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ORIGINAL PAPER

Learning Technology Models that Support Personalization within Blended Learning Environments in Higher Education

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Abstract
Personalized learning has the potential to transfer the focus of higher education from teacher-centered to learner-centered environments. The purpose of this integrative literature review was to provide an overview of personalized learning theory, learning technology that supports the personalization of higher education, current practices, as well as case studies of implementing technology models to support personalized learning. The review results revealed the following: three technological models that support personalized learning within blended learning environments in higher education, an increase in personalized learning implementation in higher education with the support of the referenced technology models and platforms, and a lack of data-driven and independent research studies that investigate the effectiveness and impact of the personalized learning and technology models on student learning. The article informs educators and higher education administrators of the emerging models, platforms, and related opportunities to implement personalized learning in higher education settings. The review discusses the barriers, challenges, and theoretical and practical implications of implementing a personalized learning approach in higher education. Finally, recommendations for future research are discussed.

Keywords Personalized learning · Digital badges · Adaptive learning · Competency-based learning · Learning analytics · Higher Education · Technology models

Introduction

There has been a movement to change the focus of higher education from teacher-centered to learner-centered approaches (Watson, Watson, and Reigeluth, 2012). Barr and Tagg (1995) described the potential of this higher education paradigm shift to improve student engagement and learning opportunities. Barr and Tagg also emphasized that faculty members become learning designers and facilitators who provide students with the opportunity to construct knowledge and develop critical thinking skills (as cited in Rovai and Jordan, 2004). The movement has also shifted toward competency-driven learner advancement (Wesselink, Dekker-Groen, Biemans, and Mulder, 2010; Watson, et al., 2012), which requires compatible learner-centered technologies. Currently, most higher education institutional structures rely on a "one-size-fits-all" model that uses instructional strategies and educational technology tools to enhance teacher-centered classrooms in which students learn from standardized curriculum, instructional strategies, and time-based models of learner progress (Demski, 2012). However, higher education can currently be described as time-driven systems that can result in learning gaps that negatively effect current "information age" learners' knowledge and skills that are necessary for this era (Demski, 2012; Watson, et al., 2012). Demski (2012) described this system as the industrial-age model that assumes all learners share similar characteristics without focusing on their individual differences. The industrial-age model provides a "one-size-fits-all" classroom that is viewed as an effective method to teach all learners. This educational system treats learners as line workers while

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disregarding the opportunity to enhance problem-solving skills, collaboration, and critical thinking skills (Watson, et al., 2012). Therefore, systemic change must occur to change to a higher education system focused on learner-centered environments that can be customized and flexible to address every learner's needs and interests and enhance the twenty-first century skills that are becoming required for "information age" learners.

Personalized learning has the potential to create customized learning environments in higher education via technology platforms that offer pathways that personalize students' learning toward the mastery of their desired expertise (Lesser, 2016). However, personalized learning implementation is a challenge without information technology platforms to support the learning process. The New Media Consortium (2015) emphasized the need for personalized instruction in higher education and the development of new technologies that shift education to meet the individual learner's needs and goals. The report stated, "the increasing focus on customizing instruction to meet students' unique needs is driving the development of new technologies that provide more learner choice and allow for differentiated instruction" (NMC, 2015b, p. 26). Grant and Basye (2014) indicated that the technology integration of personalized learning provides learners with opportunities to control and design their learning to meet their goals. Sturgis, Patrick, and Pittenger (2011) emphasized the critical role of technology in personalized learning. Wolf (2010) stated that technology enhances personalized learning as well:

> Personalized learning requires not only a shift in the design of schooling, but also a leveraging of modern technologies. Personalization cannot take place at scale without technology. Personalized learning is enabled by smart e-learning systems, which help dynamically track and manage the learning needs of all students and provide a platform to access myriad engaging learning content, resources, and learning opportunities needed to meet each student's needs everywhere at any time, but which are not all available within the four walls of the traditional classroom. (p. 10)

Personalization can be implemented in higher educaiton as a philosopy, pedogogy, or structured programs (Twyman 2014b). Personalized learning can also be implemented as instructional approach in both online learning (Alamri, Lowell, Watson, Watson, 2020), and blended learning. However, this literature review focuses on technology models that support personalized learning in blended learning in higher education. The operational definition that best describes blended learning as defined for this literature review is provided by Garrison and Kanuka (2004) which defines blended learning as "the thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (p. 96). Thus, the focus of this review was to examine the theories and current practices of personalized learning as well as case studies of institutions' personalized learning platform integration within blended learning environments. Based on these practices and theories, the relevant literature was reviewed in order to identify the learning technologies that support student profiles and learning pathways that incorporate academic resources and activities based on student goals and interests beyond course requirements (Reigeluth et al., 2015; Lesser, 2016; Walkington and Bernacki, 2020). This review identified digital badges (Gibson, Ostashewski, Flintoff, Grant, and Knight, 2013; Fain, 2014; Newby, Wright, Besser, and Beese, 2016; Pearson, 2013), adaptive learning technology (Garrick, Pendergast, and Geelan, 2017a and b; Bray and McClaskey 2015), and competency-based learning (Twyman 2014b; Technavio, 2016) as three learning technology models with the potential to realize the personalized learning approach in higher education. The review answers the following research questions: 1) which emerging technology models can support personalization in higher education? and 2) What are the potential benefits and challenges of integrating personalized learning technology models in higher education settings?

Method

The goal of conducting this integrative review was to provide a summary and synthesis of the previous research on personalized learning in higher education as well as implementation attempts that integrated technology platforms to facilitate learning (Beyea and Nicoll, 1998). This review included pieces of literature (research studies, case-based studies, technology reports, conference proceedings, book chapters, handbooks, dissertations, and whitepapers) to examine the possible technological models that support personalized learning implementation within blended learning environments in higher education settings. The reviewed literature were only included if they met the following selection criteria (Cooper, 1988):

1 The reviewed literature that discussed learner-centered learning technology that support personalized learning implementation in higher education.
2 The reviewed literature that discussed technology model that provide:

   a. Students profiles and dashboards.
   b. A learning analytics feature.
   c. A pathway feature that tailors learning to the individual's needs and preferences.

3 This review focused on implementing personalization in higher education, and literature that investigated/discussed personalization in K-12 setting were excluded.
4 The results presented in a study or a literature work do not overlap with results from another study.
5 Peer-reviewed literature were exclusively included to ensure the validity of the review results. Non-peer reviewed works, such as handbooks, whitepapers, book chapters, or technology reports were searched and were only included if their focus was on technology models or platforms that support personalized learning implementation.
6 The reviewed literature only included if it is published between 2000 and 2020 and written in English.

