lecture Notes in Educational Technology tops the list, followed by Smart Innovation Systems and Technologies and Emerging Issues in Smart Learning, all of them published more than twelve articles.

Tab.3 Top 10 contributing source publication

| Rank | Source publication                                         | Frequency |
|------|-----------------------------------------------------------|-----------|
| 1    | LECTURE NOTES IN EDUCATIONAL TECHNOLOGY                   | 35        |
| 2    | SMART INNOVATION SYSTEMS AND TECHNOLOGIES                 | 24        |
| 3    | EMERGING ISSUES IN SMART LEARNING                         | 13        |
| 4    | INTERACTION DESIGN AND ARCHITECTURES                      | 10        |
| 5    | IEEE INTERNATIONAL CONFERENCE ON ADVANCED                 | 8         |
| 6    | STATE OF THE ART AND FUTURE DIRECTIONS OF SMART           | 8         |
| 7    | CHALLENGES AND SOLUTIONS IN SMART LEARNING                | 7         |
| 8    | EDULEARN PROCEEDINGS                                     | 7         |
| 9    | IEEE GLOBAL ENGINEERING EDUCATION CONFERENCE             | 7         |
| 10   | INNOVATIONS IN SMART LEARNING                             | 7         |

3.2 Knowledge mapping results

3.2.1 High-frequency keywords. As seen in Tab.4 and Fig.2, the top 10 high-frequency keywords, as well as their frequencies on the studies of smart learning, were shown. “smart learning” was the most frequent keywords, “smart learning environment”, “e-learning”, “learning analytics” and “smart education” were positioned in the 2nd, 3rd, 4th and 5th places on the list. It is indicated that smart learning, smart learning environment, e-learning, learning analytics, and smart education attracted researchers’ attention.

Tab.4 Top 10 keywords

| Rank | Keywords                     | Frequency |
|------|------------------------------|-----------|
| 1    | smart learning               | 53        |
| 2    | smart learning environment   | 47        |
| 3    | e-learning                   | 18        |
| 4    | learning analytics           | 17        |
3.2.2 Popular research topics. Fig 3 outlines the top six largest clusters, which were “smart learning”, “smart learning ecosystem”, “learning analytics”, “embedded intelligence”, “mobile devices” and “smart-learning”. As shown, the largest cluster was “smart learning (#0)”, which contained 12 articles and its S value is 0.90. The high-frequency keywords of this cluster contain “smart learning”, “technology”, “learning object” and “adaptive learning”. The second-largest cluster was the “smart learning ecosystem (#1)”, which contained 11 articles and its S value is 1.00 The high-frequency keywords of this cluster contain “smart learning ecosystem”, “internet of thing”, “environment”, “space” and “perspective”. The third-largest cluster was “learning analytics” (#2), which contained 11 articles and its S value is 0.87. The high-frequency keywords of this cluster contained “learning analytics”, “performance”, “mobile learning”, “IOT” and “management”. The fourth-largest cluster was “embedded intelligence” (#3), which contains 11 articles and its S value is 0.82. The high-frequency keywords of this cluster contained “smart education”, “system”, “education”, “augmented reality” and “embedded intelligence”. The fifth-largest cluster was “mobile devices” (#4), which contained 10 articles and its S value is 0.83. The high-frequency keywords of this cluster contained “higher education”, “self-regulated learning”, “smart learning”, “smart environment” and “mobile device”. The sixth-largest cluster was “smart-learning” (#5), which contained 8 articles and its S value is 1.00. The high-frequency keywords of this cluster contained “smart learning environment”, “e-learning”, “context-aware” and “smart-learning”.

| Rank | Keyword                          | Frequency |
|------|----------------------------------|-----------|
| 1    | Smart learning                   | 12        |
| 2    | Smart learning ecosystem         | 11        |
| 3    | Learning analytics               | 11        |
| 4    | Model                            | 11        |
| 5    | Smart learning ecosystem         | 9         |
| 6    | Performance                      | 7         |
Conclusions and further research

The research on smart learning mainly involves the connotation of smart learning, the smart learning environment, the smart learning academic platform, the smart learning resources, the smart learning mode, intelligent learning analysis, smart learning experience, the smart learning service, the smart learning design, the smart learning space, etc. However, the development of smart learning and the specific content of the related research are still unclear. The bibliometric analysis results show that the area of smart learning started in 2002 while there were several pieces of research in the next seven years. There was an upward trend until 2010 and appeared at a historical peak in 2016 with 62 articles. Kinshuk tops the contributing authors' list, followed by Mikulecky and Giovannella, each of them published more than six articles. China was the best performer on the contributing countries list, followed by South Korea and the USA, each of them contributed more than twenty-one articles. Lecture Notes in Educational Technology tops the contributing source publication list, followed by Smart Innovation Systems and Technologies and Emerging Issues in Smart Learning, all of them published more than twelve articles.

In the section of Knowledge mapping analysis, the high-frequency keywords shown that “smart learning” was the most frequent keywords, “smart learning environment”, “e-learning”, “learning analytics” and “smart education” were positioned in the 2nd, 3rd, 4th and 5th places on the list. It is indicated that smart learning, smart learning environment, e-learning, learning analytics, and smart education attracted researchers’ attention. The clusters analysis results show that “smart learning”, “smart learning ecosystem”, “learning analytics”, “embedded intelligence”, “mobile devices” and “smart-learning”, which are the research hotspots in the domain of smart learning from 2002-2019. Among them, “smart learning (#0)” is the largest cluster, and the high-frequency keywords of this cluster contain “smart learning”, “technology”, “learning object” and “adaptive learning”, indicating that smart learning is influenced by educational information technology.

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