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A systematic review in understanding stakeholders' role in developing adaptive learning systems

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Abstract

The creation and development of adaptive learning systems involve various stakeholders in the overall development process. To understand how the involvement of these stakeholders is approached, we conducted a systematic literature review to determine which stakeholder groups are actively involved within different stages of system creation. We identified 35 papers published between 2018 and 2022 relevant to this review and used these to identify specific areas where stakeholder involvement has been carried out. We show that educators have very little involvement in the design, implementation, and evaluation of adaptive learning systems. We suggest that this is an area where further research is required.

Keywords Adaptive learning systems · Stakeholder involvement · System design · System implementation · System testing

Introduction

Adaptive learning allows for the creation of a personalised learning experience for students where each learner can complete a course differently. In an adaptive learning environment, the path taken by the learner varies from one learner to another. For example, some learners may cover subject areas that others do not, while some learners may gain details on topics that others do not need (How & Hung, 2019). Adaptive learning systems allow for the personalisation of

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instructional content, reading, practical activities, and assessment for individual students based on their current abilities and performance (Robert & Combescure, 2021). The personalisation of Adaptive learning systems creates a unique learning environment for each learner (Liu et al., 2017) that focuses on continually improving students' knowledge (Rosita Cecilia et al., 2016).

One of the main benefits seen for adaptive learning is positive outcomes for student attainment. Adaptive learning has pedagogical advantages including acceleration, remediation, meta-cognition, mastery-based learning, immediate feedback, and interactive learning (Hattie, 2008). These benefits are made possible as adaptive learning systems can dynamically adjust the way content is delivered to students based on their own learning preferences or their responses to in-course assessments (Osadcha et al., 2020). Despite the potential benefits of adaptive learning systems, there are also some drawbacks associated with their implementation. Factors such as limitations in the use of specific learning styles within individual systems can reduce a system's overall effectiveness and usefulness for learners (Truong, 2016). Changes made to content in an adaptive learning system are designed to be "dynamic and interactive" (Moriña, 2022) and are viewed as an emerging instructional technology within higher education (Pedrini & Ferri, 2018).

A key area of research for adaptive learning focuses on learners' consumption of adaptive content and subsequent analysis of their performance by educators. In adaptive learning systems, educators can immediately see where learners are struggling and, more importantly, which teaching methods can help them improve and master the material (Aeiad & Meziane, 2019). Adaptive learning software can use AI and ML techniques to adjust the learning path of learners in real-time, which can then be analysed by educators to better understand the needs of individual learners within a course (Robert & Combescure, 2021).

However, despite a large amount of work that has been carried out to focus on improving learner attainment and attitudes towards adaptive learning systems, very little in comparison has focused on understanding how different stakeholders are involved in the adaptive learning process. The importance of highly skilled subject matter experts within education is one of the highest drivers for learner attainment (Johnson, 2017). The ability of an excellent educator to engage with a topic and consider the needs of a class is highly complex (Fauth et al., 2019) and involves several interlinking steps (Hamroev, 2019). Therefore, additional research is needed to understand the different stakeholders' roles within an adaptive learning environment.

Previous systematic reviews examining adaptive learning have focused on publication trends, teaching context, components of research methods, research priorities, and adaptive strategies and techniques (Martin et al., 2020a). The purpose of this systematic review is to develop an understanding of the various stakeholders that are involved in the creation of an adaptive learning environment and what their roles are in this process. Determining the roles and activities these different stakeholders carry out will enable us to demonstrate whether the role of 'educator' has been considered in adaptive learning environment development.

Our study makes the following contributions:

1. A systematic review examining the role of stakeholders in the development of adaptive learning systems (described in Sect. 3),
2. Identification of key stakeholders and how they interact with the design, implementation, evaluation, and testing components of adaptive learning (described in Sect. 4),
3. Areas for future research to promote increased stakeholder involvement within adaptive learning systems (described in Sect. 5).

In this paper, we first situate our research within the broader context of related work focusing on adaptive learning (Sect. 2). We then present the methods for our systematic review (Sect. 3). Next, we describe the roles that different stakeholders take and the stages of adaptive learning system development they are involved in (Sect. 4). Finally, we provide future work recommendations on how increased stakeholder involvement within adaptive learning systems could be achieved (Sect. 5).