Literature that did not meet the selection criteria were excluded. The inclusion of the whitepapers and technology reports were due to the importance of describing each technology model and platform. The included whitepapers (provided by the technology platforms venders) provided details and data-driven studies that reveal the effectiveness and the significant impact of the platforms' implementation in higher education. Finally, studies or book chapters that discuss the roots and theory of personalized learning was included even the publication date was not within the review time period.

This review was conducted using a systematic search of the online libraries and databases such as *ERIC, PsycINFO, EBSCO, Elsevier, WorldCat, Gale, ProQuest, ISI Web of Science database, the Social Sciences Citation Index (SSCI), Professional Development Collection, Taylor & Francis Group, Google Scholar, Primary Search, LearnTechLib, and Wily Online Library*. In addition to these databases, we conducted a specific search of the mostly-known educational technology journals such as *TechTrends, Computers & Education, Journal of Research in Technology on Education, the Journal of Computer Assisted Learning, Technology, Knowledge and Learning, Journal of Personalized Learning, British Journal of Educational Technology, Educational Technology Society, Interactive Learning Environments,* and *Educational Technology Research and Development* to further examine the three technological models that can be implemented to support personalized learning in higher education. We used the various search terms and keywords such as (*"personalized learning" and "higher education"), ("personalized learning"), ("personalized learning" and "adaptive learning"), ("personalized learning" and "digital badges"), ("personalized learning" and "competency-based learning"), ("personalized learning technology platforms"), ("personalized learning implementation") ("adaptive learning platforms") and ("competency-based platforms").* We used the aforementioned selection criteria for the articles and published works referenced in this review since the trends and direction of the personalized learning research are focused mainly on providing "personalized content" and "learning pathways feature" to support students' learning (Xie, Chu, Hwang, and Wang, 2019). Each article was examined and included if it demonstrated a sufficient description, theory, or empirical evidence of the effectiveness of each technological model that supports personalized learning implementation in higher education.

Results

The systematic search results identified 84 pieces of literature (research studies, case-based studies, technology reports, conference proceedings, book chapters, handbooks, dissertations, and whitepapers) that defined and described the theory and practices of personalized learning in higher education, and presented evidence of the technological models' benefits that may support personalized learning within blended learning environments in higher education (see Appendix A). The review results revealed three different technological models that assist personalized learning implementation in higher education. Open digital badges, competency-based learning technology, and adaptive learning technology were identified as emerging learning technology models with the potential to support the personalized learning movement in higher education. These models guided the design and development of learning platforms that share students' profiles, learning analytics, and pathway features to track students' learning and inform instructors of learning progress. The platforms can be incorporated within blended learning environments to facilitate student learning, retention, and engagement. These technology models and the platforms align with personalized learning principles. Students navigate their own learning progress independently via the recommended learning feeds that the platforms tailor to their needs and preferences.

There are overlapping definitions and purposes between the identified technology models since digital badges can be implemented using adaptive learning technology that are part of competency-based learning program (Clements, West, and Hunsaker, 2020). Adaptive learning systems can also be integrated in a competency-based learning program in higher education. However, the aforementioned technology models can be implemented individually to support personalized learning in higher education and can be integrated simultaneously as these technology models/approaches complement each other to reach effective personalized learning implementation. The three technology models were found in the literature to be integrated individually to support personalized learning in higher education; therefore, this review focused on identifying and addressing the technology systems and cases of implementing such systems to support personalized learning in blended learning environment in higher education. Finally, it was concluded that these three technology models are still in their testing phases. It may require some time for their broad implementation in various disciplines of higher education.

The search results also indicated a lack of data-driven studies that reveal the effectiveness and impact of the personalized learning approach and three technology models in higher education. Some of the relevant studies relied on theories and research funded by the platforms' vendors, rather than independent research efforts.

Personalized Learning in Higher Education

Definition and Theory

Personalized learning is rooted in Bruner's constructivism to support autonomous, active, and independent learners as well as Vygotsky's focus on social interaction, contextualization, and the zone of proximal development model (Watson and Watson, 2017). The goal-setting theories of personalized learning adopt Zimmerman's (2002) self-regulated learning, in which learners' metacognitive behaviors and motivation guide the learning process. Deci, Ryan, and Williams' (1996) self-determination theory emphasized the impact of goal setting in learners' achievements. Ames and Archer's (1988) goal-oriented theory prioritized students' mastery or performance of learning goals (Watson and Watson, 2017).

The Department of Education Office of Educational Technology (2016) defined personalized learning as

> the "instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) all may vary based on learner needs. In addition, learning activities are meaningful and relevant to learners, driven by their interests, and often self-initiated" (p. 7).

Personalization is "a fundamentally different mode of learning as the learner drives their own learning, actively participating and designing their learning" (Garrick et al., 2017a and b, p. 6). Wolf (2010) stated that personalized learning reverses education from the traditional time-based and place-dependent model to one that engages student learning and proficiency regardless of time, place, and pace (Redding, 2014 and b). Personalized learning adheres to a learner-centered paradigm and differs from the differentiation and individualization of a teacher-centric model (Garrick et al., 2017a and b). Differentiation uses instructional strategies for different learner groups, and individualization provides the opportunity for students to proceed on their own and learn independently. Individualization and differentiation rely on teachers to set the overall learning objectives and methods, while personalization shifts the role of the teacher to the facilitator of individual learning (Garrick et al., 2017a and b).

Status of Personalized Learning Implementation in Higher Education

Personalized learning frees learners from the time, place, and pace constraints of the traditional classroom, and allows them to gain proficiency on their own (Redding, 2014; Walkington and Bernacki, 2018). Spoelstra et al. (2014) indicated that higher education personalized learning reduced students' learning and practice gaps and enhanced their skills, knowledge, and confidence when preparing for the workplace. Xie, Chu, Hwang, and Wang (2019) conducted review of the literature of the trends and direction of the personalized learning/ adaptive learning research between 2007 to 2017 and conlcuded that most selected learners for implementing personalized/adaptive learning systems were in higher education. Foss, Foss, Paynton, and Hahn (2014) conducted a case study on the implementation of personalized learning instruction in two courses (Rhetorical Theory and Public Speaking), and the results showed that personalized learning instruction contributed to learning choices available to students, allowed students to use their time more effectively, and provided students with the opportunity to experience hands-on activities. This personalized learning instruction also met faculty members' objectives for student mastery of the course content. Moreover, personalized learning instruction contributed to enhanced faculty-student interactions by eliminating the "rules that govern many classrooms—rules about attendance, tardiness, late papers, and the like" (Foss et al., 2014, p. 10).

