

# Ubiquitous learning: A bibliometric research

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## ABSTRACT

The purpose of this research is ubiquitous It is an examination of research on learning (u learning) using bibliometric analysis method. Ubiquitous Learning, or u-learning environment, or time- and location-independent learning, generally refers to the integration of different learning objects into a digital environment and presentation to students using QR code applications. U-learning allows students to access information on tablets or phones and achieve targeted outcomes. U-learning offers students the opportunity to learn independently of time, location, and network connection. The Web of Science (WoS) database was used to identify trends in research on u-learning, examine research methods, classify them by year, and conduct citation analysis. The WoS database was chosen because it has a widespread article network, is frequently used by researchers, and provides research evaluations. An examination of research on u-learning in the WoS database identified 6,890 articles. The studies were conducted between 1988 and 2026, involved 23,251 researchers, and used 19,132 keywords. It was determined that the number of studies varied by year. Within the framework of the research conducted, it can be said that research can be conducted on u-learning using different methods, the different effects of u-learning on students can be examined, and u-learning can become widespread.

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## Introduction

With the advancement of technology and software, the use of mobile devices has increased. Many of the innovations and portability offered by mobile devices contribute to individual learning in education, as in every field. Technology has become an effective tool that provides people with broad access to diverse learning content every day in heterogeneous learning environments where the environment is context-aware, objects have comprehensive support, and extensive resources contribute to recreating immersive learning experiences (Ogata et al., 2009). Environments built on mobile devices, which allow individuals to access educational environments anywhere and at any time, have given rise to the concept of u-learning. U-learning is defined as the state of being present or present everywhere at the same time (Webster, 2017) and essentially being present at all times and in all places.

With u-learning, students can access the learning environment wirelessly anytime, anywhere, and it has been shown to enable learning anywhere and anytime, regardless of whether mobile devices are used (Hwang et al., 2008). However, such a paradigm becomes possible when the u-learning system understands students' behavior and real-world parameters (e.g., time and location).

In line with the opportunities offered by technology, the digital world is influenced by the diversity of learning environments such as online and offline applications, as well as social and virtual reality. The diversity and domain knowledge in areas such as gamification and assessment encompasses, for example, the natural, governmental, social, and health sciences (Peña-Ayala & Cárdenas, 2016). Furthermore, the broad range of learning paradigms addressed and their impact on learning increases the possibilities for the use of approaches adapted to education, from primary school to postgraduate academic levels. Thanks to

such u-learning, systems characterized by a diversity of devices and technologies used, capable of recreating common and ubiquitous scenes, are becoming increasingly widespread. In short, most u-learning applications are tailored to meet specific needs (Cárdenas-Robledo & Pena- Ayala, 2018). The primary and most important function of u-learning in the context of u-learning is to create a comprehensive learning environment that facilitates learning opportunities for individuals regardless of location or time (Pimmer et al., 2016).

### **Purpose of the research**

This research aimed to examine research on u-learning and reveal its trends. For this purpose, articles published in the Web of Science (WoS) database were examined. The WoS database was chosen because it contains a large number of indexed journals, includes studies exploring current issues from different perspectives, and provides easy access to statistical data (Öner & Hakköz, 2024). This made it possible to examine, interpret, and draw inferences from research conducted in the field.

While examining the articles identified for this purpose, the following questions were sought to be answered;

1. What is the distribution of research by year?
2. Who are the researchers who receive the most interaction in their research?
3. What are the trending topics of the research?
4. What are the most frequently used keywords in research?
5. What is the conceptual structure map of the research?
6. What is the number of articles published in journals based on research conducted over the years?
7. What is the distribution of the research by country?
8. What are the most frequently used keywords in the research?
9. Is there a thematic relationship between the most frequently used keywords in the research?
10. What is the conceptual structure map like in the research?
11. Which institutions provide the most support to research?

### **Literature review**

Today, wireless, mobile, ubiquitous, and widely used learning technologies are well-known. Zydney and Warner (2016) reviewed 37 articles published between 2007 and 2014 that included educational research and used the mobility feature of devices as part of the study and stated that mobile users have increasingly preferred these technologies. However, Sung et al. (2016) conducted a meta-analysis of 110 articles published from 1993 to 2013 that reported the effects produced by integrating mobile devices in teaching and learning and estimated a mean effect size of 0.523 for the application of mobile devices in education. Pimmer et al. (2016) conducted a systematic analysis of 36 thematic m-learning and u-learning approaches in higher education settings published between 2000 and 2013, and discovered that student-centered, constructivist, and situated-action approaches were the most common educational designs. Additionally, Amara et al. (2016) conducted a systematic review to evaluate how 12 studies conducted between 2005 and 2013 addressed the problem of group formation in mobile device-supported collaborative learning, where most of the solutions did not allow instructors to customize the grouping task.

Cardenas-Robledo & Pena- Ayala (2018) examined 176 studies between 2010 and 2017. They examined the research taxonomy, a proposed model, statistical interpretations, mining findings, and critical analyses. The research findings suggest that u-learning can transform traditional classroom-level and e-learning education. This is primarily because students at different academic levels experience authentic environments, follow appropriate learning paradigms, learn a variety of educational domains, are immersed in dual-reality scenes, utilize context-aware support, cope with diverse influences, and interact with diverse devices and technologies in a blended way.

