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Article

A Review of Emerging Technologies and Their Acceptance in Higher Education

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Abstract: The pandemic caused by COVID-19 impacted the entire world, but technological progress led to the appearance of new and innovative emerging technologies (ETs). These technologies proved to have a wide potential for use as support in education, but being a new technology, certain complications arose when it came to their application in the educational model. Nowadays, there are many digital technologies, so it is necessary to identify those that can be used in today's education. Digital technologies have been implemented in all types of sectors, one of them being education, and the use of these technologies translates into significant improvements in educational processes and learning outcomes. Despite this, there is currently little research on the use of ETs as a support in the academic process. This research uses systematic mapping (SM) of the last 5 years, together with the Unified Theory of Acceptance and Use of Technology (UTAUT) model to identify the use and acceptance of ETs in higher education. For the SM, a keyword search string was used in three scientific databases (Scopus, Web of Science, and IEEE Xplore). To apply the UTAUT, a survey was conducted with 120 students on the acceptance of ETs as support in higher education. The results obtained indicate that ETs provide some optimization of educational processes, with greater immersion and application of knowledge when using technologies such as augmented reality, virtual reality, and mobile learning. Likewise, ETs can motivate students, allowing them to reach new academic and professional achievements.

Keywords: emerging technologies; intelligent education; personalized education; active education

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1. Introduction

In recent years, learning has become increasingly open, collaborative, informal, flexible, blended, massive, and portable [1]. These characteristics allowed for ubiquitous access to educational resources during the mandatory lockdown due to the pandemic caused by COVID-19, which was of great help to educational institutions, teachers, and students [2]. In this context, digital technologies play a very important role so that the educational system does not stop, and students can continue with an online and distance learning curriculum [3]. These technologies proved to have ample potential for use as a support in education, but being a relatively new technology, complications arose when they were applied in the educational model [4].

There are currently a large number and types of technologies, so it is necessary to identify those that can be used in education and can contribute to the teaching and learning model [5,6]. Digital technologies have been implemented in all types of sectors, one of them being education; the use of these technologies results in significant improvements in educational processes and learning outcomes [7,8].

ETs are characterized as innovative technologies that provide an improvement over other traditional technologies in a specific area [6]. These technologies are not at an adequate level of maturity, because they are still under development [9]. ETs are science-based innovations with the potential to create a new industry or transform an existing one [10,11]. On the other hand, an ET is defined as a new technology that is being developed and that will substantially alter the business and social environment [10]. Other research argues that ETs are technologies that could be commercially available in the next few years (5 to 15 years), which are currently at an early stage of their development process [11–13].

A digital technology can be considered emergent depending on where it is being used, the domain and knowledge of its operation, and the application given to it [14]. An important characteristic of an ET is that it does not need to have a limited lifetime, and even when it has been used for a long period of time, it can begin to become emergent when it is used in novel ways to serve people to achieve their goals [10,11]. For example, radio frequency identification (RFID) technology is not considered an ET in developed countries, whereas in other undeveloped countries, where the Internet and communication technology infrastructures are still deficient, it is considered an ET [11].

In recent years, higher education has undergone significant changes marked by technology, which alerts higher education institutions, who must try to adapt to the digital culture of their students [15]. These changes involve generating new educational strategies and methodologies based on digital technologies, which must innovate learning [15]. There are challenges that need to be addressed such as the shortage of educational materials, lack of content, lack of equipment for practices, and laboratories [9]. In this sense, digital technologies can be the solution to these problems and can help to improve the quality of teaching and contribute to the creation of new learning opportunities [16].

The use of technology as a support in education makes it flexible and stimulating for students, because they acquire skills such as spatial visualization, innovative thinking, problem solving, and analytical and critical thinking [9]. In addition, its use allows for an increase in the exchange of knowledge between teachers and students and the personalization of learning [6]. For this reason, this paper aims to give a broader view of the use of this technology in educational processes and its acceptance in higher education. This research uses systematic mapping (SM) to identify the different ETs and how they are being used in higher education. This could create opportunities for new lines of research on the use of ETs in higher education. The objective of this SM is to identify the most commonly used digital technologies to identify their acceptance in higher education as a support in education.

Furthermore, student acceptance of ETs is necessary to ensure the successful deployment of these technologies in support of higher education [17]. Therefore, factors affecting student acceptance of these technologies should be identified. There are isolated efforts to study the adoption and acceptance of ETs [18,19], which indicate the factors for the acceptance of individual technologies such as mobile learning, augmented reality (AR), and virtual reality (VR) [19,20] and not as ETs in a general way. This research attempts to fill this gap by integrating a variation of the Unified Theory of Acceptance and Use of Technology (UTAUT) [17]. For this purpose, a survey was conducted with 120 students, which consisted of 16 questions that identified the factors associated with the intention to use ETs as a support in the educational model. The initial hypotheses were based on the following research questions:

RQ1. What types of ETs are used in higher education today?

RQ2. Are these ETs accepted as a support in the educational model for higher education?

The initial part of this article introduces the reader to the concept of ETs; the rest of the article is organized as follows: Section 2 shows the literature on ETs in higher education and models of technological acceptance. Section 3 presents the methodology used for the development of this research. Section 4 indicates the results obtained. Section 5 shows the discussion of the findings, Section 6 presents the limitations of the research presented, and finally, Section 7 indicates the conclusions and future work.

2. Literature Review

2.1. Emerging Technologies in Current Education

A determining factor in the process of digital transformation in the world, and especially in educational institutions, was the pandemic and the resultant restrictions due to compulsory lockdowns in various parts of the world [3,21]. The use of ETs as a support in the educational model allowed students to continue without interruption in their educational process [22]. Moreover, expectations were exceeded, not only in terms of having incorporated interactive and immersive models that enhanced student learning but also in terms of having brought education to people all over the world [6]. ETs applied to education have become a valuable learning resource because they motivate students to develop competitive skills to meet the job needs of the present and the future [23]. Innovation in education allows students to effectively use digital technologies to generate, transform, discuss, collaborate, collect, and disseminate criteria, enabling the evolution of knowledge [24]. Educational environments supported by technologies can generate interactive learning experiences, which are evaluated based on the actions, choices, and performance of the learner [25].

The variety of ETs that are implemented in education is significant. An example is VR or AR, which help create an immersive educational experience [8,26]. Teachers who have applied VR and AR in their classes notice benefits from the application of these technologies and even suggest various applications within their classrooms [27].

On the other hand, there are those technologies that allow students to access educational material from anywhere in the world, for example, mobile learning, virtual platforms, virtual classrooms, virtual libraries, etc. [28]. An initiative with the use of this technology took place at Strathmore University, who recorded their classes in a screencast and uploaded them to a server with an e-learning platform. Most of the students who watched the videos found them useful for completing assignments, retain concepts, and study for the exam [29].

Another type of ETs is social networks, which allow for constant communication between students and teachers. This enables students to have support during the fulfillment of their academic activities [30]. Additionally, social networks can be used to involve and motivate students when they are outside their classroom activities [30]. An advantage of this type of ETs is that the current generation of students grew up with access to mobile devices, internet access, and social networks, which makes them familiar with this type of technology [31,32].

Mobile devices today range from wearable, which are accessories worn on the body, to larger devices such as smartphones, tablets, and even small computers [33]. All these devices have the characteristic of being connected to the Internet, helping teachers, tutors, and mentors support students outside of school hours and school environments [7]. For example, mobile devices are used to support the teaching of English as a foreign language, allowing students to learn a language other than their native language [34].

