Digital tools for innovative higher education teaching - a Scoping Review of Empirical Studies

Karina Cicha
University of Economics in Katowice
Katowice, Poland
karina.cicha@ue.katowice.pl

Paulina Rutecka
University of Economics in Katowice
Katowice, Poland
paulina.rutecka@ue.katowice.pl

Abstract

Since the COVID-19 pandemic has outbursts, changes in the teaching process are observable. What was a temporary countermeasure against the pandemic is now considered a didactic tool. More and more teachers and entire higher education institutions decided to permanently implement digital tools or innovative teaching methods into the didactic process. The continuous development of technology fosters innovation in the teaching process. It allows teachers to use newer and newer teaching tools, better and better adapted to the real needs of students. The main goal of this article is to point out, by a scoping review of the papers published between 2020 and 2023, the digital tools used in the teaching process at the higher education level. The review focuses only on the original articles written in English, which present studies on implementing innovative digital teaching tools. The article is a form of a preliminary catalog of didactic tools used at the higher education level in the last three years, with their quantitative presentation. The tools have been categorized according to the technologies they use and then assigned to the scientific disciplines in accordance with the OECD classification in which they were used.

Keywords: digital tools, higher education, multimedia technology, teaching tools.

1. Introduction

The COVID-19 pandemic has revolutionized the teaching process in terms of both teaching tools and techniques. One of the trending topics and a subject of many studies conducted since 2020 is e-learning and its adoption in the teaching process [32, 35]. However, the change was forced by the circumstances since every country in the world needed to react to the ongoing pandemic by switching education to online classes [22] due to the closure of physical facilities [41]. Even teachers reluctant to change had to start using modern tools for e-learning [6]. The term e-learning itself for the past years has also been broadly discussed. The researchers, as well as the teachers, tried to draw a definition line between e-learning and other forms of remote learning. Among the distinctive features, which can differentiate the term e-learning from distant learning, 3 are often emphasized. Those are: proximity (distance learning is characterized by non-contiguous communication, while new interactive communication technologies used in e-learning enable synchronous communication between students and teachers), target clienteles (e-learning offers learning solutions for people of various social groups and interests, while distance learning focuses on special clienteles that for a variety of reasons cannot attend a face-to-face gathering), and cost considerations (the distance learning broadens access to higher education by providing economies of scale, while e-learning, especially in form of online courses, is profit-driven) [17].

As many researchers pointed out, e-learning can be considered a part of the new dynamic that characterizes educational systems at the beginning of the 21st century [34].

The e-learning commonly known today resulted from merging disciplines such as computer science, communication technology, and pedagogy [34]. Nevertheless, there are still challenges to e-learning for every party involved. For higher education institutions, for example, one of those challenges is understanding how e-learning can be improved so the students and teachers can benefit from it. Also, studies are required to know why students and teachers reject this method. And finally, discovering how to improve teaching techniques with the use of ICT (Information and Communications Technology) seems to be a deal of a great matter.

Many studies on various areas emphasized that the pandemic might have been a moment of resetting the existing situation [33] and providing an opportunity to re-evaluate the functioning of different branches of business, industry, and education. In our opinion, forcing the introduction of e-learning has created an excellent opportunity to introduce modern teaching methods adequate to the new challenges posed by the labor market among university graduates, which they will enter, and a lifestyle and work adapted to them. Studies also show that young people, such as students, understand the need for digital competencies that will allow them to engage better in learning, find a job in a rapidly changing market after graduation [20], and develop professionally and personally [2].

The broad usage of the Internet and the implementation of technological solutions for businesses [22] have shown that there are already observable differences in ICT literacy and information acquisition skills between students' generation and their parents [38]. Even though the younger generation is often referred to as "digital natives", they often define their ICT skills on a much higher level than observable [38, 42]. The younger generation needs the skills to use ICT [16] to understand and manage resources in digital formats [29]. At the same time, this generation of digital natives must be aware of the dangers of using ICT.

E-learning is broadly used and accepted by students in different countries and fields of education [29, 30, 40]. However, the scope of our interest is broader. It focuses on using digital technology to support the teaching process in every form, remote and on-site. We are particularly interested in the possibilities of new teaching tools applied in the teaching process to empower students and develop their ICT competencies.

These premises make us look for digital tools used in modern education at the higher education level. The usage of digital tools is needed so that teachers know how they can use new technologies and how they have worked so far [31]. This knowledge can speed up the transformation of education. The importance of this matter also emphasizes that in Poland, similar research is being carried out by the Ministry of National Education and Science to extend the catalog of recommended digital teaching tools. Although these studies focus on primary and secondary schools, they clearly show the direction of consideration. Our area of interest concerns universities. Although researchers eagerly discuss the topic of modern technologies in education, there is no comprehensive catalog of methods and tools that can be used as a guideline for teachers. Creating such a catalog will lead to the organization of existing knowledge. It may allow us to determine which methods and tools are adequate for teaching in various fields of study. Furthermore, in our opinion, it will also be a good starting point for further research on the use and technological acceptance of different innovative teaching methods.

Therefore, the research questions for this paper stand as follows:

RQ1: What digital tools are implemented in the higher education teaching process?

RQ2: In what areas of education the digital teaching tools are used?

