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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

Educational Technology: A Bibliometric Approach *

Eğitim Teknolojileri: Bibliyometrik Bir Analiz

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Abstract

Educational technology (EdTech) possesses comprehensive content and an accumulation of topics requiring extensive analyses for monitoring its development over time. Conducting comprehensive analyses facilitates acquiring a plural perspective instead of subjective experiences and facilitates focusing on the places where deficiencies occur in the field. This research aims to determine general EdTech research trends and to monitor its developments over time and investigates EdTech research from aspects such as year, publication type, country, journal, institution, author, scientific field, keywords, inter-country relationships, citations, and interactions using the bibliometric method. The study analyzes 135,835 EdTech publications published between 1950-2021 in 156 journals located in the EdTech Journals 2021 list and Scopus database and presents the findings under four headings: numerical development of EdTech research by year, content changes, relationships among the research,

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and research impact. The number of publications on EdTech research increased post-2000, with most being performed in the fields of social sciences and computer sciences, a large portion are composed of articles, and USA is prominent in the country rankings and coauthor analyses. When examining the common word analyses, the topics of interactive learning environments, learning-teaching strategies, pedagogical issues, virtual reality, and distance learning are prominent. The most-cited journals in EdTech research are Computers and Human Behavior, Computers and Education, and Journal of Computer-Mediated Communication. This study evaluates EdTech research's numerical, contextual, and impact trends and is thought to contribute to the framework formed for future EdTech research.

Keywords: Educational Technology, Bibliometric Analysis, Educational Technology Trends, Instructional Technology, Citation Analysis, Common Words Analysis, Scopus, Science Mapping.

Öz

Eğitim teknolojisi, zaman içindeki gelişimin takip edilebilmesi için geniş kapsamlı analizler gerektiren kapsamlı bir içeriğe ve konu birikimine sahiptir. Kapsamlı analizlerin yapılması, o alandaki eksikliklerin olduğu yerlere odaklanılmasının kolaylaştırmanın yanı sıra öznel deneyimler yerine çoğul bir bakış açısının edinilmesini kolaylaştırmaktadır. Bu araştırmada, eğitim teknolojileri alanındaki araştırmaların genel eğilimlerinin belirlenmesi ve zaman içindeki gelişiminin takip edilebilmesi amaçlanmıştır. Eğitim teknolojisi araştırmaları yıl, yayın türü, ülke, dergi, kurum, yazar, bilim alanı, anahtar kelime, ülkeler arası ilişki, atıf, etkileşim vb. açılardan bibliyometrik yöntemle incelenmiştir. EdTech Journals 2021 listesinde ve SCOPUS veri tabanında eğitim teknolojileri alanında yer alan 156 dergideki 1950-2021 yılları aralığında yayınlanan 135,835 yayın üzerinden analizler gerçekleştirilmiştir. Araştırma bulguları eğitim teknolojisi araştırmalarının yıllara göre sayısal gelişimi, içerikleri bakımından değişimi, araştırmalar arasındaki ilişki ve araştırmaların etkileri olmak üzere dört başlıkta sunulmuştur. Eğitim teknolojileri araştırmalarında 2000 yılından sonra yayın sayısının arttığı, akademik çalışmaların büyük bölümünü makalelerin oluşturduğu, ülke sıralamasında ve ortak yazar analizlerinde Amerika'nın öne çıktığı, en çok sosyal bilimler ve bilgisayar bilimleri konu alanlarında çalışmalar yapıldığı görülmüştür. Ortak kelime analizleri incelendiğinde ise etkileşimli öğrenme ortamları, öğrenme-öğretme stratejileri, pedagojik konular, sanal gerçeklik ve uzaktan eğitim konularının ön plana çıkmıştır. Eğitim teknolojisi alanındaki araştırmalarda en çok atıf alan dergiler Computers in Human Behavior, Computers And Education ve Journal Of Computer-Mediated Communication dergileri; en çok atıf yapılan kurum ise Michigan State Üniversitesi olmuştur. Eğitim teknolojisi alanında yapılan araştırmaların sayısal, içeriksel ve etkisel eğilimlerinin değerlendirildiği bu çalışmanın, alanda yapılacak araştırmalar için oluşturacağı zemin açısından katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Eğitim Teknolojileri, Bibliyometrik Analiz Analysis, Eğitim Teknolojileri Trendleri, Öğretim Teknolojileri, Atıf Analizi, Anahtar Kelime Analizi, Scopus, Bilim Haritalaması.

Geniş Özet

Giriş

Teknolojinin hızlı gelişimi, bu süreçte yaşanan dijitalleşme ve toplumsal değişimler tüm alanları olduğu gibi eğitim alanını da derinden etkilemekte, değişen eğitim sorunları için yeni çözüm ve yaklaşımlar üretilmektedir. Bu yaklaşımlardan biri de teknolojinin öğrenme ortamlarına

entegrasyonu olarak ortaya çıkmaktadır. "Uygun teknolojik süreçleri ve kaynakları yaratarak, kullanarak ve yöneterek öğrenmeyi kolaylaştırmaya ve performansı iyileştirmeye yönelik çalışma ve etik uygulama" şeklinde tanımlanan (AECT; Richey, 2008, s. 24) eğitim teknolojileri; eğitimciler ve öğrenciler arasındaki etkileşimin güçlendirilmesi, iş birliği ortamı sunulması, eşitlik imkânı tanınması ve erişilebilirlik boşluklarının kapatılması gibi birçok açıdan farklı avantajlar oluşturmaktadır (U.S. Department of Education, 2017).

Eğitim teknolojileri, kuramsal tanımının kapsayıcılığına rağmen uygulamada dar bir alana sıkıştırılabilmektedir. Bu terimin "eğitim amaçlı kullanılan araçlar" tanımından zamanla uzaklaşarak çok disiplinli bir alandan geldiğinin kabullenilmesi, uygulamada da kuramsal gelişimle eş güdümlü bir gelişimin gerçekleşmesi önemli görülmektedir (Şimşek vd., 2008). Eğitim teknolojilerinde eğilim gösterilen alanlar ve bunlara verilen öneme göre ağırlıkları zamana göre değişim gösterebilmekte, bazı alanların gördüğü ilgi zamanla azalırken bazı alanlar yüksek bir ivmeyle trend olan konular arasına girebilmektedir. Örneğin Kimmons ve diğerleri (2021), çevrimiçi öğrenmenin, yaşanılan salgın sürecinin de etkisiyle tarihsel olarak eğitim teknolojileri alanında en çok araştırılan konu olduğunu, son on yılda daha "açık" ve "sosyal" konulara geçişin ele alındığını belirtmiş; felsefi çoğulluk, eşitlik, pratiklik gibi konulara yoğunlaşılmasının önemini vurgulamıştır. Scanlon (2021) ise eğitim teknolojisi araştırmalarının gelişimini incelediği çalışmasında kişiselleştirme, sosyal öğrenme, öğrenme tasarımı, makina öğrenimi ve veriye dayalı iyileştirme gibi eğitim teknolojisi araştırmalarındaki çağdaş eğilimleri tartışmıştır.

Bu araştırmada, eğitim teknolojileri alanındaki araştırmaların genel eğilimlerinin belirlenmesi amaçlanmıştır. Yapılacak geniş kapsamlı analizler zaman içindeki gelişimin takip edilebilmesi, öznel deneyimler yerine çoğul bir bakış açısının edinilmesi ve eksikliklerin olduğu yerlere odaklanılmasının kolaylaşması (Lin vd., 2019) açısından son derece önemli görülmektedir. Ayrıca eğitim teknolojisi alanının genişliği (Wilson, 2012) sebebiyle bu alanın gelişimi hakkında derinlemesine araştırma yapılması ayrı bir önem taşımaktadır (Bodily vd., 2018). Bu araştırmada eğitim teknolojisi araştırmalarının sayısal bakımdan yıl, tür, ülke, dergi, kurum ve yazar dağılımları; konu bakımından bilim alanı ve anahtar kelime dağılımları; araştırmalar arası ilişkiler bakımından ülke, dergi ve yazar dağılımları ile araştırmaların yazar, makale ve dergi bakımından etkileri araştırılmıştır.

Yöntem

Bu araştırma bir bibliyometrik analiz araştırmasıdır. Bibliyometrik çalışmalar bir alanda yapılmış bilimsel yayınların analiz edilerek içerik, sonuç ve etkinliklerinin belirlenmesini sağlamaktadır. Bilimsel çalışmaların bibliyometrik analizi genellikle söz konusu alandaki dergilerin analizi ya da alanla ilgili anahtar kelime aramasıyla yapılmaktadır. Bibliyometrik bir çalışmanın ortaya konması için öncelikle bibliyometrik çalışmanın amaçlarını ve kapsamını tanımlamak gerekir. İkinci adım olarak bibliyometrik analiz teknikleri belirlenen amaç doğrultusunda tasarlanmalıdır. Daha sonra ikinci adımda seçilen bibliyometrik analiz teknikleri için gerekli veriler toplanmalıdır. Son olarak toplanan veriler ve yapılan analizler raporlanmalıdır.

Bu çalışmada taramalar bibliyometrik analizde yığın olarak kullanılan uluslararası özet ve atıf veritabanı SCOPUS'ta yapılmıştır. Eğitim teknolojisi alanında yayın yapan dergiler EdTech Journals 2021'de listelenmiştir. Bu kaynakta eğitim teknolojileri alanında yayın yapan 252 adet dergi bulunmaktadır. Bu dergilerin yaklaşık %32'si açık erişimli dergilerdir. SCOPUS'ta 252 adet dergiden yalnızca 156'sı taranmaktadır. Analizler sadece bu 156 dergide 1950 yılından 26 Aralık 2021 tarihine kadar yayımlanan 135.825 yayın üzerinden yapılmıştır. Araştırma kapsamına dahil edilecek dergiler belirlendikten sonra bu dergilerde yayınlanan makaleler "eğitim + teknoloji" kavramlarını içerenler bakımından süzülmüştür. Süzme işleminde yıl, dil, ülke, alan vb. başka herhangi bir sınırlayıcı kelime ya da kavram kullanılmamıştır.