Aljawarneh (2020) conducted a study evaluating various e-learning tools used in m-learning environments, including Moodle, Wikipedia, Blackboard, Web 2.0, and Web 3.0. This study provided a global perspective on current and future trends in standard e-learning tools and compared the tools used for u-learning. The study concluded that Moodle is effective in developing e-learning in teaching processes. Moodle was preferred over Blackboard by the majority of authors and practitioners. The importance of monitoring the educational content in tools used in higher education settings was also emphasized.

Furthermore, e-learning 3.0 has been observed to be an increasing trend in using Web 3.0 tools for social learning. Furthermore, on the Internet, new services, such as integrating Wikis with Web 3.0, can be easily integrated into existing applications. The main risk here is that faculty and students are not fully aware that these web services are not controlled by their universities. Mobile learning studies are also being conducted across different disciplines. Karagöz and Şeref (2021) examined 88 theses published in higher education and evaluated their results. The results of the study revealed that doctoral theses receive more citations, handbooks are being written on mobile learning, digital transformations in education on mobile learning are increasing, and research is being conducted across different disciplines. Additionally, Wang et al. (2017) examined 12 studies conducted between 2009 and 2014 on language u-learning in socio-cultural contexts, finding that many museums have adopted ubiquitous location-based systems that use mobile devices to strengthen social ties as students collaboratively engage in language learning activities.

Crompton et al. (2017) conducted a systematic review of 113 m-learning studies in PK-12 education between 2010 and 2015, finding that 63% of the studies aimed to determine the impact of mobile devices on learning, while the remainder focused on the design of m-learning systems. Finally, Chee et al. (2017) employed text mining to analyze 144 articles published between 2010 and 2015, uncovering trends in m-learning, including impact evaluation, system design, perceptions, reviews, and factor exploration. They researched u-learning, ubiquitous computing-based education (Gilman et al., 2015), p-learning (Laru et al., 2015), and mobile pervasive learning (Lucke & Rensing, 2014; Shuib et al., 2015).

## Method

Bibliometric research is research that reveals the direction, status, and development of studies in the existing literature on a specific field of science through numerical values (Üstdiken & Pasadeos, 1993). It is also considered a quantitative analysis because bibliographic features are presented as numerical data (Hawkins, 2001). Bibliometrics is a branch of library and information science that uses quantitative approaches to examine bibliographic content (Martinez-Lopez, 2018). It also encompasses a systematic, open, and repeatable review process based on a comprehensive measurement of scientific studies (Aria & Cuccurullo, 2017). The Web of Science database, which contains a large number of publications in this field and provides statistical data, was utilized during the research conducted using bibliometrics.

### Data collection process

Web of Science (WoS) database was used to collect data in the study. WoS is one of the most comprehensive databases. Many researchers use it to examine and research questions related to their fields (Arslan, 2022; Avcı & Kurudayıoğlu, 2022). In this study, the WoS database was accessed on May 7, 2025, and the ubiquitous database was used. A search was conducted using the keyword "Ubiquitous learning." From the resulting findings, abstracts, book chapters, conference papers, and other research results were separated, and only research classified as articles were selected. The remaining 6,890 studies were downloaded in BibTex format. The BibTex format provides information such as author names, publication dates, journals published, most frequently used keywords, most published researchers, and research conducted by year.

### Data analysis

The WoS database was analyzed using the R programming language. Results, such as data analysis, data mapping, classification by the researcher, and word clouds, can be obtained and expressed in figures (Erkan, 2020). The "Bibliometrix" library in the R programming language has been prepared and made available for bibliometric research. The "Bibliometrix" library in the R programming language and the "biblioshiny" software were used to perform analysis in the library (Erkan, 2020). Biblioshiny it allows analysis of raw data obtained from the WoS database through a new application. Bibliometrics makes it possible to perform bibliometric analysis techniques such as networking, classification, and thematic maps based on different variables and terms (Xu et al., 2022).

## Findings

The findings of the bibliometric research on u-learning are presented and explained below. Research on u-learning by year is presented in Figure 1.

