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ARTIFICIAL INTELLIGENCE AND ONLINE EDUCATIONAL CREATIVITY: A CRITICAL ANALYSIS AND EMERGING PERSPECTIVES

INTELIGENCIA ARTIFICIAL Y CREATIVIDAD EDUCATIVA EN LÍNEA: ANÁLISIS CRÍTICO Y PERSPECTIVAS EMERGENTES

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Resumen: Introducción: En los entornos de aprendizaje en línea, la participación estudiantil y la creatividad son factores clave para el éxito académico, aunque su desarrollo se ve condicionado por las altas demandas de autonomía y autorregulación. En este contexto, los avances recientes en inteligencia artificial (IA) abren nuevas posibilidades para diseñar experiencias de aprendizaje más personalizadas, interactivas y adaptativas.
Método: El presente estudio realiza una revisión teórica sistemática de la literatura publicada durante la última década sobre el uso de la IA para fomentar la participación estudiantil y la creatividad en entornos de aprendizaje en línea. Se analizaron artículos indexados en la base de datos Web of Science mediante técnicas de análisis bibliométrico y de contenido.
Resultados: Los resultados muestran que la IA se implementa principalmente a través de modelos de aprendizaje automático para la detección de la participación, el análisis multimodal de datos, los sistemas de tutoría inteligente y los mecanismos de retroalimentación adaptativa. La participación estudiantil se evalúa fundamentalmente mediante cuestionarios, sistemas de reconocimiento basados en IA y analíticas de aprendizaje, mientras que la creatividad se promueve mediante entornos interactivos y colaborativos.
Discusión – Conclusiones: La revisión pone de manifiesto el potencial de la IA para mejorar la participación y la creatividad en el aprendizaje en línea, así como la necesidad de avanzar hacia enfoques pedagógicos más integrados y coherentes en la investigación futura.
Abstract: Introduction: Student engagement and creativity are key factors in the success of online learning environments, yet sustaining both remains a challenge due to the high levels of autonomy and self-regulation required. Recent advances in artificial intelligence (AI) offer new opportunities to support engagement and foster creativity through adaptive and personalized learning systems. **Method:** This study presents a systematic theoretical review of research published in the last decade on the use of AI to promote student engagement and creativity in online learning. Articles indexed in the Web of Science database were analyzed using bibliometric and content analysis to identify technological approaches, data resources, and engagement measurement methods. **Results:** The findings indicate that AI is primarily implemented through machine learning models for engagement detection, multimodal data analysis, intelligent tutoring systems, and adaptive feedback

mechanisms. Student engagement is commonly assessed using survey-based instruments, AI-driven recognition systems, and learning analytics derived from activity data. Creativity is mainly promoted through interactive, adaptive, and collaborative learning environments supported by AI technologies.
Discussion – Conclusions: The review highlights AI's growing role in enhancing engagement and creativity in online learning while revealing persistent challenges related to data use, measurement consistency, and pedagogical integration. These findings provide valuable insights for researchers and practitioners seeking to design effective AI-enhanced learning environments.
Résumé: Introduction: Dans les environnements d'apprentissage en ligne, l'engagement des étudiants et la créativité constituent des facteurs essentiels de réussite, bien que leur développement soit freiné par les exigences élevées d'autonomie et d'autorégulation. Dans ce contexte, les avancées récentes de l'intelligence artificielle (IA) offrent de nouvelles opportunités pour concevoir des expériences d'apprentissage plus personnalisées, interactives et adaptatives.
Méthode: Cette étude présente une revue théorique systématique de la littérature publiée au cours de la dernière décennie portant sur l'utilisation de l'IA pour favoriser l'engagement des étudiants et la créativité dans les environnements d'apprentissage en ligne. Les articles indexés dans la base de données Web of Science ont été analysés à l'aide d'analyses bibliométriques et de contenu.
Résultats: Les résultats indiquent que l'IA est principalement mise en œuvre à travers des modèles d'apprentissage automatique pour la détection de l'engagement, l'analyse multimodale des données, les systèmes de tutorat intelligent et les mécanismes de rétroaction adaptative. L'engagement des étudiants est généralement mesuré à l'aide de questionnaires, de systèmes de reconnaissance basés sur l'IA et d'analyses de l'apprentissage, tandis que la créativité est encouragée par des environnements interactifs et collaboratifs.
Discussion – Conclusions: Cette revue met en évidence le potentiel de l'IA pour renforcer l'engagement et la créativité dans l'apprentissage en ligne, tout en soulignant la nécessité de développer des approches pédagogiques plus intégrées et cohérentes dans les recherches futures.
Palabras Clave: entornos de aprendizaje en línea; inteligencia artificial; aprendizaje automático; participación estudiantil; revisión sistemática; creatividad
Key words: online learning environments; artificial intelligence; machine learning; student engagement; systematic review; creativity
Mots clés: environnements d'apprentissage en ligne; intelligence artificielle; apprentissage automatique; engagement des étudiants; revue systématique; créativité

INTRODUCTION

Since OpenAI announced GPT-3 in 2020, the release of this impressive language model has marked a significant milestone in the development of artificial intelligence (AI). Researchers and practitioners have indicated great interest in the development of AI and believe that it could lead to another technological revolution in the 21st century. Widespread interest and innovation have been sparked in almost every aspect, including online learning. For the purposes of this study, online learning refers to educational experiences conducted entirely through digital platforms, where students access course materials, participate in discussions, and complete assignments without in-person instruction (Castro & Tumibay, 2021). This contrasts with blended learning, which involves a combination of online and in-person activities (Castro, 2019), and flipped classrooms, where traditional classroom learning activities are reversed with out-of-class assignments (Baig & Yadegaridehkordi, 2023).

In these online settings, student engagement, defined as the level of participation, emotional investment, and cognitive involvement that students demonstrate during their learning process, plays a critical role in student success. Engagement can be observed through students' active participation in course activities, their emotional connection to the content, and their deep cognitive engagement with the material. However, it is important to note that engagement is a multi-dimensional concept and can vary across different contexts (Fredricks, 2022). It is critical to promote student engagement because more engaged students tend to have more positive academic and non-academic outcomes (Wong & Liem, 2022).