Analizler üç aşamada yürütülmüştür. İlk aşamada bütün makaleler analize tabi tutulmuştur. Bu aşamada araştırmanın ilk sorusu kapsamına giren bulgulara ulaşmak amacıyla makaleler yıllara, ülkelere, dergilere, kurumlara ve yazarlara göre frekansları bakımından sıralanmıştır. İkinci aşamada atıf sayısına göre en fazla atıf alan 2 bin makale analize tabi tutulmuştur. Bu aşamada araştırmanın ikinci, üçüncü ve dördüncü soruları kapsamında yine en çok atıf alan (8043-174 arası) 2 bin makalenin VOSViewer ile atıf analizi (dergi, yazar, kurum, ülke), ortak yazar analizi (ülke) ve ortak kelime analizi yapılmıştır.

Araştırma kapsamında yapılan analizlerin geçerlik ve güvenirliğini sağlamak için veri setine erişme yolları, analiz yöntemleri ve uygulanan istatistiki işlemler detaylıca aktarılmıştır. Ayrıca erişilen makalelerin listesi erişime açılmıştır.

Bulgular

Eğitim teknolojisi araştırmalarının analizine ilişkin bulgular; yıllara göre sayısal gelişim, içerikler bakımından değişim, araştırmalar arasındaki ilişki ve araştırmaların etkilerine ilişkin bulgular olarak dört başlık altında sunulmuştur.

Eğitim teknolojisi araştırmalarının yıllara göre yayın sayısı dağılımları bakımından 1950 ile 1970 yılları arası durağan bir süreç olarak gözükmektedir. 1970-2000 yılları arasında üretim hızı ve yayın sayısı artmış, 2000 yılından sonra daha da hızlanmıştır. 2019-2021 yılları arasında ise en yüksek artış hızı ve yayın sayısı görülmüştür. Eğitim teknolojisi araştırmalarında akademik çalışmaların büyük bölümünü makalelerin oluşturduğu; inceleme ve editör yazılarının da öne çıkan akademik yayınlardan olduğu anlaşılmaktadır. Konferans bildirileri ve akademik notlar ise bu alanda kendisine sınırlı olarak yer bulmuştur.

Eğitim teknolojileri araştırmalarına katkıda bulunan ilk on ülke incelendiğinde Amerika, sırasıyla Birleşik Krallık, Kanada, Avustralya, Tayvan, Hollanda, Almanya, İspanya, İsrail ve Güney Kore'nin toplamından daha fazla atıf ve yayın sayısına sahiptir. Ortak yazar analizlerinde de ABD'nin merkezde yer aldığı ve Birleşik Krallık, Kanada, Almanya, Avustralya ve İspanya ile güçlü bir yazar iş birliği olduğu görülmektedir. Eğitim teknolojileri alanında ilk on ülke ile ortak yazar analizleri birbiriyle örtüşmektedir.

Eğitim teknolojisinin konu dağılımlarında sosyal bilimler ve bilgisayar bilimleri en önemli konu başlıklarıdır. Mühendislik, sanat ve beşerî bilimler, psikoloji ve matematik de öne çıkan konu başlıklarındandır. Araştırma kapsamında ele alınan eğitim teknolojileri araştırmalarında, son 70 yılda yapılan çalışmaların anahtar kelimeleri incelediğinde, anahtar kelime gruplarının beş farklı grupta yapılandığı görülmektedir. En büyük grubu etkileşimli öğrenme ortamları, öğrenme-öğretme stratejileri, pedagojik konular, sanal gerçeklik ve uzaktan eğitim konuları oluşturmuştur. Diğer gruplar "sosyal medya, internet", "e-öğrenme, yükseköğretim, sosyal mevcudiyet, teknoloji kabul modeli", "insan-bilgisayar etkileşimi, kullanışlılık, iş birliği, motivasyon, akıllı öğretim", "artırılmış gerçeklik, teknoloji entegrasyonu, anlamsal (semantic) web çalışmaları" konuları üzerinde yoğunlaşmıştır.

Araştırma kapsamında incelenen son 70 yılda yapılan eğitim teknolojileri çalışmalarının başlık ve özetlerinde öne çıkan kelimeler ise dört farklı grupta yapılanmıştır. Birinci grupta "makale, problem, görev", ikinci grupta "öğrenme, öğretmen, kurs, motivasyon, yetenek, öğretim", üçüncü grupta "etki, deney, performans, şart, hafıza, konu" ve dördüncü grupta "faktör, ilişki, kullanıcı, insan, davranış, etkilemek, algı, davranış, kullanışlılık" öne çıkmıştır. Bu bulgular, eğitim teknolojisi çalışmalarının öğrenmeye odaklandığı, öğrenme sürecine etki eden teknoloji ve etkenlerle etkileşim hâlinde olduğu şeklinde yorumlanabilir (Berrocoso vd., 2020).

Eğitim teknolojisi araştırmalarında öne çıkan yazarlar incelendiğinde, 7 yayın ve 15.790 atıfla Ellison N. B.'nin güçlü bir etkiye sahip olduğu görülmüştür. 267 yayınla Hwang G. J., 260 yayınla Rudall B. H., 204 yayınla Tsai ve 203 yayınla Andrew öne çıkan isimlerdir. Araştırmalarda en çok atıf yapılan kurumlar incelendiğinde Michigan State Üniversitesi'nin 14.402 atıfla ilk sırada yer aldığı anlaşılmıştır. En çok alıntılanan yayın ise, 8.043 atıfla "Social network sites: Definition, history, and scholarship" olmuştur.

Tartışma

Dijital teknolojiler; eğitime erişim, yoksulluğu azaltma ve sosyal ihtiyaçlar için fırsatlar oluşturmaktadır (UNDP, 2022). Son yıllarda eğitim teknolojileri alanında yapılan araştırmalardaki hızlı artış ve Covid-19 salgını sürecinde eğitimdeki hızlı dijital dönüşüm, uygulamalardaki çeşitliliğin oldukça etkili olduğunu göstermektedir (Livari vd., 2020). Eğitim teknolojilerindeki eğilime ve bu teknolojilerin odaklandığı alanlara dair analizler eğitim/teknoloji entegrasyonunun bilinçli olarak yapılandırılmasına önemli katkı sağlayacaktır.

Introduction

Although technology usage in education dates back historically to ancient times (e.g., clay tablets, pen/paper), the appearance of technology as a concept and discipline occurred more recently. Revealing field studies and monitoring historical developments contribute to strengthening EdTech academically as a relatively new discipline among other disciplines. As in every field, historically monitoring developmental processes in EdTech is additionally important in terms of better understanding the point currently reached. Simultaneously, these types of studies provide

opportunities to evaluate gaps in the relevant field and thus facilitate determining new developmental directions.

Problem Statement

The rapid development of technology, digitalization process, and social changes closely affect education and all other fields by producing new solutions and approaches for the changing educational problems, with technology integrated into learning environments being one effect. The Association for Educational Communications and Technology (AECT) defines educational technology as "the study and ethical practice aimed at facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources" (Richey, 2008, p. 24). EdTechs are also expressed as the process of designing, implementing, and developing learning-teaching processes (Alkan, 1997) and as a multidisciplinary field by nature that includes studies from different professions and fields (Schneider, 2009). EdTechs are said to possess different advantages, such as strengthening educator and student interactions, providing a cooperative environment, enabling equal opportunity, and closing accessibility gaps (U.S. Department of Education, 2017). Effective efforts from EdTech teams are additionally argued to be able to transform students' and teachers' academic experiences, shape higher education instruction, and clarify the need for in-house and inter-institutional implementation communities (Sonnenberg, 2021). Alongside all these, many studies are found to have stated the use of technology in education to positively impact academic performance, competitiveness, and motivation (Bower, 2017; Lai & Bower, 2019; Cheng et al., 2022).

In addition to its theoretical definition, EdTech has an extremely important place in practice. Despite its comprehensive theoretical definition, EdTech is compressible into a narrow area in practice. The introduction of digital technologies in the teaching and learning process has been stated to be a theme covering the EdTech literature, and EdTech has continued to get stronger since the 1980s with personal computers and then with developments regarding the Internet, portable devices, and social media platforms (Pedro et al., 2018). While the focus of EdTech had been computers in the past, other interactive devices are emphasized to have begun taking place among the technologies that support teaching and student processes with the spread of smartphones (Jack & Higgins, 2019). Still, importance is seen in adopting this term as a multi-disciplinary field by moving away from the definition of "tools used for educational purposes" and in realizing coordinated improvement through theoretical development regarding implementation (Şimşek et al., 2008). One should not forget that technological developments together with learning tools have created a difference in the mentality and pedagogy of educators (Cheng et al., 2022). The need to use tangible and intangible technologies to complement one another in educational processes has been emphasized, as well as the importance of EdTech's ability to be effective with digital competence and literacy (Bozkurt et al., 2022). The need to perceive EdTech as a tool requiring separate adjustment for each learning context rather than being used similarly in all environments has additionally been suggested (Sonnenberg et al., 2021).