RQ3: Are there tools dedicated to a specific field of study?

These research questions led to the achievement of the objective of our paper, which can be formulated as follows: (i) to reveal the innovative tools used in the teaching process at the higher education level, presented in the Literature of the last three years; (ii) and to reveal the fields of studies in which those tools have been often used.

2. Methods and materials

This section reports the following stages of the conducted analysis. Due to the broad scope of topics in this study, we decided to use the scoping review method, using the first five

stages of the methodological framework proposed by Arksey and O'Malley [9], which were then clarified by Levac et al. [24]. Although the scoping review framework was initially dedicated to medical science, it is also used in education research, including educational tools and methods [3, 21, 36].

We conducted the scoping review on using innovative digital tools in the teaching process at higher education institutions. We applied Arksey's and O'Malley's [9] methodological framework to conduct the study. The research steps taken during the procedure are as follows:

- to identify the research questions,
- to identify the relevant studies,
- to select appropriate studies,
- to chart the data,
- to summarize and report the results.

We began by formulating research questions for the search concerning such aspects as the usage of digital tools and media technology in the higher education teaching process.

Next, we searched for relevant studies by focusing on articles published from January 2020 to March 2023 (inclusive). We used the Scopus and Web of Science databases as primary data sources as the largest abstract and citation databases for academic literature. Moreover, Scopus is the most relevant research repository in the related disciplines, publishing Literature on online teaching, teaching methods, and remote learning. We hadn't decided, however, to use the search results from the Google Scholar database, although there were articles available that included the defined set of keywords. Mainly because, although Google Scholar covers every document which contains the defined keywords, those are not necessarily scientific, peer-reviewed work.

Combinations of the following search terms and subheadings were considered appropriate for the conducted study: "teaching methods", "teaching tools", "digital tools", "multimedia technology", "multimedia tools", "innovative", and "modern". All of the above were combined with the term "higher education". Quantitative search results for defined key phrases in specific databases are presented in Table 1.

Table 1. Key search phrases and the search results in Scopus and Web of Science databases.

	Scopus	Web of Science
"multimedia technology" AND "higher education"	9	6
"multimedia tools" AND "higher education"	28	10
"digital tools "AND" higher education"	278	175
"teaching tools "AND" higher education"	127	47
"teaching methods" AND "higher education"	841	471
innovative AND tools AND "higher education"	461	329
"digital tools "AND" higher education"	9	6
innovative AND methods AND "higher education"	28	10
modern AND tools AND "higher education"	278	175

The next stage was defining inclusion and exclusion criteria to limit the resources found. The chosen original research papers (published between January 2020 and March 2023) were restricted to those written in English, which described tools and methods, including digital tools and multimedia technology, used in the teaching process in higher education. There were no exclusions either due to the type of the study ex. book chapters or editorials, nor methodologies, ex. expert reviews, systematic reviews, scoping reviews, and narrative reviews.

While searching for relevant articles, which would later be used for data extraction, we first removed articles that appeared in both databases and screened the titles of publications. A total number of 2628 articles were reduced to 698 articles. While scanning the titles, we considered that the article's title should include the type of digital tool used in the teaching process and the field of study in which the digital tool had been implemented. We eliminated all papers with unrelated titles.

The next step was to investigate the articles' abstracts. At that point, we were searching for such information as are the scopes of the articles relevant to this particular study; do

they concern higher education level; do they present information on the teaching tools; do in abstracts defined keywords appear; were studies original? All articles which were literature reviews (conducted according to any approvable methodology) were eliminated. The total number of articles that qualified for inclusion was 291.

The last stage of elimination focused on access to the full papers. Since not every article was accessible as a full-text in the online databases, this phase reduced 39 articles, which allowed us to establish a final number of 252 articles included in the study. The process of articles' elimination is presented in Figure 1, and the data set is available at: https://zenodo.org/record/8017271

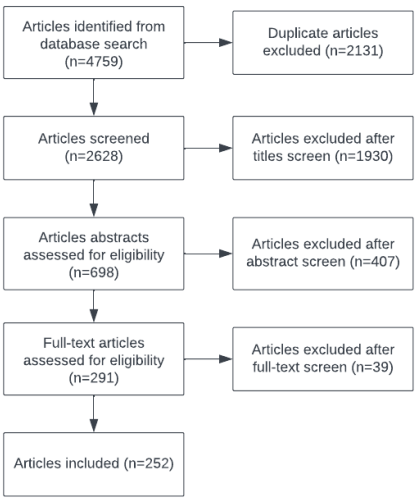

Fig. 1. Captions belonging to a figure should always appear under the illustration.

The data extraction process began by defining the two main categories to present the information thoroughly. The first category was the field of study, in which innovations in the teaching process took place. We used the OECD (Organisation for Economic Co-operation and Development) classification of Fields of Science and Technology (FOS) to define them correctly. We did not, however, use the first level of classification, regarding only six major categories, including natural sciences (1), engineering and technology (2), medical and health sciences (3), agricultural sciences (4), social sciences (5), humanities (6). We decided to use the forty-two minor disciplines (sub-disciplines) singled out of the main categories to gain as much adequacy as possible. A minor OECD category was assigned for each article presenting an innovative teaching tool. In the researched articles, we distinguished tourism as a field of study due to its absence in the OECD classification and interdisciplinary nature. We assigned the non-specific category to studies that concerned the entire community of a given university, without being distinguished as a field of study.

