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A review of the Development Trend of Personalized learning Technologies and its Applications

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ABSTRACT

Personalized learning tailors material and strategy to student requirements, interests, and goals in e-learning. These developments help educational institutions and other organizations to keep up with the fast pace of information technology, communications, and computing power. Studies show that self-adaptive learning and relevant learning information improve study efficiency. Compared to traditional teaching methods, the practice of online education is well in its infancy. On the other hand, the pedagogy and evaluation of students in online courses have a large gap that has to be filled, necessitating significant improvements in e-learning. We call this approach to education "personalized learning," which is a central focus of today's leading online education platforms. Several studies have been conducted on e-learning and personalized learning, but few investigated the development trend of personalized learning technologies and applications. Therefore this study examines the literature to close the gap and promote the development trend for personalized learning technologies and applications in higher education from 2010 to 2021 by analyzing related journal articles. The pivotal studies used inclusion criteria after a search generated 372 complete research articles and reduced them to 146 publications based on their proposed learning domains and research themes. Through carefully reviewing current trends and successes in numerous aspects of personalized learning, this discussion analyzes prospective future research directions in the field of personalized learning.

Keywords: Personalized Learning, Constructivism, E-learning, Adaptive Learning, Customized Learning, Personalization.

1. INTRODUCTION

Information and communication technologies (ICT) and the internet are changing, and so are how people use learning systems [1]. The educational business process has developed from conventional learning to e-learning, with its benefits and drawbacks, and then to personalized learning (PL). Due to these innovations, educational institutions and other organizations can better keep up with the ever-increasing speed of information technology, communications, and computing power [2]. However, studies demonstrate that adopting a self-adaptive learning technique and offering relevant learning information increases study efficiency [3]. As a result, institutions appear to be transitioning from chalk-and-talk to e-learning methods to enhance student learning [4]. With e-learning adoption, personalized learning refers to content and strategy; the process customizes learning techniques to student characteristics to fulfill the learner's needs, interests, and objectives [5-7].

2. LITERATURE SURVEY

2.1 E-Learning

The idea of e-learning has changed a lot in the last few decades. Web 1.0 was called the "web of knowledge," Web 2.0 was the "web of communication," Web 3.0 was the "web of interaction," and now Web 4.0 is the "web of integration" [8]. Chookaew et al.

[9] developed an e-learning environment for undergraduate students based on computer programming fundamentals to enhance or replace the traditional learning environment. These studies aim to help students acquire an ideal learning method or material for their learning status [9]. While the widespread use of e-learning technologies at universities has facilitated the spread of e-learning in university institutions, the cost of obtaining and reducing the risk of obsolescence is relatively high for technology adoption and use [10].

Moreover, suppose higher education institutions want to increase enrollment and retain students [11]; they must make their programs more accessible, inexpensive, and individualized to prepare graduate students for 21st-century jobs and try to gain a competitive edge [12, 13]. E-learning adoption assists older students with physical restrictions and adult responsibilities by enabling self-paced study and individualized learning [14]. Timelines, objectives, and progress monitoring make e-learning efficient and provide students with individualized university e-learning sessions. Traditional teaching methods are still in their elderliness compared to online education, which is in its infancy [15]. In contrast, a significant gap in the pedagogy and assessment of group work in online courses requires substantial improvement in e-learning teaching and learning [16]. Hence, modern online learning platforms actively work to design tailored lessons that cater to individual students' needs, interests, and abilities; we speak about personalized learning [17].

2.2 Personalized Learning

Personalized learning (PL) means tailoring instruction to students' strengths, shortcomings, and areas of interest [18]. Students participate in tailored sessions and choose their preferred learning style. However, learners can use a variety of approaches to demonstrate their competence and participate actively in a student-centered classroom, where the teacher provides guidance and tools for students to succeed [19, 20]. Personalization can be a philosophy, a way of teaching, or a well-planned program in higher education, used for both online and hybrid learning [21]. Further research recommended that learning theories can guide the design and execution of PL and identify critical, recurrent challenges, which will help us determine how PL can improve student learning [20, 22]. Many modern learning management systems (LMS) provide automated features, including grading and feedback for instructors and plagiarism detection, to ease the load on instructors. Integrated artificial intelligence (AI) tools help teachers track student development and offer proactive guidance and coaching [23].

Gallagher [24] defined personalized learning as learning tailored to the needs of the individual. While the instructor studies the student's learning preferences, including the topic and various learning approaches or study methods, the student must make their own decision. Personalized learning emphasizes individualized educational aid centered on the student [25]. Questions concerning the usage and technology development impact of technology developed necessitate the development of new teaching and learning standards [26]. Academic achievement depends on learning strategies and mental activities such as planning and coding [27, 28].

According to recent studies, e-learning systems create collaborative study tools for discussion forums and direct contact. According to studies, the most efficient learning approach is to draw on the student's inner self [25, 29]. Teachers who adapt to new teaching methods and customize information to students' needs increase student learning performance [30]. The survey conducted by Tang & Wang [31] has shown that search-recommendation algorithms cannot make personalized educational recommendations because of their typical features. Mousavinasab et al. [32] work on suggesting information utilizing algorithms like collaborative filtering and content-based recommendation. As a result, higher education increasingly uses Artificial Intelligence (AI) to develop tailored learning experiences [32].

2.3 Intelligent Tutoring Systems techniques on personalized learning

Recent studies suggest that Intelligent Tutoring Systems (ITS) can efficiently solve issues and satisfy learning objectives using AI [30, 33, 34]. ITS seems to enhance personalized learning, student performance, and time management. Akyuz [35] focuses on developing individualized learning tools and applications using a sophisticated, intelligent tutoring system that tailors each student's knowledge to their present level of comprehension. Intelligent Tutoring Systems use complicated algorithms to tailor their teaching methods to the strengths and limitations of each student. Individualized education is more effective than traditional group education approaches [36, 37].

Personalized learning systems change course contents based on students' knowledge of a particular subject. The objective is that the AI technologies utilized by ITSs will facilitate training through machine learning and personalized instruction [38]. Machine learning depends on techniques that allow a computer system to learn from training data and make choices or forecasts automatically. People assert that personalized learning makes learning more efficient and relevant to a student's needs when individual feedback and assessment tailor the curriculum [37]. Though intelligent systems are self-aware and capable of complex interactions, such as those enabled by the Deep, Wide, and Adaptive Learning Principles in Education [39], these characteristics alone do not qualify them as intelligent [40].