Upon examining EdTech's historical development, Caffarella's (1999) study examined doctoral theses on EdTechs between 1977-1998 and stands out as one of the first studies investigating trends

in this field. This research found computers, instructional design, simulations, games, television, and video research to be prominent. Şimşek et al.'s (2008) study examined EdTech trends in Turkey between 1996-2006, identifying the main trends as learning in computerized systems, instructional design, and learning approaches and stating the focus to be on studies conducted on experimental models and formal education systems. Meanwhile, the COVID-19 pandemic has brought many opportunities regarding digital transformation despite its many negative aspects, with different steps being taken by using EdTechs to continue education safely in many parts of the world. One example is the experience of emergency distance learning processes (Hodges et al., 2020) that accompanied school closures and mandatory quarantine processes in many regions. Many changes have occurred in EdTech policies, practices, and attitudes during this process, with technology used for educational purposes such as Zoom, Google Meet, and Nearpod becoming widespread to enable safe teaching (Kimmons et al., 2021). Kimmons et al. stated online learning to have historically been the most researched topic in this field, with transitions to topics such as open learning and social learning being discussed more in the last decade; they emphasized the importance of focusing on issues such as philosophical plurality, equality, and practicality. Scanlon's (2021) study examined and discussed the evolution of and contemporary trends in EdTech research, such as personalization, social learning, learning design, machine learning, and data-driven improvement.

Purpose

This study aims to determine general EdTech research trends. Making comprehensive analyses is considered extremely important for monitoring developments over time, acquiring a plural perspective rather than subjective experiences, and facilitating focusing on deficient areas (Lin et al., 2019). Due to the broad field of instructional technology (Wilson, 2012), particular importance is additionally had in conducting in-depth research on developments in this field (Bodily et al., 2018). Answers to the following research questions are sought in this context:

1. What numerical developments in EdTech research are shown regarding:
    a. Year
    b. Type
    c. Country
    d. Journal
    e. Institution
    f. Author
2. What developments are show in terms of EdTech research topics regarding:
    a. Field of Science
    b. Keywords
3. What relationships exist among EdTech research in terms of:

a. Countries

b. Journals

c. Authors

4. What is the impact of EdTech research regarding:

a. Author

b. Article

c. Journal

Method

Because EdTech is related to many other fields, monitoring/examining its developments is challenging. Therefore, EdTech research that examines its historical developments or current trends may require a methodology that comparatively analyzes a rich, versatile data set. Thus, the current study prefers bibliometric analysis.

Design

This research uses bibliometric analysis. Bibliometric studies enable the content, results, and effectiveness of publications published in a field to be determined by analyzing scientific studies. Namely, bibliometric analysis is useful for decoding/mapping the cumulative scientific knowledge and evolutionary nuances of well-established fields by rigorously making sense of large volumes of unstructured data. Therefore, well-performed bibliometric studies can provide solid foundations for uniquely and meaningfully advancing a field. They provide opportunities to gain single viewpoints, identify knowledge gaps, enable/empower means of study, and locate research ideas and contributions to the field (Qin et al., 2021). This technique allows quantitative information to be produced based on information obtained from past research and a general summary of publication information using many statistical data such as productivity and citation rankings of countries, institutions, and journals plus study distributions regarding number of citations, number per year, authorship models, and frequency distributions of keywords (Keshaval et al., 2008).

Bibliometric analysis of scientific studies is usually performed by analyzing journals in a field or searching for field-related keywords, and its techniques are examinable under two categories: performance analysis and scientific mapping. While performance analysis explains the contributions from the research components, scientific mapping focuses on their inter-relationships. Scientific mapping techniques include citation, co-citation, co-word, and coauthorship analyses and bibliographic matching. When combined with network analyses, various types of techniques are effective at presenting the research field's bibliometric and intellectual structures. To present a bibliometric study, one first needs to define the bibliometric study's aims and scope. The second step is to design techniques in line with the determined purpose. Next, one should collect the data

necessary for the bibliometric analysis techniques selected in the second step, and lastly report on the collected data and analyses.

Study Group

Publications in journals publishing on EdTechs were scanned to view global EdTech trends. Searches were made in Scopus, the international abstract and citation database commonly used in bibliometric analyses. Journals publishing on educational technology are listed in EdTech Journals (2021), which revealed 252 journals, around 32% being open-access journals with only 156 of the 252 journals being scanned into Scopus. We analyzed 135,825 publications published in these 156 journals between 1950-December 26, 2021. The dataset for all publications is accessible from Gunes (2022).

Data Compilation and Analysis

After determining which journals to include, these journals' articles were then filtered for those containing EdTech concepts. No other limiting words or concepts (i.e., year, language, country) were filtered out. As a result, a total of 135,825 articles were accessed. The data from these articles were gathered onto a database file for analysis in OriginPro software according to the research questions.

Analyses were conducted in three phases, with Phase 1 analyzing and ranking all the articles according to frequency by year, country, journal, institution, and author(s) in order to arrive at findings that fall within the scope of the research's first question. Phase 2 analyzed the 2,000 most-cited articles (between 8,043 and 174 citations), performing citation (journal, author, institution, country), coauthor (country), and common word analyses on them with VOSviewer regarding the second, third, and fourth research questions.

Validity and Reliability

To ensure validity and reliability of the performed analyses, the dataset's access methods, analysis methods, and applied statistical processes are explained in detail. The list of accessed articles has also been made available.

Findings

The research presents findings under four headings within the scope of the research questions. Findings related to changes in terms of content, relationships among research, effects from research, and numerical developments regarding EdTech research by year are presented in tables and figures.

Numerical Developments in EdTech Research

The first research question involves findings directed at viewing numerical developments in EdTech research. Accordingly, distributions for research published between 1950-2021 are presented in tables and figures with respect to year, type, country, journal, institution, and author.

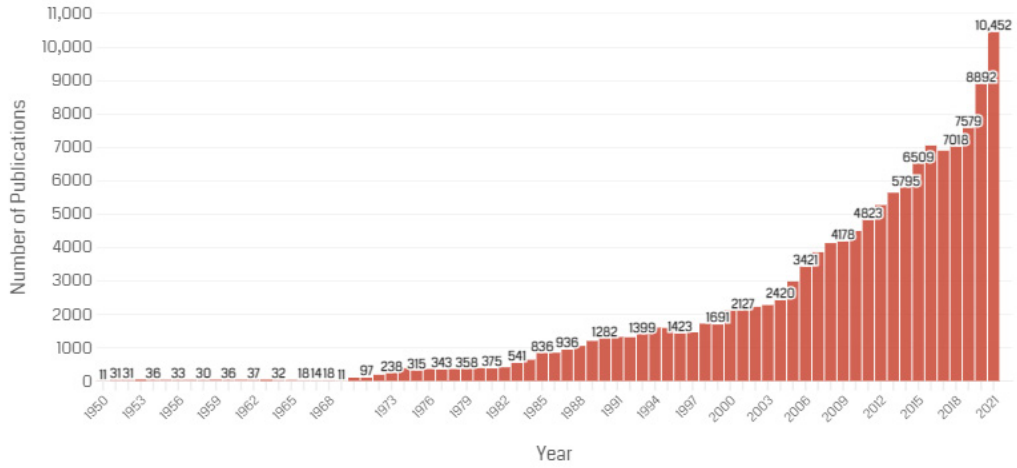

Figure 1. EdTech research distribution regarding annual number of publications.

The annual distribution of EdTech research followed a stable course between 1950-1970 (see Figure 1). An increase occurred between 1970-2000, and sped up after 2000. The rapid post-2000 increase and widespread use of the Internet and digital processes coincide with changes in information storage and sharing. The sharp upward increase between 2019-2021 reflects COVID-19's impact on digitalization processes in EdTech research.

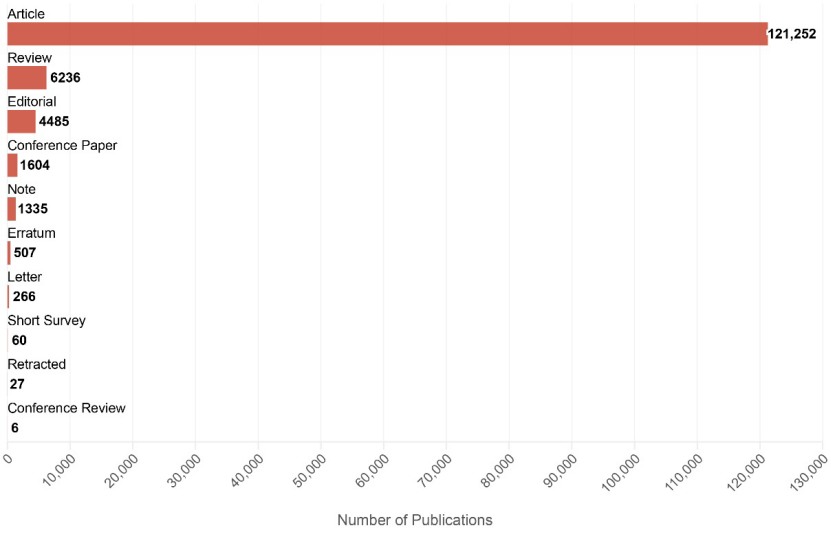

Figure 2. Distribution of EdTech research by type.

Most EdTech research is published as articles, then reviews, editorials, and reports. Because the research universe involves academic journals, most is expected to be published as articles. However, the number of review articles is also at a level not to be underestimated.