Learning Analytics for Personalized Learning

Learning analytics was defined by the Society for Learning Analytics Research as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (as cited in Siemens, 2012, p. 4). Siemens (2012) also viewed learning analytics as "the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning" (p. 1). The use of learning analytics embraces the concept of personalized learning in higher education. The NMC report (2015a) concurred that the use of learner analytics in higher education supports personalized learning experiences. The report stated that learning analytics has the potential to impact learners, educators, and researchers by providing "crucial insights into student progress and interaction with online texts, courseware, and learning environments used to deliver instruction" (p. 12). Higher education has begun to utilize big data to gain insights on student learning behaviors and attitudes, optimize and improve instructional design, teaching and learning methods (Rubel and Jones 2016), as well as predict student content retention and provide personalized feedback (Roberts, Howell, Seaman and Gibson, 2017). Technological advancements have increased the potential applications of learning analytics and student profiles in higher education settings (Roberts et al., 2017) to provide insights into student engagement (Reimers and Neovesky, 2015) and interaction with learning materials and resources (Dyckhoff, Zielke, Bültmann, Chatti, and Schroeder, 2012).

Learning analytics can be used to provide each student with personalization and customization opportunities (Roberts et al., 2017), enhanced autonomy (Rubel and Jones 2016), and self-regulated learning (You and Kang, 2014). In addition, learning analytics have the potential to personalize the learning experience by directing resources and learning materials toward learners' proficiencies, goals, and interests (Long and Siemens, 2011), which in turn tracks each student's progress and establishes personalized relationships between faculty and students (Roberts et al., 2017). Regarding the use of personalized and adaptive learning technologies and techniques in higher education, Cali Morrison, the Director of Alternative Learning at the American Public University System, said, "utilizing robust analytics, such platforms allow learners to access the right material for them, at the right time" (Wolper, 2016, p. 2). Therefore, the identified technology platforms have the capacity to analyze students' learning progress and notify faculty of students' learning. The analytics can assist educators as well as the venders to identify the weaknesses and possible improvements to provide well-design learning environment. This feature simplifies the data collection on students' learning, so educators and researchers have the potential to analyze and investigate the effect of personalized learning approach with support of the referenced technology platforms on students' learning and progression.

Emerging Learning Technology Models that Support Personalized Learning

The personalization of learning has emerged in higher education as a result of current technological advances (Wolper, 2016). Computer-based platforms as well as other devices and tools are emerging to support and augment personalized learning in higher education settings. Redding (2014) indicated that personalized learning "requires not only a shift in the design of schooling, but also a leveraging of modern technologies" (p. 4). Moreover, the availability of educational resources and the increase in educational technology adoptions invite higher education to reconsider the structure of teaching and learning (Ossiannilsson and Creelman 2012). Educational technology supports personalized learning by encouraging students' diverse learning experiences (Ossiannilsson and Creelman 2012) and increasing their choices to improve learning outcomes (Twyman 2014a). In a review of the personalized learning/ adaptive learning literature, Xie et al. (2019) found that the majority of the studies between 2007 to 2017 that covered affection, cognition, skills, and behavior areas reported positive results in students learning outcomes. Morrison noted that "as in so many other areas of our digital lives, learners are also demanding personalized education" (Wolper, 2016, p. 1). Personalized learning principles allow for customizing the learning environment to every individual's needs, interests and competency, but implementing these principles will be challenging without effective and valid technology platforms and tools. The advanced platforms and educational technology tools will enhance the possibility of successfully implementing personalized learning in higher education to provide customizable and flexible learning environment.

After reviewing the literature on technology models that serve personalized learning, digital badges were identified as the most commonly-used technology model in higher education settings (Gibson et al., 2013; Fain, 2014; Newby et al., 2016). Adaptive learning technology (Garrick et al., 2017a and b; Johnson and Samora, 2016; Liu, McKelroy, Corliss, and Carrigan, 2017; Elsevier, 2016) and competency-based technology (Twyman 2014b; Murphy, Redding, and Twyman, 2016; Redding, 2014; Technavio, 2016) enhance the personalization of computer-based platforms by providing cloud-based curriculum that is adjustable to learners' goals, interests, and competencies. Each of these technologies has the potential to support personalized learning approaches in higher education.

Digital Badges Model to Support Personalized Learning

A digital badge is "a representation of an accomplishment, interest or affiliation that is visual, available online, and contains metadata including links that help explain the context, meaning, process and result of an activity" (Gibson et al., 2013, p. 404). Lesser (2016) defined digital badges as "a graphic representation of a skill or competency that is displayed and accessed online, is earned through specific criteria, and links to 'evidence' or portfolio data that can be reviewed by stakeholders" (p. 44). The educational badging and badge systems are emerging to "incentivize learners to engage in positive learning behaviors, identify progress in learning and content trajectories, [and] signify and credential engagement, learning and achievement" (Gibson et al., 2013, p. 404). Digital badges are implemented to motivate learners to utilize online materials and complete online activities in order to meet the learning objectives (Gibson et al., 2013). Digital badges function similarly to badge achievements in digital games and provide learners with educational artifacts to represent the completion and accreditation of their work (Gibson et al., 2013). Learners have the opportunity to share the badges through social networks, which demonstrates their skills and abilities to relevant stakeholders (Mah, 2016). Most higher education institutions apply digital badges to support personal learning environments and more of independent learning so students can represent their skills and competencies and improve their chances of employment. Jirgensons and Kapenieks (2018) stated, "personal encrypted credentials enable users to shape lifelong learning pathways and personalizes education according to individual values and needs" (p. 145).

Open digital badges are defined as "a type of digital badge that is verifiable, portable, and packed with information about skills and achievements" (IMS Global, 2020, p. 1). The idea of open digital badges is to easily allow badge issuing and management and allow earners to store and present them in a digital backpack (Randall et al., 2013). Simply, the open badge system allows the issuers to design the open badges and allows the earner to receive the badges once the criteria have been met, provide evidence of skill or competency mastery, and share the badges digitally with schools, employers, or clients.