Hardware (cameras and sensors) can be used as an innovative form of ETs in the classroom. These devices track the movement of the students' faces and capture information that, when processed, informs teachers about the satisfaction that students have with their learning [35]. In addition, by adding extra information on grades obtained, forms of evaluation, and class schedules, with the use of machine learning, it is possible to design educational, emotional, and behavioral recommendation systems, etc. [36]. Some universities in the world in the subjects of science, mathematics, technology, and engineering have adopted the development of hardware as an educational prototype using elements such as Arduino, Raspberry Pi, or BeagleBone, due to the practical value provided when using these platforms in learning [37].

One of the innovative technologies that has proliferated the most in recent years is gamification, which is based on the use of video game elements to teach and thus capture the attention and generate motivation in students [38–40].

Technological change is moving at an exponential rate, making it difficult for educational institutions and teachers to keep pace with it. Therefore, it is necessary to create new ways of teaching and learning and new methods for accessing educational material and for innovating in the organization of the interaction between students and teachers.

2.2. Technology Acceptance Models

Traditional teaching methodologies promote learning that uses memory and does not develop skills such as reading, listening, sharing, and doing [41]. For this reason, the use of digital technologies in the educational process can innovate the teaching and learning model in higher education [35]. To ensure these technologies can be used appropriately in the academic environment, the factors that may affect their adoption by students should be investigated.

The study of technology adoption by users has been conducted since the mid-1980s [42]. This is because identifying the factors that influence user acceptance is a useful prerequisite for the deployment, utilization, and realization of its potential value, regardless of the advancement of the technology [43]. There are several models that can be used to explain the acceptance of a specific technology among users. For example, the Theory of Reasoned Action (TRA) [44,45], the Technology Acceptance Model (TAM) [46,47], and the Unified Theory of Acceptance and Use of Technology (UTAUT) [48] can be useful for this. All these models have been modified, extended, and validated by multiple researchers to improve the prediction of technology acceptance and use [49]. However, UTAUT has been shown to be a model that can be used to predict user acceptance of technology use [17,50–53].

3. Methodology

3.1. Participants

The study population consisted of engineering students at a university in Quito, Ecuador, in which the age of the participants ranged from 18 to 21 years old, and of which 8.3% were female and 91.7% were male. The participants were studying a technology subject, and 100% of them had a mobile device and a laptop or personal computer of their own for personal use. Only 45% owned an extra tablet or iPad for personal use.

3.2. Systematic Mapping

For this study, the time considered was the last 5 years. The search identified multiple related papers, but only the most significant were included in the SM. The selection of papers included journal and conference articles, research reports, theses, and book chapters. In addition, this research used the one-level backward snowballing technique, which analyzes the entire reference list of the selected articles in the SM to find other valuable investigations that can contribute to the research objectives [54]. This technique allows for the discovery of papers and research that would otherwise not have been considered in the SM.

SEARCH STRING

To find the required research papers, keywords were used to construct the following search string:

("Document Title":emerging technology) AND ("Document Title":education) AND ("Abstract":education) AND ("Abstract":emerging technology).

The search was conducted in the IEEE Xplore, Web of Science, and Scopus databases, and the timeframe of the search was limited to 2018–2022, due to the risk of theoretical expiration in the use of ETs in education [55]. It is important to indicate that the databases used for this research were chosen because of their extensive content of high-quality and high-impact journals in various disciplines which include the use of technology in education. The SM was composed of four steps:

First step. The search string was used in the three databases.

Second step. Articles that were not written in the English language and that were duplicated in the three databases used for the SM were excluded.

Third step. A reading of the documents was carried out in search of information that would contribute to the SM. The type of ETs, the results, and the conclusions of the work were analyzed.

Fourth step. A reading of the references was performed using the backward snowballing technique. These papers correspond to research initiatives that were not found in the search using the proposed string, because they were published before 2018.

3.3. Technology Acceptance

As shown in Table 1, the research was based on the UTAUT that uses, as external factors, Perceived Usefulness (PU), Self-Efficacy (SE), Perceived Compatibility (PC), and Perceived Entertainment (PE) [52]. It also incorporates four constructs from the UTAUT; these are Effort Expectancy (EE), Performance Expectancy (PEX), Social Influence (SI), and Facilitating Conditions (FC) [17]. As can be seen in Table 2, the instrument used for this research was a 16-question survey that gathered information about user acceptance of the use of ETs in higher education. For this purpose, a model of questions was used that were developed from previous studies on the use of digital technologies in education and the opinions of Information Technologies experts [53]. A five-point Likert scale was used for the numerical responses to the survey. Figure 1 shows the constructs and external factors considered for this study.

Table 1. External factors and constructs of the UTAUT.

Externals Factor	Questions	Resources
Perceived Utility (PU)	2	[52,53]
Self-Efficacy (SE)	2	[52,53]
Perceived Compatibility (PC)	2	[52,53]
Perceived Entertainment (PE)	2	[52,53]
Construct	**Questions**	**Resources**
Effort Expectancy (EE)	2	[17]
Performance Expectancy (PEX)	2	[17]
Social Influence (SI)	2	[17]
Facilitating Condition (FC)	2	[17]

Table 2. UTAUT Model Survey Questions.

Externals Factor	Questions
Perceived Utility (PU)	1. Do you think that, in the future, with the advance of technology, ETs will be indispensable in the classroom? 2. Do you think that ETs is a useful tool that favors learning?
Self-Efficacy (SE)	3. How would you rate your ability to learn to use a digital technology that you have never used before? 4. Do you learn a lot more if you include ETs in the process?
Perceived Compatibility (PC)	5. Is ETs appropriate for my educational needs? 6. Is ETs compatible with my learning system?
Perceived Entertainment (PE)	7. Is it fun to learn using ETs? 8. Do I think gamification of education is important?

Table 2. *Cont.*

Construct	Questions
Effort Expectancy (EE)	9. Do you think it is easy to use an ETs system? 10. Is it easy to acquire skills to use an ETs system in education?
Performance Expectancy (PEX)	11. Do you think that, with the help of an ETs, you can improve your academic performance? 12. Do you think that the use of an ETs would improve your level of understanding?
Social Influence (SI)	13. Does any teacher or person in authority encourage the use of ETs for learning? 14. Does anyone close to you consider that you can learn using ETs?
Facilitating Condition (FC)	15. Is it easy to download documentation on the use of ETs for learning? 16. Do you think ETs is available for use in education?