The second created categories considered the tools used in the teaching process. Some of the terms used were imprecise or covered more than just one single tool of teaching. The first obstacle we came across was the definition of the tool used in the didactic process. We decided to rely on Webster's English Dictionary definition, which states that a teaching aid/tool is an object (…) or device (…) used by a teacher to enhance classroom instruction [27]. The presented definition emphasizes the tool nature of this concept.

The problem, however, was not sorted out completely. Some terms used in the reviewed papers focused on a general understanding of a tool (ex. social media), and some were more precise (ex. TikTok). To organize information on innovative tools used in the didactic process, we needed to introduce ordering categories to tag the tools. The distinction is on the area in which a specific tool operates.

At that point, 29 major categories of tools were established. Those categories are as follows: Learning Management Systems (LMS); Augmented reality (AR) and Virtual reality (VR); Social Media; Interactive online course platforms; Audio materials; Project management tools; Messaging apps; Video Communication; Simulations; MOOCs; Project-based learning environment (PBL); Response systems (RS); Game-based

environment; Artificial Intelligence (AI); 3D Visualization; Mobile apps & Internet of Things (IoT); Gamification apps; Multimedia and Interactive graphics; Video materials and instructions; Robots; Content co-creation; Real World Lab; Cooperative learning environment (COOP); E-Portfolio; Interactive Case Studies; Data Sets; Flipped Classrooms Materials; Location detection; Others (by "others" we mean every digital tool mentioned in the analyzed set of articles, that did not fit into any of the categories established).

With a clearly defined set of categories, we could start gathering the results.

3. Results

As a result of the conducted study, we present the data sets on the most frequently used digital tools in teaching at the higher level. Following the adopted categorizations described earlier, each table contains didactic tools and scientific disciplines in which they were used. In addition, each table presents the sum for a particular tool used in all minor disciplines. The codes adopted for individual scientific disciplines are consistent with the notations used in the OECD classification.

Table 2 presents a list of tools used in the disciplines included in the Natural Sciences group. The literature analysis shows that in the analyzed period, practically in each minor discipline, a didactic innovation or the use of a specific digital tool can be observed.

Table 2. The use of digital tools in Natural Sciences.
(1.01 Mathematics, 1.02 Computer and information sciences, 1.03 Physical sciences and astronomy, 1.04 Chemical sciences, 1.05 Earth and related environmental sciences, 1.06 Biological sciences)

	1.01	**1.02**	**1.03**	**1.04**	**1.05**	**1.06**	**Sum**
3D Visualization	0	1	1	0	2	0	4
Artificial Intelligence (AI)	1	1	0	0	0	1	3
Audio materials	0	0	0	0	0	1	1
Augmented reality (AR) and Virtual reality (VR)	0	2	1	3	0	0	6
Collaborative learning environment (COOP)	1	0	0	0	0	0	1
Game-based environment	1	2	0	1	0	1	5
Gamification apps	0	3	0	0	0	0	3
Interactive Case Studies	0	0	0	0	0	1	1
Interactive online course platform	2	4	1	1	1	0	9
Learning Management Systems (LMS)	0	2	1	0	0	1	4
Mobile apps & Internet of Things (IoT)	0	1	0	1	1	0	3
MOOC	0	2	0	0	0	0	2
Multimedia and Interactive graphics	1	0	0	0	0	0	1
Other	1	0	0	0	0	0	1
Project management tools	0	3	1	0	0	0	4
Project-based Learning environment (PBL)	0	1	0	0	0	0	1
Response systems (RS)	0	1	0	0	1	0	2
Robots	0	0	0	0	1	0	1
Simulations	0	0	0	0	0	1	1
Video Communication	1	0	0	1	0	0	2
Video materials and instructions	1	1	0	1	0	0	3
Sum	9	24	5	8	6	6	**58**

As presented in Table 2, in the analyzed articles concerning minor disciplines from Natural Sciences, the most frequently used tool was interactive online course platforms. It was a form most commonly used for all the fields in this category, and most frequently used in the Computer Science discipline. The online course platforms used for the Natural Sciences disciplines were mainly created for particular university students and specific courses [23]. Also, the minor discipline in which most tools were used was Computer Science. The least popular tools for Natural Sciences disciplines were: simulations, project-based learning, robots, multimedia and interactive graphics, interactive case studies, collaborative learning environment, and audio materials. In this field of study, tools from the eight remaining categories weren’t once used.

Table 3 lists tools used in the Engineering and Technology disciplines. Here are two minor disciplines in which digital tools in the teaching process are used most commonly: Civil engineering and Mechanical Engineering. As for the particular tool used most often in the didactic process, Augmented (AR) and Virtual reality (VR) is the most popular.

Using AR and VR in Engineering was mainly focused on modelling in Architecture and Construction and creating virtual labs [10] or as an environment for solving discipline-related problems [7]. The least used digital tools in Engineering and Technology were: surprisingly, Artificial Intelligence (AI), collaborative learning environment, project-based learning, Real World Lab, social media, video communication, and video materials and instructions. In this field of study, tools from twelve categories weren't once used.

