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Online Training by Active Learning Approaches: A Systematic Literature Review

Suwicha Wittayakom[1], Chintana Kanjanavisutt[1] & Methinee Wongwanich Rumpagaporn[1]

[1] Faculty of Education, Kasetsart University, Bangkok, Thailand

Correspondence: Suwicha Wittayakom, Faculty of Education, Kasetsart University, Bangkok, 10900, Thailand. Tel: 66-646-525-944. E-mail: Suwicha.wi@ku.th

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Abstract

This systematic literature review explores the implementation and effectiveness of active learning approaches in online training environments. The rapid growth of online education necessitates strategies that enhance learner engagement and improve educational outcomes. The review identifies various active learning techniques, such as discussions, simulations, case studies, and collaborative problem-solving, which shift the focus from passive information absorption to active knowledge construction. Analyzing empirical studies from 2020 to 2024, the review highlights the positive impacts of active learning on learner engagement, motivation, satisfaction, and overall learning outcomes. Key findings reveal that active learning methods lead to improved knowledge retention, skill development, and practical application of knowledge, addressing the challenges of disengagement commonly associated with traditional online training methods. The review also emphasizes the importance of adaptive learning systems, personalized feedback, and interactive learning activities in fostering an engaging online learning environment. Based on the findings, the review provides recommendations for designing and implementing effective online training programs and suggests directions for future research to further enhance the effectiveness and accessibility of active learning approaches in digital education. By addressing these aspects, the review contributes valuable insights into the development of engaging and impactful online training experiences, ultimately improving learning outcomes for diverse learners.

Keywords: online training, active learning, systematic literature review

1. Introduction

1.1 Introduce the Problem

The advent of online training has transformed the learning landscape, offering unparalleled flexibility and accessibility to a diverse array of learners. However, this advancement is accompanied by a significant challenge-fostering active engagement. Unlike traditional face-to-face settings, online environments frequently struggle to facilitate interactive and engaging learning experiences.

The issue of engagement in online training extends beyond mere inconvenience and has profound implications for learning outcomes. Research has consistently demonstrated a strong correlation between passive learning and diminished knowledge retention, reduced motivation, and overall poorer learning outcomes (Bonwell & Eison, 1991; Garrison, 1997). Traditional online training methods often rely on passive techniques such as lectures or video presentations, where learners primarily receive information without actively engaging. This approach often results in superficial understanding and challenges in applying knowledge in real-world contexts.

Moreover, online training environments frequently lack the inherent social interactions and collaborative learning opportunities present in face-to-face settings. This absence can impede the development of critical thinking, communication, and problem-solving skills, which are essential for deep learning and long-term knowledge retention (Michaelsen et al., 2004).

The ramifications of disengagement extend beyond individual learners. It can lead to higher rates of dropout, decreased completion rates, and a negative perception of online training's effectiveness. This, in turn, can obstruct the potential of online training to democratize access to high-quality learning opportunities on a broader scale (Gairin et al., 2014).

Consequently, research into active learning approaches is imperative to address this complex issue. Active

learning comprises various pedagogical methods that shift the focus from passive information reception to active knowledge construction and application (Camacho & Legare, 2015). These methods may include activities such as discussions, simulations, case studies, and collaborative problem-solving.

By examining the effectiveness of different active learning strategies in online training environments, researchers can make significant contributions to the development of engaging and interactive learning experiences. This research can guide the design of online training programs, the selection of suitable learning technologies, and the creation of effective teaching practices that foster active participation and deeper comprehension.

In conclusion, addressing the challenge of passive learning in online training is not solely about enhancing engagement; it is about improving learning outcomes and the overall efficacy of online training programs. By leveraging the potential of active learning approaches, research can help create more engaging and impactful learning experiences for all learners, ultimately revolutionizing the way we learn and train in the digital era

1.2 Research Objectives

1) To identify and categorize the various active learning approaches used in online training programs across different fields.

