Smart Learning Environments

REVIEW

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Review on self-regulated learning in smart learning environment

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Abstract

Despite the increasing use of the self-regulated learning process in the smart learning environment, understanding the concepts from a theoretical perspective and empirical evidence are limited. This study used a systematic review to explore models, design tools, support approaches, and empirical research on the self-regulated learning process in the smart learning environment. This review revealed that there is an increasing body of literature from 2012 to 2020. The analysis shows that self-regulated learning is a critical factor influencing a smart learning environment's learning process. The self-regulated learning components, including motivation, cognitive, metacognitive, self-efficiency, and metacognitive components, are most cited in the literature. Furthermore, self-regulated strategies such as goal setting, helping-seeking, time management, and self-evaluation have been founded to be frequently supported in the literature. Besides, limited theoretical models are designed to support the self-regulated learning process in a smart learning environment. Furthermore, most evaluations of the self-regulated learning process in smart learning environment are quantitative methods with limited mixed methods. The design tools such as visualization, learning agent, social comparison, and recommendation are frequently used to motivate students' learning engagement and performance. Finally, the paper presents our conclusion and future directions supporting the self-regulated learning process in the smart learning environment.

Keywords: Self-regulated learning process, Model, Smart learning environment, Smart learning, Learning strategies

Introduction

A smart learning environment is an emerging learning environment that integrates learning objects using smart and mobile technologies to provide smart learning processes for active learning experiences (Muthupoltotage & Gardner, 2017; Zhu et al., 2016). It creates innovative approaches to smart learning, technological services to local on-campus and online students, easy local and remote student-to-faculty interactions and local and remote student-to-student collaborations (Hoel & Mason, 2017). The emergence of a smart learning environment as a rapidly growing area represents how learning objects, learning processes, and learning activities are interrelated that can provide personalized and inclusive learning experiences (Zhu et al., 2016; Zhu & He, 2012). A smart learning environment can be developed using smart and mobile technologies to bring learning personalization to meet learners' learning styles and needs (Singh & Miah, 2020; Uskov et al., 2017). It brings a paradigm shift from traditional learning approaches to new learning methods and offers a student-centred learning environment that integrates diverse pedagogical methods and strategies to practice and reflect on the learning process; and take in a formal and informal learning situation (Singh & Miah, 2020).

On the other hand, self-regulated learning (SRL) has been a critical factor affecting students' learning process (Dabbagh & Kitsantas, 2004). The smart learning environment is a responsive, proactive, and context-aware learning environment. Therefore, it is of interest to explore how SRL can support a learner to develop thinking strategies and promotes metacognitive and motivations towards achieving learning goals (Pérez-Álvarez et al., 2018; Durán-Sánchez et al., 2018; John et al., 2015; Zimmerman, 2002). The student's ability to control their learning process can enhance the educational process and provide the support needed to succeed in an online learning environment (Pérez-Álvarez et al., 2018; Spector, 2016; Zimmerman, 2002). How to support learners' SRL in online learning has been widely examined (Pérez-Álvarez et al., 2018; John et al., 2015). However, a smart learning environment as a new approach to online learning integrates many technologies and offered smart learning to meet learners' needs and learning style. Therefore, there is a need to explore how a smart learning environment supports SRL to inform future research directions. The findings of recent works (e.g., Pérez-Álvarez et al., 2018; Durán-Sánchez et al., 2018) show that different tools, designs, and evaluations have been used to support and evaluate the SRL process in an online learning environment. However, the findings are limited in scope, both in theory and empirical evidence on students' learning performance, achievements, retention, etc. Furthermore, there is a lack of well-documented review of SRL in a smart learning environment. The purposes of this paper are to systematically explore, analyze and report on the recent research of SRL in a smart learning environment to inform future research directions.

Background

Self-regulated learning is a self-thought, plan, and action cyclically used to achieve a learning goal (John et al., 2015; Zimmerman, 2002). It has been identified as one of the critical factors affecting students' success in a learning process (Dabbagh & Kitsantas, 2004). SRL has models such as Zimmerman (1989), Pintrich (2000), Boekaert (1988), Winne and Hadwin (1998), Efklides (2011), etc., developed from different theoretical perspectives (Panadero, 2017). However, most of the models agreed to be cyclical and categorized the learning process into three phases, i.e., forethought, performance, and self-evaluation (Nussbaumer et al., 2015; Panadero, 2017).