Background and related work

Adaptive learning systems are personalised learning platforms that adjust to the learning tactics of students, the order and complexity of task skills, the timing of feedback, and the preferences of students (Addanki et al., 2022). Learners can advance independently of the course educator while using these platforms, enabling them to track their learning journeys by including automatic feedback loops within the systems. For example, if a student is participating in a course on web development, they would be able to progress through a number of activities that focus on this topic, receiving feedback on their progress automatically from an adaptive learning system. The learning journey, in this instance, replaces the one-size-fits-all methods that are used within a traditional classroom with a more personalised experience that is better suited to an individual's own learning style.

Current challenges in higher and further education relating to increased workload pressure negatively impact the learning experience for educators and learners alike (O'Leary & Wood, 2019). The ability of educators to observe, manage, and adapt the learning process is becoming increasingly more challenging. These challenges can be overcome with various technologies and systems that aid in the knowledge transfer process and make it more efficient (Smyrnova-Trybulska et al., 2022). Adaptive learning is a technology-induced learning technique that solves problems by developing tools that allow self-paced and individualised learning.

For adaptive learning systems to be successful, care needs to be taken to understand the various needs of individual learners. One method that can facilitate this is implementing an Open Learner Model to represent learner access. Open Learner Models can be used to alter the overall context structure for learners and other stakeholders involved in the learning process, such as peers, parents, and instructors (Hooshyar et al., 2020). They allow for the maintenance of data to enable adaptation for the individual concerning their current learning needs (Barria-Pineda et al., 2018) and create ways for adaptive learning tools to promote meta-cognitive

activities, including self-monitoring, planning and reflection. To take a more holistic view of adaptive learning, Open Learner Models include essential stakeholders within the learning process. However, not all stakeholders have an immediate and direct impact on the development and usage of adaptive learning systems, for example, peers and parents. These additional stakeholders are, however, worth mentioning as it illustrates the very large and interconnected network of people that are involved in the learning process. Our work focuses on learners, educators, developers, and academic researchers as the primary stakeholders involved in adaptive learning systems.

The correct implementation of adaptive learning systems can have positive benefits within education (Imhof et al., 2020). These systems allow learners to gain knowledge and skills with limited support from tutors, lecturers, learning support tools, and technical resources (Gros, 2016). Such systems are vital since they may help IT and IS instructors rethink and adapt their course designs to give more relevant learning experiences to their students (Pappas & Giannakos, 2021). Adaptive learning systems can provide cost savings, user feedback, continual course content access, enhanced performance, and effective communication for learners (Mirata et al., 2020).

Literature reviews in adaptive learning systems

Although several literature reviews have previously been carried out that focus on adaptive learning, none have focused on the role of stakeholders within the creation of AL systems.

Previous systematic literature reviews in adaptive learning systems have focused on the application of AI and ML approaches within this space. This has included understanding how AI-enabled learning interventions can be utilised (Kabudi et al., 2021) and how systems can identify *"at risk"* students that are not engaging in the learning process (Richter et al., 2019). Work has also discussed how different metrics can be used to keep students on track with their learning (Munir et al., 2022) and to understand how behaviour changes in students can be recognised and then acted on accordingly (Okoye, 2019). Systematic reviews based on AI have also focused on how content can be adapted automatically to improve the overall learning experience (Mousavinasab et al., 2021; Gheibi et al., 2021).

Literature reviews have also examined user characteristics and how these are used to adapt systems. For example, Martin et al. (2020a) focused on how cognitive, behavioural, and emotional characteristics are used to adapt the way content is presented. Machado et al. (2021) debates that the understanding of the personal characteristics of users is important in the selection of the most suitable learning model for an AL system. In addition, Normadhi et al. (2019) concluded that learning styles adopted by both teachers and developers rely on the discovered individual personality traits of users. Nakic et al. (2015) finds that when adaptions are based on a student's learning style, background knowledge and learning preferences outcomes for students are more likely to be successful.

Finally, systematic reviews in this area have focused on aspects of learner engagement. Kusumastuti et al. (2021) examined how customising course instruction can increase the interest of learners. Ogunyemi et al. (2022) determined that areas such as instructor's feedback, learning materials, learner's personality, course duration, and active participation, can all be used to increase engagement. Building on this, Martin et al. (2020a) argues that adaptive systems should include references to learner, content, and instructional models (opposed to only learner models). Additionally, Pan et al. (2022) focused on subject-specific characteristics and how these can contribute to learner engagement. Xie et al. (2019) suggests that adaptive learning systems are likely to become more ubiquitous in the future, with wearable technologies and immersive experiences used to enhance learning.