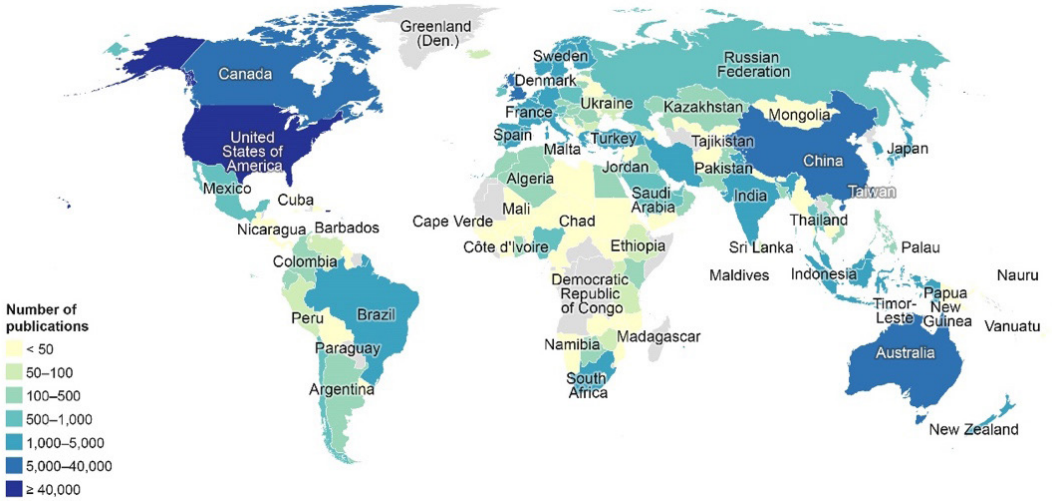

Figure 3. Number of EdTech publications by country.

Figure 3 shows the distribution of EdTech studies by country. USA is where the most EdTech research was published (more than 30% of all EdTech research). For the relationship between number of articles and population density, the most-published countries after the USA are Canada, United Kingdom, China, and Australia, each with 5,000-40,000 publications. Western European countries, India, Iran, Turkey, South Africa, and Brazil fall into the category of countries with the third highest number of publications, each with 1,000-5,000.

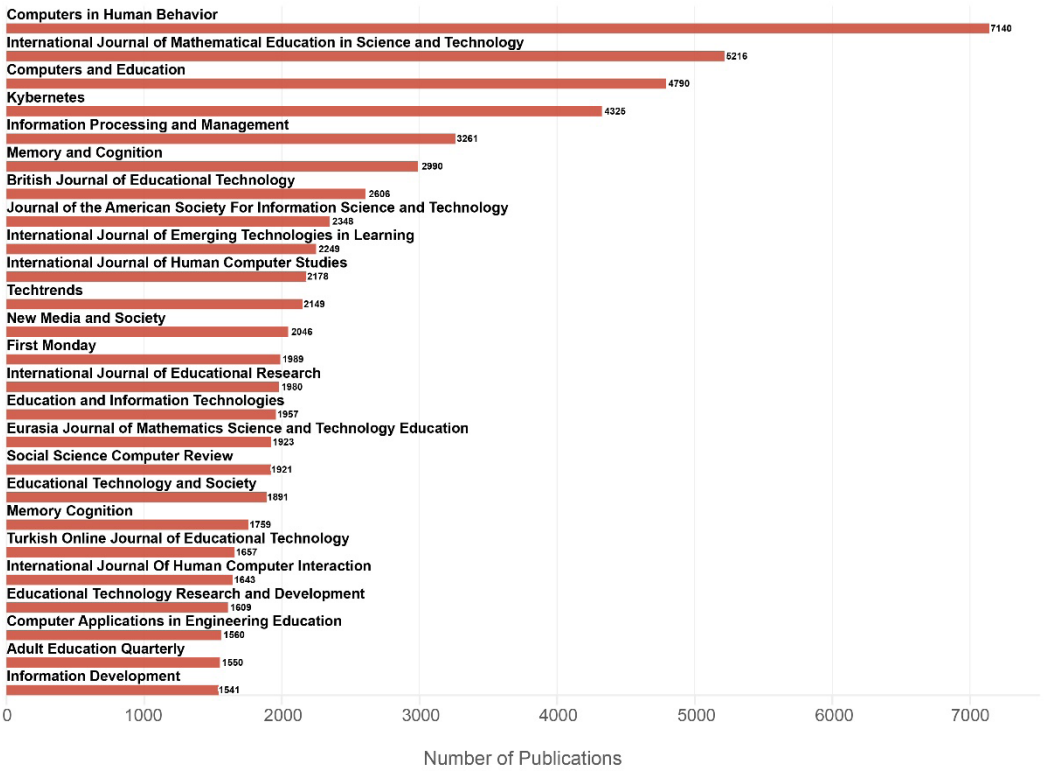

Figure 4. Number of EdTech publications by journal.

The journal publishing the most EdTech research is Computers in Human Behavior (USA, est. 1985) with 7,140 publications. Approximately 20% of the EdTech research was published in five of the 156 journals included in the research. Nearly half of all 135,000 articles were published in the 25 journals listed in Figure 4. USA is home to the top five journals with the most publications. Of these 25 journals, 14 are from the USA, seven from Western Europe, three from Asia, and one from Latin America (no journals from Africa or the Middle East). As for journals' first year of publication, only eight of the top 25 started publication pre-1980; 11 started publishing between 1981-2000, and five post-2000. No information could be found for one journal regarding first publication.

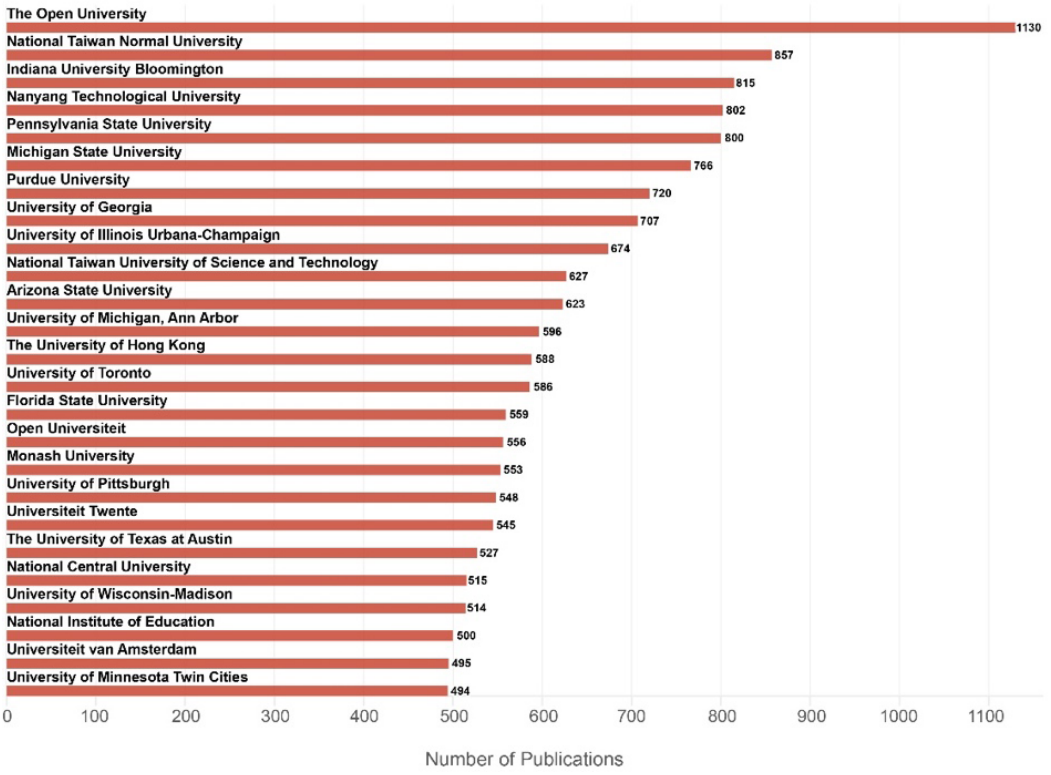

Figure 5. Number of EdTech publications according to affiliation.

With 1,130 publications, the UK's Open University comes first regarding institutions affiliated with the most-published EdTech researchers. Two of the top five institutions are noteworthily from Far Asia. In the list of the 25 institutions with the most publications, 12 institutions are in the USA, five in Western Europe, six in Far Asia, one in Canada, and one in Australia (none in Latin America, Africa, or Central Asia).

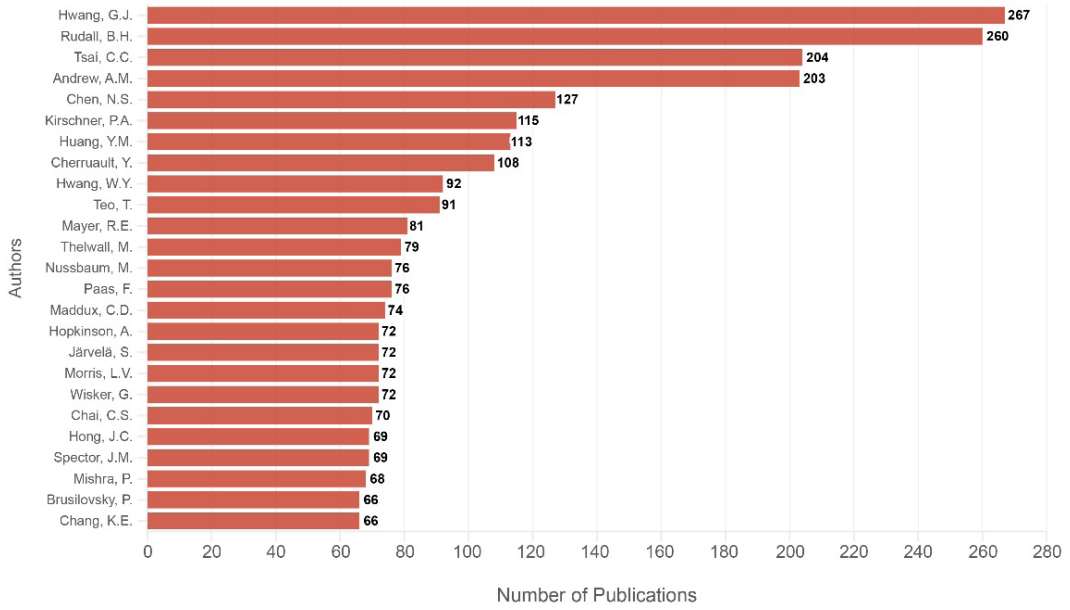

Figure 6. Number of EdTech publications by author.