Table 3. The use of digital tools in Engineering and Technology.
(2.01 Civil engineering, 2.02 Electrical engineering, electronic engineering, 2.03 Mechanical engineering, 2.05 Materials engineering, 2.07 Environmental engineering, 2.08 Environmental biotechnology, 2.09 Industrial biotechnology, 2.11 Other engineering and technologies)

	2.01	2.02	2.03	2.05	2.07	2.08	2.09	2.11	Sum
3D Visualization	2	1	0	0	0	0	0	0	3
Artificial Intelligence (AI)	1	0	0	0	0	0	0	0	1
Augmented reality (AR) and Virtual reality (VR)	1	1	3	0	2	0	0	1	8
Collaborative learning environment (COOP)	0	0	1	0	0	0	0	0	1
Game-based environment	1	0	2	0	0	0	0	0	3
Gamification apps	0	0	0	0	2	0	0	0	2
Interactive online course platform	1	1	0	0	1	0	0	0	3
Learning Management Systems (LMS)	1	1	0	0	0	1	1	0	4
MOOC	0	0	0	1	1	0	0	0	2
Multimedia and Interactive graphics	0	0	1	1	0	0	0	0	2
Project-based Learning environment (PBL)	1	0	0	0	0	0	0	0	1
Real World Lab	0	0	0	0	0	0	0	1	1
Robots	0	1	0	0	0	0	0	0	1
Simulations	0	1	1	0	0	0	0	0	2
Social media (SM)	0	1	0	0	0	0	0	0	1
Video Communication	1	0	0	0	0	0	0	0	1
Video materials and instructions	0	0	1	0	0	0	0	0	1
Sum	9	7	9	2	6	1	1	2	**37**

Table 4 presents digital tools used commonly in Medical and Health Sciences. Medical Sciences were the only ones in all groups of disciplines in which the use of digital tools can be observed in every minor discipline.

Table 4. The use of digital tools in Medical and Health Sciences.
(3.01 Basic medical research; 3.02 Clinical medicine; 3.03 Health sciences)

	3.01	3.02	3.03	Sum
3D Visualization	1	0	1	2
Artificial Intelligence (AI)	0	0	1	1
Audio materials	1	0	0	1
Augmented reality (AR) and Virtual reality (VR)	0	1	1	2
Content co-creation	0	0	2	2
Datasets	0	0	1	1
e-Portfolio	0	0	1	1
Flipped Classroom materials	0	0	1	1
Game-based environment	2	0	2	4
Gamification apps	0	0	1	1
Interactive Case Studies	1	0	1	2
Interactive online course platform	1	1	0	2
Learning Management Systems (LMS)	0	1	0	1
Mobile apps & Internet of Things (IoT)	1	0	1	2
Project-based Learning environment (PBL)	0	0	1	1
Simulations	0	1	1	2

Social media (SM)	0	1	0	1
Video Communication	1	0	0	1
Sum	8	5	15	**28**

Health Sciences is a group of smaller disciplines in which the most significant diversification in the use of digital tools is observed. Health sciences students, like, for instance, chiropractic and homeopathy students, use content co-creation tools to take photographs of environmental factors involved in causing disease [18]. In contrast, nursing students use the escape room game as a part of the course [8]. Emergency medicine students responded to major trauma incidents with simulated patients and high-fidelity mannequins [45]. In this field of study, tools from the eleven remaining categories weren't once used.

Table 5 lists digital tools used in Agricultural Sciences, including agriculture, animal and dairy, and veterinary science. Like Health Sciences, digital tools were applied in every minor discipline, but in contrast to previously reported results, far less extensively.

Table 5. The use of digital tools in Agricultural Sciences.
(4.01 Agriculture, forestry, fisheries; 4.02 Animal and dairy science; 4.03 Veterinary Science)

	4.01	**4.02**	**4.03**	**Sum**
Augmented reality (AR) and Virtual reality (VR)	1	0	0	1
Content co-creation	0	0	1	1
Interactive Case Studies	0	1	0	1
Multimedia and Interactive graphics	0	0	1	1
Real World Lab	1	0	0	1
Robots	1	0	0	1
Video Communication	0	1	0	1
Sum	3	2	2	**7**

In this group, a single case of use of such tools as Augmented reality (AR) and Virtual reality (VR), Content co-creation, Interactive Case Studies, Multimedia and Interactive graphics, and Video Communication can be observed. However, in this group, the use of Real World Lab appeared in the teaching of Agroforestry Systems. Particularly interesting in this case was that this tool had been used in teaching long before the pandemic outburst. The analyzed paper was a report after five years of experience with this tool [26]. In this field of study, tools from the twenty-two remaining categories weren't once used.

Table 6 presents the use of digital tools in Social Sciences. The Social Sciences group is also one of the groups with the most diverse usage of digital tools in the teaching process. In this group, the most frequently used tools were those of a game-based environment. The extensive usage of game-based solutions can be observed in Economics and business.

Economics and business use game-based tools mainly in business simulations, allowing students to discover the complexity of interactions among different business operations [16]. In fields such as accounting or management, serious games were introduced as an alternative instructional approach to enhance students' learning outcomes [15, 25]. At the same time, the widest variety of digital tools usage has been observed in Educational Sciences. In that case, no leading digital tool was used in the teaching process.