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Malpani et al. [41] conducted a study that used an adaptive student model that assesses individuals' learning patterns using Reinforcement Learning. The study compares the effectiveness of our teaching system with non-intelligent tutoring systems using coarsely labeled data [41]. Due to the lack of labeled data, ITS's personalized learning has helped enhance the teaching process and has proven beneficial in education. In this regard, several achievements have been made, particularly in detecting some traditional teaching techniques [30]. Finding specific data in data pools is becoming more difficult as students use more internet resources. Adaptive learning and recommendation systems help personalize the designs [42]. Adaptive learning uses computers to personalize learning materials and activities for each student. In comparison, Intelligent tutoring systems use a data-driven strategy to instruct the learner. Thus, customized learning maximizes students' potential and success [43].

Several studies have shown that e-learning does not meet the needs of all learners; therefore, personalization of learning is crucial [44]. Mansur et al. [25] customized online learning platforms, including personalized learning materials and unique graphical user interfaces that tend to center on creating resources for group work, such as discussion forums and instant messengers. However, we discovered significant individual variances in learning speed and style; therefore, the challenge of enhancing personal accomplishments persists [2, 45].

Jando et al. [2] evaluate the individual components of the learners; developing a personalized learning environment necessitates an e-learning method that encourages the technological and human development of analytical abilities and e-comprehension. Electronic learning technology goes from a system to a customized approach in which learning processes tailor to individual students' capacities [46, 47]. According to Vesin et al. [48], an adaptive learning system analyses the demands of each student and personalizes instruction and learning. Students can learn with an adaptive learning system as if they had their tutor instead of "sitting through a mass lecture" [48]. Various studies have researched personalized learning, but few have examined personalized learning technologies in higher education; hence, this paper conducts studies on personalized learning technology and applications.

2.4 Personalized adaptive learning systems environment

Researchers have considered various factors of an individual's characteristics when designing adaptive learning systems [49]. The proposed research gives valuable insights for developing practical aspects for personalized learning environments: layout presentation, customized learning materials, learning styles, and preferences [50]. According to a recent survey on adaptive, personalized learning systems, PL models present layouts and study materials with the following four essential components: students profiles that map out each student's unique set of skills, interests, and aspirations; individualized learning plans that are adapted to each student's unique trajectory; a focus on mastering customized subjects and assessment for skills growth; adaptable learning environments which is accessible anywhere and anytime, which also consider individualized learning styles and preferences [51]. The PL systems make it easier to deliver teaching and learning subject matter based on the needs of the learners. In contrast, Intelligent tutoring and Adaptive Hypermedia build adaptive, personalized e-learning solutions to provide individualized material tailored to specific learning preferences and student attributes [9].

The study by Kannan et al. [52] focused on AI in language acquisition dating back to the 1980s and their promise of personalized education. They were seen as "systems that 'care' about learners" because they tried to meet their needs. The teaching option provided unlimited repetitions and practices due to the restricted pedagogical design of ITS applications. A review of 39 studies covering 22 different ITSs in higher education found that these technologies only had a moderately beneficial effect on students' academic performance. After nearly 40 years, modern AI revives the individualized learning field's promise[52, 53].

Vesin et al.'s [48] study show that the Programming Tutoring System (ProTuS) delivers intelligent and interactive material, customization choices, adaptive features, and learning analytics to help users acquire challenging cognitive abilities. The study describes the interactive learning analytics component built-in ProTuS and the findings of adaptive learning systems beneficial for tracking students' progress, encouraging reflective behaviours, and getting feedback to understand their actions and learning techniques better. However, individuals are the topic of learning in personalized learning environments, encompassing many areas. In addition to knowledge management and expert systems, researchers have suggested a system using data mining and ontology [2]. Recent research in Intelligent Tutoring Systems (ITS) is essential in Virtual Learning Environments (VLEs) analysis to deliver personalized learning content, training, and immediate contact to individual learners [54].

Su et al. [55] outlined a Personalized Learning Content Adaptation Mechanism (PLCAM) that employs data mining approaches to manage numerous past learners' requests efficiently. Through the proposed adoption decision and content synthesis procedures, the proposed method would intelligently and immediately offer appropriately tailored learning content with a higher degree of fidelity from a Sharable Content Object Reference Model (SCORM)-compliant Learning Object Repository (LOR) [56]. Madadipouya & Chelliah [57] introduced the adoption of recommender systems that prompted specialists to explore their application in an e-Learning system to provide an automated approach to assist learners in locating appropriate resources instead

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of depending on peers, tutors, and other resources. The benefit of the adopted system may change its material for the learner's specific requirements and adjust the environment accordingly [56, 58].

Several studies on personalized learning technologies and applications required a complete evaluation to determine changes, tendencies, difficulties, and potential research directions. Mobile learning, for example, has recently been focused on learning technologies [59, 60], language learning [61-63], and health profession education [64, 65] rather than on other topics[65]. An essential aspect of learner-centered research is the first exhaustive and comprehensive evaluation of research on technology-supported personalized learning, comprehending how ICTs and AI are linked to support customized learning [19, 66]. Xie et al. [67] reviewed the literature from 2007 to 2017 on the global developments in technologically enhanced personalized learning. They reported that wearables, smartphones, and tablets get less attention than desktop and laptop PCs [67, 68]. According to Zhang et al. [18], customized learning improves academic outcomes, engagement, learning attitudes, and meta-cognitive abilities, mainly when supported by technology. To enable Personalized Learning, technology-enhanced Adaptive Learning, and personalized learning recommendation systems, researchers are developing Personalized Learning Algorithms [69, 70]. However, in education, personalization is still a new research area; few studies have studied personalizing learning technologies and applications in higher education.

3. RESEARCH OBJECTIVE

According to current studies, more research is needed on personalized learning technologies and applications, even though numerous researchers have written on customized learning algorithms, personalized learning, and adaptive learning [71]. Therefore, this study aims to conduct a systematic literature review from 2010 to 2021 on the development trend of personalized learning technologies and applications in higher education. These findings are essential because they help connect prior research on personalized learning with future technical advances, such as new customized learning models and techniques.