Despite the number of literature reviews that have been conducted in areas related to adaptive learning systems, our initial inspection in this area has shown that none have attempted to understand the stakeholders that are involved in the design of these systems, and the role that these stakeholders have played.

Stakeholders in adaptive learning systems

The development of adaptive learning systems requires involvement from several stakeholder groups. These stakeholders participate in designing, implementing, evaluating, and testing adaptive learning systems. Stakeholder involvement is primarily based on including people present in a traditional education setting, supplemented by a mixture of software developers and academic researchers.

The primary stakeholder involved in adaptive learning systems is the *learners* themselves. Learners provide the usability function for AL systems, which is fundamental to the overall deployment. Learners, in their capacity as students, play an essential and active part in the educational process. Because of how times have changed, the function of the student in education has shifted from that of a facilitator to that of a task monitor. The implementation of adaptive learning systems relies on understanding an individual's learning style to define algorithms that can improve the experience and self-management of learners (Fasihuddin et al., 2016). Learners participate in discussions, behave in a responsive manner, engage with other learners and teachers, and participate in education activities (How & Hung, 2019). Hence, their input and contribution are diverse in implementing adaptive learning systems.

Second, *educators* are stakeholders based on their primary role within the educational sector. Their role as content creators and sources of course material cannot be underestimated in AL design (Khosravi et al., 2020). In addition, meta-cognitive teachers think about students' needs before, during, and after teaching, enabling them to adapt to students' differences and learning needs (Aeiad & Meziane, 2019). Teachers play a leading role in learning activities, providing students with a wide range of opportunities to freely choose the learning path and training them to use it

An additional stakeholder group involved are *academic researchers*. Researchers enable knowledge by discovering different facts, theories, viewpoints, and ideas concerning the deployment of adaptive learning systems (Al Abri et al., 2020). They identify teacher factors such as experience, beliefs, knowledge, and thinking related

to adaptive teaching. (McLaughlin & Talbert, 2001). Academic researchers have also identified provisions for adaptive teaching in educational institutions, such as the teaching methods and assessment practices involved (Aeiad & Meziane, 2019). Researchers propose an adaptive agent-based architecture to extend the learning process to support educational decision-making and adaptive behaviour.

Research approach

In this work, we conduct a systematic literature review to answer the following research question:

RQ   What involvement do stakeholders (i.e. learners, educators, developers, and academic researchers) have in the development of Adaptive Learning systems?

Our systematic review protocol follows guidance created by Boland et al. (2017) and was chosen due to familiarity with the method, guidance from academics within our home institution, and the usage of this protocol within subject domains similar to that of our own. The protocol consists of the following four phases:

1. Identify Potentially Relevant Papers
2. Filtering Initial Set of Papers
3. Carry out a Detailed Review of Papers
4. Paper Analysis

A summary of our literature review process is shown in Fig. 1. The remainder of this section discusses our review process and the limitations of our approach.

Review process

Stage 1: identify potentially relevant papers

After an initial set of scoping searches were carried out, five databases were searched for relevant publications. Table 1 gives additional information relating to each database used.

Our final search term consists of four parts connected by OR operators. The keywords in the first section are related to adaptation and are intended to cover adaptation and adaptive systems. If these terms do not appear in the subject of the corresponding work, we include the term personalisation so that the term (adapt* OR personal*) is used as the first fragment of the search term.

