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Completed Research

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Abstract

Contemporary learning environments are gaining traction due to their ability to deliver learning content and adapt to individual student needs. However, few examples of implemented contemporary learning interventions have been identified. Also, updated literature on the new generation of AI-enabled adaptive learning systems is lacking. Therefore, a systematic literature mapping (SLM) on AI-enabled adaptive learning systems was performed, and 122 studies published between 2014 and 2019 were analysed. This paper presents a discussion regarding the SLM's main findings and challenges, as well as a summary of interventions for AI-enabled contemporary learning systems identified by the SLM. The major contribution of the study is bringing awareness to researchers and system developers on contemporary learning systems and AI techniques. This review will act as a guide for future studies on how to better design AI-enabled adaptive learning systems to solve specific learning problems and improve users' learning experiences.

Keywords

AI, Adaptive Learning Systems, Contemporary Learning Systems, Systematic Literature Mapping.

Introduction

Mobile internet, cloud computing, Big Data technologies and significant breakthroughs in AI have transformed education. Contemporary learning environments are increasingly integrated with new technologies to develop more personalized educational settings (Mousavinasab et al. 2018). These environments are characterized by students' thriving in a digital environment in which current technologies shape students' expectations and their "abilities to access, acquire, manipulate, construct, create and communicate information" (Green and Donovan 2018).

The physical and virtual resources in contemporary learning environments are designed to deliver effective learning by helping students construct their knowledge. Good examples of recent contemporary learning environments are adaptive learning systems and recommender systems. Recommender systems are "software tools based on machine learning and information retrieval techniques that provide suggestions for potential useful items to someone's interest" (Syed et al. 2017). Adaptive learning systems, on the other hand, are platforms for personalized learning that adapt to students' learning strategies, the sequence and difficulty of the task, learning styles, abilities, time of feedback and preferences (Johnson and Samora 2016). The adaptive learning systems are developed from research on intelligent tutors, Big Data analytics, learning analytics and educational data mining techniques. Adaptive learning systems consist of adaptive hypermedia systems and intelligent tutoring systems. The positive effects of utilizing adaptive systems include efficiency, interaction, support and effectiveness (Hasanov et al. 2019). These systems encourage students to own their learning journey via automated feedback cycles that allow the students to progress independently from the course instructor. These systems are gaining traction due to their ability to deliver learning content and adapt to individual student needs.

Progress in developing new data analytical techniques has produced more successful learning systems in the education sector. Additionally, numerous studies have discussed and modelled how AI techniques can be applied to learning systems. However, few examples of implemented contemporary learning

interventions have been identified (Wakelam et al. 2015). Thus, implementation of these systems in education settings seems to be at its infancy. Verdú et al. (2015) stated, "Many of these learning systems as well as Intelligent Tutoring Systems (ITS) are described in the literature, and their effectiveness has been proved. However, these systems are rarely used in real educational settings practices in ordinary courses." The most mentioned adaptive learning systems in literature are ITS, which basically enable tutoring and personalized support. However, updated literature on the new generation of AI-enabled adaptive learning systems is lacking (How et al. 2019). Additionally, another significant challenge is bridging the gap between pedagogy and emerging AI techniques.

The purpose of this study was to map recent literature and present the summarized findings of some of the topics related to adaptive learning systems. The topic discussed in this paper is AI-enabled adaptive learning systems, which provide solutions for overcoming challenges students face. These challenges include inefficiently capturing student proficiency, lacking metacognition to self-assess students' knowledge decay, lack of accommodation of practical skills in the systems, facing student disengagement and poor student motivation and utilizing outdated adaptation technologies (Hampton et al. 2018; Tommy et al. 2016). Hopefully, this review will act as a guide for future studies on the use of adaptive learning systems and their AI applications to solve specific learning problems. Section 2 introduces the systematic literature mapping (SLM) process, search protocol and results from the execution of the SLM. Section 3 presents the results and discusses the findings from the retrieved literature. Section 4 concludes the paper.