Research has shown that digital badges increased learners' engagement, enhanced their learning, and gauged their prior knowledge (Abramovich, Schunn, and Higashi, 2013; Glover and Latif, 2013) as well as increased student retention in higher education (Mah, 2016). Other articles have identified digital badges as a technology that offered efficient personalized learning for adult learners (Gamrat, Zimmerman, Dudek, and Peck, 2014; Lesser, 2016). However, the digital badge itself is not personalized learning technology; it must be integrated into a larger curricular structure. Thus, it is the educator's responsibility to design personalized learning instruction and provide students with opportunities to set learning goals and learn within a competency-based, personalized learning environment (Voorhees and Bedard-Voorhees, 2017). The digital badge system itself might serve as a platform that can be used to support personalization where instructors use the digital badges as pedagogy (Ahn, Pellicone, and Butler, 2014), and not just as a tool, and develop the badges into the systems to provide students with learning pathways and digital portfolios to visualize their learning and progress toward mastery and the meeting of personalized goals and needs. Ahn et al. (2014) stated, "in systems where badges are visible to the learner they can serve as a way to visualize the learning path of content and activities" (p. 4). Digital badges can be integrated into adaptive learning platforms or platforms that were developed based on competency-based education principles. The badges can be earned through those platforms and used as credentials in other social media and open digital badges systems.

Instructors have the opportunity to personalize the learning environment by providing additional resources and activities that may guide students toward content mastery (Guskey, 2007). Digital badge platforms can assist with this method of personalization. Learners may select the intended badge and assigned objectives toward mastery via the badge system. Finkelstein, Knight, and Manning (2013) emphasized that digital badges can personalize learning when instructors provide self-directed learners with the resources necessary to personalize their learning and develop new expertise. The authors claimed that open educational resources (OERs) provide crucial opportunities for instructors to personalize learning and digital badges "offer alternative methods for recognizing appropriately rigorous use of these resources for personal and professional growth" (p. 16).

Current Digital Badge Platforms

Digital badge platforms are utilized by many universities and colleges. Several institutions have begun to integrate and enhance student learning with badges. Both private (e.g., Purdue Passport) and large venders digital badges platforms (e.g., Acclaim) are already emerged as educational digital badges technology.

Universities and colleges that have already established digital badge integration include Purdue University, University of California-Davis, Madison-Area Technical College, Carnegie Mellon University, DePaul University, Arizona State University, among others (Gibson et al., 2013; Fain, 2014; Newby et al., 2016; Pearson, 2013). Various independent learning companies have also developed digital badge platforms for educational settings. Some well-known digital badge platforms include IMS Open Badges, Acclaim, Accredible, and many others (Gibson et al., 2013; Fain, 2014; Newby et al., 2016; Pearson, 2013, IMS Global, 2020).

However, most digital badge platforms do not provide algorithms that tailor the badges to learners' needs and preferences. Therefore, the instructors or instructional designers are required to use a model that guides the course structure and incorporates a personalized learning approach using digital badges. This requirement is similar to the hierarchy model provided by Randall et al. (2013).

Digital Badges and Personalized Learning Implementation Experiences

Randall et al. (2013) indicated that digital badges have the potential to motivate learners to go beyond their course requirements. The authors designed digital badges for an instructional technology course in order to provide students with personalized learning experiences. They utilized digital badges using a badge hierarchy model with different levels of mastery and included a list of the instructional technologies taught during the course. In addition, the authors included new technologies beyond the course requirements that may be of interest to students after the course ended.

Another example of digital badge integration in personalized adult learning environments was the collaboration between Penn State University, the National Aeronautics and Space Administration (NASA), and the National Science Teachers Association (NSTA), which designed the Teacher Learning Journeys badge system to provide teachers with professional development opportunities. The findings of this implementation indicated that the project supported teachers' decision-making and learning customization (Gamrat et al., 2014).

Adaptive Learning Technology Model to Support Personalized Learning

Adaptive learning technology can be defined as the "software and online platforms that adjust to individual students' needs as they learn. Through interacting with the technology, behavioral and cognitive patterns are recorded and personalized learning experiences are shaped accordingly" (Garrick et al., 2017a and b, p. 44). The authors suggested that adaptive learning technology is essential to the enhancement of personalized learning technology. They argued that adaptive learning technologies have the potential to impact the education sector and provide learners with the pathways relevant to their individual needs and interests. The New Media Consortium (2015) indicated that adaptive learning technologies provide the opportunity to create personalized learning pathways and support individual learning progression. Adaptive learning systems/ courseware can be divided in two types: "(1) courseware where an instructor can author content within a provided adaptive delivery method (i.e., instructor-authored content), and (2) courseware from publishers or other vendors who provide the content as well as the adaptive delivery method, often affiliated with a particular textbook (i.e., publisher authored content)" (Gebhardt, 2018, p. 7). Adaptive technology necessarily generates learners' analytics to provide all stakeholders with learners' progress and achievements and suggest zones for developments and improvements (Garrick et al., 2017a and b; NMC, 2015). Vygotsky's zone of proximal development (ZPD) emphasized that learners need to be provided with resources suitable to their current learning levels in order to more optimally progress towards mastering the target learning objectives (Yang, Gamble, Hung, and Lin, 2014). Adaptive learning platforms treat every learner as an individual, and provide the needed learning feeds that align with the learner's competency and ability. Such precise advanced technology can be implemented to reduce instructors' efforts in tracking every individual's learning and personalize the learning experience toward individual needs (Murray and Pérez, 2015; Nakic, Granic, and Glavinic, 2015).

Adaptive learning technology provides the opportunity for instructors to organize the learning content to be personalized based on students' abilities and needs through learning resources and personalized profiles or interfaces (Mampadi, Chen, Ghinea, and Chen, 2011; Yang, Hwang, and Yang, 2013; Plass and Pawar, 2020). Most systems that adopt such a model focus on personalizing learning content. In a review of the literature on personalized/ adaptive learning systems, Xie et al. (2019) stated that 29 out of the 70 studies that were conducted between 2007 to 2017 were mainly focused on adopting personalized learning content as the approach to supporting learning through this type of systems. This means that most implementation of personalized/adaptive learning systems were to provide students with tailored learning curriculum to meet their learning needs and interests and improve students' progression on mastering the learning content.