Research works have shown that a smart learning environment can support students' SRL process (Pérez-Álvarez et al., 2018; Singh & Miah, 2020). This learning process implies that learners become active and reflective of their learning process, and it requires both will and skills from the learners to succeed (Gavriushenko et al., 2017). One of the reasons for the interest in SRL is the increasing development of online skill-based courses both in the formal and informal learning process (John et al., 2015; Zimmerman, 2015; Schwendimann et al. 2016), which provided an opportunity for developing skills needed to live and function in society. SRL has some common components:

cognitive, metacognitive, and motivation (Lee et al., 2019; Zimmerman, 2002). Cognitive ability refers to conscious mental activities and include thinking, reasoning, understanding, learning, and remembering (Verbert et al., 2014); the metacognitive is the ability to become aware of ones' awareness or the processes used to plan, monitor, and assess one's understanding and performance; and while the motivation is a perception of being self-competent, efficacious and autonomous (Gambo & Shakir, 2021; John et al., 2015; Zimmerman, 2015). Zimmerman (2002) opined that SRL occurs with the interaction of the learning environment and learner. The learner can learn by observing and interacting with parents, teachers, peers, and those who demonstrate these behaviors (Pérez-Álvarez et al., 2018). The SRL strategies such as "self-efficacy, goal setting, time management, task strategy, and learning strategies and self-evaluation" are useful among literature in studying the SRL process (Pérez-Álvarez et al., 2018).

Methods

Procedure

This paper was conducted based on a systematic review that followed the procedure proposed by Petticrew and Roberts (2008). Systematic reviews are "a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies to answer a particular question (or set of questions)" (Petticrew & Roberts, 2008, p. 9). This study followed the seven stages of Petticrew and Roberts' (2008) which includes: "defining the research questions or the hypothesis, determining the types of studies, conducting a comprehensive literature search, screening the search results, appraising the included studies, synthesizing the studies and assessing heterogeneity among the studies." Also, including reviewing references and citations in the systematic review (Greenhalgh & Peacock, 2005).

Thus, the first stage is the research questions which are drawn from a systematic review of literature on SRL and online learning environment:

RQ1. What implementation strategies have been used to support SRL in a smart learning environment?
RQ2. What SRL strategies and components have been supported in a smart learning environment?
RQ3. What design functionalities have been used for supporting SRL strategies in a smart learning environment?
RQ4. How the implementations of the SRL process in a smart learning environment evaluated?
RQ5. What are the impacts of the SRL process in smart learning on students' learning process?

Search criteria

The second stage was to established criteria to determine related studies. The search articles defined as articles written in English and published in peer-reviewed journals or conference proceedings that proposed, implemented, or evaluated the SRL process in a smart learning environment, and focus on quality, practicality, and accessibility; and limited between 2012 and 2020 based on the fact that smart learning environment officially commences and published work began in 2012 (Putra & Putro, 2019). Finally, the inclusion and exclusion criteria were defined to screen and select relevant articles. Table 1 shows the inclusion and exclusion criteria as defined for this review.

Conducting search

The third stage is conducting a comprehensive search in relevant databases using search terms. Several databases and search terms were chosen for the searching process. The search terms were adopted from the previous systematic review on SRL in online learning environments, smart learning environment and smart learning (Pérez-Álvarez et al., 2018; Durán-Sánchez et al., 2018; Pérez-Álvarez et al., 2018). In addition, the searched process was conducted in ACM Digital Library, Scopus, IEEE Xplorer, Springer, Science Direct, and Google scholar to track other related articles are adopted from Pérez-Álvarez et al. (2018).

The first strategy in searching the relevant articles are using "self-regulated learning AND smart learning environment". The second strategy in searching the articles is the combination of related terms as stated in search terms in Table 2. A total of 35 search terms were used following Boolean expression (A1 OR A2 OR A3 … OR A25) AND (B1 OR B2 … B10). The asterisk was used in the search terms to expand a search by discovering a combination of words that begin with the same letters and incomplete search terms used for the searching process.