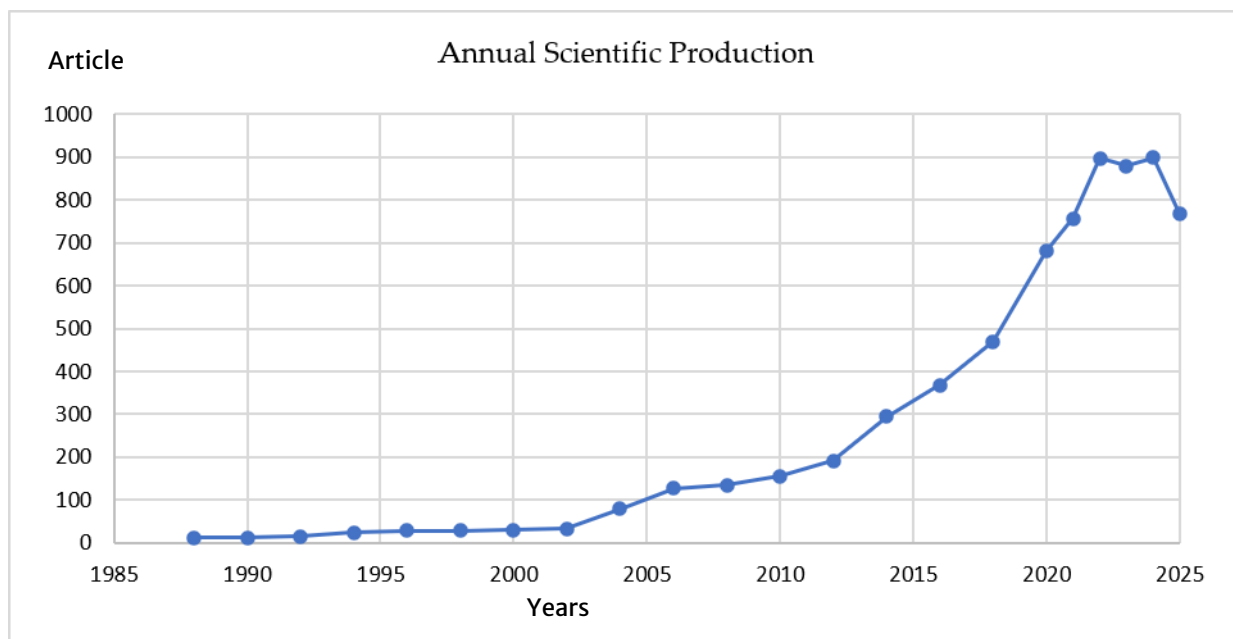


Figure 1. Number of studies on u learning by year

When Figure 1 is examined, it is determined that research on u-learning began in 1988, that there has been an increase in research in this field in the following years, and that this increase has accelerated in recent years. When the research on u-learning is examined, the research training of the countries by year is shown in Figure 2.

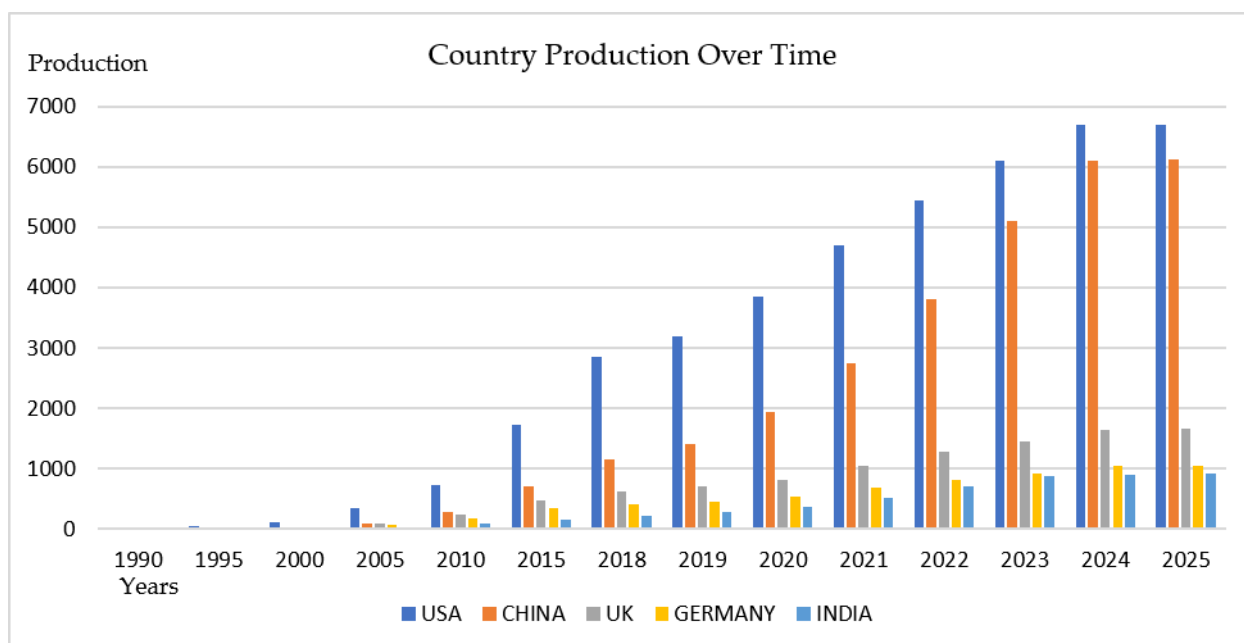


Figure 2. U-learning studies of countries by year

Figure 2, researchers in China, Germany, India, and the United Kingdom have increased their research on u-learning in recent years. Data on citations to these studies are shown in Figure 3.