Research Methodology

This section describes the applied systematic literature methodology. The authors followed the guidelines for systematic literature proposed by Kitchenham and Charters (2007). The method follows a well-defined and structured protocol of the review. The search terms are derived from formulated research questions (RQs). Then, relevant databases are selected. Inclusion criteria and exclusion criteria are defined to find relevant results. Titles and abstracts are screened thoroughly to determine whether the paper answers the research questions or not. Also, titles and abstracts are analysed with the goal of extracting significant data. The methodology is described in form of research protocol in figure 1. In preparing the review was identifying the target research objectives related to the literature of AI applications in contemporary learning systems. This ensured that the SLM was well structured. To obtain existing evidence of AI applications in modern learning environments published in the past five years, two RQs were formulated:

RQ1: What problems and concerns do the studies address in contemporary learning environments?
RQ2: What type of interventions utilize AI in contemporary learning environments?

The research strategy was formulated based on a formed review protocol that can reduce potential research bias. Key search words were identified, and search strings were generated to reduce the number of articles. Synonyms and substitute spellings were identified for the keywords, too. Then, the search structure was put together, and finally, the search process was conducted. To perform the database searches, focus was placed on two main terms of interest: "adaptive learning system" and "artificial intelligence." The terms "artificial intelligence" and "machine learning" are sometimes used interchangeably; therefore, two parallel searches were conducted. Synonyms for adaptive learning systems were utilized as well, such as "adaptive learning ecosystem," "adaptive learning environment," "adaptive learning platform," "adaptive learning setting" and "adaptive learning technology." The Boolean operators *OR* and *AND* are used for connecting the terms.

For the process, the researchers utilized EndNote X9, NVivo 11 and Excel spreadsheets to extract publication outlets, find duplicates and organize the information. The search was conducted between November and December 2019 on the following nine databases: ACM, EBSCO Host, SAGE Journals, Scopus, Taylor and Francis, Web of Science, Wiley, AIS Library and Emerald. The databases were selected to have a wide selection of relevant and recent journals and conference proceedings in this SLM. These databases include several AI-related academic journals such as IEEE Transactions on Pattern Analysis and Machine Intelligence, International Journal of Intelligent Systems, Journal of Artificial Intelligence and Soft Computing Research and British Journal of Educational Technology. Using the selected search strings, 1672 articles were retrieved, and after removing the duplicates (321) 1351 articles. Studies were selected by considering inclusion and exclusion selection criteria to ensure their relevance and their ability to answer the RQs. Furthermore, titles and abstracts were screened to determine whether the papers answered the

RQs or not. Thus, 121 papers were included in this study after data extraction was completed and inclusion criteria were applied (see Figure 1).