One of the challenges in online learning is that students often show lower levels of engagement compared to traditional face-to-face environments. This may be due to the greater autonomy required in online learning environments, where students are expected to take more responsibility for managing their learning without immediate supervision or structured classroom time. Furthermore, because online learning environments often require greater self-regulation and independent time management, students who struggle with these skills may experience difficulty maintaining consistent engagement (Daniel et al., 2024).

AI presents a promising solution to this challenge by enhancing student engagement through personalized learning experiences, real-time feedback, and interactive, adaptive learning content (Ouyang et al., 2023; Seo et al., 2021; Xu et al., 2023). Machine learning algorithms can help predict student performance and engagement levels, enabling educators to provide timely support and interventions when needed (Crompton & Burke, 2023). In addition, AI-powered tools such as virtual tutors and chatbots can foster a more interactive and engaging online learning experience (Alam, 2023). This study aims to review and synthesize existing literature on the implementation of AI to support and enhance student engagement in online learning environments.

Research gaps and problem statements

Lack of Comprehensive *Review on AI Implementation*

While various studies explore AI's role in online learning, no research has systematically reviewed how AI is implemented to foster student engagement. This gap in the literature prevents a unified understanding of AI's potential and its practical application.

Multiplicity of Data Resources in AI Systems

The types of data resources used to train AI models in online learning systems vary widely, and there is no clear consensus on the most effective resources. This lack of clarity complicates the development of best practices for implementing AI in a way that maximizes student engagement.

Inconsistent Measurement of Student Engagement

While student engagement is key for assessing the effectiveness of AI in learning environments, existing studies use a wide range of methods to measure engagement (surveys, teacher ratings, interviews). There is no synthesized approach to understanding how engagement is measured specifically in AI-driven online learning.

Research questions and objectives

RQ1: AI Implementation to Promote Student Engagement in Online Learning

Previous research suggests that AI can be implemented in online learning to promote student engagement in various aspects. For instance, AI can provide real-time recommendations for customized course materials to help students find the most useful content and keep them engaged (Chassignol et al., 2018). AI can also be used to generate adaptive assessments and provide personalized feedback or recommendations to better engage students in online learning (Seo et al., 2021). Moreover, AI can be incorporated into online learning to create intelligent tutoring systems for engaging learning experiences (Alam, 2023). It can also be used to predict student performance and engagement status to allow for early support and interventions from the instructors (Crompton & Burke, 2023; Fernández-Batanero et al., 2021).

Understanding how AI is implemented to promote student engagement in online learning can help researchers and practitioners create more engaging experiences, personalized content, real-time feedback, and adaptive recommendations to meet the diverse needs of online students. To date, no study has reviewed or summarized how AI is implemented to facilitate student engagement in online learning. This research aims to address this gap by conducting a comprehensive literature review. The first research question is as follows:

RQ1: How was AI implemented to promote student engagement in online learning?

RQ2: Exploring Data Resources in AI-Driven Online Learning

Besides the various implementations, exploring the types of data resources researchers use when implementing AI in online learning is highly important. High-quality and relevant data is essential for training AI models or implementing AI (Aldoseri et al., 2023). Using appropriate data resources can ensure that AI systems are trained or implemented correctly to deliver accurate, reliable, and unbiased results in online learning. Additionally, Gligorea et al. (2023) suggest that “Educators and practitioners must be equipped to effectively utilize AI technologies and applications, tailoring them to enhance learning experiences within specific educational contexts.” Knowing the data resources used can provide better assistance and important references for future educators, researchers, and practitioners.

Using different data resources paired with various AI technologies may lead to innovative solutions and continuous improvements to promote student engagement in online learning. By thoroughly understanding and utilizing the right data resources, researchers and practitioners may develop more effective AI systems to enhance student engagement. Therefore, it is important to understand the types of data resources used in previous literature. To address this, the second research question is proposed as:

RQ2: What types of data resources can be used when researching the implementation of AI in online learning?

RQ3: Measuring Student Engagement in AI-Powered Online Learning

This research focuses on implementing AI that promotes student engagement in online learning. The measurement of student engagement is one of the key considerations. In previous literature, researchers have used various measures to evaluate student engagement, including but not limited to self-report surveys, teacher ratings, interviews, and observations (Fredricks, 2022; Fredricks & McColskey, 2012). However, a significant body of research was developed to evaluate student engagement in the context of empirical studies (Trolian, 2023). A synthesized review of how student engagement was measured when implementing AI in online learning needs to be conducted. The third research question is developed to fill this gap.

Understanding how student engagement was measured when implementing AI in online learning can assist researchers in conceiving and developing the most effective strategies in future research to promote student engagement using AI techniques. In addition, it can also help educators and practitioners identify the most effective AI tools and personalized learning experiences to better engage students in online learning activities (Ouyang et al., 2023; Xu et al., 2023). Thus, the research question is:

RQ3: How was student engagement measured when implementing AI in online learning?

METHODOLOGY

Database selection

Numerous databases offer extensive research articles, including Web of Science (WoS), Scopus, Dimension, and EBSCO. Singh et al. (2021) suggest that WoS is one of the most widely used databases for bibliometric and content analyses. It has been identified as supporting high-quality journals due to its selective nature (Chavarro et al., 2018). Based on the Science Citation Index, WoS has expanded its coverage of the world's leading research to around

34,000 journals today (Birkle et al., 2020). In this study, WoS was adopted to identify the studies related to the topic of interest.