Screening process

The screening processes involves stages four to seven, including reviewing references and citations in the systematic review (Greenhalgh & Peacock, 2005), which are described as follows:

The search query resulted in 1117 related articles, and these resulted in 85 in ACM, 248 in IEEE, 243 in Scopus, 267 in Springer, 210 in science Direct, 64 in Google scholar.

By applying the fourth stage, which involved a screening search result based on the inclusion and exclusion criteria in Table 1, a total of 64 articles remained.

Table 1 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Empirical studies exploring SRL in smart education environment	Empirical studies exploring SRL outside smart learning environment
Empirical studies exploring SRL in partially smart education environment	Articles that present the same subcomponents of SRL but were grounded in other theories
Empirical studies that used SRL as theoretical model or framework	Articles that provide only abstract
Empirical studies that apply components of SRL	Articles that are presentation material
Publications that represent subcomponents of SRL based on the SRL theory	Articles that don't offer results of a study
Articles that provide results	Duplicate report of the same study
Articles developed models or design tools or support for smart learning environment inclusive criteria	Social network learning Online portfolio
Approved manuscripts which meet the above inclusive criteria in peer review journal or conference proceedings	Approved manuscripts which meet the above exclusive criteria

Table 2 Search terms*

A1. Self-regulat* learning	B1. Smart education environment
A2. Metacog*	B2. Smart education system
A3. Learning skills	B3. Mobile learning
A4. Rehearsal	B4. Smart learning
A5. Elaboration	B5. Smart web-based learning
A6. Critical thinking	B6. Smart learning environment
A7. Monitoring	B7. Smart IoT-based learning
A8. Time management	B8. Intelligence learning environment
A9. Effort regulation	B9. Smart learning
A10. Self-directed learning	B10. Smart education
A11. Help-seeking	
A12. Goal setting	
A13. Environment structur*	
A14. Self-efficiency	
A15. Task value	
A16. Planning	
A17. Task strategy	
A18. Intrinsic goal orientation	
A19. Extrinsic goal orientation	
A20. Control belief	
A21. Test anxiety	
A22. Task interest	
A23. Outcomes expectation	
A24. Self-consequence	
A25. Self-evaluation	

We further applied stage five, which is appraising the included articles based on the titles, abstracts, keywords, and applied inclusion criteria; a total of 37 remained.

We synthesized the articles (stage six) and assessed heterogeneity (stage seven); a total of 18 articles remained, and then applied the snowball method (Greenhalgh & Peacock, 2005) to the reference lists of the 18 articles by scanning their citations through Google scholar databases, and three more duplicate articles were removed. Finally, 15 articles are deemed to support SRL in a smart learning environment.

The combined searching and screening processes are shown in Fig. 1. Table 3 shows the search results of the 15 articles deemed relevant to address the research questions.

Result and discussions

Based on the research questions defined, the contents of the 15 articles presented in Table 3 were analyzed. The results and discussion were presented below:

RQ1: What implementation strategies have been used to support SRL in a smart learning environment?

In analyzing the articles to support the SRL process in Tables 3, 11 tools are implemented to provide intervention, and 4 proposed design models to support SRL. Among the 11 tools implemented to support SRL, 9 tools were implemented as a web-based application, while 3 are mobile apps. This study is consistent with Pérez-Álvarez et al.