3.1 Research Questions

The following research questions served as a guide for the review:

1. What are the current research publications trends in personalized learning? (Journals and years of publication, and articles published)
2. What are the criteria for adopting personalized learning technologies?
3. How do the adopted Personalized Learning Technologies improve the student's outcomes in higher education?

This article intends to assess personalized learning technologies and application research for the work published from 2010 to 2021. The study relied on high-quality data sources [67, 72] and searched six reliable databases: IEEE Xplore, Google Scholar, Science Direct, Springer Link, ACM digital library, and Web of Science. Only works published and written in English were considered for inclusion in the review. Other review studies recommended the article publication style to ensure enough data to analyze research trends [67, 73]. In addition, we used search terms including personalization, personalized learning technology, personalized adaptive learning, personalized learning systems, intelligent tutor personalized learning, and personalized learning technologies to locate papers that were relevant to the research.

Figure 1 shows the study's selection procedure. A total of 372 studies were identified using the keyword string. However, 77 studies were eliminated as duplicates using the EndNote library. The remaining 295 studies met the inclusion and exclusion criteria. This criterion removed 25 irrelevant articles, leaving 270 articles related to personalized learning. We also examined the 270 articles for duplicates, eliminating 124 more. The total dataset consisted of 146 papers. Figure 1 depicts the whole data gathering and processing methods.

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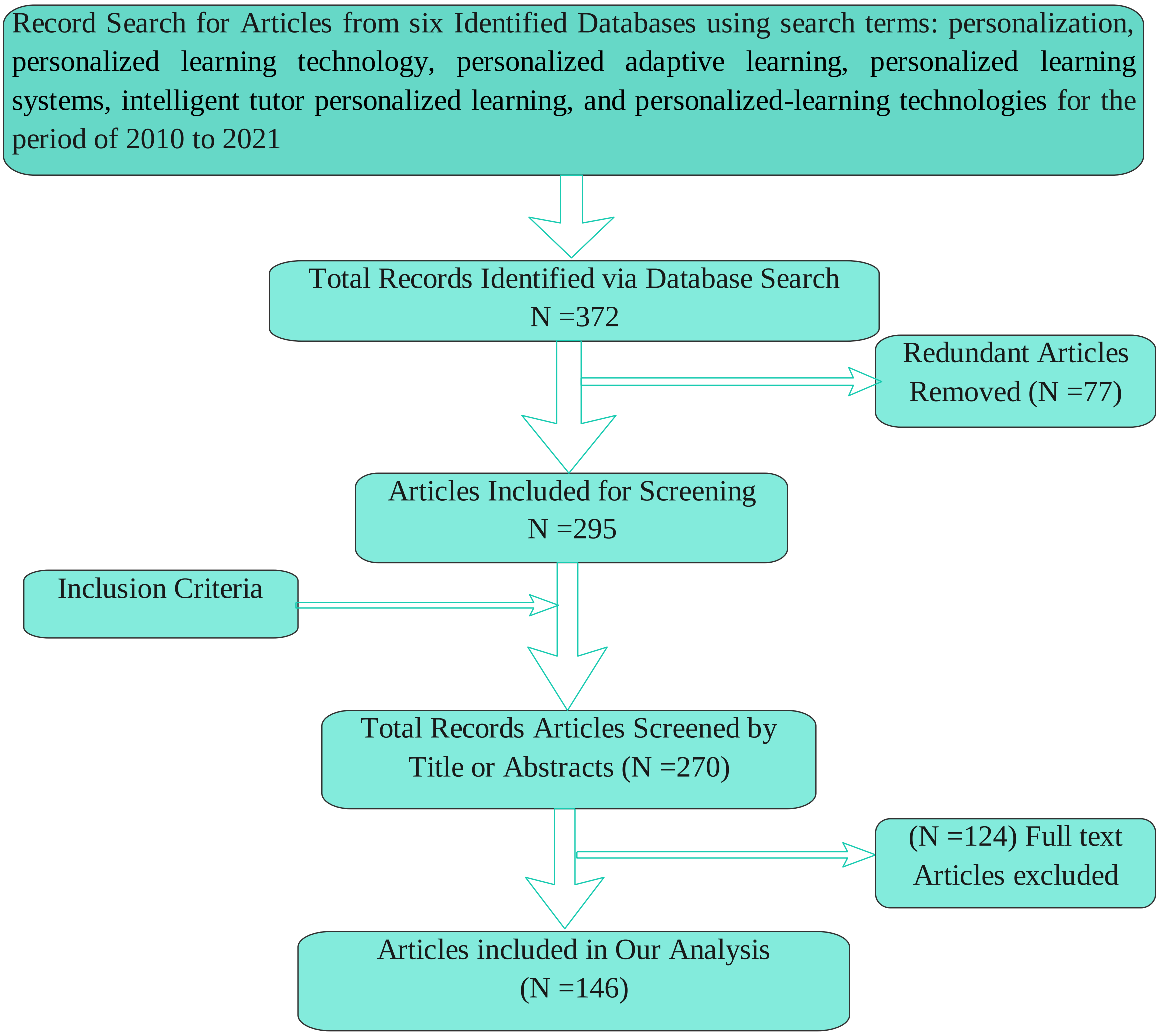

Figure 1. The collecting and processing of data

Research-selected articles were coded and categorized according to their distinctive learning characteristics, and the researchers concluded that uncertain conditions were the best option. This study used all empirical research articles published to investigate trends in personalized learning technologies and applications. Although many publications cover more than one research topic or sample group, the coding categories make analysis easier [74, 75].

3.2 Coding Scheme Theoretical framework

This study proposes a theoretical framework based on a definition of constructivism in the philosophy of education. In a sense, this framework supports the suggested coding system [67]. This kind of constructivism claims humans learn about the world by experiencing and commenting on it [76]. When we acquire anything new, we must reconcile it with our prior knowledge and experience, altering our beliefs or dismissing it as unimportant [77]. Constructivism and technology combine their strengths to create an effective learning platform. However, constructionist learning views instruction as a process that promotes construction rather than communication. Educators may use constructivism to personalize student learning while improving cognitive and metacognitive abilities [78, 79]. The study conducted by Tsai et al. [80] defined constructivism as forming internal models through learners' interactions with their external environment. From experience, Tsai et al.[80] outlined the primary interaction mechanisms of
assimilation and accommodation. We assimilate new knowledge while accommodating further information and experiences from the external environment [81, 82].