The New Media Consortium (2015) (NMC) report indicated that the Bill and Melinda Gates Foundation has established a Personal Learning Network of personalized and adaptive learning that includes more than a dozen colleges and universities. Some of these universities have already established personalized and customized learning initiatives (e.g., the University of Mississippi's College of Liberal Arts).

Current Adaptive Learning Platforms

Adaptive learning platforms, such as algorithm-based systems, were developed based on data analytics and tutoring systems research (Johnson and Samora, 2016). These platforms identify each student's learning methods and behaviors, and direct their individualized readings, activities, and assessments (Wozniak, Lilly, Hambrock, Richter, and Reiseck, 2016). Adaptive learning platforms enhance online, face-to-face (Wagner, 2017), and blended learning environments (Liu et al., 2017). Moreover, adaptive learning platforms can serve as an effective solution to the challenge of class size increases in higher education by providing personalized learning tailored to each student's knowledge and skills (Elsevier, 2016). Over 30 software companies currently provide adaptive learning platforms (Johnson and Samora, 2016; Gebhardt, 2018) for higher education or K-12 settings, including McGraw Hill Education, D2L, Knewton, Realizeit, Adaptemy, Domoscio, Elsevier as well as many other platforms (Johnson and Samora, 2016; Elsevier, 2016; Liu, et al., 2017; Gebhardt, 2018). Another platform that may facilitate the implementation of personalization is Edmentum Courseware for higher education, a private educational corporation that specializes in personalized learning platforms. Edmentum provides adaptive curriculum, assessment, and practices to engage students in active learning. However, there are variability among these systems/ coursewares in regard to their usability with personalized learning, algorithms, and "depth of coverage" (Gebhardt, 2018). Every adaptive learning system has its own algorithmic method to customizing the learning content. The systems also vary based on whether they allow instructors to author instructional content (Gebhardt, 2018). Gebhardt (2018) stated that "depth of coverage can also vary across courseware where some courseware emphasizes foundational learning objectives at the bottom of Bloom's taxonomy and other courseware involve higher levels of Bloom's more frequently" (p. 8).

Adaptive Learning and Personalized Learning Implementation Experiences

The University of Mississippi's College of Liberal Arts has integrated a personalized learning approach in high-enrollment courses such as Biology, Chemistry, Writing, and Mathematics via the Personalized Learning and Adaptive Teaching Opportunities Program (PLATO), which allows for blended learning environments (PLATO, 2017). Austin Community College has also implemented adaptive learning to build the world's largest adaptive learning math lab and adapted McGraw-Hill Education ALEKS as their adaptive learning courseware for their personalized courses (Fain, 2015). Administrators reported that student dropout rates decreased from 25 to 35% to 7.5–10% (Fain, 2015). Arizona State University, Colorado Technical University, University of Central Florida, and American InterContinental University plan to adopt and implement computer-based adaptive learning platforms as well (Johnson and Samora, 2016; Wagner, 2017).

Other institutions and departments (e.g., Madison Area Technical College, Accounting; Austin Peay State University, Education; Bethel University, Chemistry; and University of Alabama, Tuscaloosa, Sociology) have initiated efforts to utilize McGraw-Hill Education computer-based platforms (Connect and SmartBook). These initiatives were launched to provide personalized and adaptive learning opportunities within individual courses or programs across a variety of majors (McGraw-Hill Education, 2016). Connect platform provides unique personalized experiences for learners and helps educators to manage and track student progress through learning analytics. Within the Connect platform, the McGraw-Hill corporation developed the SmartBook adaptive learning experience to provide personalized resources tailored to each learner to close the knowledge gaps. This adaptive learning technology purposefully facilitates the learning process. McGraw-Hill Education partnered with researchers in the aforementioned institutions to conduct 20 case studies that determined the impact of SmartBook and Connect on student achievements, retention, engagement, and progress. They claimed that Connect has increased student retention (70.1% to 89.9%), pass rates (72.5% to 85.2%), average exam scores (71% to 80.1%), and improved instructors' time management (McGraw-Hill Education, 2016).

Colorado State University received a grant from the Bill & Melinda Gates Foundation to implement adaptive learning courseware (APLU, 2016), and the implementations included majors such as Mathematics, Chemistry, Physics, Economics, Languages, etc.) (Gebhardt, 2018). The university adopted LearnSmart by McGraw-Hill Education as the adaptive learning courseware, where the software assesses learners' knowledge, skills, and confidence to track their learning progression toward mastery of the learning content. Then, the software assesses each student's learning progression to provide learning recommendations that matches their learning interests and needs and adjust their learning objectives which shape their learning pathways and learning profiles (Tyton Partners 2016; Gebhardt, 2018). The implementation of this courseware was for high enrollment courses that had many struggling students. This implementation was investigated in a research study by Gebhardt (2018) to understand the relationship between students' interaction with the learning content and their mastery of the content. The results of this comparison study revealed that students who completed low-stakes adaptive assignments scored higher on easy and moderate exam questions than those who did not complete the adaptive assignments (Gebhardt, 2018).

Competency-Based Learning to Support Personalized Learning

Jones, Voorhees, and Paulson (2002) defined competency as a "combination of skills, abilities, and knowledge needed to perform a specific task" (p. 8). The purpose of personalization using a competency-based model is to promote individual proficiency of the intended competencies. Twyman (2014a) indicated that competency-based learning can be considered as a component of the personalized learning movement. Competency-based learning emphasizes learners' progress based on their mastery of measurable and transferable competencies. Specified learning outcomes ensure the development of knowledge and skills, provide relevant assessments that track learners' progress and mastery, and enhance differentiation as well as scaffolding (Twyman 2014b). The Technavio (2016) analysis of the competency-based education (CBE) market for higher education in the U.S. indicated that the number of students enrolled in CBE programs has increased from 50,000 in 1990 to 200,500 in 2015. The report also expected that 750 U.S. colleges will offer CBE programs to 500,000 students by 2020. Accordingly, educators and researchers cannot overlook the current and forecasted implementation and adoption of this movement in higher education.