Keywords selection

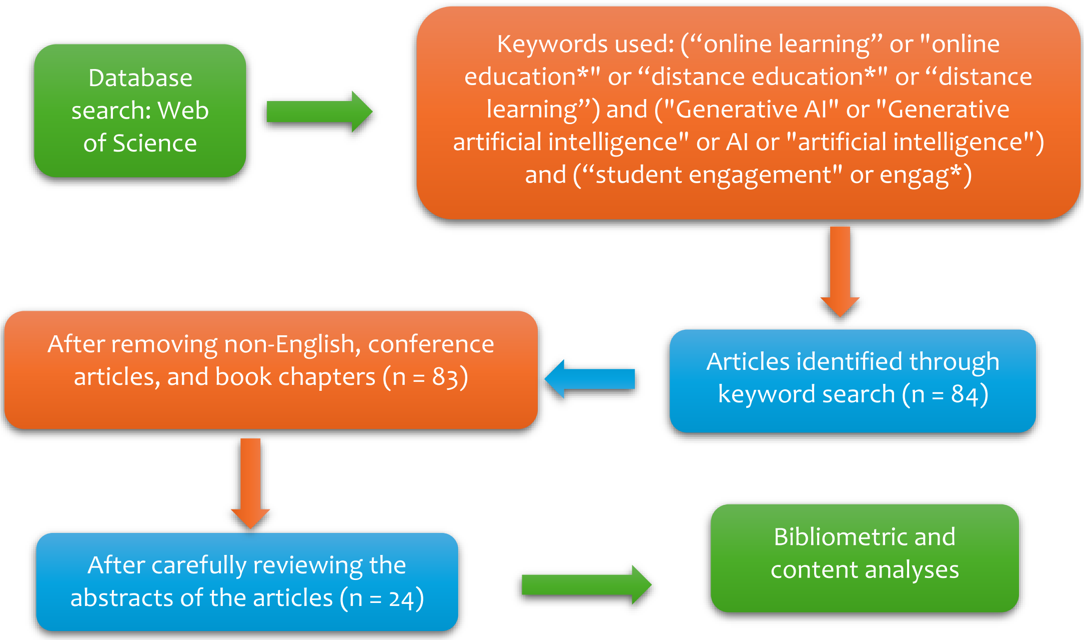
The "Topic" search was employed, which searches in the title, abstract, and keyword fields of the WoS records, and it is widely used in practice for more accurate and efficient results (Zhu & Liu, 2020). This review study has three major focus areas: 1) artificial intelligence, 2) student engagement, and 3) online learning. Thus, the keywords selected to identify the research articles in the WoS database were:

TS = ("online learning" or "online education*" or "distance education*" or "distance learning") and ("Generative AI" or "Generative artificial intelligence" or AI or "artificial intelligence") and ("student engagement" or engag* or creativity).

Inclusion and exclusion criteria

Conference papers and book chapters were excluded. Only journal articles were included as they usually have a strict review process. Also, non-English written articles were excluded, which resulted in a total of 83 articles. After carefully reviewing the abstracts of these 83 articles, 24 were kept for further bibliometric and content analyses as they are more closely related to the research focuses of this study. The flowchart of the methodology is presented in Figure 1.

Figure 1. Flowchart of methodology. Source: Own elaboration.



RESULTS

Bibliometric analysis

Bibliometric analysis helps identify the relevant research trends in terms of year-wise publications and citations (Galetsi & Katsaliaki, 2020). Though only 24 articles were identified as closely related to the research focus of this study, the citation report from WoS was used for a brief bibliometric analysis. Figures 2 and 3 show that research in the field has just gained attention in 2021, and there is an increasing trend in publications and citations in the following years. As this review study is being carried out in 2024, only two publications are available. It is expected that the topic of implementing AI to promote student engagement in online learning will draw more attention and be further explored in the near future.

Figure 2. Year-wise publication trends. Source: Own elaboration.

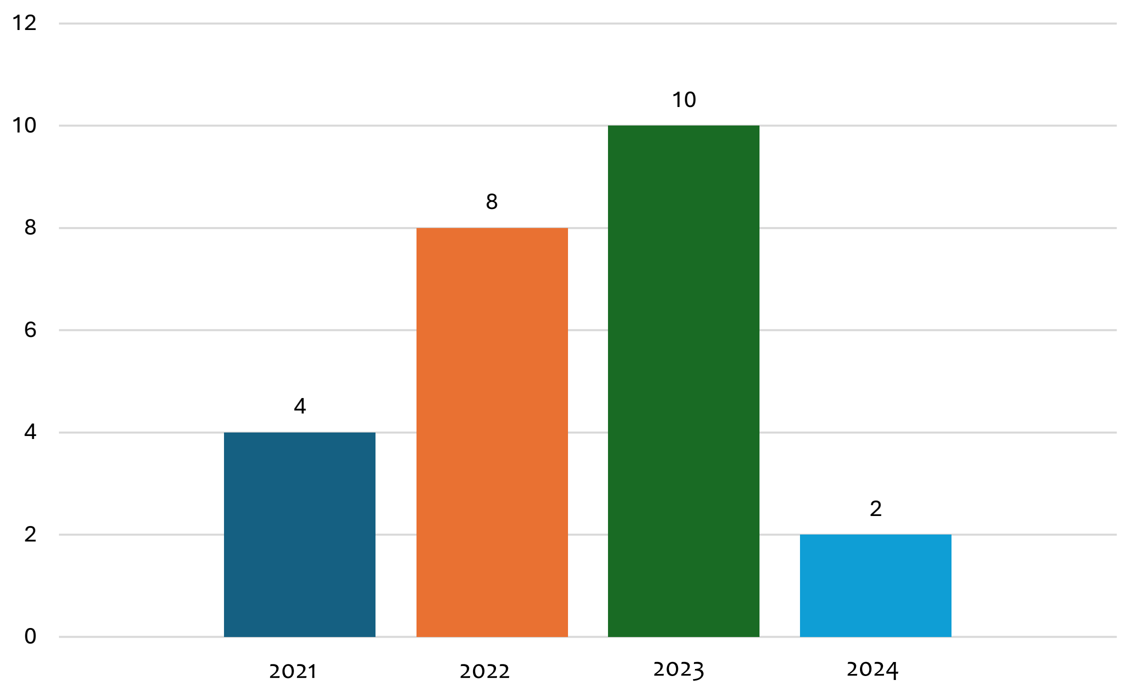
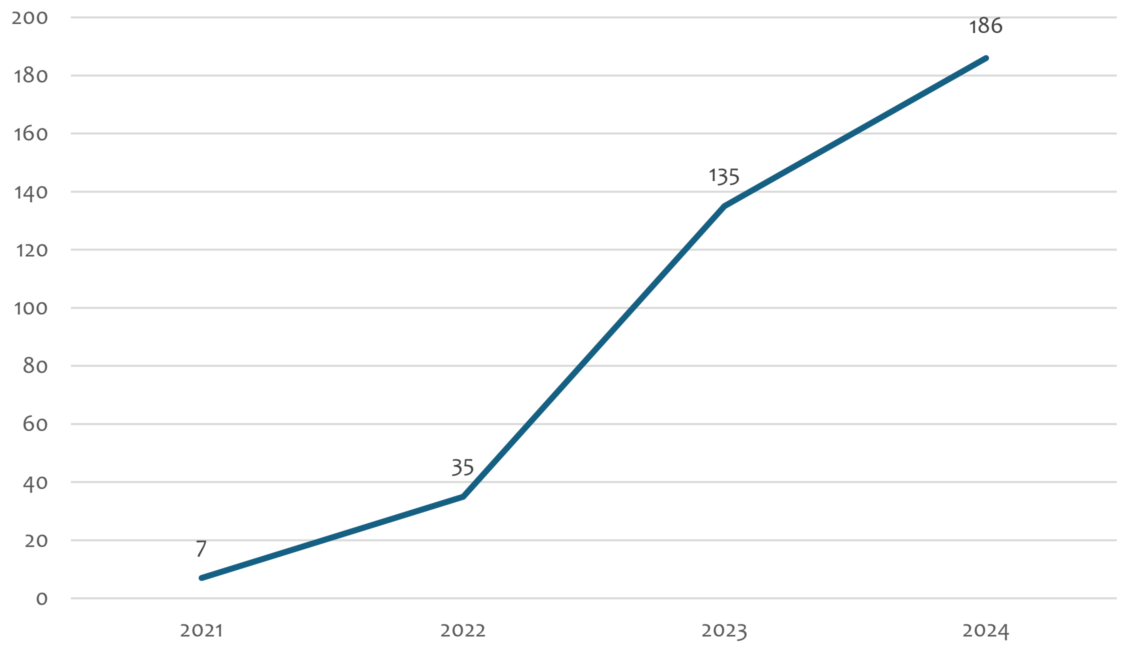