Table 6. The use of digital tools in Social Sciences.
(5.01 Psychology; 5.02 Economics and business; 5.03 Educational sciences; 5.04 Sociology; 5.05 Law; 5.06 Political Science; 5.07 Social and economic geography; 5.08 Media and Communication)

	5.01	**5.02**	**5.03**	**5.04**	**5.05**	**5.06**	**5.07**	**5.08**	**Sum**
Artificial Intelligence (AI)	0	0	0	0	0	0	0	1	1
Augmented reality (AR) and Virtual reality (VR)	0	2	1	0	0	0	0	1	4
Collaborative learning environment (COOP)	0	1	0	0	0	0	0	0	1
Content co-creation	0	2	1	0	0	0	0	0	3
Datasets	0	0	0	0	0	0	1	0	1
e-Portfolio	0	0	1	0	0	0	0	0	1
Flipped Classroom materials	0	0	1	0	0	0	0	0	1
Game-based environment	0	7	1	0	0	0	0	0	8
Gamification apps	0	1	0	0	0	0	0	0	1

Interactive online course platform	0	1	1	0	0	0	0	0	2
Learning Management Systems (LMS)	0	0	0	0	1	0	0	2	3
Messaging app	1	0	0	0	0	0	0	1	2
Mobile apps & Internet of Things (IoT)	0	1	0	1	0	1	0	0	3
MOOC	0	2	1	0	0	1	0	1	5
Multimedia and Interactive graphics	0	0	1	0	0	0	0	0	1
Project management tools	0	1	0	0	0	0	0	0	1
Response systems (RS)	0	0	1	0	0	0	0	0	1
Simulations	0	3	1	0	0	0	0	0	4
Social media (SM)	0	4	1	0	0	0	0	0	5
Video Communication	1	0	1	0	0	0	0	1	3
Video materials and instructions	0	0	0	0	1	1	0	1	3
Sum	2	25	12	1	2	3	1	8	**54**

The disciplines in which digital tools were barely used were Law and Sociology, with the single application of a tool in a teaching process in the analyzed articles. Law students used Learning Management Systems in the virtual legal classroom [14], while Sociology students worked with their smartphones in the collaborative mobile learning environment [46]. In this field of study, tools from the eight remaining categories weren't once used.

Table 7 lists digital tools implemented in the teaching process among students of Humanities. In this group, the most excessive usage of digital tools can be observed among Language and Literature students. A dominant tool for those students was Social media, most commonly used in the fields of Language and Literature. Social media was used as a supportive tool in remote interpreters' training [43], as a motivational element of a project that the course participants had to edit for the British History class [44], or even as a vocabulary learning support measure [4].

Table 7. The use of digital tools in the Humanities.
(6.01 History and Archaeology; 6.02 Languages and Literature; 6.03 Philosophy, ethics, and Religion; 6.04 Art)

	6.01	**6.02**	**6.03**	**6.04**	**Sum**
3D Visualization	1	0	0	1	2
Artificial Intelligence (AI)	0	2	0	1	3
Augmented reality (AR) and Virtual reality (VR)	1	1	0	4	6
Collaborative learning environment (COOP)	0	0	1	0	1
Content co-creation	0	2	0	0	2
Datasets	0	1	0	0	1
Flipped Classroom materials	0	1	0	0	1
Game-based environment	0	3	0	0	3
Gamification apps	0	2	0	3	5
Interactive online course platform	0	4	0	0	4
Learning Management Systems (LMS)	0	4	1	0	5
Messaging app	0	1	0	0	1
Mobile apps & Internet of Things (IoT)	0	1	0	2	3
MOOC	1	2	0	0	3
Multimedia and Interactive graphics	0	0	1	2	3
Project-based Learning environment (PBL)	0	1	0	0	1
Response systems (RS)	0	1	0	0	1
Robots	0	0	0	1	1
Social media (SM)	0	5	0	0	5
Video Communication	0	1	0	0	1
Video materials and instructions	0	1	0	1	2
Sum	3	33	3	15	**54**

In Art, Augmented reality (AR) and Virtual reality (VR) were often used as digital tools. This tool was used for 3D architectural modeling [19] and for creating an interactive skills development space for fashion students [12]. The discipline that made the least use of digital tools in the teaching process was history and archaeology. In one case, 3D Visualization was used to create a virtual artifacts collection [11], while Augmented reality

(AR) and Virtual reality (VR) were used to prepare a learning app [37]. In this field of study, tools from the eight remaining categories weren't once used.

The analyzed articles also included the discipline of tourism (one paper) not mentioned above. We adopted the non-specific category for forty-three articles since described examples of using digital tools did not refer to the particular field of study. In the group of non-specific fields of study, Gamification apps and Learning Management Systems (LMS) were used most often (six times). In Tourism, the only example that qualified for this analysis was a Game-based environment used in the online flipped learning process [13].

In general summarization of the conducted research, one can point out those disciplines in which digital tools in the teaching process are used most often. The fields, along with the percentage share in the entire analyzed material, are: non-specific (15,2%), Language and Literature (11,7%), Economics and business (8,9%), Computer and information sciences (8,5%), Health sciences (5,3%) and Art (5,3%).