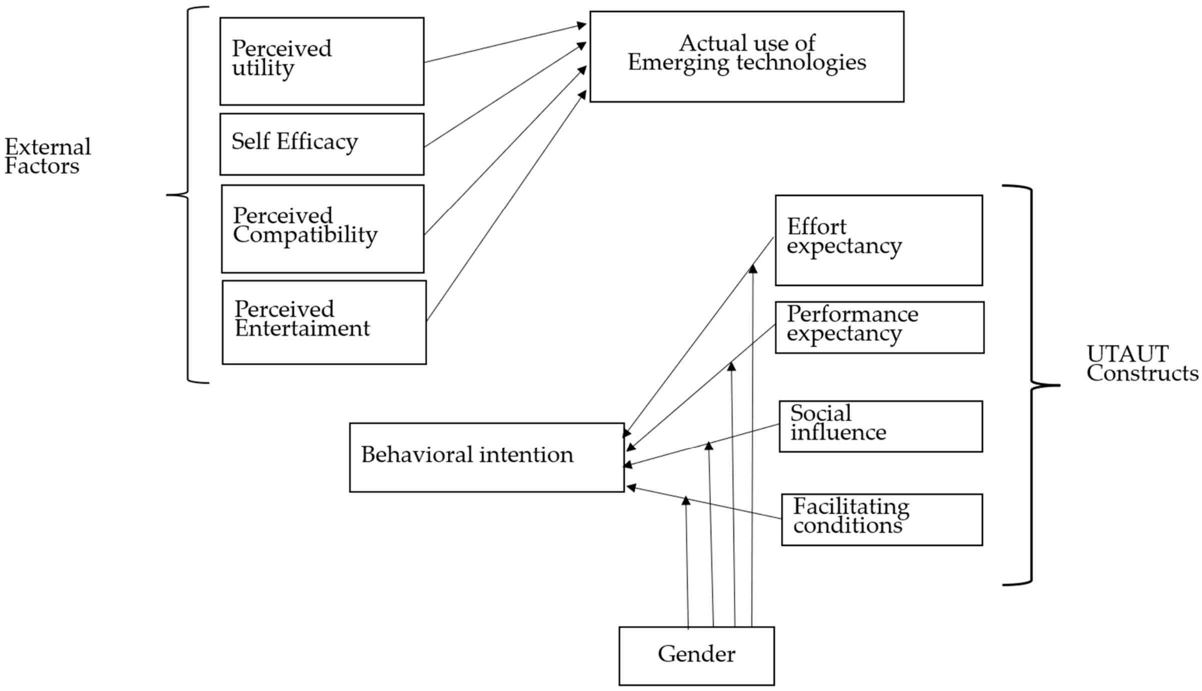

Figure 1. Variation of the UTAUT.

3.4. Experimental Protocol

Each participant signed an informed consent that was distributed through a web form. The results obtained with the first methodology applied in this research (SM) were used to expose the participants to the main ETs and the use that they can have in higher education. Participants were able to ask questions and make comments on the topic. This was followed by the second research methodology, where students responded to a survey on technological acceptance consisting of 16 questions. This experiment lasted about 35 min per participant. The people who participated in the survey provided valuable information about the use of ETs, as well as their individual and group preferences. This information allowed us to get a real idea of the acceptance of ETs in current education. Furthermore, this information may be useful for teachers and educational institutions that want to include ETs to innovate traditional methodologies and thus respond adequately to current learning challenges.

4. Results

4.1. Systematic Mapping

The SM was composed of four steps:

First step. A total of 131 articles were found. IEEE Xplore contains 12 papers, Web of Science contains 78 papers, and Scopus contains 41 papers.

Second step. A total of 89 documents were eliminated, resulting in a total of 42 documents.

Third step. As a result, 29 documents that did not contribute to the research objective were excluded, resulting in a total of 13 documents that were included in the SM.

Fourth step. Five papers were included.

At the end of the four-step technique, a total of 18 final papers were obtained that constituted the SM documentation corpus. The information obtained in the final set of papers was the title of the papers, the first author and their country of origin, the year, and in which journals and conferences they were published. Figure 2 shows the four-step method applied.

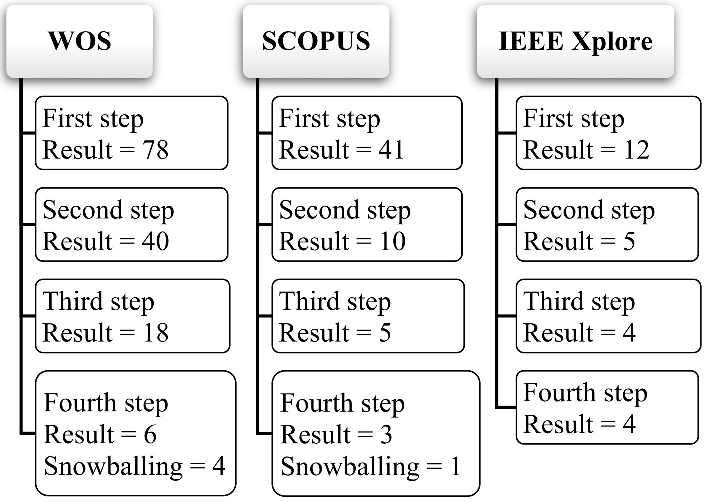

Figure 2. Four-step method for systematic mapping.

Table 3 shows the results of the research found in the last 5 years. The years 2018 and 2019 have a lower number of publications on this topic. In contrast, since 2020, the number of research initiatives in this area has increased.

Table 3. Corpus of articles found in systematic mapping.

Source	2018	2019	2020	2021	2022	Snowballing	All
Total of articles	1	0	6	4	2	5	18

The first findings refer to the key characteristics of learning, which should be personalized, ubiquitous, collaborative, lifelong, and authentic, as these characteristics are what support the adoption of various digital technologies in educational processes [56]. To help readers and stakeholders better understand how to use ETs to create innovative learning environments, Luo, H et al. [57] classify ETs used for education into four types:

- Educational networks;
- Web-based learning;
- Mobile learning;
- Classroom equipment.

This also shows a classification based on the way in which learning is supported using the different ETs used in the educational process:

- Technologies that support learning to understand and create;
- Technologies that support learning through collaboration;
- Technologies that support anytime, anyplace learning;
- Technologies that support learning through gaming.

Based on the results obtained, a new classification of ETs is proposed that uses five categories, which cover the largest number of digital technologies used in education. Table 4 shows the categories defined for each type of ET found in the SM. These technologies have been used in higher education [58] and in lifelong learning [59]. On the other hand, Table 5 shows each ET and its categorization. The main findings about the use of ETs in education have been published in journals, scientific conferences, and book chapters, as shown in Table 6.

Table 4. Categories of ETs in education.

Code	Category
A	Technologies that support adaptive learning
B	Technologies that support learning through collaboration
C	Technologies at the service of ubiquitous learning
D	Technologies that support learning through gaming
E	Technologies to understand and create using equipment and hardware

Table 5. Classification of emerging technologies by category.

Item	Type of Emerging Technology	Category Code				
		A	B	C	D	E
1	Artificial intelligence	X				
2	Augmented reality	X			X	X
3	Big data	X				
4	Blockchain	X				
5	Cloud computing	X	X	X		
6	Collaboration tools		X			
7	Gamification	X		X	X	
8	Hardware					X
9	Internet of Things					X
10	Learning management systems	X	X	X		
11	Machine learning	X	X			
12	Mobile learning	X	X	X	X	X
13	Mooc's			X		
14	Podcasts, Vodcast, Screencast		X	X		
15	Social networks		X	X		
16	Virtual reality	X			X	X
17	Wikys		X	X		
18	World-Wide Web		X	X		

RQ1. What types of ETs are used in higher education today?

Table 6 shows the articles selected for the SM and the most relevant information such as the name of the first author, the country of origin, the year of publication, and the conference or journal where it was indexed. These publications are ordered from the oldest to the most recent, and it can be observed that the first five correspond to the articles found with the backward snowballing technique, since the year of publication is outside the range chosen for the SM. The country with the most initiatives in the use of ETs in education is the USA with five publications [60–63]. The second place goes to China with two investigations in this area [58,59]. It can also be observed that the use of ETs as a support in education had an upturn in 2020; this may be due to the digital transformation that occurred due to the global pandemic, and in this year, the largest number of articles on technologies in education was published. Scientific journals were the major source of information for this research, because, in the corpus of articles, there are 14 documents published in journals and 4 from conferences.