In other words, constructivism emphasizes learning as a dynamic and personalized process with three fundamental elements for teaching: adaptation, process, and content, as represented in Figure 2. On the other hand, students must be prepared to learn since the contents indicate the learner's materials are absorbed and given in the most effective sequences. Fu & Hwang [60] conveyed three notions as essential aspects: (i) academic support, (ii) learning characteristics, and (iii) learning assessment, all of which address the question of how tailored learning is used in e-learning systems. The learning platform allows learners to publish and share material and track their choices and actions. Two factors led to the selection of constructivism as the guiding theory for this

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review: (1) it addresses how students (participants) learn, and (2) it is now the most popular educational theory [83, 84]. When it comes to online education and teaching, connectivism is a new online education and teaching approach with contrasting constructivist ideas [85]. The method extends Vygotsky's philosophy to internet communities and uses these theories in constructivist initiatives and e-learning [84, 86, 87], developing a personalized learning environment [2].

As shown in Figure 2, academic support (Technical-Support) is a system-level function that focuses on instructional personalization. Personalized learning systems link the coding schema and essential components in applying constructivism as a theoretical foundation for individualized learning technologies [88]. Constructivism asserts that people need to know things to make sense of their experiences [89-91]. Constructivism doesn't use learning and performance goals only about one subject. As a result, they investigate actual actions and allow the learner's personal goals to be developed and achieved. Then both constructivism and technology make learning environments better [92]. Several studies argue that teaching is a process that helps people build rather than communicate. In contrast, constructivism allows teachers to change how students learn to fit their needs [81, 93, 94], as seen in Figure 2 below.

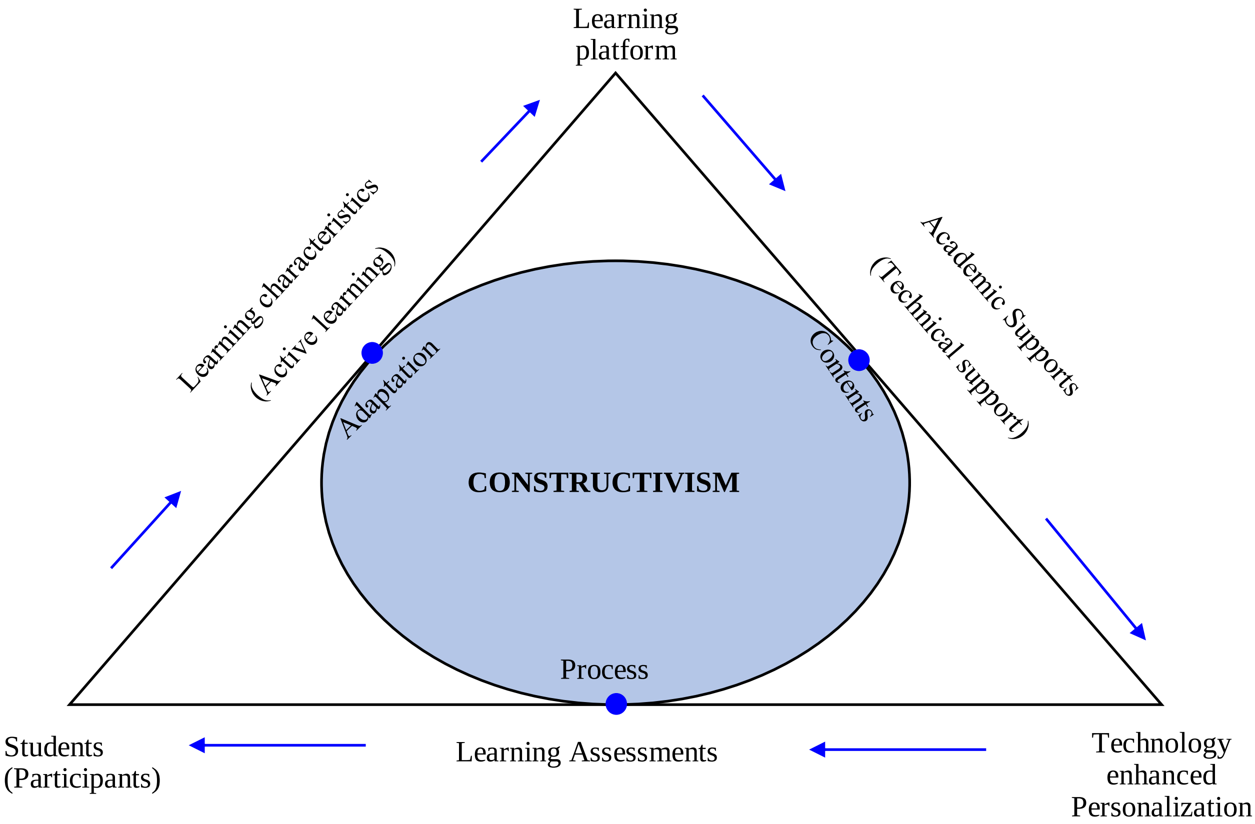

Figure 2. The Constructivism Coding Scheme Theoretical framework [67].

3.3 Coding Scheme

The study was categorized according to a coding system to examine and assess the growth and trends of personalized learning technologies and applications. This coding approach is grouped into five categories, each coded separately for each participant. The following are the coded groups:

- the number of papers published and the year of publication,
- students/participants,
- learning contents,
- technology-enhanced personalized learning,
- academic support/device used to access learning systems.

4. RESULTS ANALYSIS

This section analyzes the survey's results, presented following the parts offered during the study to undertake successful exploratory data analysis using the survey data.

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4.1 The number of papers published and the year of publication.