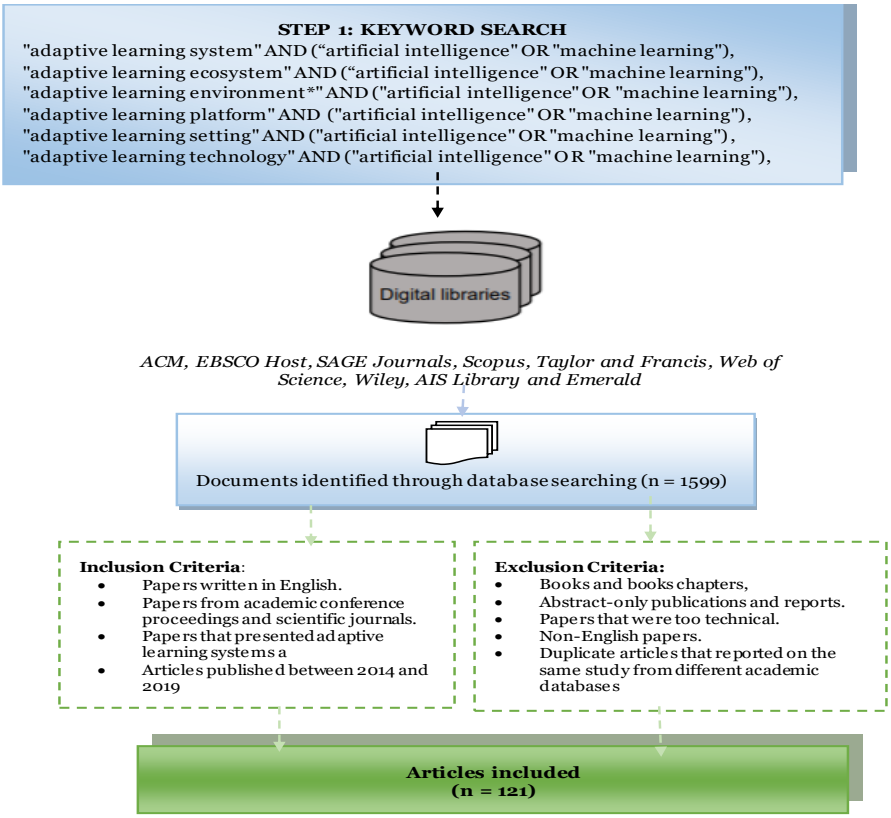

Figure 1: SLM process

Results and Analysis

The 121 selected papers were published between 2014 and 2019. In terms of publication channels, 52% (63) of the included papers were scientific journals, 45% (55) were conference papers, and 3% (3) were published in conference proceedings. The articles were categorized based on the type of research approach used, and the categorization used in this study was based on an existing research approach classification by Wieringa et al. (2006). The most utilized research approach was evaluation research (33 articles), followed by validation research (30 articles). The philosophical approach and literature review approach were third and fourth, with 24 and 22 papers, respectively. The distribution of documents per year is shown in Figure 2.

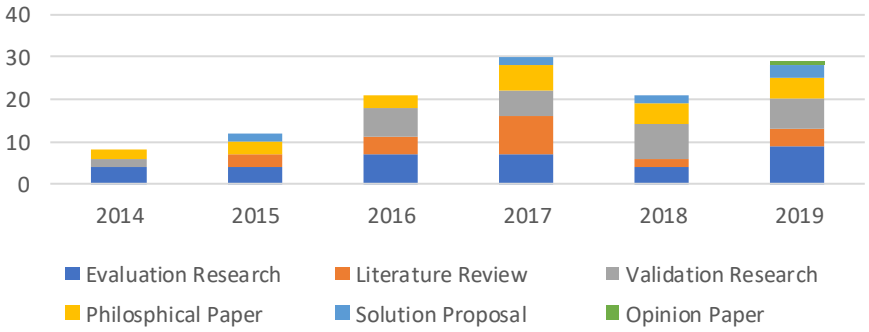

Figure 2 Type of paper and number of publications per year

RQ1: Problems and Concerns Addressed in the identified studies

The study's second RQ aimed to identify the problems and concerns addressed in the identified papers. These issues were coded and grouped into various categories, as seen in Table 2. A note to the reader: The complete database that include all the 121 references in RIS format can be downloaded (Kabudi et.al. 2019)