> *"Adaptive learning strategies" OR"Adaptive learning context" OR"Adaptive learning design" OR "A systematic review of Adaptive learning" OR"A systematic review of Adaptive learning design" OR"adaptive learning Technology"*
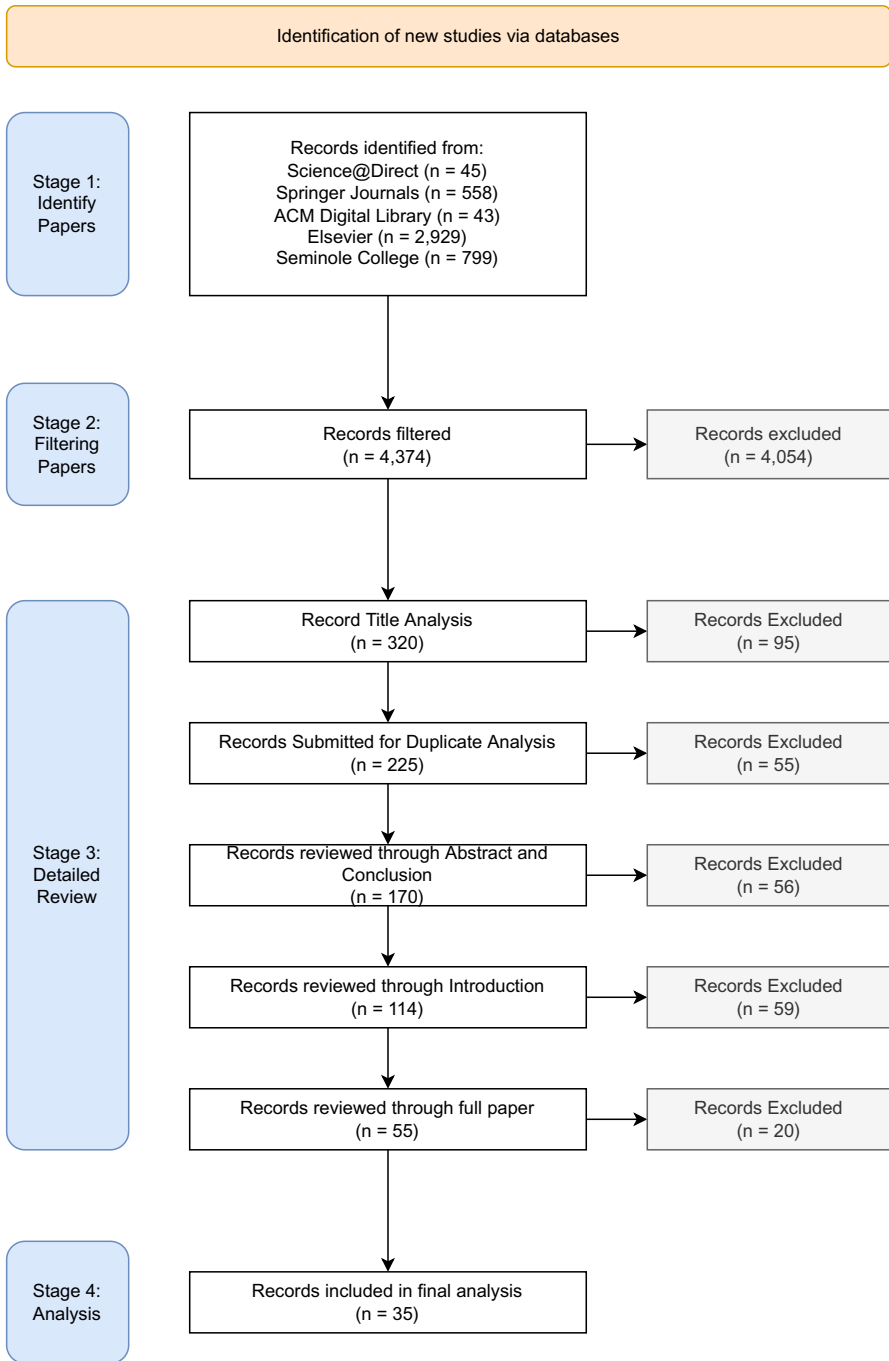
Fig. 1 Summary of our literature review process

Table 1 Electronic databases used

Source	URL
Science@Direct	https://www.sciencedirect.com/
Springer Online Journals Complete	https://link.springer.com/
ACM Digital Library	https://dl.acm.org/
Elsevier	https://www.elsevier.com/
Seminole state college	https://www.seminolestate.edu/library

Table 2 The number of references in the search sites according to the procedures and method of the search

Source	Results
Science@Direct	45
Springer Online Journals Complete	558
ACM Digital Library	43
Elsevier	2929
Seminole state college	799

Similar to other systematic reviews in this area (i.e. Farshchian and Dahl (2015), Martin et al. (2020a), and Rahayu et al. (2022)), we include secondary research sources (i.e existing systematic reviews) in our corpus of results. This is carried out in order to fully explore the role that different stakeholders have when developing tools for adaptive learning.

Stage 2: filtering initial set of papers

All titles, abstracts, and metadata from the 4,374 papers identified in Stage 1 were reviewed (Table 2). Papers that met one or more of the following exclusion criteria were removed:

- Articles that are not full peer-reviewed articles (e.g. workshop submissions, extended abstracts).
- Articles that did not involve any user research (e.g. theoretical models or simulations)
- Articles published prior to 2018 and after 2022.
- Articles that are not focused on adaptive learning systems.
- Articles that are duplicated within our corpus.