The most-published EdTech researcher is G. J. Hwang (267 publications; see Figure 6). Seven of the top 25 most-published researchers are affiliated with institutions in the USA, and another seven with institutions in Taiwan, followed by four with England, then by one each in Finland, Canada, Netherlands, and India. Information about three researchers was inaccessible. The highest frequency of publications from these 25 occurred between 2001-2021.

Changes in EdTech Research in Terms of Content

The second research question analyzes EdTech research in terms of content. In this context, the distribution of research published between 1950-2021 is presented in tables and figures regarding *field of science and keywords.*

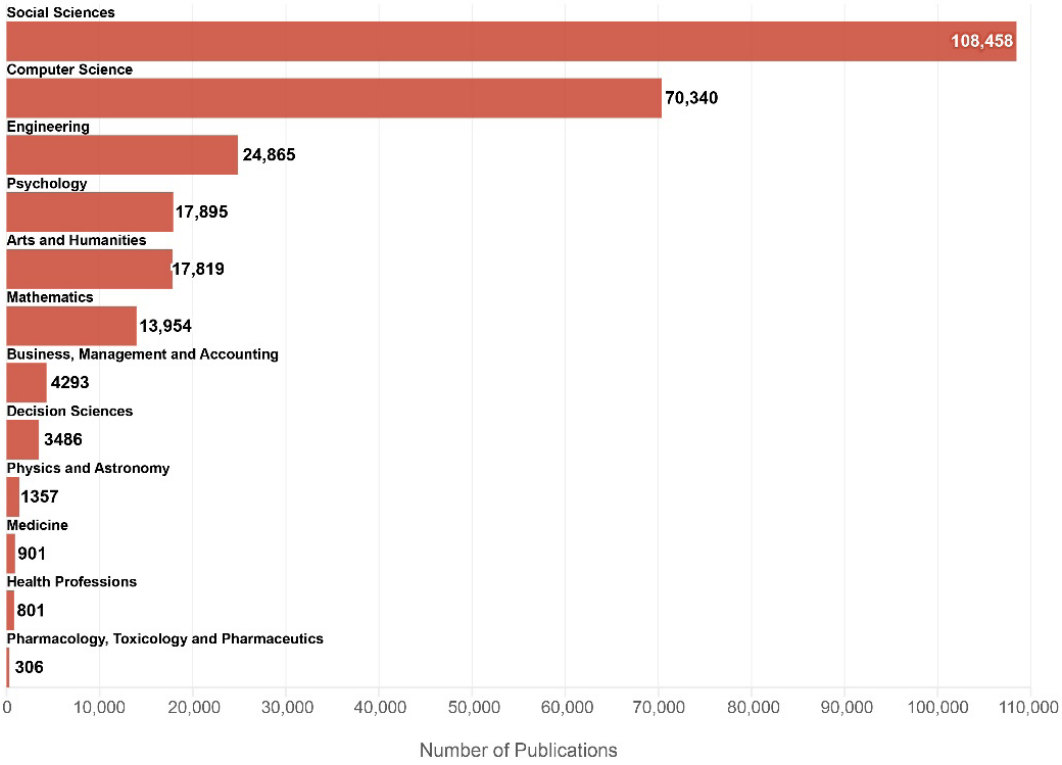

Figure 7. Number of EdTech publications by subject area.

Figure 7 shows the distribution of EdTech research by subject to be concentrated on social sciences and computer sciences. EdTechs are related to aspects of technological factors focused on education and supported by computer sciences. Engineering, psychology, arts and humanities, and mathematics are other prominent fields in EdTech studies.

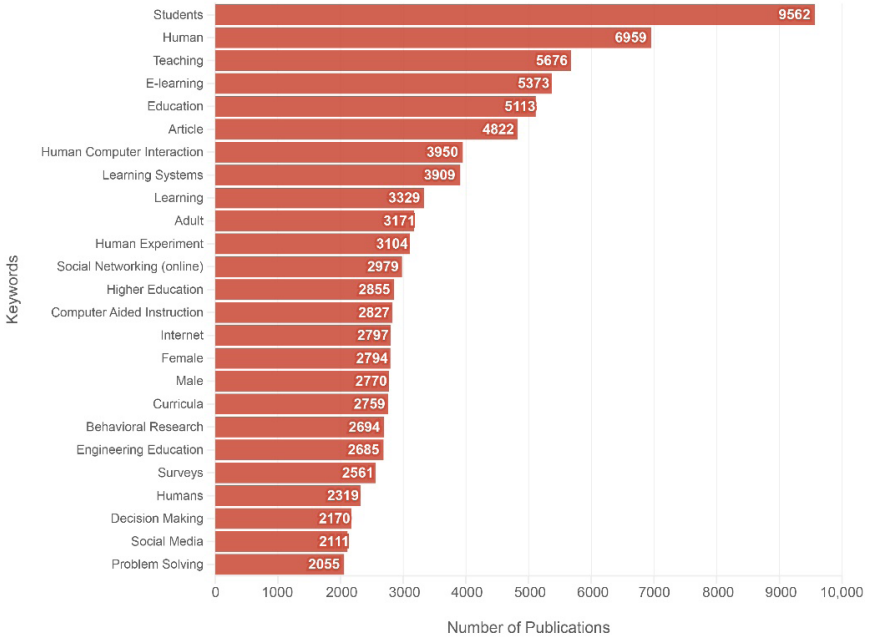

Figure 8. Amount of EdTech research according to keyword.

Figure 9. The 160 most-used EdTech keywords.

When examining the most-used keywords in EdTech research, *students* is seen to come first (See Figures 8 and 9). These figures show the keywords of student, human, teaching, education, and article to top the lists in terms of keyword frequency in EdTech research. Online learning, human-computer interaction, learning systems, and social networking studies are also understood to be trending topics in EdTech.

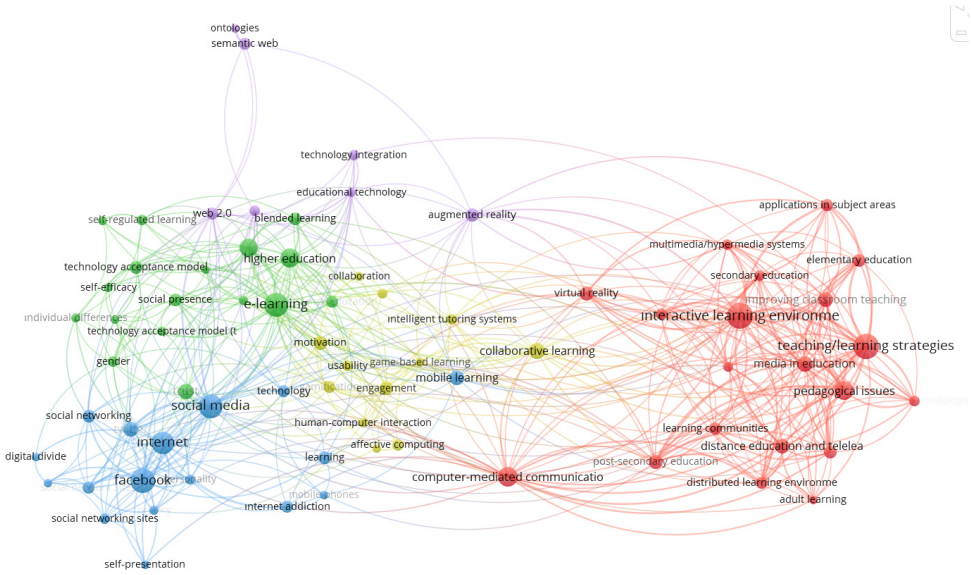

Figure 10. The relationships among keywords on educational research.

Common/Keyword Word Analysis

Upon examining keywords repeated in the analyzed publications, 3,175 keywords are understood to be frequently used. Of these, 73 used at least 10 times. When examining the occurrence map of these keywords, they are gathered in five clusters (green/purple/blue/yellow/red).

i. ***Learning-Teaching Environment and Strategies:*** The frequently-repeated terms of interactive learning environments, teaching/learning strategies, media in education, pedagogical issues, and computer-mediated communication appear in the relatively larger red cluster and shows studies that focused on learning-teaching environments and strategies. Virtual reality, distance education-related issues, and learning communities are also found in this cluster.

ii. ***Social Media and the Internet:*** The blue cluster is composed of the terms of *social media, Internet,* and *Facebook* and to mostly involve publications with social media-related topics. Facebook appearing separate in this cluster from other social media platforms likely due to it being one of the first and longest-used. The terms of *Internet addiction, self-presentation,* and *digital divide* have also been frequently discussed in social media studies.

iii. ***E-Learning and Technology Acceptance:*** The green cluster involves the concepts of e-learning, higher education, blended learning, social presence, and technology acceptance model and seems to relate to e-learning environments and technology acceptance. Considering the size and closeness of the terms in this cluster (e.g., e-learning, higher education) compared to the other clusters, many more studies appear to have occurred on the subject of higher education-based e-learning. The works in this cluster representing e-learning and technology acceptance frequently studied and consider the factors of self-regulated learning, self-efficacy, social presence, and individual difference to be important.

iv. ***Collaboration and Human-Computer Interaction:*** The yellow cluster includes terms indicating collaboration and participation such as *collaboration, motivation, engagement,* and *collaborative learning;* the human-computer interaction field is simultaneously represented by terms such as *human-computer interaction, usability,* and *intelligent tutoring system.* This cluster is in the middle of the keyword analysis map, which shows studies in this cluster to be closely related to studies in the other clusters. The prominent repetition frequency of collaborative learning as a concept in this cluster noteworthily shows the importance of collaborative learning in EdTech studies.

v. ***Augmented Reality and Technology Integration:*** The purple cluster contains augmented reality-, technology integration-, and Web 2.0-related studies, as well as semantic web – and ontology-related studies. Augmented reality, technology integration, and Web 2.0 also appear as frequently studied topics in other clusters.