PROBLEMS AND STUDIES (N)	**REFERENCES**
Student learning issues (24)	Verdú et al. 2015; Ghorbel et al. 2015; Samarakou et al. 2016; Hssina and Erritali 2019; Wongwatkit and Prommool 2018; Cui et al. 2019; Hayati et al. 2017; Kakish and Pollacia 2018; Syed et al. 2017; Tosheva et al. 2017; Louhab et al. 2019; Ciolacu et al. 2019; Gallego-Durán et al. 2018; Mavroudi et al. 2016; Birjali et al. 2018; Bhaskaran and Swaminathan 2014; Sosnovsky and Chacon 2014; Kurisu et al. 2014; Ruan et al. 2019; Shawky and Badawi 2018; Mudrak 2017; Kasinathan et al. 2017; Ishak and Ahmad 2016b; Padron-Rivera et al. 2018
Difficulty in attaining learners' skills (14)	Isaías 2018; Slater and Baker 2019; Mousavinasab et al. 2018; Afanasyev et al. 2017; Ford et al. 2019; Fletcher 2019; Wongwatkit 2019; Lippert et al. 2019; Pandey et al. 2014; Gavriushenko et al. 2017; Nurjanah 2016; Hampton et al. 2018; Kurisu et al. 2014; Stacy and Freeman 2016
Outdated models or methods or complex models (13)	Jonsdottir et al. 2015; Vogel-Walcutt et al. 2016; Janati and Maach 2017; Sosnovsky and Chacon 2014; Dargue and Biddle 2014; Brawner and Gonzalez 2016; How et al. 2019; Bradáč and Kostolányová 2017; Costa et al. 2017; Almohammadi et al. 2017; Chin et al. 2018; Liang and Hainan 2019; Rosé et al. 2019
Lack of comprehensive review of contemporary learning environments (12)	Villanueva and Moreno 2018; Fardinpour et al. 2014; Grimon et al. 2017; Hasanov et al. 2019; Aldowah et al. 2019; Kardan et al. 2015; Bimba et al. 2017, Mavroudi et al. 2016; Güyer and Çebi 2015; Bradáč and Kostolányová 2017; Zhao et al. 2015; Wakelam et al. 2015; Cui et al. 2019
Background and profile of student issues (11)	Ghorbel et al. 2015; Samarakou et al. 2016; Hssina and Erritali 2019; Yang et al. 2019; Zhong 2019; Tommy et al. 2016; Oskouei and Kor 2017; Oliveira et al. 2017; Idris et al. 2017; Ishak and Ahmad 2016a; Hampton et al. 2018; De Santana et al. 2016
Low usage of adaptive systems (9)	Somyürek 2015; Liu et al. 2017; Verdú et al. 2015; Cui et al. 2019; Holthaus et al. 2018; du Boulay 2019; Andaloussi et al. 2017; Nosenko et al. 2019
Design issues (7)	Chen et al. 2018; Dounas et al. 2016; Khan and Mustafa 2017; Hou and Fidopiastis 2017; Liu et al. 2017; Dounas et al. 2019; Ewais and De Troyer 2014
Lack of evaluation standard or method (7)	Dhouib et al. 2016a; Erdt et al. 2015; Dhouib et al. 2016b; Papoušek et al. 2016; How et al. 2019; Berry et al. 2017
Engagement and motivation issues (7)	Afini Normadhi et al. 2019; Maravanyika et al. 2017; Beyyoudh et al. 2019; Janati and Maach 2017; Ferrándiz and Fonseca 2019; Ruan et al. 2019; Padron-Rivera et al. 2018
Designing and assessing adaptive courses issues (3)	Bimba et al. 2017; Chen et al. 2018; Tsarev et al. 2019
Other (9)	Edwards and Cheok 2018; Saâdi et al. 2019; Milham et al. 2015; Gelaim et al. 2019; Marín-Marín et al. 2019; Gunel et al. 2019; Faisal et al. 2015; Durães et al. 2019; Alexandru et al. 2015

Table 1. Problems and Concerns identified in SLM and references

Many of the published papers identified student learning process challenges as a major concern. The researchers identified difficulty in sharing learning resources, high redundancy of learning materials, learning isolation, inappropriate information load and personalization of information affecting learning process of students (Syed et al. 2017). Other challenges related to the student learning experiences include lack of an integrated adaptive mechanism to manage students' learning experiences; too much information and, thus, a lack of personalized learning (Louhab et al. 2019). In addition, the existing e-assessments and the personalized learning paths (PLPs) were generally inadequate for the learning content in the systems (Birjali et al. 2018). To address this main concern, several authors proposed adaptive learning mechanisms to be integrated to the existing systems in order to manage the learning process of students. For instance,

Louhab et al. (2019) presented a model that can be combined with Moodle platform to provide adaptive learning. The proposed model was validated by implementing Smart Adaptive Management for Flipped Learning (SAM-FL) plugin.