2) To analyze the existing research on the effectiveness of active learning approaches in online training: impact on learner engagement, and learning outcomes.

3) To synthesize the findings from the reviewed studies to create a comprehensive understanding of the current state of knowledge regarding the use of active learning approaches in online training environments.

4) To formulate recommendations and directions for future research.

By addressing these objectives, this systematic literature review will provide valuable insights into the effectiveness and feasibility of various active learning strategies in online training settings. This knowledge can inform the design and implementation of more engaging and impactful online training programs, ultimately contributing to improved learning outcomes for a diverse range of learners.

1.3 Research Gap and Importance of Problems

While online training provides significant flexibility and accessibility, ensuring active engagement remains a substantial challenge. Predominant passive learning methods in online training frequently lead to superficial understanding and impede the acquisition of vital skills (Gu et al., 2022). This underscores a critical research gap in comprehending the efficacy and implementation of active learning strategies in online training environments.

Addressing this gap is crucial for several reasons. Disengagement in online training diminishes learning outcomes, increases dropout rates, and fosters a negative perception of its effectiveness (Akar, 2024). By investigating the effectiveness of active learning approaches, this systematic literature review aims to enhance the development of engaging and impactful online training experiences. The insights gained from this research can guide the design and implementation of online training programs, resulting in more effective and engaging learning experiences for all participants.

1.4 Theorical Background

1) Online Training

In the dynamic field of learning and development, online training has emerged as a prominent and versatile approach to acquiring knowledge and skills. Defined as the structured delivery of instruction via electronic and internet-based technologies (Rosenberg, 2016), online training offers numerous benefits for both learners and organizations.

To understand the foundation of online learning, it is essential to examine the theoretical frameworks that support its effectiveness. Andragogy, the theory of adult learning developed by Malcolm Knowles, asserts that adults are self-directed learners driven by intrinsic motivations such as personal relevance and immediate application (Knowles et al., 2011). This theory aligns well with online training, which often enables learners to control the pace and sequence of their educational journey, catering to their individual needs and preferences.

Moreover, online training corresponds with constructivist learning theory, which emphasizes the active construction of knowledge through experience and interaction (Jonassen, 1999; Damşa & Ludvigsen, 2016). This theory resonates with the interactive nature of many online training programs, which incorporate discussions, simulations, and collaborative activities to promote active engagement and knowledge construction.

Beyond theoretical considerations, online training offers several advantages that have contributed to its widespread adoption. A key advantage is increased accessibility. Online training programs are

location-independent and available 24/7, making them ideal for individuals with busy schedules or geographical constraints. This flexibility allows learners to complete training modules at their convenience, fostering self-directed and personalized learning experiences.

Another significant advantage is cost-effectiveness. Compared to traditional face-to-face training, online programs reduce travel and logistical expenses, making them a more financially viable option for both individual learners and organizations (Bartley & Golek, 2004). Additionally, online training materials can be easily updated and revised, ensuring participants have access to the latest information and industry best practices.

Online training programs also offer scalability, allowing them to serve a large and diverse audience simultaneously without incurring substantial additional costs. This scalability makes online training an ideal solution for organizations needing to train extensive workforces or geographically dispersed teams.

Furthermore, online training can be customized to accommodate specific learning styles by incorporating various multimedia elements such as videos, animations, and interactive exercises. This variety caters to different learning preferences, enhancing knowledge retention and engagement for a broader range of learners.

The combined advantages of convenience, cost-effectiveness, scalability, and adaptability have contributed to the increasing popularity of online training across various sectors, including education, corporate training, and professional development. Businesses and organizations leverage online training to equip employees with the necessary skills and knowledge to remain competitive in the ever-evolving workplace. Similarly, educational institutions use online platforms to provide flexible and accessible learning opportunities to students worldwide.