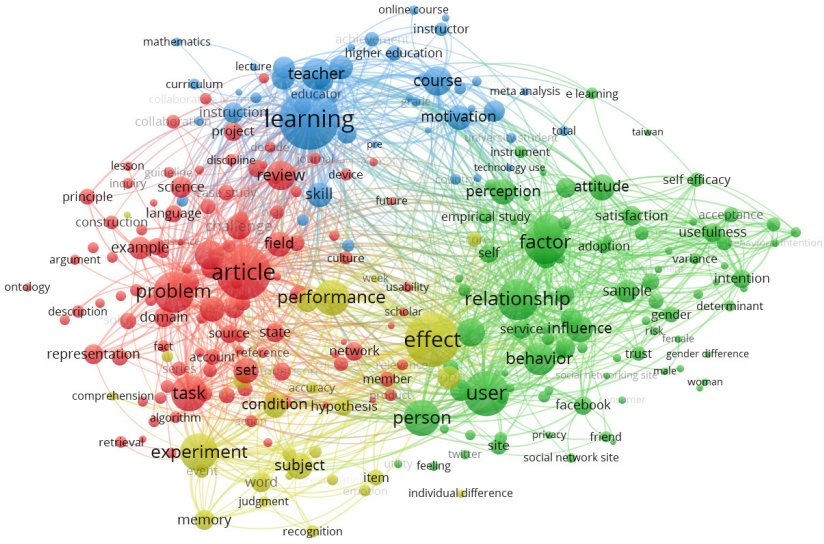

Figure 11. Inter-keyword relationships in EdTech research.

Common Keywords Analysis (Abstract Analysis)

Textual data-based cluster analyses using VOSviewer for exploring frequently repeated words in the analyzed publications' abstracts were performed and accessed 29,624 terms. Upon setting the requirement of being used at least 20 times, 447 frequently used terms were found. Of these, 60% of the most relevant were selected according to the eligibility scores calculated for each of these terms and clustered using VOSviewer. Figure 11 shows the four cluster structures covering the 268 terms resulting from the analysis. Based on the common word analyses, these publications' abstracts appear to represent the following four themes:

a) ***Academic Scope:*** The red cluster shows how EdTech has been addressed academically, with article, problem, task, field, review, example, and science being the prominent words in this cluster. The size of article and review as words and their proximity to the other clusters can be said to support the weight of the types of articles and reviews in EdTech studies shown in Figure 2. Analyses on problem and task as words have also had a prominent place in EdTech studies.

b) ***Psychological Scope: T***he green cluster involves psychology-related terms that show the impact EdTech has had on people. The studies in this cluster are mostly seen to be interpreted using terms such as perception, attitude, relationship, behavior, satisfaction, adoption, self-efficacy, and feeling and to be focused on people. Studies regarding social network platforms are also represented in this cluster.

c) ***Learning and Teaching:*** The blue cluster contains studies highlighting EdTech studies' impacts in learning and teaching environments. Learning, teacher, course, motivation, and skill are the prominent words in this cluster, which suggests studies on learning-teaching environments to mostly be associated with motivation and skills. Learning and motivation being the most-repeated words shows the learning-focused approach to be prominent in EdTech studies. The size of the terms teacher and course shows the teaching step to have also been frequently examined in EdTech studies.

d) ***Process Management:*** Performance, effect, condition, experiment, and subject are the prominent terms in the yellow cluster and generally represent process management in EdTech studies. Performance and effect being seen as words near the middle of the figure shows these concepts to also be frequently used in other clusters.

Relationships Among EdTech Research

The third question of the research analyzes the interrelationships of EdTech research. The distribution of research published between 1950-2021 in this context is presented through tables and figures according to the relationships among countries, journals, and authors.

What are the interrelationships of EdTech research in terms of:

a. Countries

b. Journals, and

c. Authors

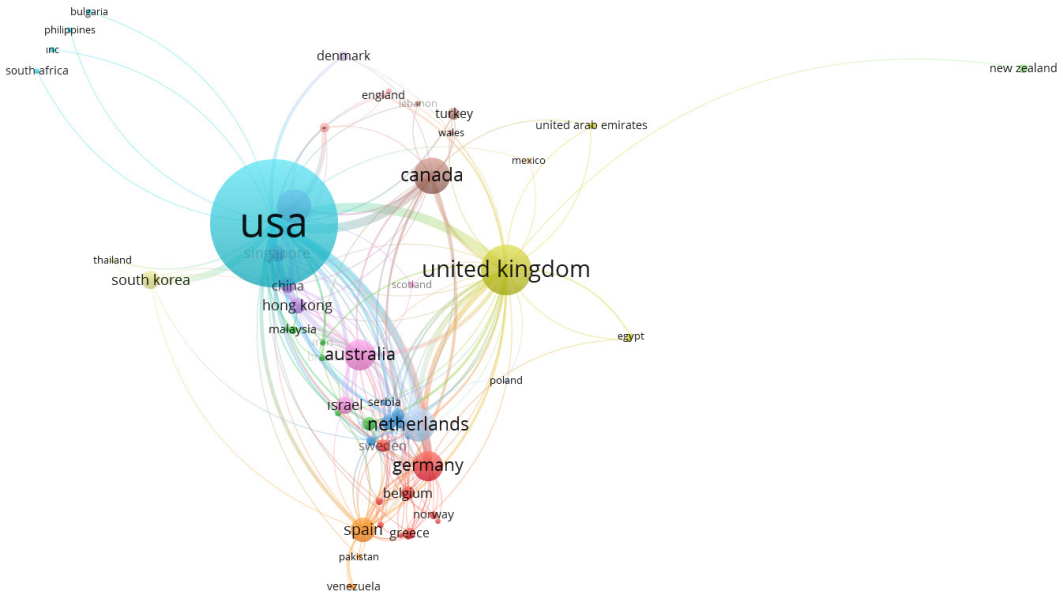

Figure 12. Collaborations among countries regarding educational research.

Country-Based Coauthor Analysis

Multi-authorship is increasingly being adopted in scientific research (Fatima & Abu, 2019), and this has become an important element in creating high quality, interdisciplinary research. Coauthor analysis has been performed using bibliographic data covering author information such as institution and country; in this way, inferences can be made about inter-countries and interinstitutional collaborations based on the collaborations and social ties established among authors (Zupic & Cater, 2015). Figure 13 presents the coauthor analysis regarding intercountry collaborations. Coauthor analyses show the extent of the collaborations established in scientific publications and the social ties that form. The coauthor analysis map (Figure 12) shows the USA is central regarding collaborations established among authors in EdTech and possesses the strongest authorship ties. The UK, Canada, Netherlands, Germany, Australia, and Spain also have high levels of author collaborations.

Coauthor Citation Analysis

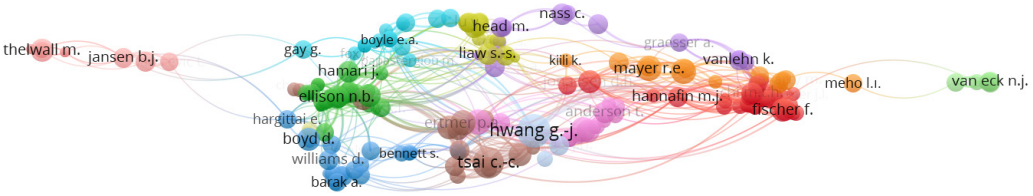

Figure 13. Coauthor citation analysis.

When examining the joint citation analysis for authors of the 2,000 most-cited articles included in the research, 4,008 authors were cited in these publications. When setting the criteria as having more than 1,000 citations, this number becomes 317. Each color on the map represents a cluster, and authors with multiple citations are found in the same cluster. When examining the entire map, Hwang, Tsai, Liaw, and Ellison appear in the relative centers of the map, are associated with many different clusters, and stand out as authors with high co-citation strength.

EdTech Research Effectiveness

The fourth research question analyzes EdTech research effectiveness. The citation distributions of research published in this context between 1950-2021 are presented through tables and figures regarding authors, article type, and journals.

1. What impact has EdTech research had regarding:

   a. Authors,

   b. Institutions,

   c. Journals

   d. Country?