Another main challenge identified in the SLM was difficulty in attaining learners' skills learners taught in a course; 14 papers discussed this difficulty. These skills may be computer programming skills, or critical thinking in form of problem solving and decision-making. Mousavinasab et al. (2018) in their systematic literature review noted how little AI techniques have been utilized in ITS to address this issue. Moreover, Afanasyev et al. (2017) also noted that adaptive learning systems had problems integrating theory taught in class and continuous practical training assessment of the current competency levels of the students. Most students face difficulties with university exit exams on IT literacy because of low knowledge retention levels and a lack of exercises to practice necessary skills (Wongwatkit 2019). Therefore, machine learning techniques or AI must be applied to "accelerate the development of technical expertise by novices" (Fletcher 2019). Mousavinasab et al. (2018) recommend and identify AI techniques used to mitigate the problem. For instance, Fuzzy-based techniques, condition-action rule-based reasoning, case-based reasoning, the intelligent multi-agent, and data mining methods are AI techniques that can be used for education of computer programming.

The SLM also identified outdated and more complex models in the systems as a problem. These learning systems, especially ITS, comprises of three primary models i.e. expert, system and student models. Most of these models in the existing ITS, as noted by Dargue and Biddle (2014), "quite complex to enable just about any learner to get the optimum tailored experience possible". Brawner and Gonzalez (2016) noted that the models used "generalised data obtained from a large sample of human subjects, which lacks applicability to individuals." Thus, the applicable impact of these systems is seriously limited (Vogel-Walcutt et al. 2016). Thus, these researchers such as Dargue and Biddle (2014), Brawner and Gonzalez (2016) and Vogel-Walcutt et al. (2016) in their papers discuss of creating non-complex and non-expensive models in contemporary learning systems as solution. Another interesting concern that was addressed was a lack of comprehensive review of new contemporary learning environments (12 papers). Comprehensive reviews of adaptive learning systems are lacking, especially of those that have utilized modern AI techniques (Mavroudi et al. 2016; Wakelam et al. 2015). Several reviews have been conducted, but they are outdated in terms of the application of novel AI techniques (Hasanov et al. 2019). Thus, a recent and updated literature on the new generation of AI-enabled adaptive learning systems is to be done.

Eleven papers addressed concerns related to student profiles and backgrounds. These papers express a need to use AI techniques to make learning systems adaptable to the profile of students. Existing educational systems utilize standardized teaching methods that do not fit the individual characteristics of each student (Oliveira et al. 2017). Zhong (2019) proposed the use of genetic algorithms to automate the search of courses adapted to learners' profiles. Another issue identified in the SLM related to low usage of adaptive learning systems. The eight papers identified that these contemporary learning systems are rarely used in real educational settings (Cui et al. 2019; Holthaus et al. 2018; Liu et al. 2017; Verdú et al. 2015). Somyürek (2015) mentioned four challenges as explanations for why adaptive learning systems are not used on a large scale. These challenges are "inter-operability, open corpus knowledge, usage across a variety of delivery devices and the design of meta-adaptive systems". To address such concern, Cui et al. (2019) recommends further rigorous evaluation studies should be conducted to assess the impact of contemporary learning systems. The authors evaluated impact of an intelligent adaptive learning systems, Yixue Squirrel AI on student's math and English language learning.

Concerns in designing an adaptive learning system, a lack of methods to evaluate contemporary learning systems and problems related to engagement and motivation were also highlighted (7 papers for each category). Designing and assessing a course that uses an adaptive learning system was also identified as a concern. The remaining papers noted instructor's workload, shortage of teachers, limited resources, poor organization of information and unsuccessful data mining techniques in the education sector as problems. Therefore, from what has been highlighted in this section, there is a need of contemporary learning systems to address the issues mentioned above. In the next research question, several AI interventions in their coded categories are discussed to show how they address the main problems and concerns highlighted in SLM.