In conclusion, online training has established itself as a valuable and practical approach to learning. Rooted in established learning theories such as andragogy and constructivism, its inherent advantages-accessibility, cost-effectiveness, scalability, and adaptability-make it a compelling alternative to traditional learning methods. As technology continues to advance and online learning platforms become increasingly sophisticated, online training is poised to play an even greater role in shaping the future of learning and development.

2) Active Learning Approach

In the ongoing pursuit of effective educational practices, active learning has emerged as a compelling approach that goes beyond the mere passive absorption of information. Defined as a pedagogical strategy that involves learners in the process of knowledge construction through participatory activities, reflection, and practical application (Bonwell & Eison, 1991; Cooperstein & Kocevar-Weidinger, 2004), active learning starkly contrasts with traditional, teacher-centered methods that prioritize passive listening and rote memorization.

To grasp the theoretical foundations of active learning, one must consider the constructivist learning theories developed by Jean Piaget and Lev Vygotsky. These theories assert that knowledge is actively constructed through meaningful experiences and interactions with the environment and others (Fosnot, 2006; Devi, 2019). Active learning strategies, such as discussions, simulations, and problem-solving activities, align with this theory by enabling learners to engage with the material, connect it to their prior knowledge, and construct their own understanding.

Additionally, active learning is closely associated with David Kolb's experiential learning theory. This theory highlights the cyclical nature of learning, which involves concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Active learning activities support this cycle by providing learners with hands-on experiences, opportunities for reflection and discussion, and avenues to apply their knowledge in real-world contexts.

Active learning offers numerous benefits that enhance the learning experience. One key advantage is the improvement of knowledge retention and understanding. By actively engaging with the material, learners process information more deeply and form stronger connections between concepts, leading to more enduring comprehension compared to passive learning methods focused solely on memorization (Sridharan, 2003).

Another significant benefit is the development of critical thinking and problem-solving skills. Through participation in discussions, collaborative activities, and problem-based learning, learners are encouraged to analyze information, evaluate evidence, and devise solutions. This fosters essential skills needed for success in various academic and professional settings (Nelson & Crow, 2014).

Active learning also promotes increased student engagement and motivation. Allowing learners to take an active role in their educational journey makes them more invested and engaged in the learning process. This intrinsic motivation enhances the learning experience and fosters a greater desire to learn (Zengaro & Zengaro, 2022).

Furthermore, active learning facilitates the development of communication and collaboration skills. Engaging in

group discussions, teamwork, and collaborative projects helps learners refine their ability to express ideas effectively, listen actively, and work cooperatively with others. These interpersonal skills are crucial for success in both academic and professional environments.

The compelling advantages of active learning have led to its widespread adoption across various educational institutions and disciplines. Instructors employ diverse active learning strategies, from case studies and role-playing to simulations and debates, to accommodate different learning styles and subject matter.

In conclusion, active learning provides a powerful alternative to traditional, passive learning methods. Grounded in established learning theories, active learning promotes deeper understanding, critical thinking, and increased engagement, thereby enriching the educational experience and fostering lifelong learning. As educators continue to explore and implement various active learning strategies, the future of education promises to be an increasingly engaging and impactful journey for learners of all ages.

2. Literature Review

2.1 The Role of Active Learning for Online Training

The advent of online training has transformed learning by providing flexibility and accessibility to a broad audience. Nonetheless, fostering active engagement in online environments remains a significant challenge compared to traditional face-to-face settings.

Numerous studies have demonstrated the positive effects of active learning approaches on engagement and learning outcomes in online training. For example, Sitzmann et al. (2006) conducted a meta-analysis of 96 studies, revealing that active learning strategies, such as discussions and simulations, result in substantially higher achievement than traditional methods. Similarly, Garrison & Cleveland (1997) underscores the importance of active participation in online learning environments, noting a strong correlation between active learning and enhanced student satisfaction and learning outcomes.