Furthermore, Table 6 shows the information related to the type of technology used and the category (Table 4) to which it belongs. These publications are ordered from the oldest to the most recent. In the SM, 18 technologies were found that have been used as emerging in current education. Table 5 shows that the most used ET was mobile learning. Mobile device-supported learning is a trend that is positioning itself strongly in academic innovation [64]. This technology is so versatile that it can be used in primary [65], secondary [66], and higher education and lifelong learning [67]. The second place is shared by gamification, cloud computing, LMSs, AR, and VR. These technologies have been used in support of education at all educational levels, from primary to lifelong learning [9,68,69]. The third place in this ranking goes to the World-Wide Web, podcasts, vodcasts, screencasts, and wikis. These technologies have been used for a decade and involve all educational levels [67,70–72].

An important finding in this research is the use of hardware as ETs, which has been used in the construction of laboratories [73] and the creation of assistant robots for learning enhancement [74]. The integration of platforms that are used to create hardware prototypes such as Arduino, Raspberry Pi, or BeagleBone Board in education is continuously increasing [37]. These hardware resources are widely used to support the teaching of programming skills, low-scale electrical and electronic construction, and the use of sensors for monitoring temperature, humidity [75], etc.

Table 6. Relevant studies on ETs in education (2016–2022).

Article	First Author	Country	Year	Publication	Category of ET
[60]	Godwin-Jones, Robert	EEUU	2016	*Language Learning and Technology*	A
[73]	Kritpolviman, Khajitpan	Thailand	2016	*International Journal of Digital Information and Wireless Communications*	A, E
[76]	Gomes, Natalia Fernandes	Portugal	2016	International conference on education and new learning technologies	B, C
[61]	Foronda, Cynthia	EEUU	2017	*Nurse Educator*	A
[69]	Ozdamli, Fezile	Turkey	2017	*International Journal of Emerging Technologies in Learning*	A
[56]	Isaias, Pedro	Australia	2018	*Journal of Information Communication and Ethics in Society*	E
[59]	Wang, Ping	China	2020	*Wireless Communications & Mobile Computing*	A
[62]	Milovich, Michael	EEUU	2020	*Journal of Information Systems Education*	A
[77]	Wali, Ahmad Zahir	Afghanistan	2020	*International Journal of Emerging Technologies in Learning*	B, D
[78]	Hidrogo, Irving	Mexico	2020	*International Journal on Interactive Design and Manufacturing*	A, C, E
[37]	Al-Masri, Eyhab	EEUU	2020	*IEEE Access*	E
[79]	Vasileios, A. Memos	Greece	2020	International Conference on Computer Communication and the Internet	A
[64]	Gao, Chuan	EEUU	2021	*RECALL*	A
[80]	Prochazka, Alex	Czech Republic	2021	*IEEE Signal Processing Magazine*	A
[58]	Gao, Y	China	2021	*Journal of Sichuan University*	B, C
[81]	Hung, Hui-Chun	Taiwan	2021	*Australasian Journal of Educational Technology*	E
[82]	Kosasi, Sandy	Indonesia	2022	International Conference on Science and Technology	A
[83]	Baniyounis, Moahmmed	Jordan	2022	International Multi-Conference on Systems, Signals & Devices	E

4.2. Technological Acceptance

4.2.1. Analysis of Variance in UTAUT

RQ2. Are these ETs accepted as support in the educational model for higher education?

Figure 3 shows that, in general, participants have a good acceptance of ETs in current education. However, it can be identified that Social Influence (SI) is the construct that contributes the least to the behavioral intention regarding the use of ETs in higher education, with 37% (strongly disagree and disagree) of participants indicating that they were not influenced by any authority or close relative to use ETs in education. It can also be observed that Perceived Compatibility (PC) is the external factor that contributes the least to the acceptance of ETs in education, with 23.3% (strongly disagree and disagree) of participants indicating that ETs are not compatible with their current learning services.

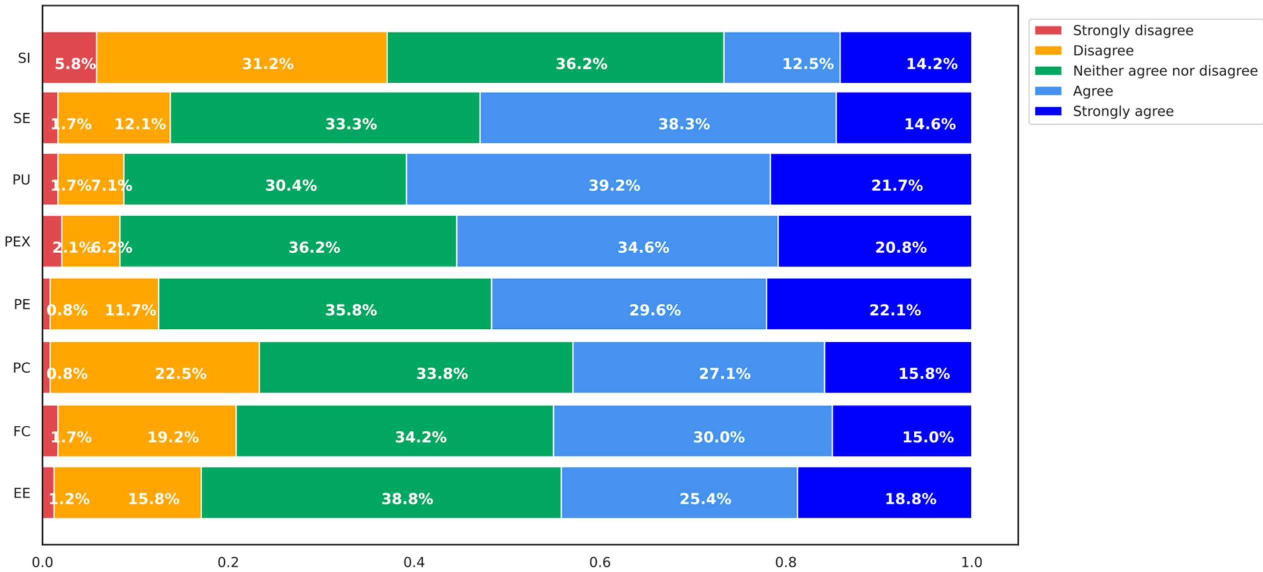

Figure 3. Responses to the acceptance survey.

On the other hand, Perceived Utility (PU) is the external factor that most contributes to the acceptance of ETs in education, with 60.9% (strongly agree and agree) of participants indicating that ETs are useful tools that promote learning. It can also be observed that Performance Expectancy (PEX) is the construct that contributes the most to the behavioral intention regarding the use of ETs in higher education, with 55.4% (strongly agree and agree) of participants indicating that the use of ETs can improve the level of understanding and academic performance.

Figure 4 shows the responses to the 16 survey questions on a five-point Likert scale with the following weighting: I strongly disagree = 1; I disagree = 2; I neither agree nor disagree = 3; I agree = 4; I strongly agree = 5. The results obtained indicate there is a positive assessment by the participants on the use and acceptance of ETs for use in higher education. Tables 7 and 8 show the mean, median, and standard deviation of the survey values on technological acceptance with the proposed UTAUT. It is important to note that the research instrument was validated prior to data analysis through a reliability test using Cronbach's alpha. The result of this analysis yielded a value of 0.7, and therefore, the survey and the results obtained are reliable.