A total of 4054 papers were removed and 320 were taken forwards for further analysis in Stage 3.

Stage 3: detailed review

After an initial filtering exercise, all remaining articles were examined in a detailed review. Additional papers were then excluded based on the following criteria:

- Paper titles reviewed and papers excluded if the title did not match with objectives of this study ($n = 95$)
- Papers excluded that had duplicate entries in our dataset ($n = 55$)
- Paper abstracts and conclusions were reviewed and papers excluded that did not match with objectives of this study ($n = 56$)
- Full papers reviewed and articles excluded that did not match with objectives of this study ($n = 20$).

Once the above steps were completed, a total of 285 additional papers had been excluded and a total of 35 articles were taken forward for analysis in Stage 4.

Stage 4: analysis

Our final dataset of 35 papers was entered into a spreadsheet and the data were collected on each one for the following criteria:

- Paper Demographic Information (e.g. author affiliating countries, publication venue, publication year).
- Study Method (e.g. interview, focus group, workshop, artefact development)
- Software system development phases reported in paper (e.g. requirements gathering, development, testing, evaluation)
- Type of stakeholder involvement for system development phases discussed in the paper (e.g. learners, educators, developers, and academic researchers)

Our analysis then focused on exploring the stakeholders that are involved in the development of adaptive learning systems and identifying potential opportunities for increased involvement by stakeholder groups in the future.

Limitations of approach

We limited the inclusion of articles based on specific search terms cited in Sect. 3.3.1 and the databases cited in Table 1. The search terms and databases used in this work were selected after an initial scoping review that focused on the research topic, aims, objectives, and contextual relevance. They allow for the aggregation of materials and literature that are relevant to this work.

In addition to limiting our corpus based on the search terms, we also only selected papers that were published between 2018 and 2022. These dates were

Table 3 Frequency of systematic review paper and non-systematic review paper on adaptive learning

Year	Systematic review	Non-systematic review
2018	1	
2019	3	4
2020	6	6
2021	4	3
2022	6	2

chosen in order to ensure that the work we included was up to date in regard to methods of user inclusion and overall research approach.

A further limitation to this work is related to the time period (2018–2022) that was selected. These dates were chosen due to the relative infancy of Adaptive Learning compared to other HCI domains. Prior to 2018, there is very little work that focus on stakeholder involvement.

Finally, this review contains no specific theory or framework that is used within pedagogic literature. We examined several methodological studies and used these to answer our research questions. Our approach was to separate pedagogic practice from the overall design and implementation of adaptive learning systems so that we could best understand how stakeholders are currently included.

Results and discussion

In this subsection, we provide an overview of our dataset. We begin by presenting descriptive information on the number of articles and their distribution by place of publication and year of publication. We then summarise a series of high-level information about our corpus, focusing on including the research topic, research objectives, and research methods. In all, our dataset contains 35 articles, with the most popular topics being those related to student models, teacher models, and educational contexts. The journals in the 2018–2022 study period, the frequency of published adaptive learning studies, and the number of articles published by year are shown in Table 3.

Paper demographic information

Four characteristics were explored for the demographics of the articles. Firstly, the year of production was explored to determine the distribution based on the findings. Overall, the last five years between 2018 and 2022 have considerable representation with limited domination by one year.

It is worthy of note that 2021 and 2022 have 10 materials each, demonstrating the abundance of recent discussion in the subject area.

Table 4 shows the studies and countries that provided these studies. India has the most publication with 14% of papers coming from this region.

Table 4 Countries involved in adaptive learning research publication

Country	Systematic review studies	Publication papers	Sum of paper	Percent
Norway	3		3	9
Estonia	1		1	3
Switzerland	2		2	6
Germany	1		1	3
Malaysia	1	1	2	6
Usa	2	1	3	9
Brazil	2		2	6
Iran	2		2	6
Belgium	1		1	3
Indonesia	2	1	3	9
Japan	1		1	3
Australia	1		1	3
Uk		2	2	6
Oman		1	1	3
India	1	4	5	14
China		1	1	3
Taiwan		1	1	3
Egypt		1	1	3
Greece		1	1	3

Stakeholder involvement

In this section we discuss different stakeholder groups, and how they are involved in the development of adaptive learning systems. To complete this analysis, each paper was examined and any reference to stakeholder groups and adaptive learning system development stages were highlighted. Our approach in identifying papers uses an approach similar to deductive reasoning where we carried out our analysis with predetermined categories created.