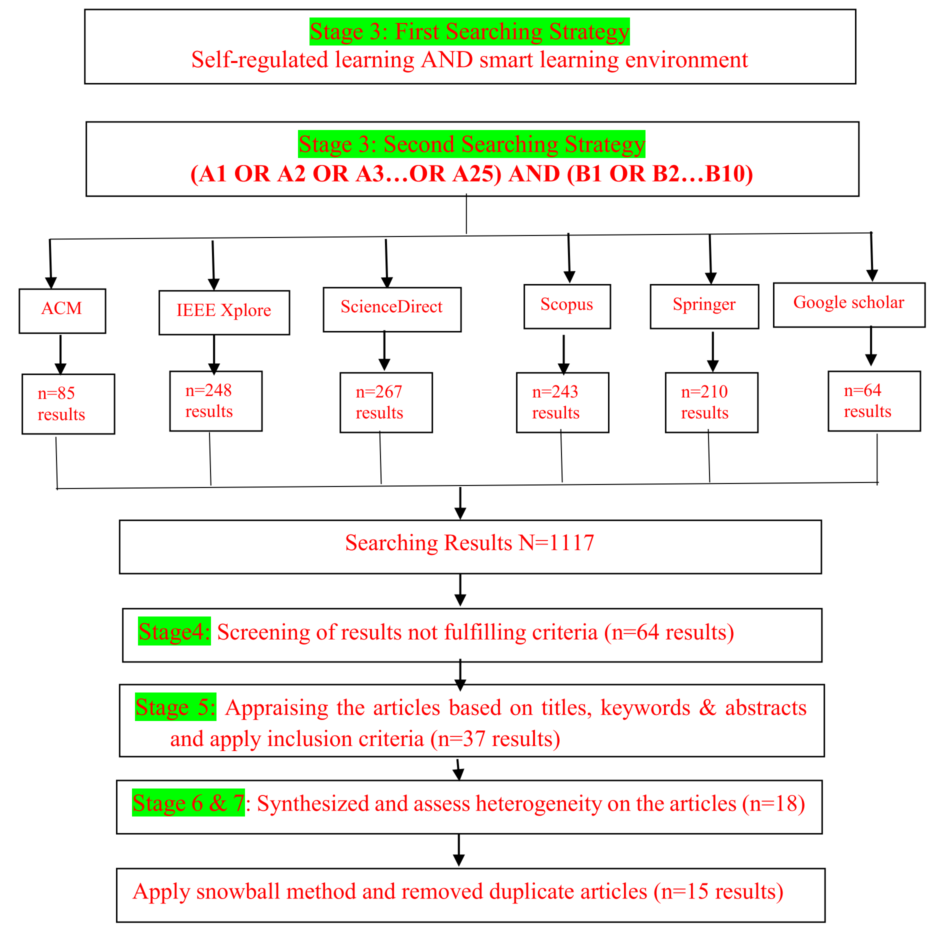

Fig. 1 Searching and Screening Processes

(2018), who found that the SRL strategies have been supported in a smart learning environment to provide skills development and personalized learning experiences.

RQ2: What SRL strategies and components have been supported in a smart learning environment?

In analyzing the tools developed to support SRL strategies, we identified 6 SRL strategies that are frequently supported in a smart learning environment as follows:

- Goal setting: This strategy appears in 11 implementations, that is, those developed smart learning environments that provided a mechanism for selecting or defining goals to developed skills, improve performance, or defining activities to be achieved in a learning process.
- Task Strategy: This strategy appears in 7 implementations. Those developed a smart learning environment to provide a mechanism for planning activities before performing on them.
- Help-seeking: They are supported in 6 implementations; these were implemented through agents and forums.
- Time Management: The strategy appears in 7 implementations. These developed a smart learning environment to monitor the time spent on learning, assessment, or planning.