Table 7. Characteristics of the external factors of the UTAUT (μ = Mean; M = Median; σ = Standard Deviation).

External Factor	Question	Answer	μ	M	σ
Perceived utility (PU)	Q1	120	3.70	4	0.94
	Q2	120	3.74	4	0.94
Self-Efficacy (SE)	Q3	120	3.58	4	0.93
	Q4	120	3.47	4	0.95
Perceived Compatibility (PC)	Q5	120	3.59	4	1.04
	Q6	120	3.10	3	0.95
Perceived Entertainment (PE)	Q7	120	3.62	4	0.97
	Q8	120	3.59	4	1.00

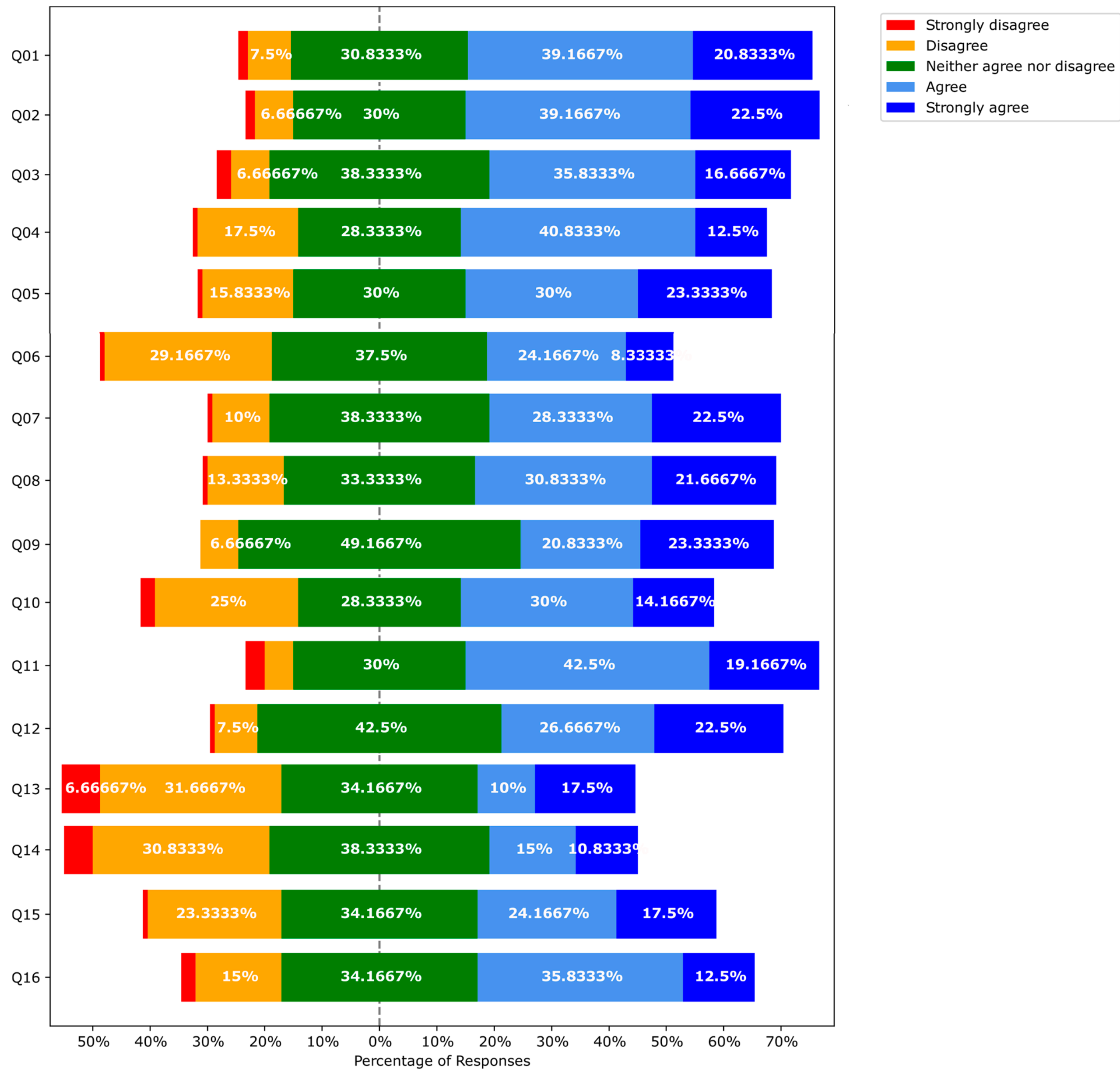

Figure 4. Responses to the questions of the conducted acceptance survey.

Table 8. Characteristics of the UTAUT model constructs (μ = Mean; M = Median; σ = Standard Deviation).

Construct	Question	Answer	μ	M	σ
Effort Expectancy (EE)	Q9	120	3.61	3	0.92
	Q10	120	3.28	3	1.07
Performance Expectancy (PEX)	Q11	120	3.69	4	0.95
	Q12	120	3.63	3	0.94
Social Influence (SI)	Q13	120	3.00	3	1.18
	Q14	120	2.96	3	1.05
Facilitating Conditions (FC)	Q15	120	3.34	3	1.05
	Q16	120	3.41	3	0.97

Table 7 shows the external factors which affect the current use of ETs in higher education. In these data, many of the participants have an average acceptance rating that is higher than 3.5 and a standard deviation that is lower than 0.97, which means that there is a general acceptance of the participants regarding the use of ETs in higher education. The factors that contribute most to the use of ETs are Perceived Usefulness (PU) and Perceived Entertainment (PE). In other words, participants accept ETs in education because they find it useful and entertaining.

On the other hand, Table 8 shows the constructs that influence the behavioral intention on the use of ETs. It can be observed that most of the participants have a mean acceptance that is higher than 3.3 and a standard deviation that is lower than 1.05. This means that most of the participants have an intention to use ETs for education. The constructs that contribute the most to behavioral intentionality are Performance Expectancy and Effort Expectancy (EE). This means that participants consider that the use of ETs in current education is directly proportional to their performance and, moreover, they are willing to learn how to use ETs to support their educational process. Also, Figure 4 shows graphically the responses to the 16 questions asked in the acceptance survey with the proposed UTAUT. It can be observed that questions Q13 and Q14 have the lowest weighting. In other words, the knowledge and use of ETs has not been influenced by any authority figure or close relative. It can also be seen that questions Q2 and Q11 have the highest weighting. That is, the participants think that the use of ETs can favor learning and improve academic performance.

To exhaustively identify the acceptance of ETs in higher education, a correlation analysis was carried out using groupings based on the similarities of the answers obtained in the survey carried out. This analysis is presented below.

4.2.2. Correlation Analysis

Figure 5 shows the correlation between the questions of the external factors and the constructs of the proposed UTAUT. The correlations between questions Q5–Q13 mean that students who indicated that ETs are appropriate for their educational needs also indicated that they use these technologies on the recommendation of a family member or authority figure. In addition, the correlation between questions Q6 and Q9 is also significant, meaning that students who think that ETs are compatible with their learning system also agree on the ease of use of ETs for higher education. Finally, the other important correlation is between questions Q3 and Q5, which indicates that students who consider that they can learn to use a new technology also think that these are appropriate for their educational needs.