Looking at specific tools used in the teaching process in analyzed papers, one can also indicate those tools used most often. The tools, along with the percentage share in the entire researched material, are Augmented reality (AR) and Virtual reality (VR) (11,0%), Game-based environment (8,9%), Learning Management Systems (LMS) (8,2%), Interactive online course platform (7,4%), Gamification apps (6,4%), MOOCs (5,7%) and Social media (SM) (5,3%).

4. Discussion

This article reviews research on using digital tools in university teaching. The work aimed to reveal the tools used in the teaching process, examined and described in the literature in the years 2020-2023, and to disclose the disciplines of education in which these tools were used and tested.

In this study, we distinguished 29 major categories of tools and found that some tools are used and researched more often than others. First, we can conclude that there are clear groups of tools used and explored in higher education (RQ1). AR and VR technology, Game-based environment, and LMS systems are the most popular.

Secondly, we observe areas where more research is conducted on using digital tools than in others (RQ2). The smallest number of tools were tested in Agricultural Sciences (in terms of the total number of tests and the number of tested categories of tools). The most significant number of studies concerned Natural Sciences, followed by Social Sciences and Humanities.

Thirdly, since the same tools are used in various areas, there are no specific tools dedicated to a specific field of study (RQ3). Also, the number of studies is too small to confirm that some tools are dedicated to specific disciplines. However, as a result of cross-checking disciplines with tools, we found that there are popular combinations. The comparison links the following fields to tools: Economics and business with a Game-based environment; Languages and Literature with Social media (SM), Interactive online course platforms, and Learning Management Systems (LMS); Computer and information sciences with Interactive online courses platforms; Art with Augmented reality (AR) and Virtual reality (VR).

Although work on solutions such as artificial intelligence, 3D printing, and augmented and virtual reality was carried out long before the pandemic, their application in the educational environment was not widespread. However, the global lockdown of educational institutions made teachers and students see that it could work differently, as they were forced to switch to e-learning, even if they were reluctant to change. Although research on the acceptance of technology in education, both among students and teachers, is still being conducted [39], it is certain that these studies have moved from the level of theoretical considerations to the study of real feelings and attitudes. This situation paved the way for the transformation of education in a more digitized direction, significantly increasing the number of research and solutions compared to previous years [1]. Teachers prepared e-learning materials for the pandemic situation, but these materials are also used now. World-renowned Universities have made their educational materials and courses, video recordings of lectures, and laboratory resources available, allowing students

worldwide to access them through dedicated platforms, such as YouTube or MOOCs [28]. Access to a high level of education was also granted to students of poorer or less technologically developed countries [5]. The original trend of creating apps focused on specific objects has also changed. Currently, the same technologies are used in different fields in different contexts.

4.1. Contribution of the research

The major contribution of this work is the review of the papers in which the usage of innovative teaching tools in higher education was presented. In the process of literature review, the authors have (i) described synthetically the research conducted in each of the papers, (ii) compared the scope of implementation of innovative teaching methods and tools in researched articles, and (iii) indicated limitations in research methodology of the papers.

As a result, we have examined the works for this research and discovered new knowledge that may be used for more profound studies on tools and methods for the innovative higher education teaching process.

4.2. Limitations of this literature review

The first limitation of our research stems from the lack of a catalog of digital learning tools, which we could not identify in the literature. On the one hand, their identification was the purpose of this study, but having such a catalog at the stage of searching for literature for review could change the list of key phrases and thus lead to the identification of more publications to provide better answers to questions about fields of study.

The coronavirus pandemic causes the second limitation of our review during the search period. The research conducted during the closure period concerned only those tools that can be used entirely online, which may carry the risk that the pandemic forced the popularity of tools. Research in the future may not focus so much on e-learning tools.

Third, some studies looked at students from all majors at the university or from several HEIs. These studies, assigned to the non-specific category, do not indicate the popularity of tools in specific areas.

In addition, as a fourth limitation, we want to note that the works do not have a uniform structure. They also have different levels of technical detail. Therefore, we can assume there may have been mistakes in interpreting the tool and its correct assignment to the category in our review.

4.3. Avenues for future research

This review is a good starting point for further research in terms of deepening the search and analyzing the connections between teaching tools and methods. It also identifies trends and points out research gaps for future work. We see the possibility of conducting further research, both theoretical in terms of the possibility of using tools in various fields of studies and empirical. In addition, given these limitations, we plan to repeat the study with a broader range of keywords covering the created catalog and, in the longer term, to rule out the existing limitation due to the pandemic.

References

1. Abdulrahaman, M.D., Faruk, N., Oloyede, A.A., Surajudeen-Bakinde, N.T., Olawoyin, L.A., Mejabi, O. V., Imam-Fulani, Y.O., Fahm, A.O., Azeez, A.L.: Multimedia tools in the teaching and learning processes: A systematic review, (2020)
2. Adachi, C., Blake, D., Riisla, K.: Exploring digital literacy as a graduate learning outcome in higher education – An analysis of online survey. In: ASCILITE 2018 - Conference Proceedings - 35th International Conference of Innovation, Practice and Research in the use of Educational Technologies in Tertiary Education: Open Oceans: Learning Without Borders. pp. 292–297. Australasian Society for Computers in Learning in Tertiary Education (ASCILITE) (2018)
3. Adnan, S., Xiao, J.: A scoping review on the trends of digital anatomy education, (2023)
4. Alhajaji, B.H., Algmadi, J.S., Metwally, A.A.: Exploring the success of GMT technique: Games, mind-mapping, and twitter hashtags in teaching vocabulary in EFL higher education