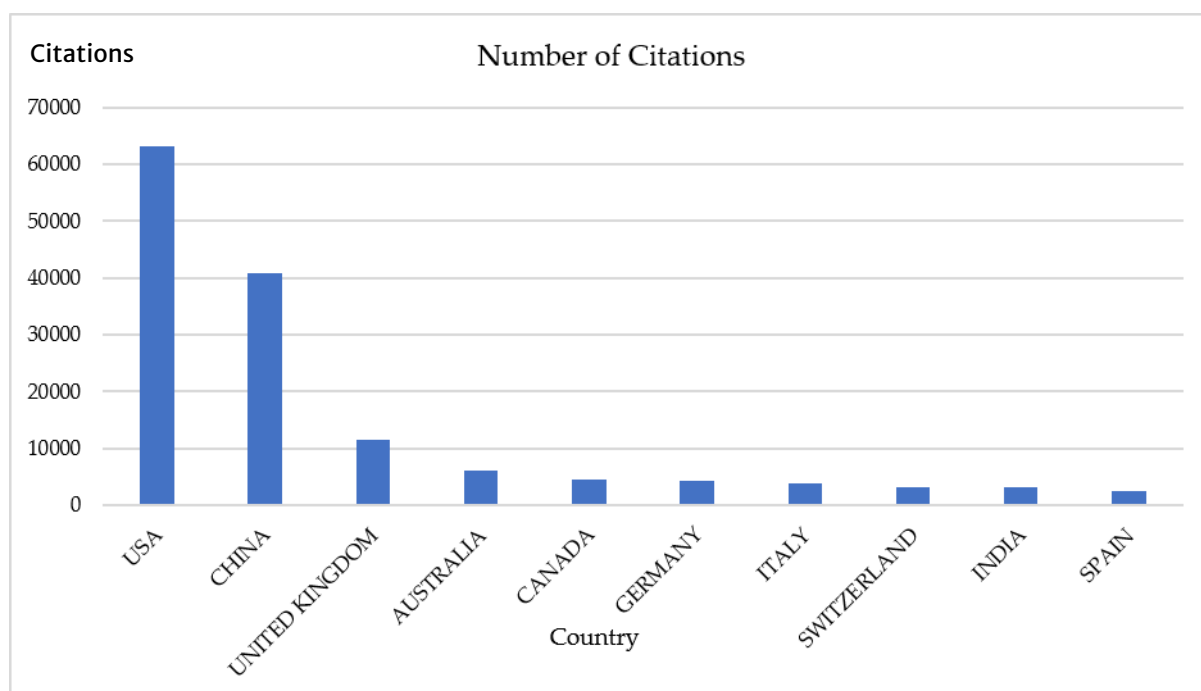


Figure 3. Citations to u-learning by Country

As seen in Figure 3, the most cited studies on u-learning were those conducted in the United States. This was followed by studies conducted in China and the United Kingdom. A map of the number of studies conducted by country is shown in Figure 4.

### Country Scientific Production

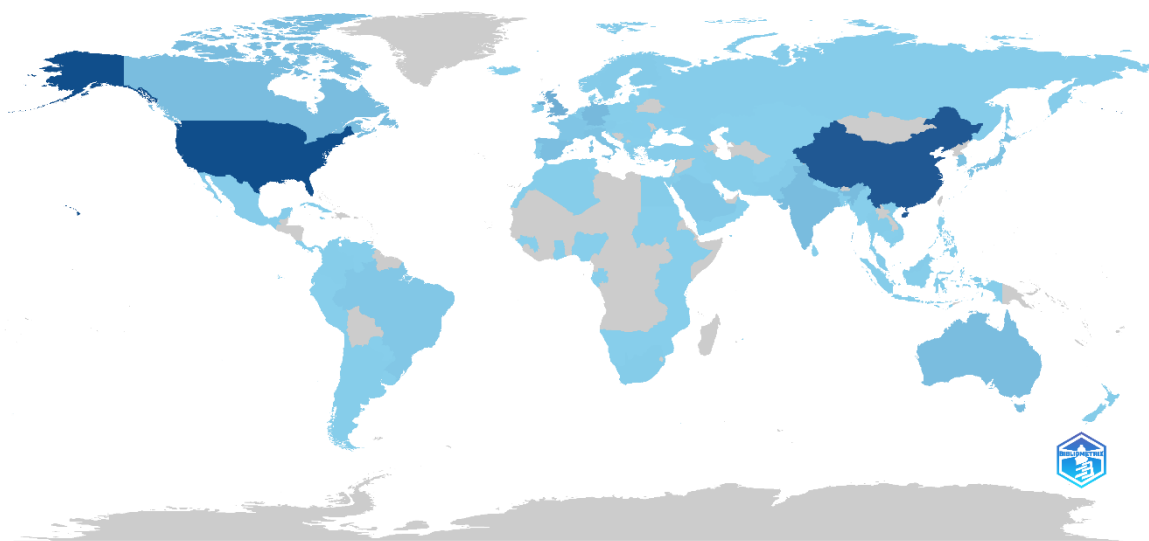
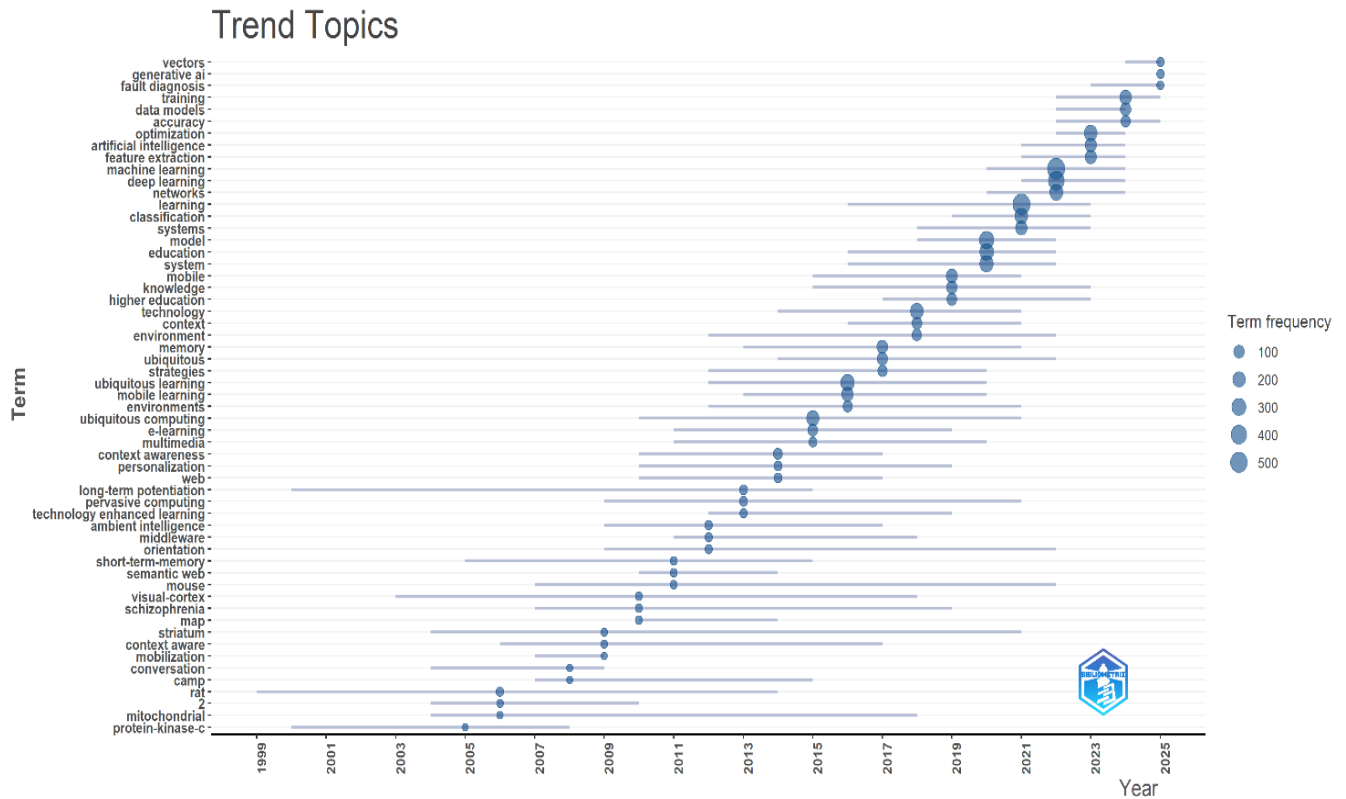