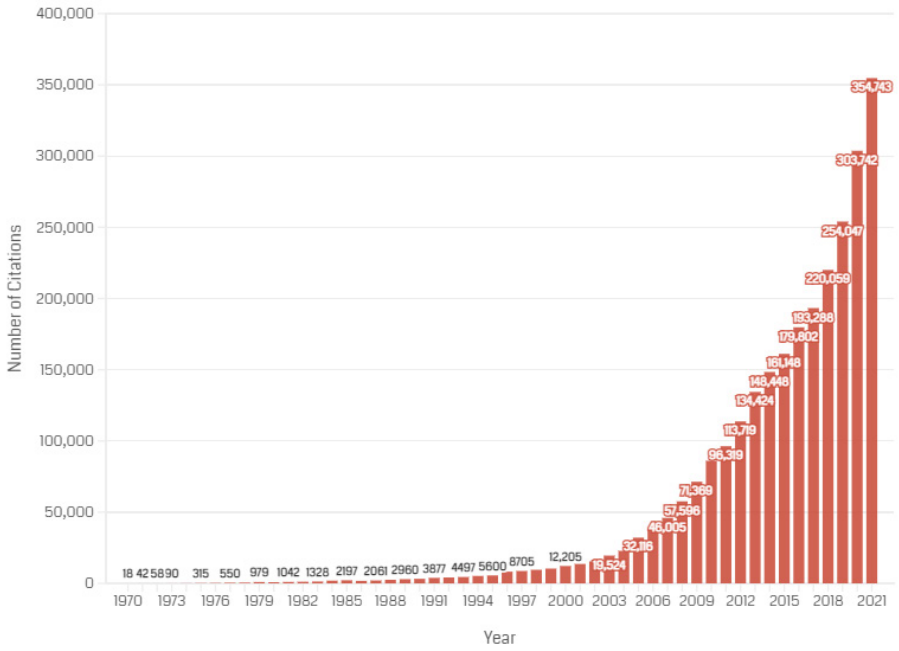

Figure 14. Number of annual EdTech citations between 1950-2021.

Figure 14 shows the citations EdTech research received to tend to increase alongside the number of publications. No data is found on the extent to which these studies' citations are from directly related-EdTech research and publications or other fields. However, EdTech interest has increased in other fields alongside COVID over the last two years, which explains the last two years' acceleration.

Table 1.

The 10 Most-Cited Authors between 1950-2021 in EdTech Research

Author	Documents	Citations	Total Link Strength
Ellison N.B.	7	15,790	152
Boyd D.M.	1	8,043	9
Lampe C.	5	7,558	135
Steinfield C.	4	7,119	109
Garrison D.R.	9	6,772	137
Sweller J.	9	6,187	111
Buckley C.	2	5,891	2
Salton G.	2	5,891	2
Brown A.L.	3	5,096	133
Bizer C.	3	5,045	6

Regarding the citation order of authors with the 2,000 most-cited articles studied here, Table 1 shows Ellison to be the most-cited with 15,790 citations (seven publications), followed by Boyd with 8,043 citations (one publication), and Lampe with 7,558 citations (five publications).

Table 2.

The 10 Most-Cited Journals Regarding EdTech Research between 1950-2021.

Source	Documents	Citations	TLS
Computers in Human Behavior	271	88,844	577
Computers and Education	243	77,234	932
Journal of Computer-Mediated Communication	85	47,142	199
Journal of the American Society for Information Science and Technology	87	33,364	98
International Journal of Human Computer Studies	85	33,159	211
Memory & Cognition	101	31,765	51
Journal of the Learning Sciences	65	28,384	291
Information Processing and Management	63	25,826	58
Learning and Instruction	74	24,329	187
New Media and Society	70	23,775	92

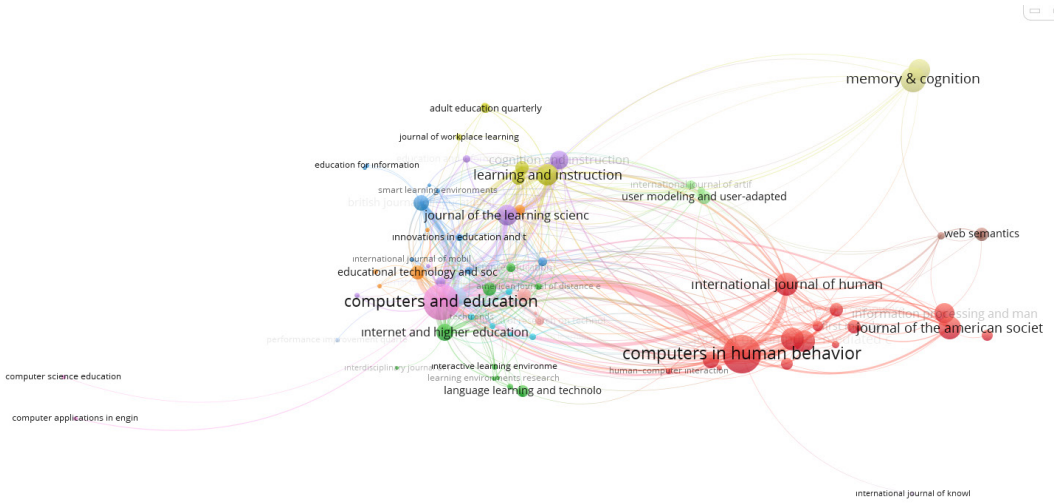

Figure 15. Title in sentence case.

When examining the most-cited journals, *Computers in Human Behavior* ranks first with 88,844 citations, followed by *Computers and Education* with 77,234 and the *Journal of Computer-Mediated*

Communication with 47,142. Figure 15 presents the citation network map accompanying Table 2. Colored circles and lines represent the common references and connections with other references, and circle size indicates citation weight. The red cluster containing *Computers in Human Behavior* occupies a particularly large place in the citation ranking, and the I*nternational Journal of Human Computer Studies* and *Journal of the American Society for Information Science* in this cluster are seen to have strong citation relationships. The journals *Computer and Education* and *Leaning and Instruction* are also prominent in the citation rankings and have strong citation relationships with many other journals.

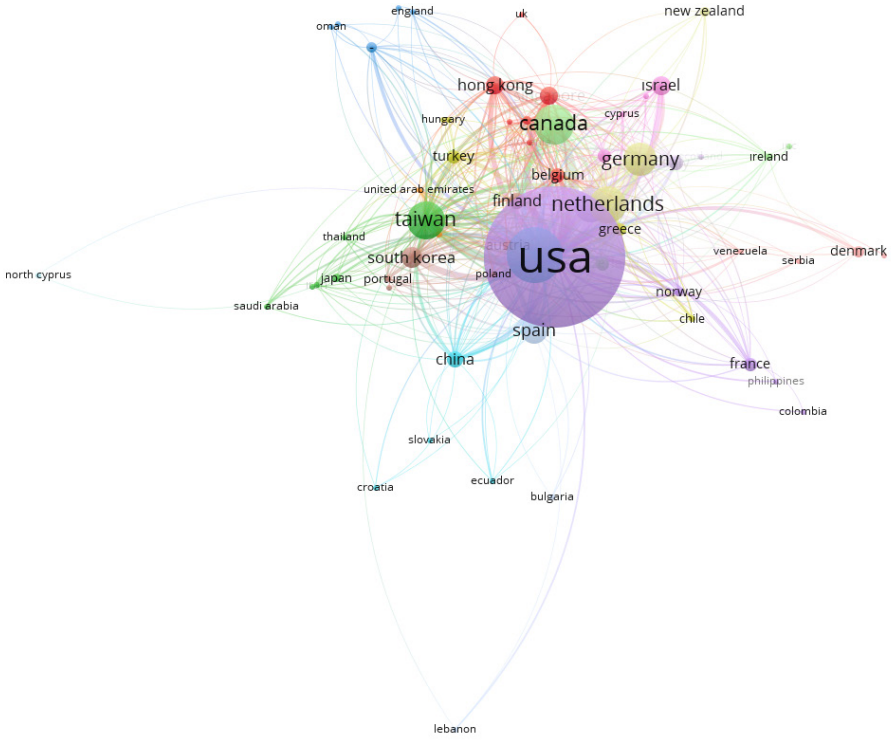

Figure 16. Citation network map of the 10 most-cited countries regarding EdTech research.

Table 3 shows the 10 most-cited countries regarding significant contributions to EdTech studies. When examining the most-cited countries, USA ranks first with 396,579 citations, followed by the UK with 77,717, and Canada with 47,600. The citation network map (Fig.16) is presented to accompany Table 3. The colored circles and lines represent countries' citation rates and their common connections with other countries (circle size indicates citation weight). As understood from the map and table, Canada, Australia, Taiwan, the Netherlands, and Germany follow the USA and UK regarding citation ranking and are also among the most-cited.

Table 4.
The 20 Most-Cited Publications

Authors	Title	Year	Source title	Cited by
Boyd D.M., Ellison N.B.	Social network sites: Definition, history, and scholarship	2007	*Journal of Computer-Mediated Communication*	8,043
Salton G., Buckley C.	Term-weighting approaches in automatic text retrieval	1988	*Information Processing and Management*	5,596
Ellison N.B., Steinfield C., Lampe C.	The benefits of Facebook "friends:" Social capital and college students' use of online social network sites	2007	*Journal of Computer-Mediated Communication*	5,513
Gruber T.R.	Toward principles for the design of ontologies used for knowledge sharing	1995	*International Journal of Human – Computer Studies*	4,001
Bizer C., Heath T., Berners-Lee T.	Linked data – The story so far	2009	*International Journal on Semantic Web and Information Systems*	3,105
Shenton A.K.	Strategies for ensuring trustworthiness in qualitative research projects	2004	*Education for Information*	2,892
Palincsar A.S., Brown A.L.	Reciprocal Teaching of Comprehension-Fostering and Comprehension-Monitoring Activities	1984	*Cognition and Instruction*	2,801
Burke R.	Hybrid recommender systems: Survey and experiments	2002	*User Modelling and User-Adapted Interaction*	2,549
Liben-Nowell D., Kleinberg J.	The link-prediction problem for social networks	2007	*Journal of the American Society for Information Science and Technology*	2,541
Sokolova M., Lapalme G.	A systematic analysis of performance measures for classification tasks	2009	*Information Processing and Management*	2,459
Garrison D.R., Anderson T., Archer W.	Critical Inquiry in a Text-Based Environment: Computer Conferencing in Higher Education	1999	*Internet and Higher Education*	2,282
Dey A.K., Abowd G.D., Salber D.	A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications	2001	*Human-Computer Interaction*	2,085
Brown A.L.	Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings	1992	*Journal of the Learning Sciences*	2,024
Lombard M., Ditton T.	At the heart of it all: The concept of presence	1997	*Journal of Computer-Mediated Communication*	1,933
Marwick A.E., Boyd D.	I tweet honestly, I tweet passionately: Twitter users, context collapse, and the imagined audience	2011	*New Media and Society*	1,851