environment. Int. J. High. Educ. 9 (3), (2020)
5. Aljawarneh, S.A.: Reviewing and exploring innovative ubiquitous learning tools in higher education. J. Comput. High. Educ. 32 (1), (2020)
6. Almaiah, M.A., Al-Khasawneh, A., Althunibat, A.: Exploring the critical challenges and factors influencing the E-learning system usage during COVID-19 pandemic. Educ. Inf. Technol. 25 (6), (2020)
7. Alqallaf, N., Chen, X., Ge, Y., Khan, A., Zoha, A., Hussain, S., Ghannam, R.: Teaching Solar Energy Systems Design using Game-Based Virtual Reality. In: IEEE Global Engineering Education Conference, EDUCON. (2022)
8. Anguas-Gracia, A., Subirón-Valera, A.B., Antón-Solanas, I., Rodríguez-Roca, B., Satústegui-Dordá, P.J., Urcola-Pardo, F.: An evaluation of undergraduate student nurses' gameful experience while playing an escape room game as part of a community health nursing course. Nurse Educ. Today. 103 (2021)
9. Arksey, H., O'Malley, L.: Scoping studies: Towards a methodological framework. Int. J. Soc. Res. Methodol. Theory Pract. 8 (1), (2005)
10. Ballinas-Gonzalez, R., Abella, R., Barrios, J., Garibay, R., Garrido, J.: A hydraulic 3D-lab based on virtual Gora dam visits at Call of Duty Warzone to Develop Student's Competencies During the COVID-19 Pandemic. In: IEEE Global Engineering Education Conference, EDUCON. (2022)
11. Bayle, P., Armand, D., Bessou, M., Cochard, D., Couture, C., Deguilloux, M.F., Ferrier, C., Haget, C., Jaubert, J., Knüsel, C., Martins, S., Pubert, É., Rottier, S., Souron, A., Beauval, C., Caillo, A., Dutailly, B., Girault, T., Hesry, M., Lacrampe-Cuyaubère, F., Ledevin, R., Masset, C., Mesa-Saborido, M., Mora, P., Muth, X., Pinson, R., Thibeault, A., Thomas, M., Vanderesse, N., Bordes, J.G.: Enhancing the learning of evolutionary anthropology skills by combining student-active teaching with actual and virtual immersion of Master's students in fieldwork, laboratory practice, and dissemination. Ecol. Evol. 12 (4), (2022)
12. Braithwaite, N.J.: The Virtual Shoe Salon: A creative and active approach for teaching research and data analysis to fashion students. In: International Conference on Higher Education Advances. (2021)
13. Chen, K.-W., Wang, Z.-Y.: Online flipped learning methods for teaching hospitality skills and management practices in an epidemic situation: A study on learning attitude and effectiveness. Front. Psychol. 13 (2023)
14. Chen, S.: Application of computer information technology in the reform of law classroom teaching method. In: IOP Conference Series: Materials Science and Engineering. (2020)
15. ElKelish, W.W., Ahmed, R.: Advancing accounting education using LEGO® Serious Play simulation technique. Account. Educ. 31 (2), (2022)
16. Gawel, A., Strykowski, S., Madias, K.: Implementing Sustainability into Virtual Simulation Games in Business Higher Education. Educ. Sci. 12 (9), (2022)
17. Guri-Rosenblit, S.: "Distance education" and "e-learning": Not the same thing. High. Educ. 49 (4), 467–493 (2005)
18. Haffejee, F.: The use of photovoice to transform health science students into critical thinkers. BMC Med. Educ. 21 (1), (2021)
19. Hajirasouli, A., Banihashemi, S., Sanders, P., Rahimian, F.: BIM-enabled virtual reality (VR)-based pedagogical framework in architectural design studios. Smart Sustain. Built Environ. (2023)
20. Handley, F.J.L.: Developing digital skills and literacies in UK higher education: Recent developments and a case study of the digital literacies framework at the university of Brighton, UK. Publicaciones la Fac. Educ. y Humanidades del Campus Melilla. 48 (1), 109–126 (2018)
21. Jaleniauskiene, E., Kasperiuniene, J.: Infographics in higher education: A scoping review. E-Learning Digit. Media. 20 (2), (2023)
22. Keržič, D., Alex, J.K., Alvarado, R.P.B., da Silva Bezerra, D., Cheraghi, M., Dobrowolska, B., Fagbamigbe, A.F., Faris, M.A.I.E., França, T., González-Fernández, B., Gonzalez-Robledo, L.M., Inasius, F., Kar, S.K., Lazányi, K., Lazăr, F., Machin-Mastromatteo, J.D., Marôco, J., Marques, B.P., Mejía-Rodríguez, O., Prado, S.M.M., Mishra, A., Mollica, C., Jiménez, S.G.N., Obadić, A., Raccanello, D., Rashid, M.M.U., Ravšelj, D., Tomaževič, N., Uleanya, C., Umek, L., Vicentini, G., Yorulmaz, Ö., Zamfir, A.M., Aristovnik, A.: Academic student satisfaction and perceived performance in the e-learning environment during the COVID-19 pandemic: Evidence across ten countries. PLoS One. 16 (10 October 2021), (2021)
23. Kurambayev, Y., Yazov, B., Annacharyyeva, H., Ishangulyyev, R.: MathCient - An Innovative