Figure 4. Distribution of countries conducting research on u-learning

As seen in Figure 4, national research on u-learning focuses on China and the United States, with studies in this area conducted in various countries . Furthermore, the keywords used in the research by year are shown in Figure 5 .

Figure 5. Keywords used in research on u-learning by year



As seen in Figure 5, different words such as morphology and development were used over the years. A word cloud based on the density of words used in the research is shown in Figure 6.



Figure 6. Word cloud

Figure 6, the most frequently used keywords in u-learning research were "machine learning," "learning," "deep learning," "model," "design," "education," "ubiquitous learning", and "classification". Furthermore, research using u-learning was also found in areas such as "behavior", "language", "attitude" and "ubiquitous computing." Furthermore, the frequency of keyword use by year is shown in Figure 7.

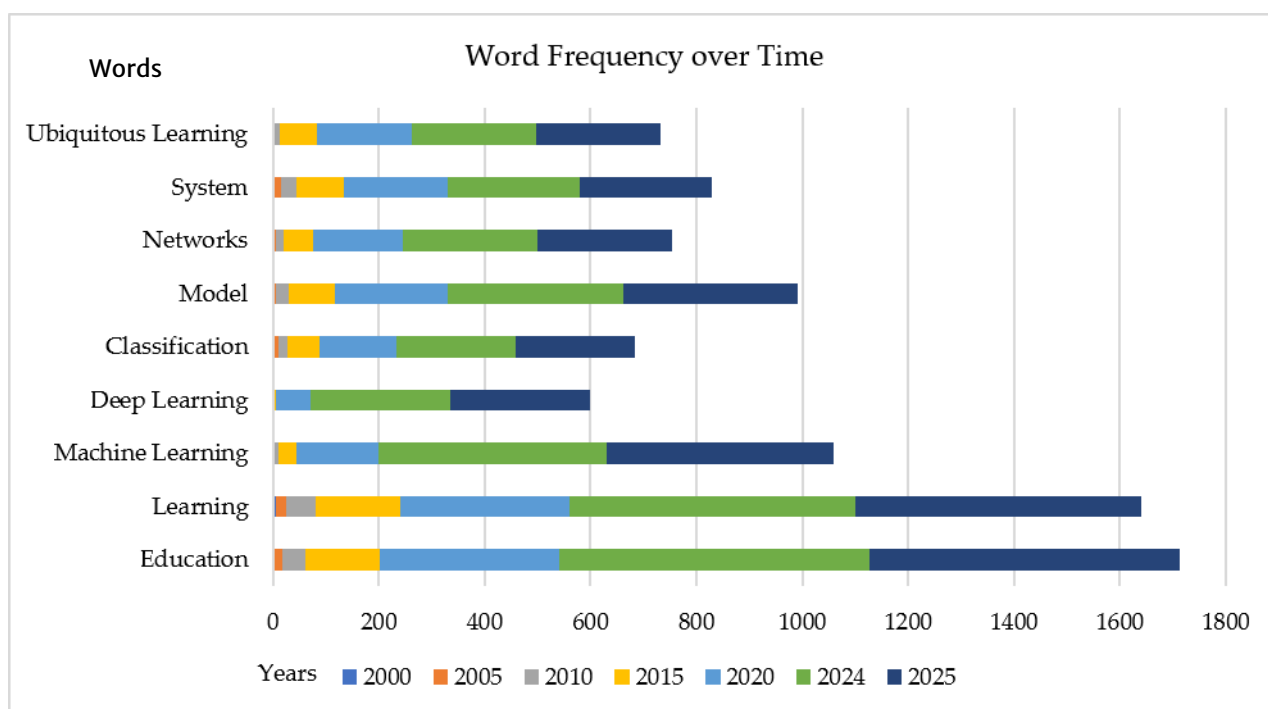


Figure 7. Keyword usage by year

Figure 7 shows the changes in keywords used in research on learning over the years. Accordingly, “machine learning”, “education”, and “deep learning” have become more commonly used in research in recent years.