We introduce each group individually and focus on their broad involvement before looking at involvement within Design, Implementation, and Evaluation and Testing. In order to accomplish this we thoroughly reviewed each paper in our corpus and identified the specific stakeholders and involvement areas that were present. A description of our three stages in adaptive learning systems development is below, and a summary of our paper classification can be seen in Table 5.

- *Design* Refers to the process of defining the requirements and specifications of overall system design and where adaptations will take place within systems. This step determines how the system will be built to meet its requirements.
- *Implementation* Involves the actual construction and deployment of the adaptive learning systems, learning materials, and construction of adaptive learning pathways using a given system.

Table 5 Involvement of different stakeholders (learners, educators, researchers) in the development of AL systems and materials

Stakeholders	Design	Implementation	Evaluation
Learner	How and Hung (2019) Al Abri et al. (2020) Machado et al. (2021) Raj and Renumol (2022)	Mavroudi et al. (2018) Kusumastuti et al. (2021)	Smyrnova-Trybulska et al. (2022) Wan and Yu (2020) Pan et al. (2022) Kabudi et al. (2021) Ogunyemi et al. (2022) How and Hung (2019) Hwang et al. (2020) Li and Zhao (2020) Al Abri et al. (2020) Smyrnova-Trybulska et al. (2022)
Educator	Pan et al. (2022) Smyrnova-Trybulska et al. (2022) Kabudi et al. (2021)	How and Hung (2019) Hardy et al. (2019)	Aeiad and Meziane (2019) Al Abri et al. (2020)
Developers	Hwang et al. (2020)	Aeiad and Meziane (2019) Al Abri et al. (2020) Richter et al. (2019) Kaliisa et al. (2022)	How and Hung (2019) Aeiad and Meziane (2019) Al Abri et al. (2020)
Academic researchers	Alzahrani et al. (2020) Martin et al. (2020a) Khosravi et al. (2020)	Kaliisa et al. (2022) Martin et al. (2020a) Kabudi et al. (2021) Gheibi et al. (2021) Saputri and Lee (2020) Khosravi et al. (2020) How and Hung (2019) Aeiad and Meziane (2019)	Khosravi et al. (2020) Aeiad and Meziane (2019)

- *Evaluation* Refers to assessing the effectiveness and impact of the adaptive learning systems after it has been implemented and determining whether it is meeting the needs and goals of stakeholders by using evaluation methods such as usability evaluation and so on.

Learner involvement

Learner involvement in the research of adaptive learning systems is seen as fundamental to success. Participation by this user group is critical in testing, curriculum design, evaluation, design, and development. This group needs to be involved in the overall user experience (UX) of system development as they are the primary stakeholders that will benefit from proper implementation.

Including learners in the development of adaptive learning systems allows for a subjective insight into the variation in learning style and how it affects the overall experience of users (Aeiad & Meziane, 2019). Learners play a fundamental role in developing learning paths within AL systems. Understanding learners' overall experience of AL systems can result in the fashioning of learning styles used for profiling users and their potential learning path (Hwang et al., 2020). This influence is key as learners provide a use-case scenario to model the different paths for the learner.

Design Learners can be included in the design of adaptive learning systems through developing an understanding of their learning needs (How & Hung, 2019) and the way that they interact with educators to build knowledge (Al Abri et al., 2020).

Learners can also be included in the design process for adaptive learning systems by examining characteristics related to their learning styles and how these impact overall system presentation (Machado et al., 2021). Learners can be classified according to dimensions such as perception, input, processing, and organisation, with these dimensions helping understand how overall systems should be designed (Raj & Renumol, 2022)

Implementation We identified very little work that uses learners within the overall implementation of adaptive learning systems. Previous systematic reviews have shown that a key metric in understanding the implementation of systems is in student performance, and a lack of understanding of how to quantify this metric must be overcome (Mavroudi et al., 2018). In Kusumastuti et al. (2021), the role of the student was to develop their own learner model, which then leads to the ability to customise the implementation of an adaptive learning system and how it is then used. Finding ways to include learners within the implementation phase of future interactive learning systems is an under-researched area that may provide interesting outcomes.