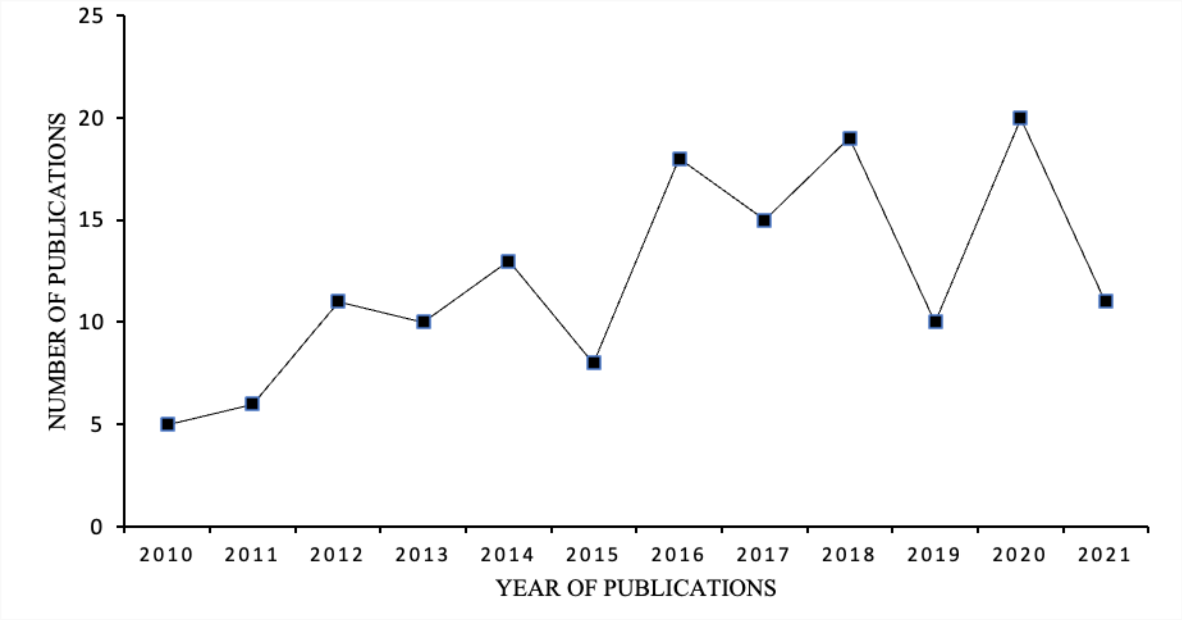

Figure 3. Year and number of publications of papers on personalized learning from 2010 to 2021.

Figure 3 represents the number of articles linked to personalized learning technologies and applications published between 2010 to 2021. Overall, publications have increased rapidly from 2010 to 2012. The reviewed papers dropped by 52% in 2015 and 62% in 2019, respectively, before recovering by 44% in 2016 and 50% in 2020. The most significant number of articles evaluated occurred in 2012, with a 21% rise in total articles reviewed. Personalized learning is becoming an increasingly popular topic of study and application. It's vital to do an in-depth analysis of the customized learning technology to identify trends, problems, and future research paths in light of the many publications and influential studies published.

4.2 The students'/participants' representation in implementing personalized learning technology.

We divided learners into groups based on their educational levels: elementary/primary school students, students in secondary (high) school, university education, teachers, elders, and vocational training students.

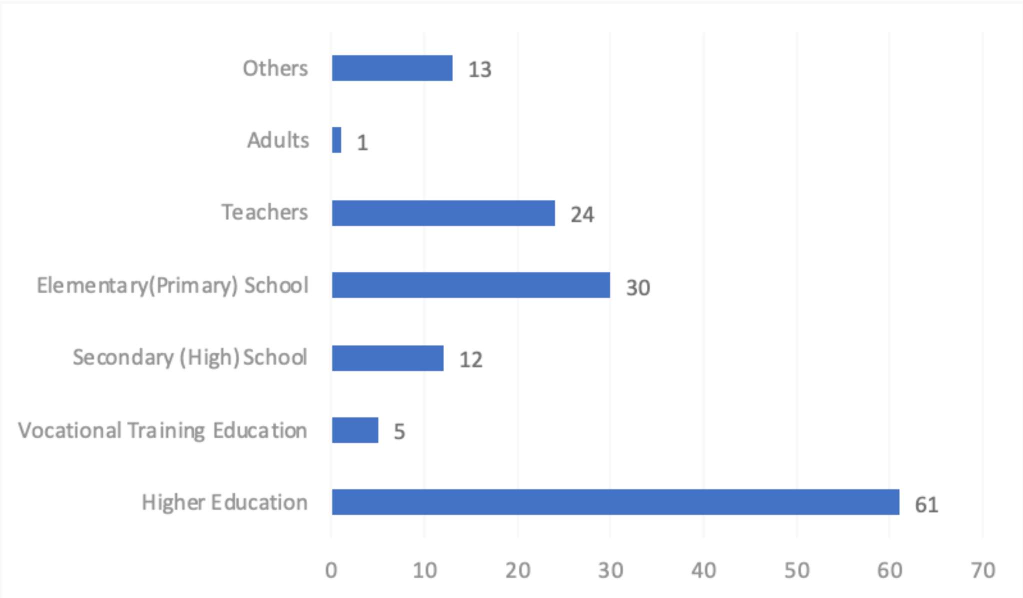

Figure 4. The number of students distributed using personalized learning technologies between the year 2010 to 2021

The rationale for distinguishing between teachers and non-teaching individuals is that the field of education and adult learning are two separate fields of study [95]. As demonstrated in Fig. 4, these studies commonly included students from higher education

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institutions as study participants; roughly 42% (61 out of 146) of the studies enrolled students from higher education institutions. The research also included elementary (primary) school students at 21% (30 out of 146), followed by teachers at 16% (24 out of 146). Regarding digital media, the younger generation is more prone to have different expectations and behaviors than their elders. For educators and academics, the question of whether ICT can produce meaningful, engaging, and individualized learning experiences for this generation of digital natives has become a significant concern [96]. The study found that, aside from the typical suspects, just 0.7% (1 out of 146) of non-teaching individuals participated. A notable 16% of all selected studies focused on teachers, proving that instructors are keen to distribute or incorporate individualized learning technology and applications into their academic tasks. Customized learning technology is now available in elementary schools and teacher training programs. Several personalized learning systems aimed to help students with exceptional needs, such as kids with disabilities. They ensured tailored learning was conducted in various school environments [96, 97].