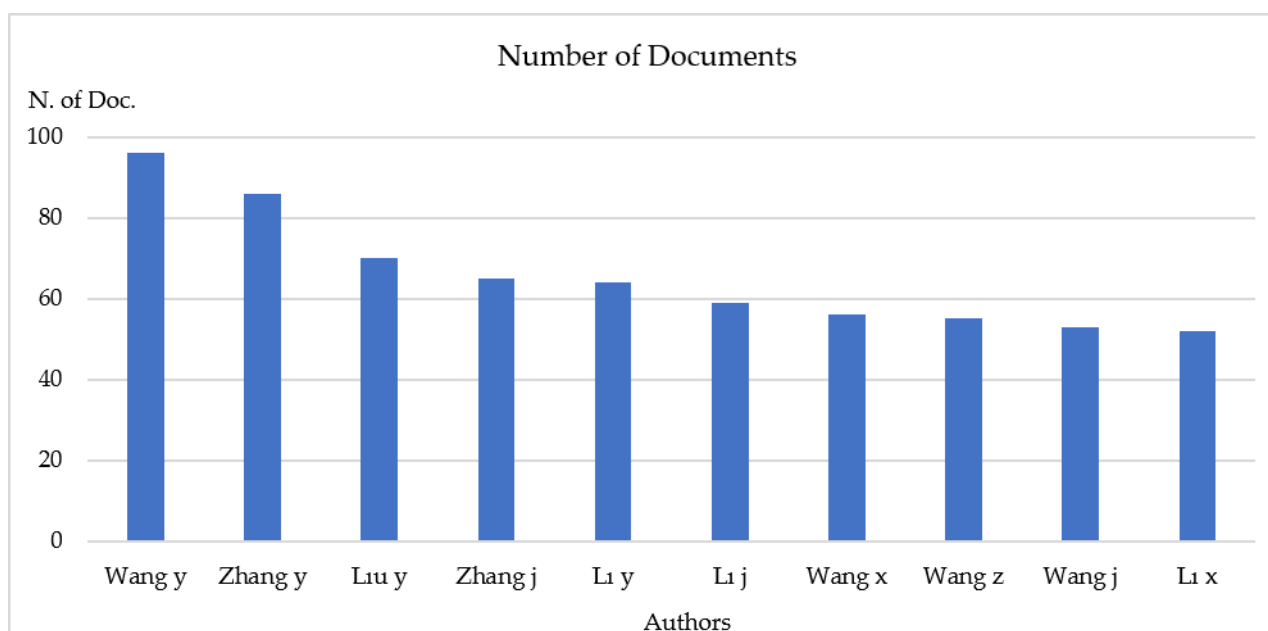


Figure 8. Researchers with the most interaction

Figure 8 shows the scientists who received the most interactions in studies on u-learning. Researchers "Wang Y." received 124 interactions, "Zhang Y." 113 interactions, "Zhang J." 104 interactions, and "Liu Y." 98 interactions. Thematic mappings of the keywords used in the study are shown in Figure 9.

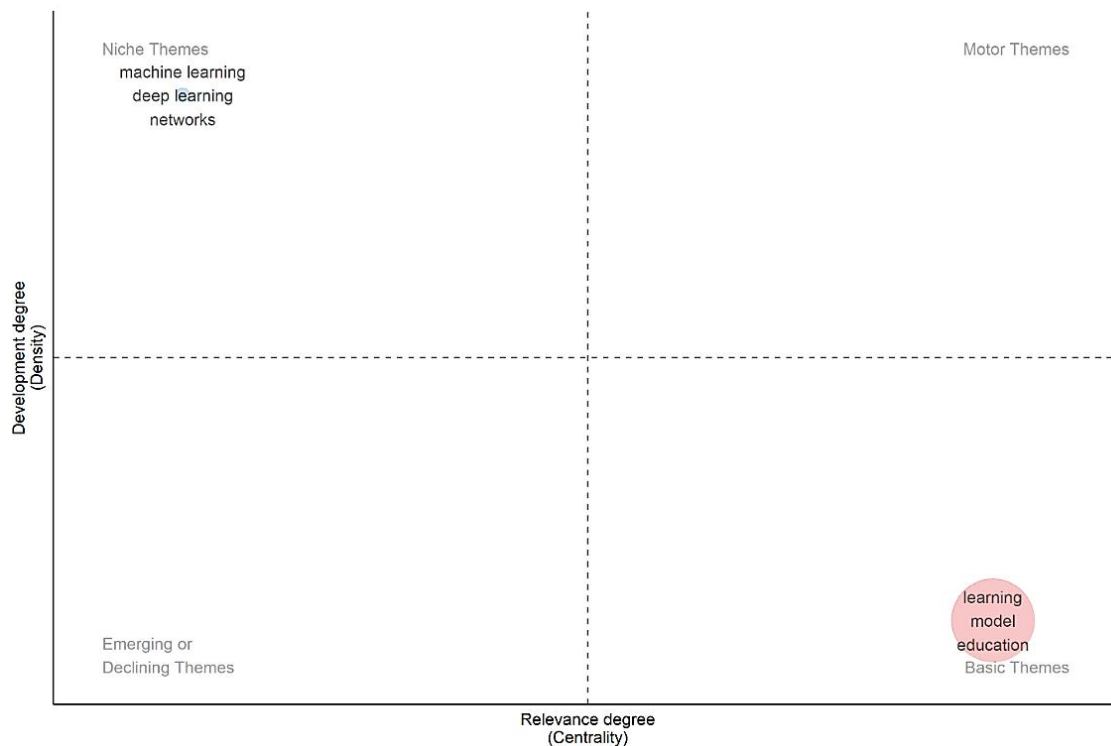


Figure 9. Theme distribution of research on u learning

Figure 9 presents the thematic classification of research conducted in the field of u-learning. An examination of the core theme relationship between development level and relevance reveals a relationship between "learning", "model", and "education". Furthermore, niche theme relationships were identified between "machine learning", "deep learning" and "networks".