Figure 3. Year-wise citation trends. Source: Own elaboration



Content analysis

RQ1: How was AI implemented to promote student engagement in online learning?

The implementation of AI to promote student engagement in online learning can be classified into six key areas: 1) integrating chatbots as a tool in course design, 2) using AI for emotion/facial/voice recognition or eye tracking, 3) applying machine learning techniques to analyze various data sources, 4) facilitating teacher-student interaction through AI, 5) providing feedback and recommendations with AI, and 6) developing AI-powered bots to support online learning and modern education. These approaches are summarized in Table 1.

1. Integrate Chatbots as a tool in course design. AI-powered chatbots have been effectively used to enhance student engagement in online learning. For instance, studies by Karatas et al. (2024) and Sadegh-Zadeh et al. (2023) integrated chatbots into language and programming courses for interactive support and content guidance. Ilieva et al. (2023) proposed a five-stage framework for chatbot use, with the most significant impact occurring before and after class. Hsiao and Chang (2023) developed AI tools for autonomous English learning, offering grammar correction, text summarization, and keyword search functionalities. These studies demonstrate the growing potential of chatbots to enhance learner autonomy, motivation, and interaction in online learning environments.

2. Use AI for emotion/facial/voice recognition or eye tracking. AI technologies such as emotion recognition, facial analysis, and eye tracking are increasingly used to assess student engagement. For instance, Dimitriadou and Lanitis (2024) and Harb et al. (2023) employed computer vision and deep neural networks to recognize student actions and emotional states. Awais et al. (2021) used IoT-based physiological sensors with LSTM models to detect emotional responses. Hasnine et al. (2023) introduced a facial expression and eye-movement framework for real-time engagement analytics. Xu et al. (2023) combined facial and voice recognition with survey data to identify engagement predictors, while Wang et al. (2021) reviewed eye-tracking tools for monitoring cognitive engagement. In addition, Sasaki et al. (2023) analyzed student video reports to estimate engagement levels. These studies illustrate the use of multimodal AI systems to detect and measure student engagement.

3. Use machine learning techniques to analyze various sources of data. Machine learning techniques are widely applied to analyze data and enhance student engagement. For instance, Raj and Renumol (2022) developed predictive models using student activity data to classify engagement levels. Huang et al. (2023) combined structural equation modeling and neural networks to predict emotional engagement, achieving high accuracy. Lee et al. (2022) used BERT-based models to classify cognitive presence from forum texts, correlating it with engagement. Ou et al. (2023) applied dynamic graph neural networks to analyze educational videos and predict student engagement. These studies highlight machine learning's potential to personalize learning experiences and foster proactive engagement strategies.

Table 1. Various implementations of AI to promote student engagement in online learning. Source: Own elaboration

Implement AI to promote student engagement in online learning	References	Use
1. Integrate Chatbots as a tool in course design	(Ilieva et al., 2023)	Chatbots integrated across five learning stages (before course, before class, during class, after class, and after course) for both instructor and student.
	(Karatas et al., 2024)	Chatbots were integrated into warm-up, pre-reading, reading comprehension, vocabulary practice, and wrap-up activities.
	(Sadegh-Zadeh et al., 2023)	Chatbots were used to answer students' questions, provide immediate feedback, and help students navigate the course content.
	(Hsiao & Chang, 2023)	Chatbots were used to design and develop write, read, and search tools to aid senior high school students in their autonomous English learning.
2. Use AI for emotion/facial/voice recognition or eye tracking	(Dimitriadou & Lanitis, 2024)	Facial recognition through online video recordings and classify students' actions into three categories: 1) physical presence, 2) active participation, and 3) distraction.
	(Harb et al., 2023)	Emotion recognition through online video recordings and classify emotion into seven categories: 1) bored, 2) distracted, 3) confused, 4) enjoying, 5) interested, 6) neutral, and 7) worried.
	(Awais et al., 2021)	Emotion recognition through online video recordings and classify emotion into four categories: 1) amusing, 2) boring, 3) relaxation, and 4) scary.
	(Hasnine et al., 2023)	Emotions were captured from students' facial expressions and eye movements, and engagement levels based on emotional data were divided into five categories: 1) strong engagement, 2) high engagement, 3) medium engagement, 4) low engagement, and 5) disengagement.
	(Xu et al., 2023)	Voice recognition was used to record the timestamp of teachers' first speech and the total length of the speech. In contrast, computer vision was used to capture the total count of learners' frontal face exposures and the total count of learners' and teachers' smiling faces.
	(Wang et al., 2021)	Use eye-tracking devices and platforms as well as machine learning and modeling techniques for the classification of eye-tracking data.