Testing and Evaluation Learners can demonstrate their impact on how adaptive learning systems are tested and evaluated. Smyrnova-Trybulska et al. (2022) examines how students rate the effectiveness of adaptive learning tools and if they meet their expectations. Similarly, Wan and Yu (2020) recruited students as evaluators in specific learning interventions that were carried out based on adaptive cognitive

mapping. Learners have also shared their experiences after interacting with adaptive learning systems, and this has been used to evaluate overall system implementation (Pan et al., 2022). In all of the above cases, learners' opinions are sought to develop a comprehensive understanding of the impact that systems have on student learning achievement.

Learners are also key in understanding general barriers to the adoption of adaptive learning systems, with this including system design and overall usability. Kabudi et al. (2021) identified that areas such as difficulty in sharing learning resources, the high redundancy of learning materials, learning isolation, and inappropriate information load are challenges for students using adaptive learning systems. Ogunyemi et al. (2022) showed that learners contribute to the learning achievement discussions and also participate in the MOOC learning environment using structured approaches

One area of adaptive learning systems in which learners see high levels of involvement is using AI and machine learning approaches to develop an overall system evaluation (How & Hung, 2019). Hwang et al. (2020) used students to test and evaluate a fuzzy expert system-based adaptive learning dependent on their cognitive ability, using this to determine personalisation options based on the cognitive uniqueness of individual users. Recent AL systems also rely on understanding learning behaviours, tying patterns to student success and using data analytics in providing immediate feedback (Li & Zhao, 2020). Learners can also guide developers of AL systems to iteratively improve system structure (Al Abri et al., 2020; How & Hung, 2019; Smyrnova-Trybulska et al., 2022).

Educators' involvement

The role of educators in developing adaptive learning systems remains distinct and highly recognised by some scholars. Content management is the core area in which educators function as they are involved in the generation, structuring, and overall presentation of the content (González-Castro et al., 2021; Ogunyemi et al., 2022).

Design Involving Eeucators in the design of adaptive learning systems is a relatively unexplored area. Previous work has examined how educators can be used to define system benchmarks and standards (Pan et al., 2022; Smyrnova-Trybulska et al., 2022), but little has explicitly focused on system design.

Another aspect of design that educators impact is the adoption of AI. Kabudi et al. (2021) showed that educators can assist in the identification and selection of the correct type of AI educational intervention to address a specific challenge. The influence of educators on design and implementation remains low and produces an area for further research.

Implementation One of the roles of educators is to implement tools to cater to users' individual needs. The retrieved knowledge and inference during the development and testing of adaptive learning systems can enable educators to provide additional guidance with learning difficulties to improve their performance (How & Hung, 2019). Considering that the learning experience varies for individual users, educators can play an active role in design that uses the disability of users in aligning the learning process. Hardy et al. (2019) further attest to this role by discovering

that teachers assist the development by using their experience in facilitating the tool in adapting to the meta-cognitive abilities of learners.

Testing and evaluation Testing during the development of a tool is fundamental to its overall development. Educators are fundamental in determining the functionality and re-designing required to achieve the desired outcome.

In testing and evaluation, educators are involved to provide both enables contextual and occupational experience to dissect content-oriented problems in making inferences that will further influence future design (Aeiad & Meziane, 2019). From their perspective, they provide viable information about the suitability of the system to different learning styles. Their informed opinion often becomes useful in discovering the problems and inadequacies of the system (Al Abri et al., 2020).

Developers' involvement

Previous research on adaptive learning has focused on the developer's role in improving performance Adaptive education to increase learner achievement levels.

Design In the design, Hwang et al. (2020) demonstrated that developers can adopt a model (such as Fuzzy logic) in designing an AL system through the deployment of the individual cognitive and emotional states of learners. The overall engineering design is the responsibility of developers.

Implementation In terms of implementation, developers can impact the selection of suitable technology for development. As an example, Aeiad and Meziane (2019) state that the overall implementation method of their system is solely based on the choice of the developers. Al Abri et al. (2020) adopted web 2.0 features including social media as a preference for the developers in implementing collaborative learning. In addition, developers often transform algorithms into functional implementation patterns for adaptive learning systems. This is reflected in developers' enforcement of learning models in the production of AL systems. For example, Richter et al. (2019) enforced learning models that allow predictions, such as the likelihood of students dropping out or being accepted into programmes, to predict the entire learning process. Overall, developers enforce methodological characteristics, pedagogical focus, and theoretical view of the curriculum in adaptive learning system Kaliisa et al. (2022).