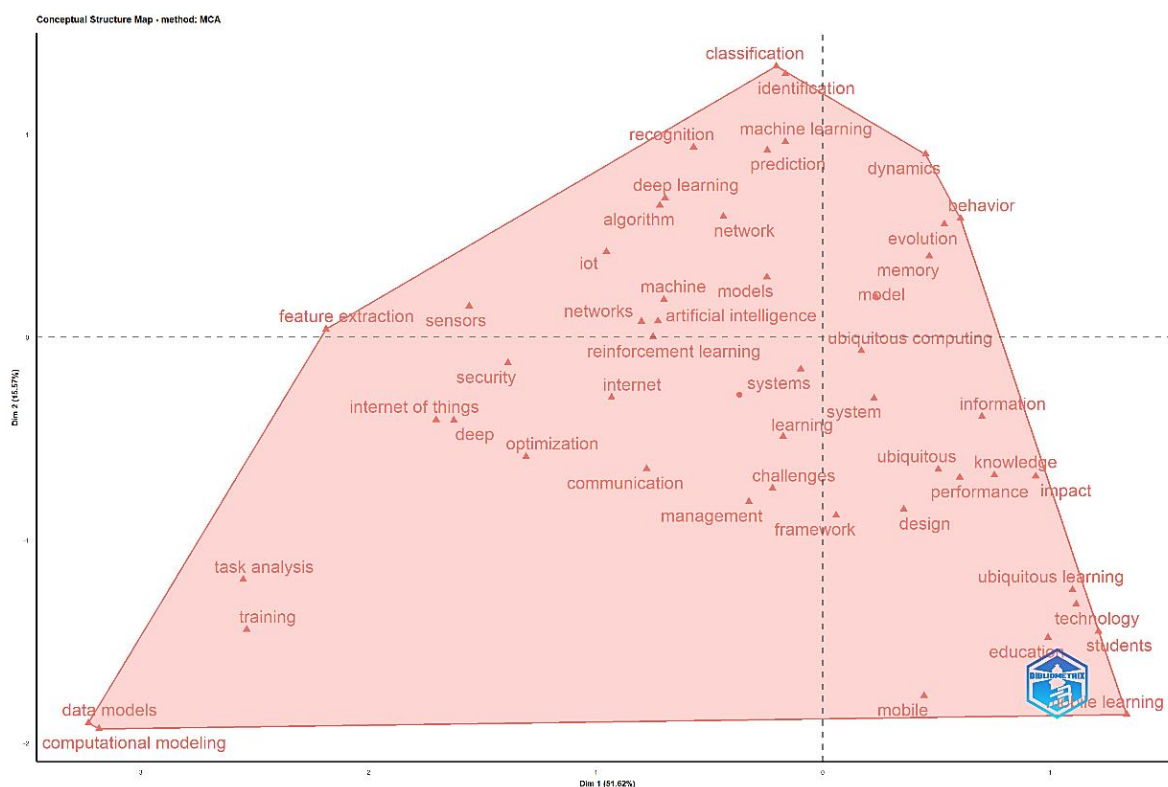


Figure 10. Conceptual structure map

This conceptual structure map shows that the literature/field examined is concentrated around Artificial Intelligence, Machine Learning, and especially Deep Learning. Studies, on the one hand, focus on the fundamental technical and cognitive aspects of these algorithms (Top section), while on the other hand, they place great emphasis on the integration of these systems with IoT and mobile devices, and especially on their impact on education/informal learning (Right section). The concepts of " Ubiquitous Computing/Learning" (Ubiquitous Computing/Learning) are used to describe technical progress in this field (machine learning). It serves as an important bridge connecting the end – user application (education, students).