4.2.3. Cluster Analysis

In this study, a cluster analysis based on the similarity of responses was performed [84]. This analysis is responsible for grouping a set of individuals in such a way that people in the same group have very similar responses to each other. The similarity between observations is defined using certain distance measures based on the correlation of questions and answers. The method used for this analysis was hierarchical clustering using Euclidean distance, with numerical values obtained from the Likert scale used in the survey [85]. Figure 6 shows the tree of distances with which a discrete clustering can be found based on the similarity of the responses of the 120 participants, concentrated in two groups. Figure 7 shows the two clusters that were found and classifies them by gender (male and female). In both clusters, the presence of the female participants is limited, because only 8.3% of the participants were women.

Additionally, Figure 8 shows the plot of the averages of the responses to the external factors' questions and the constructs of the UTAUT. These diagrams are designed based on the two clusters identified. The participants of both clusters have a certain similarity in their answers, and it is graphically corroborated that Perceived Compatibility (PC) and Social Influence (SI) are the two topics that are rated lowest by the students. In the same way, the topics that had the best acceptance by the respondents were the Perceived Usefulness (PU) and the Performance Expectancy (PEX). These data are contrasted with the results obtained, prior to grouping, in the general responses to the survey.

Figure 5. Correlation diagram between the external factors and the constructs of the UTAUT.

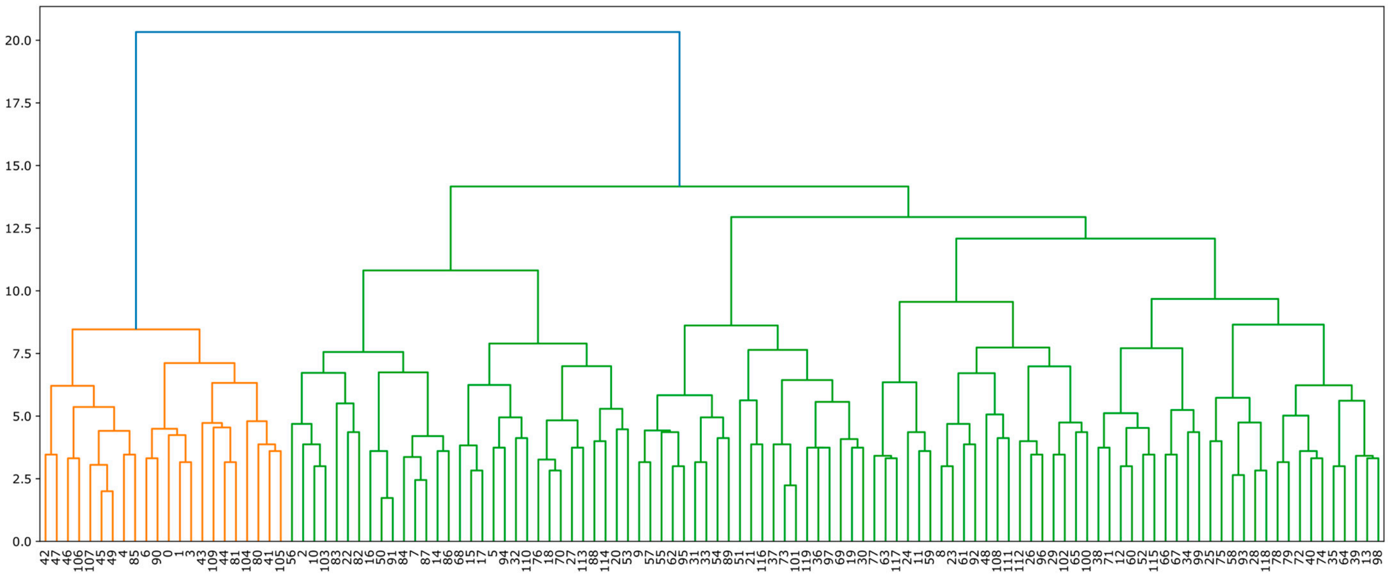

Figure 6. Hierarchical clustering dendogram.

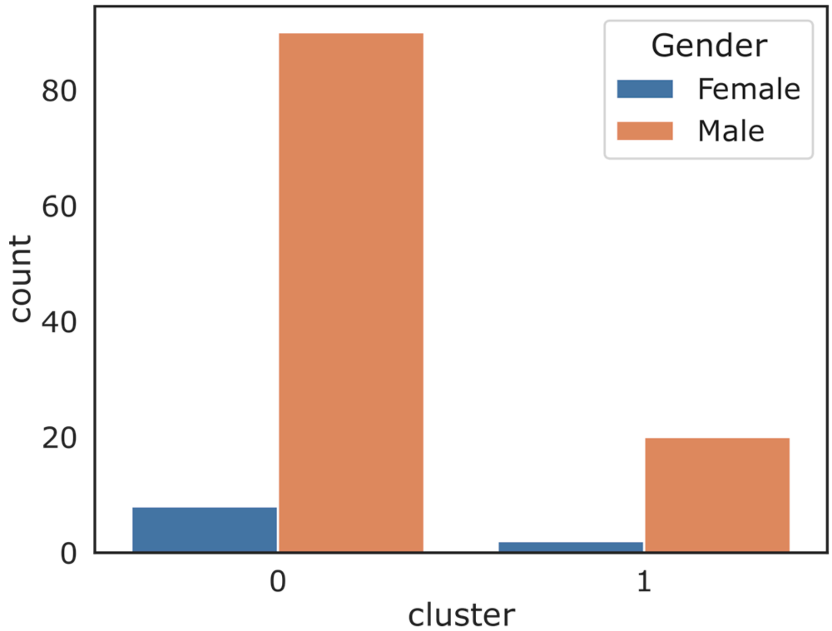

Figure 7. Optimal number of clusters found.

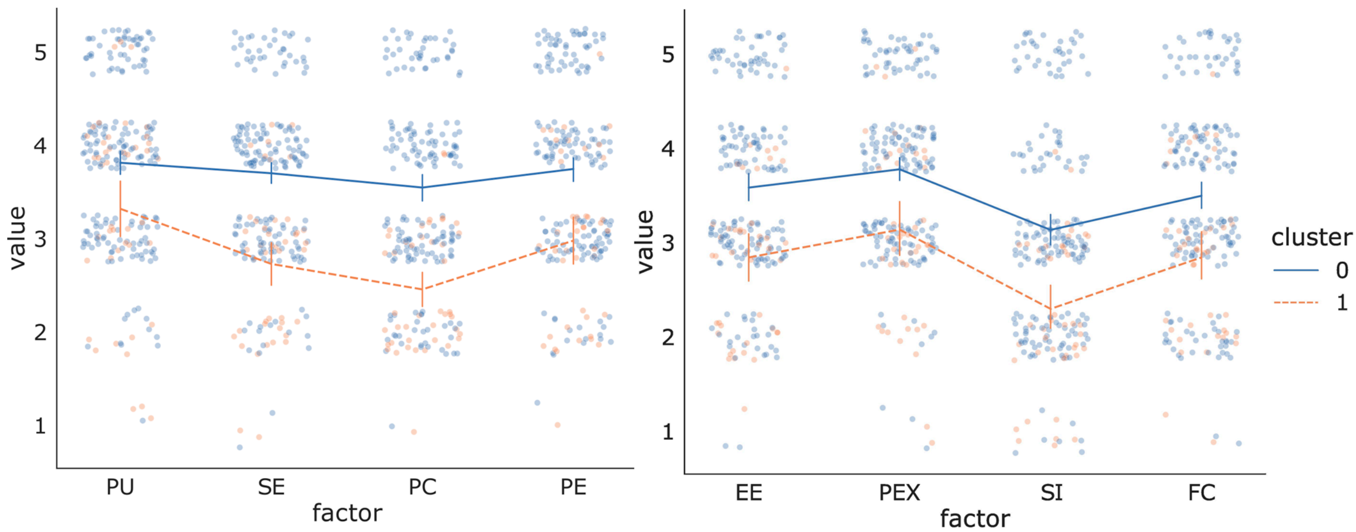

Figure 8. Diagram of averages of responses to UTAUT constructs and external factors.