	(Sasaki et al., 2023)	Use deep learning technology to analyze online students' video activity reports to identify key features such as negative phrases, filled pauses, and silent pauses.
3. Use machine learning techniques to analyze various sources of data	(Raj & Renumol, 2022)	Use students' virtual learning activity data that describes students' interaction with the homepage, content, subpage, URL, and forum to train the machine learning model.
	(Huang et al., 2023)	Use survey data regarding the variables interested and input the variables into an artificial neural network for model training.
	(Lee et al., 2022)	Use data from discussion forum posts to train the machine learning model and classify students' cognitive engagement into five levels: 1) non-cognitive presence, 2) triggering event, 3) exploration of ideas, 4) integration of ideas, and 5) resolution of problem or issue.
	(Ou et al., 2023)	Use both videos' static information, such as title count and duration, and dynamic information, such as daily views and daily shares, to train the machine learning model.
4. Use AI to facilitate teacher-student interaction	(Xie et al., 2023)	Use a real-time dynamic AI analysis system to analyze classroom interaction behaviors. Classroom discourses and teaching data were collected and analyzed, such as the percentage of teacher-student speech and response rate.
	(Seo et al., 2021)	Review eleven AI systems supporting teacher-student interaction in online learning. Then, it explores how students and instructors perceive the impact of AI systems on student-instructor interaction from six different themes: 1) quantity & quality, 2) responsibility, 3) just-in-time support, 4) agency, 5) connection, and 6) surveillance.
5. Use AI to provide feedback and recommendations	(Lv, 2023)	Use a deep learning model that can learn from the exercises performed by musicians and students, and the errors and feedback provided by experienced teachers. An AI-based system delivers adaptive feedback and error detection, contributing to the identification of errors and enhanced learning outcomes.
	(Hooda et al., 2022)	Compare various AI and machine learning techniques for providing quality and intelligent feedback to learners. Open University Learning Analytics (OULAD) dataset containing a vast amount of student records was used for analysis. I-FCN was identified as the best-performing technique.

	(Li & Peng, 2022)	Evaluate students' knowledge mastery level using an AI-based online English learning system. The results can be used to provide students with real-time feedback and recommendations regarding the relevant questions for further practice and improvement.
	(Huang et al., 2023)	The machine learning model collected information regarding students' test results, video-viewing lists, and video-viewing time for model training and used a logistic regression–based prediction model to predict students' learning outcomes. The results can be used to provide students with a list of recommended videos for review.
	(Bañeres et al., 2023)	Use the learner's profile information, performance data, and daily clickstream data to train the predictive model. The results can be used to identify learners' dropout and failure risk and recommend the best interval for a course and assessable activity.
6. Develop AI-powered bots to support online learning and modern education	(Saleeb, 2021)	Integrate AI-automated bots in class projects and activities to enhance student engagement. Two different bots, namely "Pandorabots" and "Pikkubots," were used in association with the simulation tasks "holodeck" and "Logic System."
	(Nguyen et al., 2022)	Implement four AI-powered robot systems in a smart university campus, including virtual assistant, telepresence, guide, and delivery robots. The virtual assistant robot was developed using AI techniques such as natural language processing, natural language understanding, natural language generation, and image processing based on machine learning.

4. Use AI to facilitate teacher-student interaction. AI is also increasingly employed to enhance teacher-student interaction and personalize feedback. For instance, Xie et al. (2023) introduced a real-time AI analysis system that monitored and improved teacher-student interaction through classroom behavior analysis (Lluberes & Barroso-Osuna, 2024). Similarly, Seo et al. (2021) reviewed various AI tools categorized by communication, support, and presence, highlighting their potential to enrich interaction while also raising concerns around ethics and agency. These findings suggest that AI can play a critical role in enriching instructional interactions and fostering more responsive and engaging learning environments.

5. Use AI to provide feedback and recommendations. In terms of feedback and recommendations, AI-driven systems have also demonstrated significant impact. For instance, Lv (2023) utilized a deep learning-based flipped classroom model in music education to deliver adaptive feedback. Hooda et al. (2022) compared several machine learning techniques for intelligent feedback and found that Fully Connected Networks (I-FCN) yielded the best results. Li and Peng (2022) built an AI system for online English learning that provided real-time diagnostics and personalized recommendations based on learners' mastery levels. Huang et al. (2023) developed a recommendation system using machine learning to suggest videos based on student performance, which is effective, particularly for moderately motivated students. Bañeres et al. (2023) proposed a Learning Intelligent System (LIS) that used predictive modeling to monitor student progress and recommend optimal learning intervals to prevent dropout and improve outcomes. These studies underscore the effectiveness of AI-powered feedback systems in adapting to learners' needs and encouraging self-directed improvement.

6. Develop AI-*powered* bots to support online learning and modern education. AI-powered bots are increasingly used to boost student engagement in online learning. For instance, Saleeb (2021) integrated bots like Pandorabots and Pikkubots into interactive class projects, which helped students stay engaged and meet learning goals. Similarly, Nguyen et al. (2022) introduced virtual assistants, telepresence, guide, and delivery robots on a smart campus. Their virtual assistant, built using natural language processing and machine learning, created a more interactive and engaging learning environment. These implementations highlight the expanding role of AI bots in creating dynamic, supportive, and student-centered educational experiences.

RQ2: What types of data resources can be used when researching the implementation of AI in online learning?