Table 3 Search Results

Reference	Description of Application	Evaluation Method	SRL Evaluated	Design Functionalities
Akinyi and Oboko (2020)	Proposed Self-regulated collaborative learning model based on social cognitive theory	Proposed model for reducing dropout in an eLearning environment	General self-regulated learning process	Collaboration
Manganello et al. (2019)	Examined the effect of SRL-based web platform	The mixed-method used to evaluate active engagement among students	SRL strategies in web-learning platform	Learning engagement
Bahreman et al. (2016)	The system used SRL-based achievements in the educational mobile app to motivate students to learn and practice with the mobile learning environment.	Used survey to measure the impacts of the mobile environment on learning engagement and learning outcome of a student. The result showed an increase in engagement and outcomes	Cognition, Metacognition, Motivational/ Affective	Feedback
Chatzara et al. (2016)	The system incorporated an agent called Sophia to help a student in the learning process and foster cognitive learning in disabled student	Used survey to measure students' learning performance. The results show an increase in the components measured.	Affective/ Motivational	Feedback
John et al. (2015)	SIMSELF was used an Open-ended computer-based learning environments system to support SRL.	Pretest and posttest using. The result shows that students who used the facilities in the learning platform increased in a performance that does who didn't use it.	SRL strategies: Planning, performance, monitoring, and reflection.	Visualization, Class comparison, Feedback
Manso-Vázquez et al. (2015)	The system used Tin Can API to track learners' learning activities to support them in an eLearning environment	The implementation is needed to be validated	General SRL process	Visualization
Nussbaumer et al. (2015)	The study introduced Psycho-Pedagogical- framework to find out if students were able to follow a self-regulated process	Used survey to evaluate the impacted on students' SRL. The result show students can followed the process and improved learning experiences	Cognitive, Metacognitive, Motivations/ affective	Visualization
Koorsse et al. (2014)	This system introduced formative assessments into the mobile learning environment to motivate students to practice and do more exercises.	Used survey to determine how the mobile environment motivated students learning and performance which received positive feedback and increased performances	Motivation/ Affective	Visualization
Nussbaumer et al. (2014)	The aimed of the system is to use Responsive And open learning environment to support students' SRL process.	Used multi-survey study to examine how teachers and students used the environment in terms of acceptability, usefulness and factors influencing the use of the widgets for learning which provide useful insight into improve the design.	SRL phases using the Responsive and open learning environment	Visualization, Recommendation
Tu et al. (2012)	The system incorporated Web technologies to determine if the environment can support learners' SRL.	Used online survey to evaluate show positive responses from the participants	General SRL strategies: Goal setting, time management, and task strategies	Visualization, Feedback, Collaboration, Recommendation

Table 3 Search Results *(Continued)*

Reference	Description of Application	Evaluation Method	SRL Evaluated	Design Functionalities
Lehmann et al. (2013)	The system Introduced prompt in self-regulated online learning environment to promote personalization and adaptation	Used survey to determine the usefulness of the prompts to support online personalization and adaptation	Metacognitive awareness, Motivation\ Affective, Cognitive	Interactivity
Lajoie et al. (2013)	This system introduced a BioWorld system to help the medical students receive feedback form experts while solving authentic patients' cases.	Used survey to conduct three studies which revealed that medical Student increase in the learning process in terms of diagnosis and accuracy in solving patient cases	Metacognitive	Visualization, Feedback, Recommendation, Collaboration
Winne & Hadwin (2013)	The system introduced a learning platform called nStudy to help new medical students and experts interacts during learning and diagnosing patients' cases	Used survey to evaluate trace of data and learning behaviors which show that learners have improved in the learning process	Cognitive, Metacognitive	Visualization, Feedback, Recommendation, Collaboration
Canțer (2013)	The system introduced a hybrid model of an e-learning system called MEM (Metacognitive e-learning model) to improve students' metacognitive skills	Proposed model	A model to measure metacognitive skills	Proposed design
Sahabudin and Ali (2012)	This system combined Self-regulated Learning and Personalized Learning (SRPL) to propose a personalized learning environment to support the learning environments' SRL process.	A proposed personalized learning environment	General self Regulated Learning phases.	Proposed design Process

- Monitoring: This appears in 10 implementations. This is a significant component of the SRL process. This strategy provides a mechanism to see if a student is moving towards achieving a set goal.
- Self-evaluation: This is presented in 11 implementations. This can either provide an evaluation of learners' activities or progress of learning progress.

  In analyzing the tools developed to support specific SRL components, we identified 4 related SRL components that are frequently supported as follows:
- Affective/Motivational: Both of the components are emotion and are measured at the self-evaluation phase of the SR. They are supported in 5 implementations; these were implemented through self-assessment, games, and reflective quizzes.
- Cognition: The component appears in 4 implementations. These developed to monitor and measure time spent on learning, assessment, or planning.
- Metacognition: This appears in 6 implementations. This is a significant component of the SRL process. This strategy provides a mechanism to monitor learning and achieving a set goal.

The implemented strategies developed to support SRL strategies and components in a smart learning environment highlighted three strategies and components. The goal is the most supported strategy, while help-seeking is the least support. Metacognition is the most supported literature, followed by cognition and affective/motivation on the

SRL components. This is consistent with most literature supporting SRL strategies and components and their importance in helping learners achieve a learning goal (Bahreman et al., 2016; Koorsse et al., 2014; Panadero, 2017).