Figure 9 shows the average response of the two clusters based on the gender of each participant. This figure shows the two identified clusters and allows us to observe the relationship between the male and female participants in each of them.

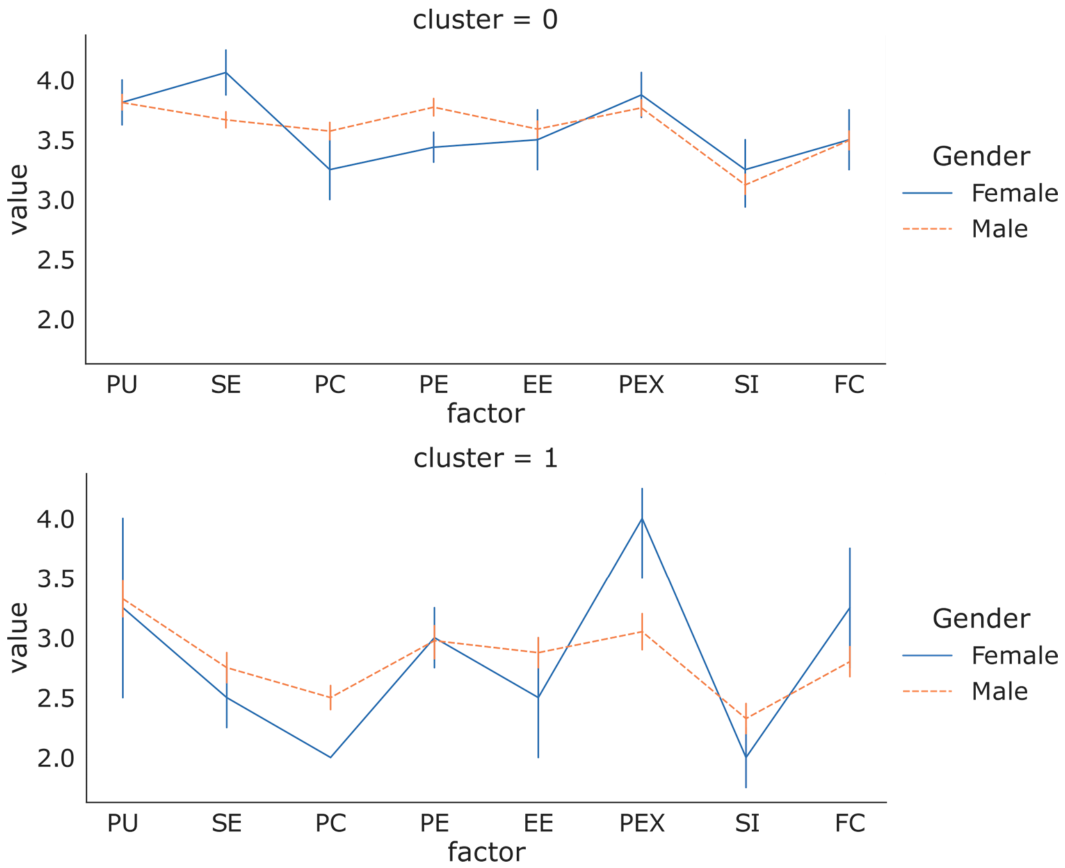

Figure 9. Diagram of responses of the two clusters based on the gender of the participants.

5. Discussion

5.1. Systematic Mapping

This research identified several types of digital technologies that are being used in an emerging manner in higher education today and grouped them into five categories. The SM yielded interesting results, because the use of technology in education is constantly evolving and can have a significant impact on teaching and learning. Furthermore, the mapping was the basis for the participants to learn about these technologies and to conduct the technology acceptance survey on the use of ETs in higher education. The results show that the most currently used technologies are mobile learning, cloud computing, AR, VR, LMS, and gamification. These results contrast with previous research on the use of digital technology as support in education [17,19,20,49,86,87]. These ETs have been studied separately in previous research with favorable results. Therefore, it can be concluded that the systematic mapping used in this research generated new information regarding previous initiatives. This research shows that, apart from the six most used ETs, there are twelve other ETs that are also being used in current education. This information is a valuable contribution and fills a gap in the literature regarding what types of digital technologies are used and can be exploited in favor of educational innovation using digital technologies.

The use of ETs in the educational model responds to a call to innovate learning. Educational models were not designed for the current generation of students, and the use of digital technologies as a support in the educational model promotes relevance to everyday life, as new generations of students grow up in a highly digitized world [88]. Incorporating these technologies in education is significant for their learning experience and preparation for the world of work [50]. In addition, the use of digital technologies can make learning more attractive and fun, and this can increase students' motivation and engagement in the learning process [89]. Moreover, digital technologies allow for the adaptation of educational content according to the individual needs and preferences of learners, as the machine learning algorithms can provide personalized learning paths [90]. The Internet and online education offer access to a vast number of educational resources and experts around the world [91]. This expands learning opportunities and encourages the exploration of diverse topics. Online collaboration tools, such as videoconferencing platforms and learning management systems, facilitate communication and teamwork, which is essential for collaboration in professional environments. Furthermore, by using digital technologies in the classroom, students acquire technological and digital skills that are essential today and in the future job market [50]. These new ways of teaching allow for instant feedback on assignments and exams, which helps students better understand their strengths and weaknesses and improve their performance [92]. Digital technologies can make learning more inclusive by providing accessibility options, such as reading aloud or closed captioning. Many jobs and professions require technology skills [93]. Familiarity with digital technologies in the educational environment prepares students for success in the current and future job market [94].

Digital technologies have become an integral part of the lives of new generations, and their inclusion in the educational model is not only relevant but can also improve the quality and effectiveness of education, preparing students for the challenges and opportunities of the 21st century [95]. However, it is important to implement these technologies in a thoughtful and equitable manner, considering individual needs and equal access.

5.2. UTAUT Acceptance Model

It can be observed, in the results obtained, that in cluster 0, the behavior of men and women is very similar, except regarding Self-Efficacy (SE) and Perceived Entertainment (PE), in which different types of responses are observed. In this cluster, we can distinguish that for women, Self-Efficacy (SE) is more important than for men. On the other hand, Perceived Entertainment (PE) is more important for men than for women. This difference in the behavior of men and women in relation to Self-Efficacy (SE) and Perceived Entertainment (PE), within Cluster 0, sheds light on the importance of gender in the adoption and perception of ETs. This difference can have important implications for how an educational model using ETs is designed and delivered. This means that the use and deployment of digital technologies in education is dynamic, and the practical use is widely varied. That is why, according to the SM, there are currently 18 ETs which can be used in a practical way in education.