Understanding the types of data used in previous studies can guide effective data collection and help researchers choose the most suitable AI techniques. The reviewed literature categorized data sources into four main types: 1) video recordings of online learners, 2) online learning activity data, 3) existing datasets, and 4) survey data collected for targeted variables (Table 2).

Video recordings of online learners were the most frequently used data type. Researchers applied machine learning techniques, such as facial, emotion, voice recognition, and eye-tracking, to analyze these recordings. These models helped classify learners into different engagement categories and predict their engagement levels (Awais et al., 2021; Dimitriadou & Lanitis, 2024; Harb et al., 2023; Hasnine et al., 2023; Sasaki et al., 2023; Wang et al., 2021; Xu et al., 2023).

Online learning activity data, extracted from learning management systems, includes data from the homepage, subpage, content, URL, and discussion forum (Lee et al., 2022), learners' profile information, test results, performance data, and daily clickstream data (Bañeres et al., 2023; Huang et al., 2023; Li & Peng, 2022), and video reviewing data such as video-viewing lists and video-viewing time (Huang et al., 2023). It also encompasses instructional interaction data like speech ratios and response rates (Xie et al., 2023) and performance logs, such as exercises performed by teachers and students (Lv, 2023).

In addition, existing datasets such as the Open University Learning Analytics Dataset (OULAD) (Hooda et al., 2022; Raj & Renumol, 2022) and YouTube dataset (Ou et al., 2023) provide valuable secondary data sources. Some studies also employed survey data to capture specific research variables (Huang et al., 2023; Seo et al., 2021).

Table 2. Types of data resources. Source: Own elaboration.

Types of data resources	Reference
1. Online learners' video recordings	(Awais et al., 2021) (Dimitriadou & Lanitis, 2024) (Harb et al., 2023) (Hasnine et al., 2023) (Sasaki et al., 2023) (Wang et al., 2021) (Xu et al., 2023)
2. Online learning activity data	(Lee et al., 2022) (Bañeres et al., 2023) (Huang et al., 2023) (Li & Peng, 2022) (Xie et al., 2023) (Lv, 2023)
3. Existing datasets	(Raj & Renumol, 2022) (Hooda et al., 2022) (Ou et al., 2023)

4. Survey data collected for the variables of interest	(Huang et al., 2023) (Seo et al., 2021)
5. No data resources were used when implementing AI	(Karatas et al., 2024) (Sadegh-Zadeh et al., 2023) (Hsiao & Chang, 2023) (Saleeb, 2021) (Nguyen et al., 2022) (Ilieva et al., 2023)

RQ3: How was student engagement measured when implementing AI in online learning?

In addition to exploring various data sources, it is also essential to understand how student engagement has been measured in AI-driven research. Based on the reviewed literature, engagement measurement methods were grouped into three main categories: 1) survey-based measurements, 2) AI-based recognition, and 3) data coding using AI or machine learning techniques. These are summarized in Table 3.

Survey-based approaches included both quantitative scales (Sadegh-Zadeh et al., 2023) and qualitative interviews (Karatas et al., 2024) to assess student engagement. AI-based recognition methods focused on interpreting facial expressions, emotions, and vocal cues. For example, Dimitriadou and Lanitis (2024) used facial recognition to categorize engagement into physical presence, active participation, and distraction. Harb et al. (2023) applied emotion recognition to identify seven engagement states: bored, distracted, confused, enjoying, interested, neutral, and worried. Similarly, Sasaki et al. (2023) analyzed voice patterns, such as negative phrases, filled pauses, and silent gaps, to determine engagement levels.

The third category involved coding engagement-related behaviors using AI or machine learning models. This included analyzing teacher-student interactions (Xie et al., 2023), learning activities (Saleeb, 2021), video engagement (Ou et al., 2023), and discussion forum participation (Lee et al., 2022). Notably, four out of the 24 reviewed articles did not directly measure engagement but instead emphasized AI's potential to support and enhance engagement in online learning environments.

Table 3. Measure of student engagement. Source: Own elaboration.

How was student engagement measured?	Reference	Measure of student engagement
1. Survey-based measurements	(Sadegh-Zadeh et al., 2023)	Survey questions (students' perceptions of their engagement in online courses).
	(Hsiao & Chang, 2023)	Both survey questions (quantitative measure) and assignments (qualitative measure) were used to assess student engagement.
	(Xu et al., 2023)	Survey instrument from Oga-Baldwin and Nakata (2017).

	(Huang et al., 2023)	Survey questions were used to assess emotional engagement.
	(Lv, 2023)	Ten survey questions were developed to determine student engagement in music education.
	(Li & Peng, 2022)	Two survey questions were developed to investigate how students perceive their engagement in the AI-based flipped class.
	(Karatas et al., 2024)	Semi-structured interview form questions (qualitative case study).
	(Seo et al., 2021)	Use semi-structured interviews to measure student engagement through students' and teachers' perceptions of the impact of various AI systems on student-teacher interaction.
2. Measuring through AI recognition	(Hasnine et al., 2023)	Measure through facial recognition and eye-tracking and classify engagement into five categories: 1) strong engagement, 2) high engagement, 3) medium engagement, 4) low engagement, and 5) disengagement.
	(Dimitriadou & Lanitis, 2024)	Facial recognition–based classification of engagement levels: 1) physical presence, 2) active participation, and 3) distraction.
	(Harb et al., 2023)	Measure through emotion recognition and classify engagement into seven categories: 1) bored, 2) distracted, 3) confused, 4) enjoying, 5) interested, 6) neutral, and 7) worried.
	(Awais et al., 2021)	Measure through emotion recognition and classify engagement into four categories: 1) amusing, 2) boring, 3) relaxation, and 4) scary.
	(Sasaki et al., 2023)	Measure through voice recognition and identify the level of engagement based on the number of negative phrases, filled pauses, and silent pauses. Survey questions (UWES-3 questionnaire) developed by Schaufeli et al. (2019).
3. Measuring by coding various types of data	(Huang et al., 2023)	Measure student engagement through eleven indicated suggested in the learning management system (LMS), including 1) days watched, 2) watching sessions, 3) total watching time, 4) videos watched, 5) previewed videos watched, 6) on-track videos watched, 7) rewatched videos, 8) videos not watched, 9) makeup videos, 10) forum post days, and 11) forum post times.
	(Raj & Renumol, 2022)	Measure based on three features: 1) learners' total number of times accessed the virtual learning environment, 2) learner's assessment scores, and 3) learners' withdrawal status.
	(Lee et al., 2022)	Measure through the coding of data from discussion forum posts to classify cognitive engagement into five levels: 1) non-cognitive