Competency-Based Technology Model

Competency-based technology model has the potential to facilitate personalized learning in higher education. This claim is due to the overlapping principles and applications of personalized and competency-based learning (Twyman 2014b), as well as the fact that the personalized learning movement encompasses competency-based components (Twyman 2014a; Murphy et al., 2016; Redding, 2014). Twyman (2014b) summarized the U.S. Department of Education (2010) (USDOE) report regarding CBE and personalized leaning as follows:

> CBE programs are likely to support personalization as they are often crafted at the outset to provide students with individualized learning opportunities, not only with regard to time, place, and pace, but also in regard to tailoring instruction according to each student's unique needs and reflective of his or her particular interests—which may lead to greater student engagement and outcomes. (p. 3-4)

The USDOE report on competency-based education and personalized learning stated that CBE "strategies provide flexibility in the way that credit can be earned or awarded, and provide students with personalized learning opportunities" (p. 1). The report also emphasized that personalization encompasses individualized and differentiated teaching and learning strategies (Redding, 2013; USDOE, 2019). The rapidly-growing technology platform market supports CBE and personalization in higher education. Technavio (2016) reported that most emerging learning technology platforms support CBE (e.g., BNED LoudCloud, D2L, Ellucian, and Flat World Education), and expected more implementation of these platforms in higher education between 2016 and 2020. Johnstone and Soares (2014) stated, "CBE can serve as a new way of organizing student learning in postsecondary education. Faculty remain in control of the curriculum (defined as what a student needs to learn and how the learning will be measured), while students have well-developed personalized learning resources that continually evolve. They can thus receive a high-quality education that leads to demonstrated learning at an affordable price" (p. 18).

Competency-Based and Personalized Learning Implementation Experiences

BNED LoudCloud is a CBE-based and a personalized learning platform that features personalized content and assessment pathways for each student's needs. The platform provides the opportunity to design, develop, and implement CBE programs tailored to institutional needs as well. The platform uses student data to track learning performance, engagement with learning resources, and peer collaboration. The software utilizes learning analytics to monitor student progress toward objectives and create personalized learning pathways and improvement areas. Finally, the platform provides open educational resources (OER) and learning analytics solutions that support higher education personalized-learning environments (BNED, 2020). Portland State University is currently collaborating with BNED LoudCloud to co-develop a degree-planning solution that provides students with personalized pathways to enhance their learning experiences and increase degree completion rates (News Bites, 2017). Penn State University, West Liberty State University, and Cuyahoga Community College piloted the platform in 2016. Kentucky Community and Technical College System (KCTCS) utilized BNED LoudCloud courseware in fall 2017 with more than 1000 students (BNED LoudCloud, 2020). In addition, the University of Wisconsin and Southern New Hampshire University incorporated personalized learning innovations to implement CBE and self-paced learning as well as personalized learning activities to provide effective and definable skills and competences (Johnstone and Soares, 2014) Tables 1 and 2.

Challenges

The development of learning technology will not continue to impact personalization "without explicit attention to the social contexts and ideological commitments that underpin and determine the ways in which these technologies are adopted and implemented in higher education" (Garrick et al., 2017a and b, p. 8). Such technologies enhance the capability of institutions and instructors to monitor students' learning progress, and these tools continue to evolve. Thus, the enhancement of "data-driven approaches" is imperative to the personalization of higher education (NMC, 2015). After all, personalized learning implementation and learning analytics are "still evolving and gaining traction within higher education" (NMC, 2015, p. 26). Another barrier is the lack of alignment between personalized learning and digital pedagogies, given that "the systems that are potential enablers are not philosophically or practically aligned to enable this outcome at this time, creating a challenge for progressing" (Garrick et al., 2017a and b, p. 34). In addition, Mohd, Shahbodin, and Pee (2014) indicated that the current challenges faced by technology integration in personalized learning environments are "organizational support, teacher attitude, expectations, and technology itself" (p. 63).

Institutional resistance to changing from a "one-size-fits-all" classroom can prevent the implementation of personalized learning in higher education. However, passionate educational leaders can implement personalized learning using

Table 1 Three Technology Models that Support Personalized Learning in Higher Education

Technology Models	Digital Badges	Adaptive Learning Technology	Competency-based technology model
Main Features	• Student dashboard • Records of accomplishment • Portfolio of learning artifacts • Metadata of learning context, process, and activities • Completion and accreditation benchmarks • Multimedia integration	• Algorithm-based tutoring systems • Student dashboard • Adaptive curriculum • Adaptive assessment • Intensive courseware in a variety of disciplines • Multimedia integration • Learning Analytics	• Algorithm-based tutoring systems • Student dashboard • Intensive courseware in a variety of disciplines • Multimedia integration • Learning Analytics
Strengths	• Facilitate personalized learning. • Can be implemented within blended learning environments. • Can be designed to create learning pathways for personalization. • Potential to motivate, engage, and enhance students. • Gauge students' prior knowledge. • Can be implemented in competency-based education. • Illustrate progression.	• Facilitates personalized learning. • Provides readiness assessment. • Adapts to students' behaviors and learning patterns to provide personalized instructions. • Increases students' motivation. • Engages students in active learning. • Provides immediate feedback. • Promotes high level of learner confidence. • Helps instructors to obtain insights regarding learners' needs and preferences. • Helps educators to manage and track student progress via learning analytics. • Supports collaborative group work and activities.	• Facilitate personalized learning. • Ensure the development of knowledge and skills. • Provide relevant and personalized content and assessment. • Course can be designed to progress through competencies. • Track learning performance. • Allow for differentiation and scaffolding. • Engagement with learning resources. • Peer collaboration.
Weaknesses	• Most of the digital badge platforms do not provide the feature of tailoring the badges to individuals' needs and preferences; however, the instructor is able to design the badges and use a model that can provide personalized learning attributes. • It is difficult to incorporate digital badges within Project Based Learning (PBL) and personalized learning environments. Most of the digital badge platforms were developed to meet individual's needs and learning progression. Therefore, incorporating digital badge platforms can be a challenge when used for learning environments that implement group work strategies (Randall et al., 2013).	• Requires careful implementation. • Poor implementation could negatively impact students' learning. • Lack of research evidence of its effectiveness to significantly improve students' learning. • Has the potential to isolate students. • Relying on machine learning only is insufficient for active learning. Besides adaptive learning, instructors need to implement a variety of class activities that establish a collaborative and active learning environment (Kara and Sevim, 2013).	• Lack of research evidence on its impact on student learning. • This review did not reveal any weaknesses of this technology model; however, the weaknesses and challenges of the CBE model can also be applied to this model. Some of the challenges include competency measurement errors and methods for evaluating unmeasurable competencies (Voorhees and Bedard-Voorhees, 2017).
Institutions Implementation of the Technology Models	• Purdue University Passport • University of California-Davis Digital Badge System • Madison-Area Technical College (DCI) • IMS Global Open Badges • Acclaim • Accredible • Blackboard Open Badges	• McGraw Hill Education ALEKS • LearnSmart • D2L • Knewton • Realizeit • Adaptemy • Domoscio • Elsevier • Edmentum Courseware	• BNED • LoudCloud, • D2L, • Ellucian, • Flat World Education

one of the technology models referenced here to provide unique and effective learning experiences. Students will benefit from their personalized learning and progress based on their skills and abilities instead of time-based progression. The findings of this review indicated that the three technology models are being used to provide learning experiences that meet students' learning needs and overcome some of the challenges they face in higher education, including retention, learning progress, engagement, and motivation.