The importance of Self-Efficacy (SE) for women compared with men within Group 0 suggests that the ETs used for education should be socialized in a way that gives them the confidence to use them effectively. This could include specific training, intuitive user interfaces, and a focus on accessibility to ensure that women feel competent in using these technologies. For example, consideration could be given to using MOOCs or LMSs to ensure self-efficacy in the group of women in Cluster 0. Alternatively, in this same cluster, men's preference for Perceived Entertainment (PE) suggests that ETs used for education should have features that enhance the entertainment experience. This could include engaging multimedia content, educational gaming applications, or interactive experiences that align with their service preferences and expectations. In this scenario, gamification meets the needs of the men in this grouping.

The observation of gender differences in the importance of Self-Efficacy (SE) and Perceived Entertainment (PE) in Group 0 emphasizes the need for a more nuanced approach in the planning and design of educational models. Thus, personalization, inclusion, and accommodation of gender preferences can contribute to the proper deployment of ETs in classrooms. Furthermore, this serves as a reminder that user preferences and needs are dynamic and must be constantly monitored and understood to keep abreast of emerging trends in the technology market.

In cluster 1, however, Perceived Compatibility (PC) is more important for men than for women. In contrast, Performance Expectancy (PEX) is more important for women than for men. This provides an interesting perspective on how different factors can influence the adoption of ETs in the context of higher education. Despite these differences, the overall trend of acceptance of ETs is similar, suggesting a consensus in the educational community about the usefulness of these technologies. The fact that Perceived Compatibility (PC) is more important to men may indicate that they are more concerned with the ease with which they can incorporate these technologies into their existing educational environment and routine. This could imply that they value technological solutions that integrate seamlessly with their study methods and learning preferences. Conversely, the importance of Performance Expectancy (PEX) for women suggests that they may be more focused on how these technologies can improve their academic performance. This could be related to the perception that ETs can provide them with advantages in terms of understanding and retaining information, which translates into better performance in their studies. Designers and developers of educational technologies must consider these gender differences when creating products and services. This implies the need to design solutions that are both compatible and effective in terms of improving academic performance. In addition, the personalization of learning experiences could be key to addressing these differences and meeting the specific needs of men and women. The observation of differences in the importance of Perceived Compatibility (PC) and Performance Expectancy (PEX) between men and women in Cluster 1 highlights the complexity of attitudes toward ETs in higher education. However, the fact that both clusters follow a general trend of acceptance indicates a fundamental consensus on the usefulness of these technologies in education. Personalization and the promotion of gender equality in educational technology are key elements in making the most of these observations and enhancing the educational experience for all.

Despite these differences in priorities, it is encouraging to note that the overall trend of acceptance of ETs in higher education is similar for men and women in clusters 0 and 1. This indicates that, despite different underlying motivations, both groups recognize the value of ETs in their educational experience.

6. Limitations

6.1. Systematic Mapping

An SM conducted between 2018 and 2022 to obtain information on the use of ETs in education can provide valuable insights into the state of research in this field. However, it may also present some limitations that should be considered. The study period between 2016 and 2022 sets a time limit that may have excluded significant research or developments in ETs that occurred before 2016 or after 2022. This could lead to the loss of relevant information. Since technology changes rapidly, findings and trends identified during that period may have evolved or changed since then. The information obtained may not be completely relevant to the current state of ETs in education. SM relies heavily on available data sources, such as academic databases and research repositories. This could have led to the omission of research published elsewhere or in different formats. ETs can be defined in different ways, and this definition may vary between studies. This may lead to inconsistencies in the identification and classification of technologies in the mapping. The interpretation of the results and the drawing of trends and conclusions may be subjective and depend to a large extent on the selection and evaluation criteria used.

Despite these limitations, an SM provides a useful overview of the existing literature and can help identify areas of research that require further attention.

6.2. UTAUT Acceptance Model

The limitations of this study on the use of ETs in education, considering the external factors mentioned, are important for understanding the validity and applicability of the results. The results of the study may be specific to the context in which it was conducted. Attitudes and behaviors toward technology may vary according to geographic region, culture, educational level, and other contextual factors. In addition, the composition of the sample used in the study may influence the results; if the sample is not representative of the target population, the findings may not be generalizable to a wider audience.

Also, because data collection is based on responses provided by participants, it may be that participants may provide socially desirable responses rather than reveal their true attitudes and behaviors. Although several external factors were analyzed, there may be other factors that were not considered but that also influence the adoption of ETs. The complex interaction of these factors may not have been fully captured. Rapidly evolving technology can quickly make the results obsolete. ETs can change dramatically in a short period of time. It is important to note that, despite the external factors considered, there may be other variables, such as financial constraints, institutional policies, and changes in technological infrastructure, that also influence the adoption of ETs in education.

This research provides valuable information on the adoption of ETs in education and gender differences in the perception of these external factors. However, it is important to consider these limitations when interpreting the results and to recognize that additional research and periodic updates may be necessary to fully understand the changing dynamics in this field.

7. Conclusions

This study generates new research on the emerging technologies that have been used the most in the last 5 years. The results presented in the systematic review can be used by researchers to propose new lines of research in educational innovation using digital technologies. On the other hand, the results on technological acceptance support the use of emerging technologies in current education. It is important to consider the constraints and preferences of users when using a type of digital technology to support the teaching and learning model. This will help with better deployment of this technology in higher education institutions.

Nevertheless, this research provides valuable information for designing strategies for the implementation and development of ETs in education. However, it is essential to recognize gender differences and methodological limitations when interpreting the results. Furthermore, it is important to consider additional research and periodic updates to keep abreast of the changing attitudes and needs of users in education.

To carry out this research, cluster analysis was used to identify patterns of similar responses among participants, and differences were found in the gender distribution among the defined clusters. Moreover, we found participants' perceptions about external factors and constructs of the UTAUT model used, which affect the intention to use ETs in education.

The results of the analysis may be specific to a particular context, such as an educational institution or a geographic region. To extrapolate to other settings, collaborative work needs to be carried out with organizations in several countries with different sociodemographic data and compared with the results obtained.

It is recommended that future researchers conduct longitudinal research, following up over time to understand how attitudes and behaviors towards ETs in education are changing. This would allow us to better capture trends over time and assess the impact of technological evolutions. In addition, other external factors that could influence the adoption of ETs, such as technological infrastructure, data security, institutional policies, and financial constraints, should be included. It is important to conduct research including multiple geographic regions and cultural contexts to identify differences and similarities in the adoption of ETs.

A recommended topic is to conduct a field study in an educational institution to understand and evaluate how ETs are implemented and used in the classroom and how these implementations affect the experience of students and teachers. On the other hand, it is recommended that research be conducted to evaluate the real impact of ETs on student learning and academic performance, as well as on the efficiency and quality of teaching. Based on the findings, it is recommended to propose educational policies and institutional practices that promote the integration and effective deployment of ETs in higher education.

It is also important to foster collaboration among experts in technology, education, psychology, and other disciplines for a more complete understanding of the factors that influence the adoption of ETs in education.

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Informed Consent Statement: Informed consent was obtained from all students who participated inthis research work.

Data Availability Statement: The data is hosted in the OneDrive cloud in a folder shared to the general public. The link is as follow: https://udlaec-my.sharepoint.com/:f:/g/personal/luis_criollo_udla_edu_ec/EpvSKqowizlDsT2-xsMtzXcBdYuntGFwyNyBikgHBrpVQg?e=Qc1hXX (accessed on 27 September 2023).

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