		presence, 2) triggering event, 3) exploration of ideas, 4) integration of ideas, and 5) resolution of problem or issue.
	(Saleeb, 2021)	Measure student engagement through two indicators: 1) number of online sessions attended and 2) number of a student's chat interactions in an online session.
	(Xie et al., 2023)	Measure student engagement through the evaluation of student-teacher interaction. Student-teacher interaction was assessed by the ratio of student-teacher speaking time in a class, percentage of teacher talk (TT), percentage of student talk (PT), teacher response rate (TRR), and student stable state ratio (PSSR).
	(Bañeres et al., 2023)	Measure student engagement based on student dropout rate. A lower student drop rate indicated a higher level of student engagement, and vice versa.
	(Ou et al., 2023)	Measure learner engagement through the evaluation of video engagement time using both YouTube videos' static and dynamic information. Normalize engagement time to represent learner engagement on a given day.
4. No measurement for student engagement	(Wang et al., 2021)	No measure for student engagement. A literature review of different types of eye-tracking and learning systems, software, datasets, and related studies.
	(Hooda et al., 2022)	No measure for student engagement. A comprehensive review of the impact of assessment and feedback on student engagement.
	(Nguyen et al., 2022)	No measure for student engagement. The paper introduced the details of how four AI-powered robot systems were implemented in a smart university campus, without assessing the effects of the implementation.
	(Ilieva et al., 2023)	No measure for student engagement. The researcher assessed students' attitudes toward AI chatbot adoption through a survey.

DISCUSSION

RQ1 explores how AI was implemented to promote student engagement in online learning. It is important because knowing how AI was implemented can help researchers and practitioners create more engaging online learning experiences that meet the diverse needs of online students. As Table 1 suggests, the previous studies can be classified into six categories.

Out of 24 journal articles reviewed, seven studies applied AI for emotion/facial/voice recognition or eye tracking, four used AI to analyze various types of data, and the other five implemented AI for generating feedback and recommendations. These 16 research studies (67%) use machine learning techniques for model construction when implementing AI. On the other hand, four out of 24 studies were interested in incorporating Chatbots into the course design, as the various implementations of the GPT language model have drawn increasing attention in recent years. Two studies discuss the use of AI-powered bots to support online learning and modern education, and the other two applied AI to promote student engagement through teacher-student interaction. As the review suggests, AI was most widely used for model construction using machine learning techniques in previous literature.

Regarding RQ2, the types of data resources used in previous literature were summarized in Table 2. It is important because pairing various data resources with AI technologies may result in innovative solutions that help researchers and practitioners develop more effective AI systems to promote student engagement in online learning. Results suggest that seven studies (29%) used online learners' video recordings, whereas six (26%) used online learners' activity data from the learning management systems. Existing datasets, such as OULAD and YouTube datasets, can also be utilized for research purposes. The remaining six research studies incorporated Chatbots or AI bots and did not use any data resources. As the review suggests, the learners' video recordings or activity data were the primary data resources used in previous studies, which may provide important references for future researchers and practitioners.

RQ3 examined how student engagement was measured in previous studies. This is important because research on student engagement is usually conducted in the context of empirical studies. Implementing AI to promote student engagement in online learning is a novel research field. Understanding how student engagement was evaluated can provide a valuable reference to the researchers and practitioners and help them develop effective strategies that can better engage students in online learning activities. Results suggest that the measurements can be classified into three categories: 1) survey-based measurements, 2) measuring student engagement through AI recognition, and 3) measuring student engagement by coding various types of data.

As Table 3 indicates, eight studies applied survey-based questionnaires to evaluate student engagement (either quantitative or qualitative), whereas five used facial/emotion/voice recognition to classify student engagement into different levels. Seven studies coded various types of data available to assess student engagement, and the other four did not evaluate student engagement in their research design. In summary, a quantitative or qualitative survey is still a preferred instrument used by many researchers when assessing student engagement. On the other hand, using AI recognition to classify the level of student engagement or coding various types of online learners' activity data are the other options available. It is highly recommended to use AI recognition to classify and measure student engagement, which may offer a more objective instrument for evaluating student engagement.

Critical reflection on findings and scientific relevance

Beyond the descriptive synthesis of the reviewed studies, the findings of this review allow for a broader and more critical reflection on the current state of research on artificial intelligence in online learning environments. One of the most significant observations is that AI has been applied to detect, measure, and predict student engagement through machine learning models and multimodal data analysis. While this trend reflects a high level of technical sophistication, it also reveals a limited pedagogical orientation, as fewer studies focus on how AI-driven insights are systematically translated into instructional interventions that actively enhance learning processes.

From a scientific perspective, this imbalance suggests that the field has advanced more rapidly in terms of data processing and engagement analytics than in the development of pedagogically grounded AI-supported learning designs. The emphasis on engagement detection highlights the need for future research to move beyond monitoring and prediction toward the design of adaptive learning systems that meaningfully integrate AI into instructional decision-making and creative learning activities.

In terms of applicability, the findings indicate that many AI-based approaches are currently more feasible in higher education institutions with access to advanced technological infrastructures, large datasets, and interdisciplinary research teams. This raises important questions about scalability and equity, particularly in educational contexts with limited resources. Consequently, the transferability of these AI-driven solutions to diverse learning environments remains a critical challenge that warrants further empirical investigation.

Additionally, the review underscores several limitations and risks associated with the implementation of AI in online learning. Ethical concerns related to data privacy, algorithmic bias, and the potential normalization of continuous surveillance emerge as persistent issues, especially in studies relying on facial, emotional, or behavioral recognition technologies. Furthermore, the lack of consensus regarding the conceptualization and measurement of student engagement complicates cross-study comparisons and limits the generalizability of research findings.