Table 2 List of Reviewed Literature

Category of Reviewed Studies	Reviewed Studies
Personalized Learning Definition, theory and technology in higher education	1. Watson, Watson, and Reigeluth (2012) 2. Watson and Watson (2017) 3. Demski (2012) 4. Grant and Basye (2014) 5. Zimmerman (2002) 6. Deci, Ryan, and Williams (1996) 7. Sturgis, Patrick, and Pittenger (2011) 8. Ames and Archer (1988) 9. The Department of Education Office of Educational Technology (2016) 10. Twyman (2014a) 11. Twyman (2014b) 12. Alamri, Lowell, Watson, Watson (2020) 13. Wolf (2010) 14. Garrick, Pendergast, and Geelan (2017a and b) 15. Bray and McClaskey (2015) 16. Redding (2014 and b) 17. Spoelstra et al. (2014) 18. Xie, Chu, Hwang, and Wang (2019) 19. Foss, Foss, Paynton, and Hahn (2014) 20. Wolper (2016) 21. Redding (2014) 22. Ossiannilsson and Creelman (2012) 23. Mohd, Shahbodin, and Pee (2014) 24. Gallagher and Garrett (2013) 25. Kirkwood and Price (2014) 26. Petegem (2008) 27. Sharma, Palvia, and Kumar, (2017) 28. Walkington and Bernacki (2018) 29. Walkington and Bernacki (2020)
Digital Badges to Support Personalization	1. Gibson et al. (2013) 2. Fain (2014) 3. Newby et al. (2016) 4. Lesser (2016) 5. Mah (2016) 6. Abramovich, Schunn, and Higashi (2013) 7. Glover and Latif (2013) 8. Gamrat, Zimmerman, Dudek, and Peck (2014) 9. Voorhees and Bedard-Voorhees (2017) 10. Finkelstein, Knight, and Manning (2013) 11. Pearson (2013) 12. Randall, Harrison, and West (2013) 13. Ahn, Pellicone, and Butler (2014) 14. Jirgensons and Kapenieks (2018) 15. IMS Global (2020)
Adaptive Learning Technology to Support Personalization	1. Garrick et al. (2017a and b) 2. The New Media Consortium (2015) 3. Johnson and Samara (2016) 4. Liu, McKelroy, Corliss, and Carrigan (2017) 5. Elsevier (2016) 6. Gebhardt (2018) 7. Yang, Gamble, Hung, and Lin (2014) 8. Murray and Pérez (2015) 9. Nakic, Granic, and Glavinic (2015) 10. Yang, Hwang, and Yang (2013) 11. Wozniak, Lilly, Hambrock, Richter, and Reiseck (2016) 12. Wagner (2017) 13. PLATO (2017) 14. McGraw-Hill Education (2016) 15. APLU (2016) 16. Tyton Partners (2016)

Table 2 (continued)

Category of Reviewed Studies	Reviewed Studies
	17. Nedungadi and Raman (2012) 18. Arienko et al. (2020) 19. Plass and Pawar (2020) 20. Spruel (2020) 21. Ascione (2016) 22. Johnson (2016) 23. Kinshuk (2016) 24. Kakish and Pollacia (2018) 25. Park and Lee (2007) 26. Wilson (2007) 27. Phelps (2019)
Competency-Based Learning to Support Personalization	1. Clements, West, and Hunsaker (2020) 2. Twyman (2014a) 3. Twyman (2014b) 4. Murphy, Redding, and Twyman (2016) 5. Redding (2014) 6. Redding (2013) 7. USDOE (2019) 8. Technavio (2016) 9. Jones, Voorhees, and Paulson (2002) 10. BNED (2020) 11. News Bites (2017) 12. Andre et al. (2017) 13. Williams, Moser, Youngblood, and Singer (2015) 14. Camacho and Legare (2016).

Students' preparation in higher education can be a challenge in itself when implementing personalized learning. They must be trained well to successfuly utilize such a learning environment. Preparation must include the technological skills and competences, communication skills, and self-learning and self-mentoring skills. Students are active and independent learners in personalized learning; therefore, they must understand the differences between this type of learning and the traditional learning approach that has dominated higher education.

Instructors also must be prepared and receive training to effectively implement personalized learning and its supporting technology models and other technologies such as Web 2.0 and Web 3.0. This can be a challenge for many universities since the implementation of such approaches to learning requires a different set of technology skills and competencies, pedagogical approaches and modes, and other associated skills such as communication skills, networking, and virtual teaching and mentoring. Universities must prepare established technology infrastructure that can be supportive for such advanced learning technology. (Gallagher and Garrett, 2013; Kirkwood and Price, 2014; Petegem, 2008; Sharma et al., 2017).

To summarize, each piece of software that can be implemented to personalize learning will have its own challenges and difficulties and will vary in its effectivness on students' learning. Thus, it is required to conduct studies to investigate the variables that can cause challenges and improve the implementation and the practices to achieve better learning results.

Conclusions

This literature review was conducted to address the need in identifying the most applicable and effective technology models that support personalized learning within blended learning environments in higher education. This review can contribute to the effective use of learner-centered learning technology and improved instructional outcomes in education by identifying the technology models that assist institutions and instructors in their implementation of personalized learning. In addition, the review describes the status of the current research and the impact of the referenced models and platforms to support and facilitate the implementation of personalized learning. The review identified open digital badges, adaptive learning technology, and competency-based learning technology as models that support personalized learning environments in higher education. The integration of these technology models has the potential to facilitate the implementation of personalized learning in higher education. Open digital badges can be structured and designed to offer personalized learning environments in which students have the option to select the badges that are relevant to their competency level, prior knowledge, and progress. Adaptive learning platforms provide personalized learning and address the challenge of high enrollment in higher education. Adaptive learning platforms recognize students' responses to online lessons and assessments and generate personalized pathways to appropriately timed and leveled resources and learning materials. Instructors then use class time for discussion and extension of the learned material. Finally, the competency-based model has been used to develop platforms that enhance personalized learning in higher education. This approach offers learners the opportunity to progress based on mastering competencies aligned with their prior knowledge, skills, and abilities.