Sadler D.R.	Formative assessment and the design of instructional systems	1989	*Instructional Science*	1,839
Sirin E., Parsia B., Grau B.C., Kalyanpur A., Katz Y.	Pellet: A practical OWL-DL reasoner	2007	*Web Semantics*	1,836
Garrison D.R., Kanuka H.	Blended learning: Uncovering its transformative potential in higher education	2004	*Internet and Higher Education*	1,828
Machanavajjhala A., Kifer D., Gehrke J., Venkitasubramaniam M.	ℓ-diversity: Privacy beyond k-anonymity	2007	*ACM Transactions on Knowledge Discovery from Data*	1,788

Table 4 presents the 20 most-cited publications of the 2,000 most-cited as examined in the research (see Gunes 2022 for the reference data file for the 2,000 publications). When examining Table 4, social networks are frequent topics among the most-cited publications, alongside qualitative research methods, formative assessment, design, and blended learning.

Conclusion

This research examined EdTech research's impacts, computational developments, content changes, collaborations, and relationships. This section shows results regarding the research purpose and questions, comparatively discussing the relevant research and presenting recommendations for further research.

Computational Development of EdTech Research

EdTech research publications' numerical distributions exhibited stagnation between 1950-1970, progressively increased between 1970-2000, and accelerated faster after 2000. The prevalence of information storage and access created alongside the Internet coincides with this period. 2019-2021 saw the greatest increase rate. The rapid increase in research in EdTech in the last three years was significantly impacted by the rapid digital transformations, applications, and diversity during COVID-19 (Livari et al., 2020).

Articles form most of the academic studies on EdTech research, and reviews and editorial articles are also prominent, while conference papers and academic notes are more limited. When examining the countries contributing to EdTech research and evaluating the number of citations among the top 10 countries, USA has more citations and publications than the sum of the next nine countries, (respectively, UK, Canada, Australia, Taiwan, Holland, Germany, Spain, Israel, and South Korea). Cheng et al.'s (2022) study examining the trends in EdTech articles similarly found the USA, Taiwan, Australia, England, and Spain to be the countries to have contributed the most to studies between 2010-2019. This also shows the importance these countries attach to EdTech studies.

The USA appeared at the center of countries involved in EdTech research in the coauthor analysis, with the UK, Canada, Germany, Australia, and Spain having strong author collaborations. The top 10

countries in the EdTech field overlap the coauthor analysis findings. The top 20 countries in terms of education occur as Norway (1st), Ireland (2nd), Switzerland (3rd), China and Iceland (tied for 4th), Germany (6th), Sweden (7th), Australia and Netherlands (tied for 8th), Denmark (10th), Finland and Singapore (tied for 11th), United Kingdom (13th), Belgium and New Zealand (tied for 14th), Canada (16th), USA (17th), Austria (18th), and Israel and Japan (tied for 19th) in the United Nations Development Programme (UNDP, 2020b) 2020 Human Development Reports. Meanwhile, the top 10 countries with the highest numbers of citations (excluding Taiwan, the Netherlands, Spain, and Israel) are G20 countries (Wikipedia, 2022).

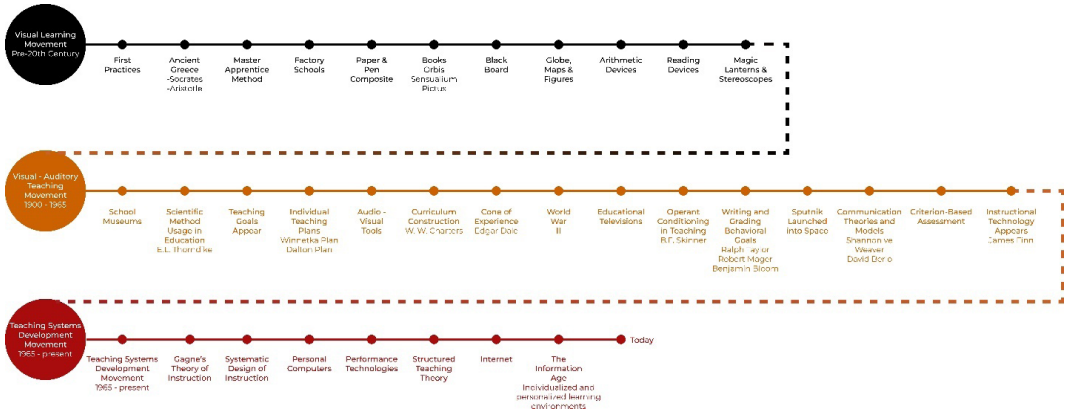

Figure 17. EdTech's historical development (Translated from Şumuer & Yıldırım, 2018).

Changes in EdTech Research Content

Social sciences and computer sciences are the most important subject titles in the subject distributions of EdTech. Engineering, arts and humanities, psychology, and mathematics are prominent topics. This coincides with EdTech being more focused on learning.

When examining the keywords from the last 70 years of EdTech studies addressed in terms of the current research, keywords are structured under five different groups. The largest group consists of interactive learning environments, learning-teaching strategies, pedagogical issues, virtual reality, and distance education topics. The other groups focus on social media and the Internet; e-learning, higher education, social presence, and the technology acceptance model; human-computer interactions, usefulness, collaborations, motivation, and smart teaching; and augmented reality, technology integration, and semantic web studies. Cheng et al. (2022) also classified EdTech articles in seven clusters using co-word analysis in their research; they stated the issues related to these

clusters to be instructional environment design, digital learning environments, digital assessment, sharing edutcation between systems and institutions, and quality assurance in education. Their results are in line with those from the current research in terms of emphasizing learning environments, pedagogical issues, and digital learning. However, the issues of quality assurance and sharing between systems and institutions not occuring among the findings of the current study, which aims to reveal the trends from 1950-2021, leads us to conclude that these issues were on the agenda more between 2010-2019, the date range discussed in Cheng et al.'s study.

The words prominent in the titles and abstracts of the last 70 years of EdTech studies addressed in terms of the current research are structured under four groups. Article, problem, and task appear in the first group; learning, teacher, course, motivation, course skills, and teaching appear in the second; effects, experiment, performance, conditions, memory, and topic appear in the third; and factor, relationship, user, human, behavior, influence, perception, behavior, and usefulness appear in the fourth. EdTech studies may be interpreted as focused on learning and interacting with technology and the factors affecting the learning process (Berrocoso et al., 2020). The current topic of artificial intelligence (AI) was not among the trending topics in our research examining the period between 1950-2021; however, it was shown among the trending topics in the Horizon Report (Educause, 2022a). Alongside this, the headings of AI for Learning Analytics, AI for Learning Tools, Hybrid Learning Space, Mainstreaming Hybrid/Remote Learning Modes, Microcredentials, and Professional Development of Hybrid/Remote Teaching overlap with the research results, but due to being considered in the context of the more current vision of the future, AI stands appears integrated. Additionally, the fields of data management and governance; unifying data sources; modern data architecture; data literacy training; diversity, equity, and inclusion (DEI) for data and analytics; data privacy/data security; and assessing and improving institutional data and analytics are closely related to current EdTech capabilities and will increase in relation to the EdTech field in the near future (Educause, 2022b).

The keywords, titles, and summary findings of the last 70 years of EdTech overlap with the historical developments in teaching technologies (see Figure 17). The groupings made under the findings on keywords and on titles and abstracts can be expressed through the common titles and internal groupings of the periods.

Collaboration and Relationship Networks in EdTech Research

As in all disciplines, collaborations and relations offer insights into EdTech. Within the research's scope, collaborations and relationships in the context of countries, journals, and authors project EdTech's past, present, and future. Having researchers and practitioners pay attention to collaborations and how these relationships are interpreted contributes to increasing the quality of EdTech processes.

Effectiveness of EdTech Research

Table 5 shows that Ellison strongly impacted EdTech research with her seven publications and 15,790 citations. Other prominent authors in EdTech research are Boyd with one publication and 8,043 citations, Lampe with five publications and 7,558 citations, Steinfield with four publications and

7,119 citations, Garrison with nine publications and 6,772 citations, Sweller with nine publications and 6,178 citations, Salton with two publications and 5,891 citations, Brown with three publications and 5,096 citations, and Bizer with three publications and 5,045 citations.

Table 1 shows the prominent authors in EdTech research as Hwang with 267 publications, Rudall with 260 publications, Tsai with 204 publications, and Andrew with 203 publications. The journals prominent for receiving the most citations in EdTech research are *Computers in Human Behavior* with 88,844 citations, *Computers and Education* with 77,234, and *Journal of Computer-Mediated Communication* with 47,142.

The most-cited publication in EdTech research is "Social Network Sites: Definition, History, and Scholarship" with 8,043 citations, followed by "Term-Weighting Approaches in Automatic Text Retrieval" with 5,596 citations and "The Benefits of Facebook 'Friends': Social Capital and College Students' Use of Online Social Network Sites" with 5,513 citations.

Digital technologies create opportunities for educational access, poverty reduction, and social needs (UNDP, 2022). Conducting analyses on the trends in and focus areas of educational technology will contribute to consciously structuring the integration of education and technology.

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