Despite these challenges, this review makes a distinct contribution to scientific literature by integrating research on artificial intelligence, student engagement, and creativity within a single analytical framework. By combining bibliometric analysis with a systematic content review, the study identifies emerging technological trends and pedagogical gaps, offering a structured foundation for future research aimed at designing AI-enhanced online learning environments that are not only engaging but also creativity-oriented and educationally meaningful.

Practitioners are encouraged to integrate AI-driven tools such as chatbots and emotion recognition systems into their course designs. These technologies can make online learning more engaging by offering personalized support, real-time feedback, and a sense of connection, helping to reduce feelings of isolation. Secondly, it is suggested that practitioners utilize diverse data sources to develop more robust AI models that can accurately assess and promote student engagement. These data sources may include video recordings, student activity logs, discussion forum interactions, and real-time performance data. Combining multiple data sources gives AI models a more complete picture of student engagement and learning behaviors. Additionally, practitioners may combine both objective and subjective engagement measures to ensure more accurate and reliable insights into student online learning experiences. Traditional surveys provide valuable insights, but AI-based tracking can offer a more accurate and well-rounded view of how students interact with online learning materials. Finally, practitioners are encouraged to use AI-powered feedback and recommendation systems to provide students with timely, targeted recommendations for improving their learning outcomes. Tools like automated alerts, engagement tracking dashboards, and personalized learning suggestions can help students stay on track, address learning challenges early, and improve their overall learning experience.

Researchers should focus on developing standardized AI-driven frameworks for classifying student engagement in online learning environments. A consistent framework would make it easier to compare studies and improve the accuracy of AI models across different educational settings. Secondly, researchers may explore the potential of machine learning, deep learning, and natural language processing in creating more adaptive and intelligent engagement models. AI should be designed to detect early signs of disengagement and offer real-time support to keep students on track. Thirdly, researchers may investigate how AI can be used to provide personalized learning feedback, automated warning systems, and intervention strategies to improve student engagement. It is important to study how effective AI-generated feedback is in improving learning outcomes. Additionally, integrating both subjective (surveys and interviews) and objective (AI-based) measures for student engagement in one study is recommended for researchers. Comparing these different approaches could reveal important insights and highlight any gaps between human-reported engagement and AI analysis. Finally, longitudinal studies that focus on assessing the AI impact on student engagement over extended periods may be an attractive avenue for researchers. Understanding how AI adapts to changing educational needs over time can provide key insights into its role in shaping the future of online learning.

Impact on society

The integration of AI to promote student engagement in online learning has great potential to impact our society. Firstly, it can promote educational equity by personalizing learning experiences to meet the unique needs of each student. This means that students from different backgrounds and learning abilities can get the support they need, helping to close knowledge gaps and provide better opportunities for marginalized communities. Secondly, it may assist in preparing a future-ready workforce with AI skills that can adapt to the fast-changing and evolving job market. As industries increasingly rely on automation and data-driven decision-making, students who learn in AI-powered environments will develop critical thinking and problem-solving skills that will set them up for success. Finally, it could drive the development of innovative teaching methodologies and make quality education more accessible to a broader population. With tools like virtual and augmented reality, gamification, and intelligent tutoring systems, AI can help create interactive lessons that keep students motivated and actively involved in their education.

Future Research and Limitations

Based on the review of the existing literature, there are several avenues for future studies in implementing AI to promote student engagement in online learning environments. First, previous literature classified student engagement into different categories and used various machine learning techniques for model construction. Future research may standardize the classification of student engagement and develop a model that is more generalizable and applicable to different scenarios. As it is the era of big data, more data will be available to train the models. Implementing machine learning techniques for model construction to promote student engagement will still be the most preferable research direction in the field. In addition, integrating Chatbots or AI-powered bots in online course design is highly recommended, as the rapid evolution of large language models can provide a strong tool to overcome the challenges of online learning and support online students to be more self-regulated and engaged in online learning activities.

Moreover, one category suggested in Table 1 may require more attention in future research: using AI to provide feedback and recommendations to improve student engagement. As the goal of implementing AI in online education is to promote online students' engagement and learning experience, more research is needed to explore how to use AI to facilitate this process through the development of feedback or warning systems. Finally, it was noticed that the previous literature measured student engagement using either survey-based questionnaires (subjective measure) or machine learning techniques to classify the levels of student engagement (objective measure). Future research may apply both measures in one study and assess the alignment through the comparison.

Except for the potential future research stated above, several limitations need to be addressed. First, only the WoS database was used to identify the relevant studies. This review did not search the articles from other databases, such as Scopus and Dimensions. Also, the conference proceedings or book chapters were not included in this review. A broader search may yield more articles to be identified. Additionally, the research interests of this study were limited in the scope of how the implementation of AI promotes student engagement in online education. A more general research scope, such as a literature review of how AI is implemented in online education, may offer a bigger picture to the researchers and practitioners.

CONCLUSION

Engaging students in online learning environments has always been a challenge as it requires more self-autonomy and self-regulation for those online students. The emergence and development of modern AI technologies may offer a potential solution. In this research, a literature review was carried out to summarize previous studies on implementing AI to promote student engagement in online learning. The findings suggest that AI was most widely used for model construction using machine learning techniques, and learners' video recordings or activity data were the primary data resources used in previous literature. In addition, it is highly recommended to use AI recognition to classify and measure student engagement objectively. Overall, the research findings may provide a valuable reference for future researchers and practitioners. By understanding the three research questions proposed, researchers and practitioners may be able to design more efficient AI systems, develop more effective strategies, and create more engaging learning experiences for online students.

This study contributes to the growing body of research on education mediated by artificial intelligence by offering a systematic and integrative overview of how AI has been used to support student engagement and creativity in online learning environments. By identifying prevailing technological approaches, data resources, and engagement measurement strategies, the review provides a coherent framework that can guide future empirical research and instructional design. In this sense, the findings highlight the need to move toward pedagogically grounded and ethically responsible AI-enhanced learning systems that not only monitor engagement but also actively support creative, inclusive, and meaningful learning experiences in digital education.

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