RQ3: What design functionalities have been used for supporting SRL strategies in a smart learning environment?

The analysis of the design functionalities considered for supporting SRL is presented. We followed the categories defined by Bodily and Verbert (2017) to categorize features of the design tools used to support the SRL process.

- Visualization: 10 used visualization to support self-regulation learning strategies. This show student can use a progress bar or chat to see the learning process's progress and outcomes.
- Class comparison: 3 used the comparison to support the SRL process. This tool provides a mechanism to compare learner's performance with their classmates.
- Feedback: 8 used textual feedback to support self-regulated learning using solutions to the current problem, personalized messages, or correction.
- Recommendation: 5 of the tools reported to the used recommendation to support self-regulated learning. The recommendation can be skill-based, strategies or widgets to help learners' skills development
- Collaboration: 5 integrated collaboration tool that supports learners' help-seeking. These include discussion forums, learning agents, or peer learning.
- Interactivity: 2 used interactivity tools to resend the information to the learners about their learning progress and performances.

The findings found both action-related and content-related as the most frequently used literature to support the SRL process in a smart learning environment.

RQ4: How the implementations of the SRL process in a smart learning environment evaluated?

In analyzing the tools or applications implemented to support self-regulated learning, 11 tools or applications were assessed to measure the impact on self-regulated learning overlapping different measurements. The evaluations indicated the following approaches:

- Usability: The analysis shows that 7 evaluated the usability of the functionalities provided. This measures the learner's opinion on whether the functionalities provided are ease to use and meet their learning need.
- Usefulness: The analysis shows that 4 evaluated the usefulness of the functionalities provided. This measure degree of importance to the learning process.
- Acceptability: The analysis shows that 2 evaluated learners' acceptability of the functionalities. This measures the degree of quality to the functionalities provided to support their learning process.
- Satisfaction: The analysis shows that 3 evaluated learner satisfaction. This is the degree to how the functionalities meet learner's learning needs and expectations.

The findings show that usability and usefulness are most frequently used to evaluate the self-regulated learning process in a smart learning environment. Usability is one of the keys to learning satisfaction, and thus a smart learning environment needs to useful and satisfied a learner for a sustainable learning performance (Pérez-Álvarez et al., 2018; Schwendimann et al., 2016).

RQ5. What are the impacts of the SRL process in smart learning on students' learning?

In analyzing the impacts of the self-regulated learning process in a smart learning.

environment on student' learning, several metrics are used and overlapping for effective.

evaluation. These measures are:

- Learning achievements: This is how the system brought a relative change in knowledge and understanding. The analysis shows that 9 evaluated learning performance.
- Learning difficulty and disorder: This is the degree to how learning intervention supported learning difficulties among students. This analysis shows that 1 evaluated learning difficulty.
- Learning progress: This is the degree to which the learning intervention supported learning skills and domain knowledge. This analysis shows that 4 evaluated learning progress.
- Learning personalization: This is how learning intervention provides learning content based on the learner's needs, skills, strength, and interest. The analysis shows that 3 of the intervention evaluated learning personalization to support learning achievements.

The findings show that learning achievements have been frequently evaluated. The essence of the self-regulated learning process in a smart learning environment is to provide support through learning personalization and skills development for learner's learning achievements and progress (Pérez-Álvarez et al., 2018). A study on self-regulated learning in a smart learning the environment is only beneficial for educators to the degree that they demonstrate how the findings link their approaches to real learning outcomes, and this has been demonstrated in this review.

Lessons learned

This paper conducted a systematic literature analysis to understand how a smart learning environment supported the self-regulated learning process. The analysis results identified results that could help future self-regulated learning strategies in a smart learning environment.

Several tools were developed and implemented to support the SRL process without a definite model or framework to understand their pedagogical theory. Providing a theory to support the design and development of a smart learning system provides a lens through which the learning environment can support the learning process and provide insights into key performance indicators.