4.3 Distribution of the learning content in personalized learning technologies research studies.

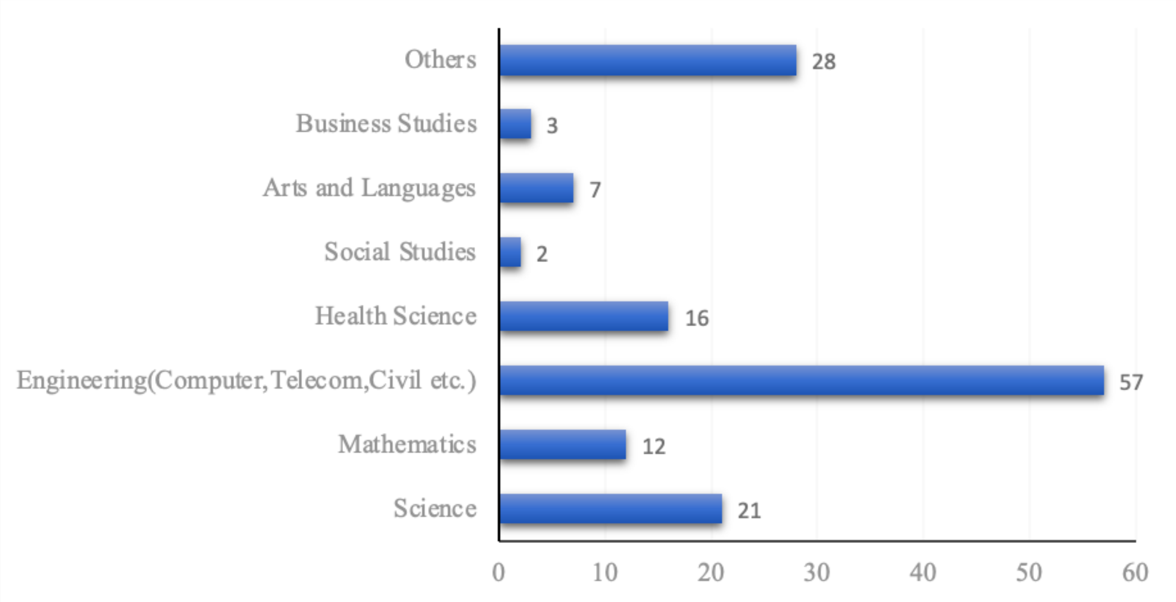

Figure 5. Representation of learning contents in personalized learning technology research studies.

The subject of engineering is the most popular learning content, with 57 studies (Fig. 5). Other learning content included 28 studies. Other is not a single subject since it contains different themes or a different topic unrelated to a particular subject. According to Chen & Wang [75], personalization is the foundation for identifying learner requirements and providing exact solutions that meet those needs. As a result, personalization is "a component of quality education," while quality education is "the main goal." In their investigations, researchers considered mathematics, health, social studies, art and language studies, engineering, and business studies to be learning subjects. Some major categories include attachment, cognition, abilities, behavior, and correlations [98]. The most prevalent personalized learning outcomes are affection, intellect, and cognition [67, 99]. Thus, the technology assists teachers in developing personal learning plans (PLPs) based on student data, proposed projects or educational resources, timetables, and team members. A Personalized Learning Plan considers an individual's unique features, preferences, and academic competence. Creating PLPs enables learning to be relevant, entertaining, and effective for the students, hence increasing the effectiveness and engagement of the learning process. Teachers can share project materials and information. Students can research, perform their assignments, study via computer-based training, and collaborate on projects. Teachers can assess student progress by administering examinations/tests on various topics, providing feedback, and certifying their achievements [100].

4.4 Technology-enhanced Personalized Learning

Fig. 6 shows the distribution of technologies that promote personalized learning types provided by various systems to assist learning. The most frequently adopted personalized learning system for academic support is personalized learning recommendation systems, used in 33 of the 146 studies. The second most commonly adopted personalized learning system for educational support is personalized mobile learning systems, the frequency of which was 30 out of 146.

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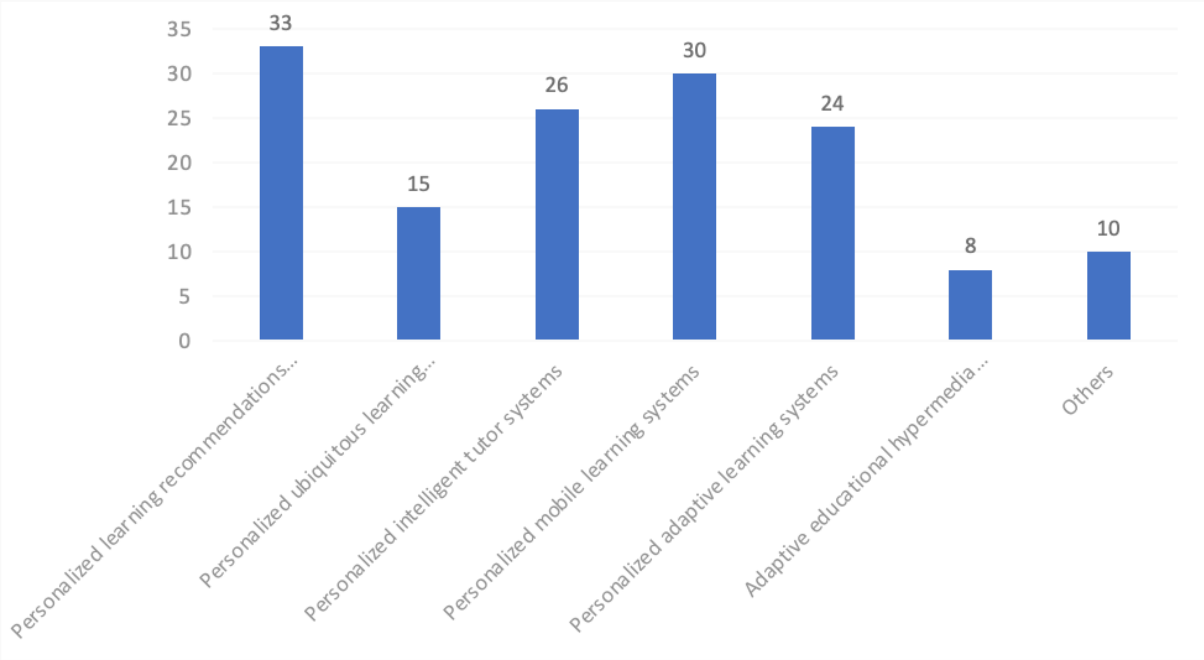