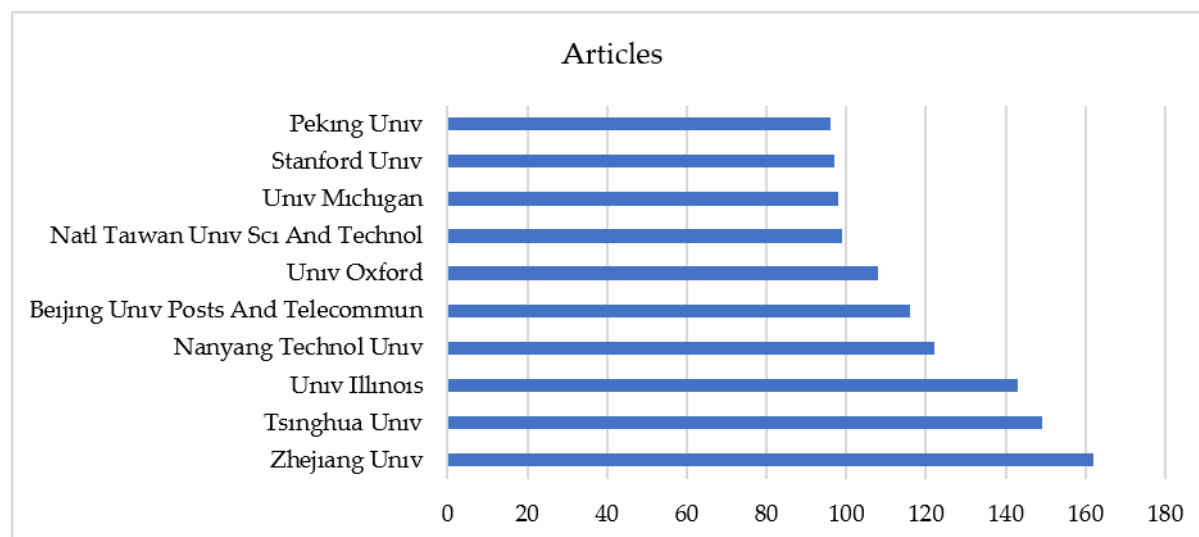


Figure 11. Institutions that contributed the most

Figure 11 shows the institutions that have conducted the most research on u-learning. Zhejiang University ranks first with 162 publications, Tsinghua University ranks second with 149 publications, and the University of Illinois ranks third with 143 publications. Then Nanyang Technological University, Beijing University of Posts and Telecommunications and Oxford University are coming.

## Conclusion and discussion

According to the results of this research, which examined the literature on U learning using the bibliometric method, there is a "ubiquitous " category in the WoS database. Research in the field of " learning " has increased over the years, with researchers in countries such as China, Germany, and India increasingly focusing on u-learning. Furthermore, presenting the dynamic and evolving field of u-learning to the user demonstrates a shift from a technology-centric concept to an integrated, intelligent, and student-focused one. While strengthening its foundations in mobile and context-aware computing, the field has also embraced artificial intelligence and learning analytics. Zydney and Warner (2016) and Malinka et al. (2023) found similar results in their research. This may be because u-learning research has been conducted within a specific framework for a long time.

It's a productive approach amidst the proliferation of pedagogical practices and the increasing focus on people in learning, coupled with current technology. The significant increase in publications and the constant emergence of new keywords demonstrate the vitality of the field and its critical importance for the future of education in an increasingly connected world. Karagöz and Şeref (2021), Dwivedi et al. (2023), and Saif et al. (2024) discussed new approaches to uL in their research, explaining the relationship between new technological updates and education. The ease of integration of updated technology in uL appears to play a significant role in this. Altınışık and Adıgüzel (2016) focused on the contributions of uL to 21st-century skills and discussed its impact on self-directed learning, self-regulated learning, and learning behaviors. In this phase, they addressed the impact of technology use on negative outcomes such as not studying and avoiding studying.

According to research results, the most used keywords used in the creation of thematic content are "Model," "System," "Performance," "Design," "Student," and "Technology". The use of these words in educational settings may be related to the development and proliferation of new technologies in mobile learning environments, as well as the focus on these areas in qualitative and quantitative research. Shuib et al. (2015) stated that design is effective in mobile learning, while Cardenas-Robledo and Pena- Ayala (2018) stated that performance and technology influence the learning culture in mobile learning, and that students

are more active in mobile learning environments. Similarly, Bhutoria (2022) stated that AI-supported, personalized mobile learning environments can be provided with advanced infrastructure in various countries to have a positive impact on educational environments and students. When the general structure is examined, it is understood that the concepts of "Machine Learning" and "Deep Learning" act as a strategic bridge at the top-center point of the Conceptual Structure Map. This finding may indicate that the field will establish a closer link between more complex prediction models and personalized education technologies (mobile learning) in the future. Education and Application mobile learning, students, education, technology, ubiquitous learning, design, and impact are seen. Machine learning, deep learning, classification, prediction, identification, dynamics, recognition, algorithms are seen in Artificial Intelligence and Algorithms. Infrastructure and Systems Internet of Things (IoT), networks, sensors, systems, management, communication, optimization are seen. Finally, Modeling and Data data models, computational modeling, task analysis, training, feature extraction were seen.

The research results provide a framework for the past and present of u-learning research conducted in recent years, highlighting significant opportunities and directions for future research. It emphasizes that the successful implementation of u-learning requires a holistic strategy that prioritizes pedagogical soundness, technological robustness, and student-centered design for both students and content developers. El Said (2021), Flavián (2022), and Haleem et al. (2022) have similarly found results on technology use in learning environments. Anywhere and anytime learning is not only a pervasive technology for users, but also a much more accessible, responsive, and personalized education for everyone. The rise of AI-supported content and the proliferation of student-specific content have been shown to have an impact on this situation.

According to the research results;

1. In future research, the effects of artificial intelligence-supported learning environments on learning can be examined.
2. The effects of the tools used for learning on students' preferences can be examined based on different variables.
3. In individualized learning environments, offline u-learning processes can be examined by taking different variables into account.

## **Declarations**

### **Ethics statements**

There was no ethical violation in this study. The study content does not require ethics committee approval.

### **Informed consent**

The study does not involve human participants.

### **Availability of data and materials**

The data is available in the relevant database.

### **Competing interests**

The author declares that there is no conflict of interest in the study.

### **Funding**

There is no source of funding.

### **Authors' contributions**

The author has made a sole contribution.

### **Artificial Intelligence**

Artificial intelligence was not used in the preparation of this article.

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