Several SRL components have been supported in the literature, i.e., cognitive, metacognitive, affective/ motivation. The metacognitive elements appear to have been supported most based on the analysis. Furthermore, goal setting, time management, and help-seeking are the most frequent strategies that influenced learners' metacognitive skills. However, little is known about how the smart learning system can be modelled to support metacognitive strategy and whether these strategies can be implemented in a smart learning environment to support the self-regulated learning process.

The design functionalities used different tools to support learners' SRL process in a smart learning environment. Visualization, feedback, recommendation, and collaboration are standard design tools for supporting learner's SRL. The result shows that visualization is the most frequent design functionalities used, influencing learners' motivation and engagement. Furthermore, feedback on learners' learning process has been positive, influencing learners' engagement in a smart learning environment for supporting the SRL process.

Several SRL models are used in literature to understand how they can support the learning process in a smart learning environment; however, both Zimmerman and Pintrich models are frequently used to implement the SRL process in a smart learning environment. The Zimmerman has model has been the most frequently used in literature.

Several approaches and metrics have been used to measure the self-regulated learning process's impacts in a smart learning environment. However, learning achievements have been frequently used, which demonstrated the intervention's essence is to link the impact on achievements.

Most of the studies are quantitative in evaluation methods, using a survey in a small-scale sample population with some closed-ended questions with limited samples, leading to limited outcomes. The smart learning system is an emerging learning concept seeking to establish its domain. Therefore, developing qualitative studies or mixed will provide a better understanding of the user experiences to provide insight into the reviews to guide implementation initiatives and theory development. Furthermore, most of the studies lack theory to underpin the evaluation methods. Using theories will provide a lens for the interpretation and validity of the evaluation results and increase confidence in generalizing findings.

Conclusion

This systematic analysis provided insights into the current state of the SRL process in a smart learning environment. This study revealed that SRL research in a smart learning environment had evolved increasingly, as demonstrated by the fact that papers were reviewed between 2012 and 2020. The result indicated that SRL strategies such as goal-setting, helping-seeking, time management, and self-evaluation are mostly supported. However, most evaluation studies lack theoretical models, which undermined the validity of the evaluation results. Using models will provide a lens through which the interpretations of the results can be validated.

Moreover, using a theoretical framework in a study gives the researcher the process to conceptualize the study in a broader context. Furthermore, we also found that most of the evaluation studies are quantitative, smart learning system as a new learning paradigm is seeking to establish its domain; therefore, there is a need to use both quantitative and qualitative to provide an in-depth understanding of the experiences of a user in the self-regulated learning environment. We also found that learning agent, visualization, recommendation, interactive, and social comparison positively impact the students' engagement and performance, which can support a self-regulated learning paradigm. Furthermore, most of the studies measured usefulness and usability; there is a need to explore beyond these functionalities to explore how SRL strategies are affected within the learning environment with real users. We also found a scarcity of intelligent systems to support the design of tools or applications for self-regulated learning processes. There is a lack of a design approach to guide a self-regulated smart education system design. Besides, it was observed that different interventions, such as visualization, feedback, recommendation, etc., are used to support learners' learning process. The results of this review may have possible new perspectives and guidance for future smart learning environment research. This research will also provide smart learning environment practitioners with the knowledge and the significance of promoting SRLs in a smart learning environment.

There are limitations to understand the consequences of this systematic analysis. First, as the scanning time for discovering possible publications ended at a specific date, any papers written after that point will not have been identified in this study. Second, this analysis's scope is restricted to articles that focused on proposed studies, implemented and evaluated the SRL process in a smart learning environment. Based on these results, guidance for the future, researchers can continue to explore SRLs in smart learning environments to add to a growing body of literature. Third, other SRL methods that have not been examined in this analysis should be explored; the construction of recommendations for self-regulated learning in the smart learning context, the computational frameworks used to develop and evaluate SRLs in the smart learning environment called for future works.

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Authors' contributions
Yusufu Gambo has made substantial contributions to conceive and design the research. And searched and analyzed the literature. Muhammad Zeeshan Shakir has made significant contributions to draft this manuscript, improved the manuscript's language, and commented on the manuscripts. Yusufu Gambo reviewed and revised the manuscript into its final shape. The author(s) read and approved the final manuscript.

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