RQ2: AI Interventions/Solutions in Contemporary Learning Environments

As shown in Table 1, the articles were placed in five categories based on the interventions that applied AI in contemporary learning environments. These categories are systems, frameworks, models, approaches and combinations of interventions.

Many of the published documents used a system (adaptive learning system, intelligent mechanism or adaptive learning platform) as an intervention (47 articles). The researchers either used an existing system, such as QuizBot, MeuTutor, Auto Tutor or Yixue Squirrel AI, or developed a customized adaptive learning system for the scenario studied. Tommy et al. (2016) developed an intelligent and adaptive test system to tackle the problem of the system's inefficiently capturing student proficiency. Hampton et al. (2018) designed a mobile adaptive learning system called the Personal Assistant for Life-Long Learning (PAL3) to prevent knowledge decay.

Interventions & Studies (N)	**References**
Adaptive learning system (48)	Louhab et al. 2019; Kurisu et al. 2014; Edwards and Cheok 2018; Cui et al. 2019; Tosheva et al. 2017; Kakish and Pollacia 2018; Stacy and Freeman 2016; Pharmer and Milham 2015; Liu et al. 2017; Govindarajan et al. 2016; Gunel et al. 2019; Sosnovsky and Chacon 2014; Zhong 2019; Fardinpour et al. 2014; Hayati et al. 2017; Jonsdottir et al. 2015; Oskouei and Kor 2017; Papoušek et al. 2016; Ruan et al. 2019; Samarakou et al. 2016; Zhao et al. 2015; Wang et al. 2019; Padron-Rivera et al. 2018; Gallego-Durán et al. 2018; Hampton et al. 2018; Kasinathan et al. 2017; Milham et al. 2015; Pandey et al. 2014; Verdú et al. 2015; Lippert et al. 2019; Wongwatkit 2019; Afanasyev et al. 2017; Tommy et al. 2016; Beyyoudh et al. 2019; Ciolacu et al. 2019; De Santana et al. 2016; Ford et al. 2019; How et al. 2019; Fletcher 2019; Dziuban et al. 2018; Oliveira et al. 2017; Martinez et al. 2016; du Boulay 2019; Bradáč and Kostolányová 2017; Sun et al. 2017; Berry et al. 2017; Ferrández and Fonseca 2019; Liu et al. 2017
Framework (22)	Janati and Maach 2017; Maravanyika et al. 2017; Dounas et al. 2016; Gelaim et al. 2019; Khan and Mustafa 2017; Hou and Fidopiastis 2017; Dhouib et al. 2016a; Shawky and Badawi 2018; Ishak and Ahmad 2016; Faisal et al. 2015; Ghorbel et al. 2015; Syed et al. 2017; Alexandru et al. 2015; Bimba et al. 2017; Mavroudi et al. 2016; W. Chen et al. 2018; Cui et al. 2019; Janati and Maach 2017; Mavroudi et al. 2016; Heffernan et al. 2016; Costa et al. 2017; Tashiro et al. 2016
Model (14)	Wongwatkit and Prommool 2018; Brawner and Gonzalez 2016; Dhouib et al. 2016b; Bhaskaran and Swaminathan 2014; Durães et al. 2019; Gavriushenko et al. 2017; Holthaus et al. 2018; Idris et al. 2017; Mudrak 2017; Birjali et al. 2018; Liang and Hainan 2019; Slater and Baker 2019; Nurjanah 2016; How et al. 2019
Adaptive approach (2)	Hssina and Erritali 2019; Ewais and De Troyer 2014
Combination of interventions (1)	Chen et al. 2018

Table 2 Categories of interventions and references

An affective tutoring system (ATS) named Tamaxtil was developed to identify when the students became frustrated and confused, at which point it would offer them help (Padron-Rivera et al. 2018). On the other hand, some research evaluated existing systems to see how they could be improved. Where the current systems had issues, the researchers improved them by adding or utilizing intelligent mechanisms, learning analytics, data mining techniques and plugins, such as Smart Adaptive Management for Flipped Learning (SAM-FL). For example, Liu et al. (2017) used Brightspace LeaP™ adaptive technology to create adaptive intervention modules. The main objective of their research was to investigate the impact of adaptive learning in a large research university in the southwestern USA. Their modules were embedded via the Learning Tools Interoperability integration on the Canvas learning management system.