Adaptive learning, competency-based learning, and digital badges can support the implementation of personalized learning in higher education, which then has the potential to change the landscape of higher education. The evolution of e-learning and advanced learning systems (e.g., adaptive learning, etc.) will contribute to transforming education from traditional and standardized to more of flexible technologically enhanced learning environments that meet students' individual learning needs and interests; further, this approach changes the role of students to active architechts of their learning (Sharma, Palvia, and Kumar, 2017) through independent, active, and self-paced learning. Universities must prepare for this shift and understand the change toward more flexible and personalized learning environments that treat every student as an individual (Sharma et al., 2017).

Implications

Personalized learning promises beneficial results in replacing traditional learning environments. This approach frees the learners from progressing on a particular timetable, which has the potential to create learning gaps that hinder learners' performance and achievement. It is worth noting that designing personalized learning environment without properly incorporating one of the technology models can result in challenges and difficulties for learners and instructors. It can be difficult for instructors to track student progress via paper-based reports or provide the appropriate learning materials for every student. In addition, it can be challenging for students to track their own learning, which could result in failure or negatively affect their achievement. Personalized learning should be properly implemented to ensure the ideal learning experiences and student achievement. These technology models can contribute to effective personalized learning implementation. Watson and Watson (2017) indicated that technology can facilitate personalized learning instruction and assist student learning. Without technology support, the authors argued that personalized learning implementation would be difficult and may cost instructors additional time and effort.

Most of the referenced platforms have a learning analytics feature that measures student learning progress and gaps. The feature tracks students' learning, needs, goals, and achievements by generating dashboards that visualize individual learning. To personalize the content, these platforms include pre-tests that analyze students' learning needs and provide the appropriate content and instructional method to enhance learning and close learning gaps. Accordingly, course content, learning materials, activities, and assessment can be tailored to fit the needs and interests of individual students, who can track their performance. In addition, some of the platforms (e.g., BNED, PLATO, ALEKS, etc.) provide instructionally designed courses that incorporate textbooks, multimedia, video tutorials, activities, assignments, and assessment plans that can be tailored toward individual's needs and preferences. Some of the platforms' preliminary findings revealed that students indicated higher engagement and motivation levels when they utilized the platforms outside of class and used class time for discussions and activities (McGraw-Hill Education, 2016; BNED, 2017).

These platforms support the implementations of flipped classrooms and project-based learning (PBL). Course content and assessment can be delivered through these platforms, and students can learn independently by progressing through the provided feeds. Instructors can then use class time more effectively by facilitating activities that further students' learning instead of instructing and delivering information. Specifically, flipped classroom may serve as a model to facilitate personalized learning in higher education and enhance students' learning opportunities "by providing learning resources to address the varied learning needs of students and transitioning classroom time to engage students in the application of content, formatively assess student progress, and work individually or with groups of students as needed" (McDonald and Smith, 2013, p. 437). Rutherfoord and Rutherfoord (2013) argued that the flipped classroom model allows for personalization and provides students with opportunities to tailor their learning to their individual needs (as cited in Bergmann and Sams, 2012). Project-based learning (PBL) can also be implemented within personalized learning environments to allow every student to design a project, work independently, and gain metacognitive ability by learning more about their own abilities and needs. These platforms assist instructors to incorporate group or individual projects that meet their instructional standards and objectives.

It is the authors' hope that the referenced technology models contribute to the successful implementation of personalized learning in higher education and encourage administrators and instructors to avoid the "one-size-fits-all" approach that prevails in most of today's higher education classrooms. Institutions can incorporate one of these technology models to provide an effective learning environment and meet their students' needs. Accordingly, their students can learn to be independent and successful learners who not only benefit from gaining knowledge and problem solving, but also expand their capacity to learn.

Recommendations for Future Research

There is a need to conduct further empirical and systematic research on the impact of personalized learning in higher education. Garrick et al. (2017a and b) indicated that there is a lack of evidence-based empirical research on the effectiveness of personalized learning in higher education. It is also important to identify the implications and challenges of implementing personalized learning within different learning contexts to identify the impact and effectiveness of the personalized learning approach in higher education. Wolper (2016) encouraged educators to report the effects of personalized learning practices in their universities to expand future implementation of personalization in higher education and enhance its literature. It is imperative to measure student engagement within personalized learning environment to reveal what effective practices that might engage students in the learning process. Motivation is another factor that should be measured in personalized learning to reveal how students feel regarding their learning. In addition, personalized learning effectiveness can be measure through learning outcomes (academic performance, test scores, skills acquisition, information recall, etc.). One of the criticisms of personalized learning is the question of how to lead learners toward deeper learning (Merrill, 1983), and develop critical thinking skills (Svenningsen, Bottomley, and Pear, 2018). This criticism requires further research that not only investigates the effectiveness of personalized learning but also the strategies and techniques needed to achieve deeper learning and higher-order thinking. Individual's differences also can be a considerable component to be investigated in personalized learning.

Educational researchers need to focus on investigating personalized profiles or interfaces and their utility in higher education. Personalized learning content and the delivery modes and approaches are important topics that must be considered when implementing personalized learning (Xie et al., 2019), especially in higher education. All other personalized learning features and functions such as personalized feedback, personalized pathways, personalized recommendations (Xie et al., 2019), and personalized assessment must be addressed in order to effectively implement personalized learning in higher education.

Indeed, there is lack of independent research that investigates the impact of these technology models and platforms on student achievement, engagement, learning progress, and pedagogical strategies. Both quantitative and qualitative research should be applied to investigate the effect of the referenced platforms to reveal the optimal practices to provide effective personalized learning experiences. Educational researchers need to investigate the weaknesses and improvements of those technology platforms to validate their effectiveness in higher education settings and within different learning contexts. Specifically, personal learner profiles can be investigated and examined to reveal information about learner attitudes and behaviors that impact learning. Moreover, learning analytics is a feature that is provided in most of the referenced platforms, and this feature can provide data that can assist educators and researchers to investigate students' learning progression. This feature can inform educators of students' learning, and that can enhance the learning cycle and lead to addressing issues such as learning gaps, retention rate, and learning progression.

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