Solution for Flipped Learning in Higher Education. In: ACM International Conference Proceeding Series. (2022)
24. Levac, D., Colquhoun, H., O'Brien, K.K.: Scoping studies: Advancing the methodology. Implement. Sci. 5 (1), (2010)
25. López, F.R., Arias-Oliva, M., Pelegrín-Borondo, J., Marín-Vinuesa, L.M.: Serious games in management education: An acceptance analysis. Int. J. Manag. Educ. 19 (3), (2021)
26. Lorenz, T., Gerster, L., Elias Wodzinowski, D., Wartenberg, A., Martetschläger, L., Molitor, H., Cremer, T., Bloch, R.: Innovative Teaching and Learning Formats for the Implementation of Agroforestry Systems - An Impact Analysis after Five Years of Experience with the Real-World Laboratory "Ackerbaum." For. 2022, Vol. 13, Page 1064. 13 (7), 1064 (2022)
27. Merriam-Webster: Teaching Aid
28. Park, J.J., Edward, H.J.K., Chung, C.W.: Innovative digital tools for new trends in teaching and assessment methods in medical and dental education. J. Educ. Eval. Health Prof. 18 (2021)
29. Park, S.Y.: An analysis of the technology acceptance model in understanding University students' behavioral intention to use e-Learning. Educ. Technol. Soc. 12 (3), (2009)
30. Pham, Q.T., Tran, T.P.: The acceptance of e-learning systems and the learning outcome of students at universities in Vietnam. Knowl. Manag. E-Learning. 12 (1), (2020)
31. Robinson, J., Dusenberry, L., Hutter, L., Lawrence, H., Frazee, A., Burnett, R.E.: State of the Field: Teaching with Digital Tools in the Writing and Communication Classroom. Comput. Compos. 54 (2019)
32. Roca, J.C., Chiu, C.M., Martínez, F.J.: Understanding e-learning continuance intention: An extension of the Technology Acceptance Model. Int. J. Hum. Comput. Stud. 64 (8), (2006)
33. Šalgovičová, J., Jánošová, D., Darázs, T., Sádecká, R.: The art of tourism marketing as a way to a sustainable restart after the pandemic. Ad Alta J. Interdiscip. Res. 278–286 (2021)
34. Sangrà, A., Vlachopoulos, D., Cabrera, N.: Building an inclusive definition of e-learning: An approach to the conceptual framework. Int. Rev. Res. Open Distance Learn. 13 (2), (2012)
35. Selim, H.M.: Critical success factors for e-learning acceptance: Confirmatory factor models. Comput. Educ. 49 (2), (2007)
36. Sormunen, M., Heikkilä, A., Salminen, L., Vauhkonen, A., Saaranen, T.: Learning Outcomes of Digital Learning Interventions in Higher Education: A Scoping Review, (2022)
37. Soto, J.H.B., Ocampo, D.C.T., del Carmen Beltrán Colón, L., Oropesa, A.V.: Perceptions of immerseme virtual reality platform to improve english communicative skills in higher education. Int. J. Interact. Mob. Technol. 14 (7), (2020)
38. Soysal, F., Çalli, B.A., Coşkun, E.: Intra and intergenerational digital divide through ICT literacy, information acquisition skills, and internet utilization purposes: An analysis of Gen Z. TEM J. 8 (1), (2019)
39. Strzelecki, A., Cicha, K., Rizun, M., Rutecka, P.: Using a General Extended Technology Acceptance Model for E-Learning (GETAMEL). A Literature Review of Empirical Studies. Int. Conf. Inf. Syst. Dev. (2022)
40. Teo, T., Ruangrit, N., Khlaisang, J., Thammetar, T., Sunphakitjumnong, K.: Exploring E-learning acceptance among university students in Thailand: A national survey. J. Educ. Comput. Res. 50 (4), (2014)
41. Venkatesh, V., Davis, F.D.: Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. Manage. Sci. 46 (2), (2000)
42. Verhoeven, J.C.: Exploring the Self-Reported ICT Skill Levels of Undergraduate Science Students. Artic. J. Inf. Technol. Educ. (2016)
43. Yan, D., Fan, Q.: Online informal learning community for interpreter training amid COVID-19: A pilot evaluation. PLoS One. 17 (11 November), (2022)
44. Yélamos-Guerra, M.S., García-Gámez, M.: The use of TikTok in higher education as a motivating source for students. Porta Linguarum. 2022 (38), (2022)
45. Zargaran, A., Houlden, R., O'Neill, P., Schaffer, S., Chang, V., Kafai Golahmadi, A., Hirniak, J., Turki, M., Zargaran, D.: Emergency medicine undergraduate simulation training during the COVID-19 pandemic: A course evaluation. Injury. 53 (10), (2022)
46. Zhampeissova, K., Kosareva, I., Borisova, U.: Collaborative Mobile Learning with Smartphones in Higher Education. Int. J. Interact. Mob. Technol. 14 (21), (2020)