The other main form of intervention used was frameworks for adaptive learning (20 articles). Frameworks are constructs that define concepts, practices, values and assumptions and provide a set of guidelines on how to implement the frameworks. The frameworks introduced in the included papers provided various solutions to different problems in the learning environments. One of the problems was feedback in the learning environment. Bimba et al. (2017) proposed a cognitive knowledge-based framework for adaptive feedback that combined pedagogical, domain and learner models. Hou and Fidopiastis (2017) proposed a

generic conceptual framework for intelligent adaptive learning systems to address the lack of guidance for transferring learning effectiveness to field training when designing such systems. Another issue was high levels of demotivation, boredom, poor engagement and frustration among the students. Therefore, Maravanyika et al. (2017) proposed an adaptive recommender system-based framework for personalised teaching on e-learning platforms to mitigate the mentioned issues. In certain situations, adaptive learning systems are limited by formal teaching activity. This creates passive attitudes and poor motivation among the students. To address this issue, a framework was developed to rely not only on the adaptation of educational content but also on presentation of the content (Janati and Maach 2017). The framework took into account the background of students (i.e., their social, cultural and geographical demographics and their knowledge and preferences). Most of the frameworks recommended as solutions in these papers comprised essential elements and features for implementation in contemporary learning environments. The proposed items were in the form of AI techniques, user (learner) models and other adaptive techniques. The frameworks highlighted and described the relationship between the suggested elements. Also, the coded frameworks provided numerous vital steps and actions for achieving a better adaptive learning experience.

Fourteen papers utilized models for adaptive learning systems. A model, is *"a pattern of something to be made, a description or an analogy used to visualize and reason about the system to be developed and its likely effects."* Stoica et al. (2015). The models were either a hypothesis, problem-solving tool, experiment or abstract narrative of a component or system to be designed, and they showed a simplified view of the part of the whole "system" being investigated. Most of the models found were constructed when issues like adapting the learner's profile to pedagogical objectives, improving the quality of the learning process and adaptive presentation of course content emerged. Bhaskaran and Swaminathan (2014) proposed and tested an intelligent adaptive e-learning model that intelligently classified students using the K-nearest-neighbour algorithm. Another intelligent model was proposed that used both supervised and unsupervised machine learning techniques to correctly and adaptively choose learning material for a particular student (Idris et al. 2017). Furthermore, a novel adaptive e-learning model based on Big Data was proposed to improve the quality of the learning process by providing the most suitable learning content for each student. This model was designed to address the inaccurate and incorrect learning material selection process in adaptive learning systems. Another example is a personalized adaptive online learning analysis model that analysed the structure of a learning process using Big Data analysis (Liang and Hainan 2019).

Two papers explored an adaptive approach as a solution. An approach is viewpoints or theoretical concepts applied to understand, explain and solve a problem in a particular phenomenon. Hssina and Erritali (2019) presented an adaptation approach for their developed adaptive e-learning system. This approach allowed learning paths to be generated that adapted accordingly to the profiles of students. They used a genetic algorithm to search for optimal learning paths and then tested and evaluated their adaptive learning system. In another study, an adaptive authoring approach was extended and developed for traditional learning material (Ewais and De Troyer 2014). The purpose of acquiring such an approach was adding adaptivity aspects to an existing 3D virtual learning environment. Finally, one paper provided a framework and systems as a combined solution to address how recommendations, a vital component of the adaptive learning system, should be made. Chen et al. (2018) proposed a mathematical framework that characterized the recommendation system process. Two plain-vanilla systems whose optimal recommendation strategies are analytically interpreted were introduced and used.