Figure 6. **The distribution of the Technologies enhanced Personalized Learning in the research studies.**

Another five types of technological systems which enhance personalized learning are as follows: personalized intelligent tutor systems - the frequency of which was 26 out of 146; personalized adaptive learning systems - the frequency of which was 24 out of 146; personalized ubiquitous learning intelligent systems -the frequency of which was 15 out of 146, others with the frequency of 10 out of 146, and adaptive educational hypermedia systems (AEHS) -the frequency of which was 8 out of 146. Additionally, all designs are capable of offering personalized feedback and self-evaluation. Similarly, the personal learning profile (PLP) was found to have a significant correlation with satisfaction. Artificial intelligence algorithms integrated with the system can assess a learner's profile and offer more relevant modules, increasing perceived efficacy and satisfaction with the learning [101]. The previous finding is consistent with results showing that AI-powered assessment focuses on more personalized learning and enables us to track the learner's steady improvements, log files, and click-stream analysis, which measure learner success. AI can develop its intelligence system to recommend the courses and approaches most beneficial to a specific learner as intelligent tutoring systems [102].

4.5 Academic Supports/devices used to access learning systems

Figure 7 shows the distribution of devices used to support students'/participants' access to systems containing learning materials. Such devices included smartphones and cell phones that run on intelligent operating systems such as Android, iOS, or Microsoft Windows mobile. Tablet computers, such as Android pads and iPads, are a type of computer. Personal computers, laptops, notebook PCs, smart wearable devices, and personal digital assistants are considered traditional computers/devices (PDAs). The term "Others" denotes that the studies did not focus on specific device categories only. Some studies did not count the hardware/device information in their analysis. According to researchers, most studies used regular computers or gadgets to run their customized learning systems [103, 104].

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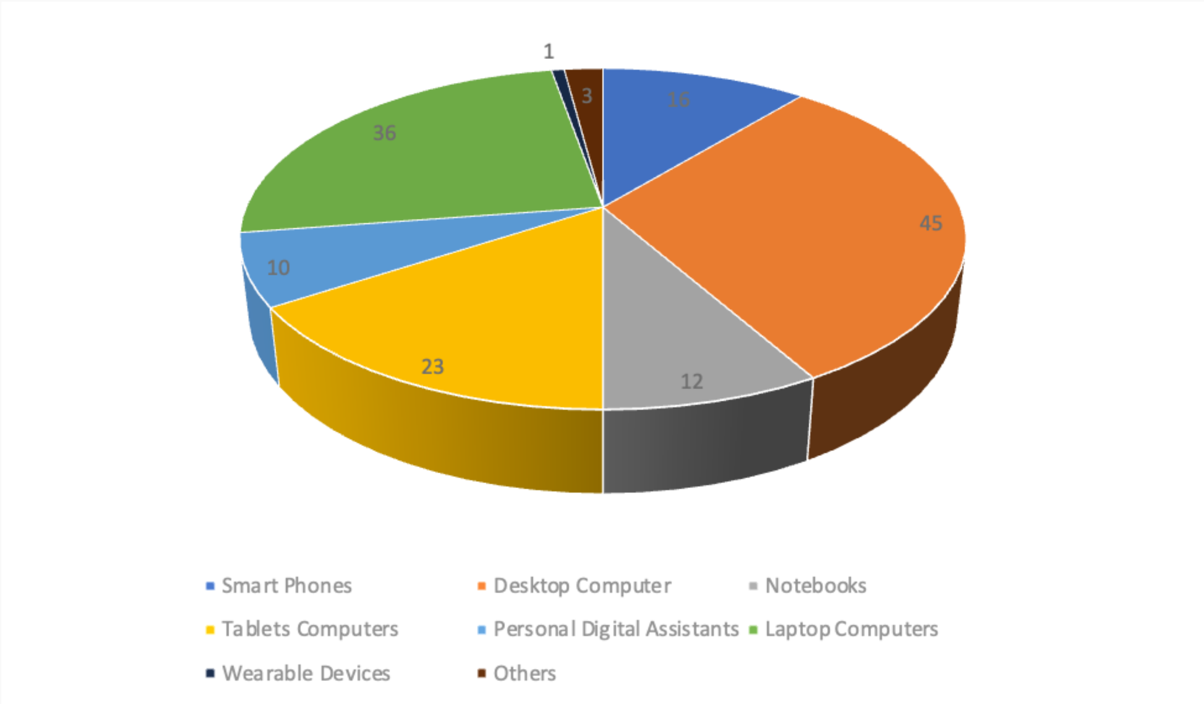

Figure 7. Distribution of academic supports/ devices using Personalized Learning technologies.

Figure 7. above, showed about 31% (represented 45 out of 146) of the studies reviewed adopted desktop computers for running their personalized learning systems to access the materials, followed by 24% (36 out of 146) represented laptop computers, and 16% (23 out of 146) used tablet computers. Our study captured more information by investigating studies representing students accessing the systems using mobile devices such as smartphones at 11% and notebook users at 8%. By "others," the students used devices other than the mentioned above and were about 2% of the study sample. Those who utilized wearable smart devices were about 1%.

5. DISCUSSION OF FINDINGS

The most recent learning technologies and data science provide personalized recommendations to everyone, regardless of computer capabilities [105, 106]. It also assists students in achieving their educational objectives by adapting their learning environment to their unique requirements. However, the student's profile matches everything related to the student's interests [67]. The purpose of the literature review was to demonstrate the growing value of the personalized learning sector. Figure 3 from the literature review shows a 50% rise in publications on personalized learning from studies conducted from 2019 to 2021. Dhawan [107] and Maphosa [108] conducted studies that show the increase in the utilization of e-learning platforms during the outbreak of the Covid-19 pandemic, whereby people were rocked down, worked, and learned from their home places. Personalized e-learning technology seems to effectively improve the current method for online learning because of the rapid development in student use of digital technology and social media, especially among the young generation [67]. In addition to resources, findings indicate that instructor preparation, confidence, student accessibility, and motivation play critical roles in ICT-integrated learning. Research suggests that teachers should embrace technology and electronic devices to boost understanding, particularly in these unusual times [109].