Testing and evaluation In testing and evaluation, developers can be responsible for carrying out testing and evaluation sessions but are not necessarily involved in the evaluation themselves. How and Hung (2019) demonstrated how developers can conduct an independent evaluation of their system to understand how it can provide opportunities to educate students' problem-solving abilities so that they can successfully learn the subject. Developers are responsible for retrieving information from users about the functionality, experience and overall usability go the systems (Aeiad & Meziane, 2019; Al Abri et al., 2020).

Academic researcher involvement

Academic Researchers have a large part to play in research focusing on adaptive learning systems, primarily due to their role in carrying out and reporting

on, research studies in this area. The information they retrieve often become a source of informed opinion during development (Ogunyemi et al., 2022). Notably, researchers provide impetus in the testing and re-design aspect of AL development. They often design data collection and analysis implementation for experiments and testing results towards determining the improvements and advancement in design (Khosravi et al., 2020). Researchers strive and become highly dominant for their skill in enhancing the usability knowledge concerning the adaptive learning systems (Martin et al., 2020a). They actively own the data and interpretation that promotes the pluralisation of users.

Design When designing adaptive learning systems, researchers can be concerned with requirement collection and analysis. Alzahrani et al. (2020) established that researchers can provide improved meanings of learning styles that can influence the development of learner models that characterise adaptive learning. This contribution can be derived from monitoring learners' online activity, simulation of usage or through data analysis. Researchers involved in the design process can assist in creating new ways for information to be laid out in a system, focusing on content layout, richness, and formatting (Martin et al., 2020b). Researchers can be actively involved in the design stage to capture core requirements and needs that will further strengthen the design (Khosravi et al., 2020).

Implementation In the implementation of adaptive learning systems, researchers use information retrieved during design to contribute to and influence the implementation process. Kaliisa et al. (2022) used derived knowledge to develop a framework to help educators interpret relevant student achievement results and suggested innovative approaches to improve adaptive learning systems. Researchers can also provide recommendations for implementation algorithms for AL systems as a way to improve system capability (Martin et al., 2020a).

Researchers can provide insight concerning the development and deployment of adaptive learning systems. For example, Kabudi et al. (2021) present the diverse available AI learning systems that can be deployed in adaptive learning systems. Gheibi et al. (2021) provide an improved understanding of machine learning applications in the implementation of self-adaptive systems showing how adaption rules and policies can be used to improve system qualities and important resource management. This idea is expanded on by Saputri and Lee (2020), who establish that researchers can establish suitable machine learning techniques within adaptive learning systems.

Testing and Evaluation In the area of testing and evaluation, researchers are fundamental in the entire process. Khosravi et al. (2020) establish that researchers can provide improved knowledge concerning the system through the exploration of user experience. Also, How and Hung (2019) established that researchers are primarily responsible for evaluating ALS, especially in terms of the deployed technology. Finally, Aeiad and Meziane (2019) discuss that during evaluation, researchers act as experts that assess the quality of the produced content and indicate whether it satisfied the learning outcome.

Conclusion

Regardless of the setting or context, learning is evolving from generalistic knowledge acquisition into individualistic and adaptive styles. This systematic literature review investigated learners, educators, developers, and academic researchers' roles in the design, implementation, and evaluation of adaptive learning systems. We demonstrate that despite the large amount of work in this area, there are significant opportunities for future research involving key stakeholders.

Within the traditional education setting, educators have a large part to play in the overall design and implementation of teaching sessions. This involvement includes the tools to transfer knowledge and the material the learner must cover. One of our main findings shows a lack of educator involvement in the initial design of adaptive learning systems.

To our knowledge, no other work has focused on identifying stakeholders within the creation of these systems, and it is, therefore, challenging to provide any additional elaboration on whether this is a problem. The results of our literature review illustrate the current gaps in how different stakeholder groups are involved in the design, implementation, and testing of adaptive learning systems. Still, at this point, we cannot determine if these gaps have created learning challenges or if the inclusion of stakeholders at different stages would improve the overall experience of using adaptive learning systems. We believe that future work should explore this in detail, attempting to understand if additional stakeholder inclusion is, in fact, beneficial.

Declarations

Conflict of interest No authors have any financial interests in this work.

Ethical approval No ethical approval is required for this work.

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