Discussion and Conclusions

The conducted SLM revealed some interesting insights. Regarding interventions, system (adaptive learning system, intelligent mechanism and adaptive learning platform) and frameworks for adaptive learning were the most utilized. Our review of the literature revealed that the use of both system and framework can play an important role to improve learning experience of students, their learning outcomes, mitigating poor levels of motivation and engagement (Bimba, 2017, Janati and Maach 2017, Padron-Rivera et al. 2018, Maravanyika et al. 2017). A possible reason to this is the recent recognition of the importance of AI enabled learning systems in solving more challenging problems in education. The growing use of systems and framework for adaptive learning is in agreement with Hampton et al. (2018) and Tommy et al. (2016) on using AI-enabled contemporary learning systems to address challenges such as student disengagement and poor student motivation. Some systems, frameworks and models were created to replace the outdated ones that existed and improving the learning experience (Liu et al. 2017, Liu et al. 2017, Chen et al. 2018). Our

reveiew indicated that still there is low number of implemented interventions designed to address the major concerns and problems identified in the papers. The overlooked concerns include difficulty in attaining learners' skills, background and profile of student issues. This observation is in agreement with Xie et al. (2019) who noted that designers of adaptive learning systems give little attention to courses that have practical skills as a prerequisite. There is a need of addressing this research gap.

The most common challenges identified in this SLM were related to student learning process, difficulty in attaining skills, outdated and more complex models in the systems and lack of use of adaptive learning systems. Our review showed that issues such as low usage of adaptive systems, design issues, lack of evaluation standard or method, designing and assessing adaptive courses issues are not highly considered. This concern is noted by Verdú et al. (2015), especially on low usage of adaptive systems. The authors stated, "Many of these learning systems as well as Intelligent Tutoring Systems (ITS) are described in the literature, and their effectiveness has been proved. However, these systems are rarely used in real educational settings practices in ordinary courses." In the research of AI enabled learning systems, this concern is to be addressed in the future. More studies should be conducted on the reasons that lead to the usage of adaptive learning systems. More studies should reflect on whether the complexity of these contemporary learning systems have been addressed and how. Also, the issue of designing and assessing adaptive courses should be given attention to increase the usage of these systems in real educational settings. Our review indicates that out of 121 papers, only three papers identified that as a problem to be addressed (Bimba et al. 2017; Chen et al. 2018; Tsarev et al. 2019). This research gap should be given more attention in the future.

The study contributes to AI applications and modern learning environments by identifying the typical interventions that are utilized. Research on AI enabled contemporary learning systems is on the rise, and is expected to continue with great potential for higher education institutions. It is important to note that the AI enabled contemporary learning systems are still under-researched in education. The major contribution of the study is bringing awareness to researchers and system developers on contemporary learning systems and AI techniques. The study provides important insights for practitioners in education settings who are interested in adaptive learning systems. For future research, more adaptive systems, frameworks and models should be developed to provide solutions for overcoming the mentioned challenges that students face, especially attaining skills (Papamitsiou *et al.*, 2018). Existing systems lack modern techniques or tools for students to practice and master their skills. This is due to the complex measurement models for skills and limited learning support. However, this difficulty can be addressed by boosting the learning content in the adaptive learning system using AI techniques (Giannakos *et al.*, 2019). Thus, a system that covers and accommodates the required skills and requirements for students is needed. Also, to address the issue of complexity existing adaptive learning models should be improved by AI techniques building on learning analytics (Papamitsiou *et al.*, 2018, Pappas, Giannakos and Sampson, 2019).

This study was associated with several limitations due to the nature of the research. Though the recommendations by Kitchenham and Charters (2007) were followed to ensure a systematic literature review, the search words, strings and databases may have limited the review. The key strings were limited to adaptive learning systems, and these may be extended to other types of contemporary learning environments, such as recommender systems. The selected databases, inclusion criteria and exclusion criteria may, by nature, have excluded some research. Additionally, questions like methodological approaches applied and purposes for which AI has been used in learning systems were not reviewed, which can be further discussed in future research.

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