Students' participation in the learning process has grown dramatically in self-directed personalized learning settings. In a more recent study, Balakrishnan & C. Long [110] discovered that 97% of students accessed the personalized learning platform, exchanged learning materials and submitted assignments tasks. This result is much higher than previous studies, showing around 45% of learners accessed e-learning systems for all three activities [111]. However, students can utilize personalized learning approaches to study new knowledge online; e-learning tools and activities, mainly social media, can be modified to meet individual needs [112]. It appears that students from higher education institutions were commonly included as study participants and most likely to use personalized learning technologies, as seen in Figure 4. Approximately 61 of the 146 analyzed students came from higher education institutions, equivalent to 42 percent of the total. Most university students are young individuals who know how to use ICT devices and are active on social media, a reason why their number has increased in the reviewed studies. Our analysis also presents the results for elementary schools and educators, and ICT facilities benefit their daily academic activities. Several studies show personalized learning tailors education for individuals with disabilities and slow learners in elementary and secondary school [96, 113].

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Furthermore, personalized learning is the premise that individuals learn via experience and knowledge. It is affected by a learner's experience through communication and personal contact. Personalized learning comprises good teaching, interactive learning, personalization, timely assistance, virtual connections, and capabilities [114]. Personalized learning resource recommendations are tricky because too many student resources lack enough organized data, which challenges the ability to identify and understand a student's needs [115]. However, knowing how to personalize and apply pedagogical practices is challenging [116-118]. Personalized learning approaches tailor learning pace, instructional strategies, content, and activities to the individual learner's strengths, limits, and interests. Personalized learning empowers students by giving them control throughout their learning, personalizing it, and providing real-time feedback [119]. Shute & Towle [120] argue that adaptive e-learning services and study materials promote individual learning in higher education.

A study found that a typical engineering college teaches the same technical skill to 30–60 students using a similar engineering approach. AI and machine learning (ML) help students identify learning gaps [23, 121] by using learner profiles and goals to define each student's route. Methodologies generally match learning theories, even if research is conducted without theoretical conceptualization. Our findings show that having explicit knowledge of change can help achieve the goals of personalized learning activities [99]. Since students are in control of their learning, teachers are not required to spend as much time with them as in a big class. Many different teaching approaches allow students to study at their own pace and on their learning path. These include individual and small groups having time with teachers, group projects, and instructional software. According to preliminary findings, tailored learning suits students [122]. Figure 5 shows that 39% of studies were engineering courses using personalized learning systems in learning and teaching, followed by subjects such as science, health science, mathematics, and others [123]. Social studies, art, languages, and business studies are rarely chosen in these subjects. However, if their credentials are not in these rarely chosen subjects, they are much less likely to possess professional competence. It is challenging to give tailored learning in these categories without domain expertise. In many sectors, personalized learning is essential, and one alternative is to personalize existing learning systems in these fields. According to previous studies, a mobile interactive approach facilitates problem-based and adaptive learning [124]. Learning is a critical cognitive process in the development of human intelligence. The more learners are aware of their mental strategies and learning content, the more control they have over matters such as aims, attitudes, and interests, and the more their minds are prepared for learning. These processes of understanding and assessment are called metacognitive knowledge [125].

In figure 6, the distributions of the systems that enhanced personalized learning showed that personalized recommendation systems were the leading ones appearing in 33 studies. The results explain that adopting the recommendation systems enhances the personalized learning approach. Furthermore, customized learning recommender systems have drawn the interest of researchers. Recommender systems are algorithms integrated with artificial intelligence and strategies that recommend courses or services to learners based on their interests, as determined by their profiles and histories. The recommender systems assist LMS and MOOC providers to flourish, and learners find more personalized offerings that fit their personalities and interests [126]. However, the analysis presented personalized mobile learning systems with 30 studies which are 21% of the selected sample of this research. Mobile learning systems attempt to support and improve learning practices that take advantage of the unique contexts of individual learners, enabling them to learn from anywhere and at any time using mobile devices [127, 128]. Due to the educational paradigm shift from conventional learning approaches to personalized learning enabled by technology promises to enhance traditional e-learning, mobile technologies emerged to support pedagogical practices that use students' unique environments. Due to this, there has been a push for adaptive and personalized mobile learning systems, which attempt to give students learning experiences via mobile devices customized to their specific educational goals, personality traits, and life situations. [128]. Since the conventional e-Learning systems have a significant flaw: they don't allow students to be given individualized attention [44]. Therefore, the study suggested and implemented a personalized learning system based on intelligent agents to suit customized learning needs. Also, the structure, work method, design, and implementation of an intelligent agent were all discussed [128]. The approach could help students take more responsibility for their learning, allowing them to receive a more tailored knowledge service [39].

We analyzed the hardware used for personalized learning technology access to adopt the technology smoothly. Devices are portrayed from the articles selected for the study, and the results are presented in Figure 7 above. We discovered that desktop computers were the most used hardware in the survey, with about 45 of 146 articles representing 31% of the selected articles of this research. This confirmed that desktop computers were the highly utilized devices to support access to personalized learning systems. Numerous personalized adaptive learning systems are available for either personal computers/desktop computers or mobile devices, but only a few are available for both [129]. Our study extended to more devices such as laptop computers which were 24% of the selected articles; tablets computers represented 16%; smartphones, 11%; notebooks, 8%; PDAs, 7% and wearable intelligent devices represented 1% of the articles. The recent technological developments have contributed to the reduction in the price of computing devices (desktops or tablets), which has resulted in increased adoption in the teaching and

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learning process by both instructors and learners. The primary objective is to blend students' educational experiences with a learning attitude and excitement [130].

6. CONCLUSIONS

This paper has revised different personalized learning technologies and informative technology models that enhance personalized learning in higher education. Based on these findings, the interest in personalized learning research has increased due to e-learning popularity related to advances in ICT and the increase of social media usage in higher learning institutions that adopt digital technologies for learning. This review shows how new technology can assist students in building their learning styles. Adopting these technological approaches may help with personalized education and increase student enrollment. Thus, the study indicates that most of the evaluated customized learning systems are available for desktop computer usage and few for mobile devices. Therefore, in the future, there is a need to research mobile and wearable learning technologies, which could encourage the adoption of personalized learning.

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