Specific active learning strategies have proven particularly effective in online training. Sun et al. (2014) examined the impact of collaborative learning in an online training program and found it more effective than individual learning in fostering knowledge acquisition and critical thinking skills. Likewise, Zheng et al. (2014) explored the use of online simulations in healthcare training and found them successful in promoting skill development and learner engagement.

Despite the evident benefits of active learning, effectively implementing these strategies in online training environments necessitates careful consideration of various factors. Garrison and Cleveland (2010) highlight the crucial role of technological considerations, emphasizing the need for online learning platforms to support interactive activities and real-time collaboration. They also stress the importance of pedagogical strategies, including instructional design and teaching practices that facilitate active learning and engage online learners.

Additionally, learner characteristics significantly influence the success of active learning implementation. Sitzmann & Ely (2011) suggest that individual learning styles and prior knowledge can impact the effectiveness of specific active learning approaches. Rovai (2007) also emphasizes the importance of learner self-regulation and motivation in online learning environments, arguing that learners must be equipped to manage their learning and remain motivated to actively participate in online activities.

Implementing active learning in online training also presents several challenges. One major challenge is the potential technical limitations of online learning platforms, as some may lack the functionalities needed to support complex interactive activities effectively. Furthermore, learners may encounter technological barriers, such as limited internet access or inadequate hardware, hindering their ability to fully engage in online activities.

Another challenge is maintaining learner motivation and engagement in online environments. The inherent isolation and lack of immediate feedback compared to traditional settings can reduce motivation and make it difficult for learners to stay focused on online activities. Moreover, the knowledge and skills of trainers are critical for successfully implementing active learning online. Trainers need proper training and development to design and facilitate engaging online activities that encourage learner participation and knowledge construction.

The existing literature provides robust evidence supporting the effectiveness of active learning approaches in enhancing engagement and learning outcomes in online training. However, successful implementation requires careful attention to various factors, including technological capabilities, pedagogical strategies, learner characteristics, and potential challenges. By addressing these factors and continually exploring innovative approaches, educators and trainers can create more engaging and impactful online training experiences, empowering learners to actively construct knowledge and achieve their educational goals.

2.2 Research Hypothesis

Implementing active learning approaches in online training programs will lead to improved learner engagement and learning outcomes compared to traditional, passive learning approaches. This hypothesis rests on the assumption that active learning fosters deeper understanding by encouraging active participation, knowledge construction, and application**.** By analyzing the existing research on the effectiveness of various active learning strategies in online training, this review aims to investigate the validity of this hypothesis. Examining the impact of active learning on learner engagement, knowledge acquisition, skill development, and knowledge retention will provide crucial insights into its potential to enhance the overall effectiveness of online training.

3. Method

This study employed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) to conduct a systematic study on the online training with active learning approach. PRISMA is a publication standard that is applicable to the Systematic Literature Review (SLR) creation procedure (Moher et al., 2009). It is commonly used in the fields of medicine and public health; however, its usage can be extended into social sciences following its efficiency in creating research questions and its methodical process for source searches. Moreover, PRISMA reduces prejudice and performs well in research synthesis.

A systematic literature search was conducted to identify and retrieve empirical studies relevant to this review. Three databases were searched: Scopus, ERIC and Project Muse. The reference sections of previous review articles were also scanned for relevant articles. We used the following set of keywords to search the relevant articles: *Online Training* in relation to *Active Learning,* and limited our search to empirical studies published in peer-reviewed/refereed journals between 2020 and 2024 (July). This search resulted in a total of 44 articles.

Next, the abstracts of all the 44 articles were read to decide whether the full text of an article should be retrieved or not. The authors initially agreed on the following criteria for inclusion and exclusion of articles. In order to be included, the study should present some kind of online training. Also, the study should include active learning approach. If any of the above criteria were not met, the study was rejected. Based on these inclusion/exclusion criteria, the abstracts of all the articles were read and coded independently. The following ratings were used during coding: 1 (the article is not suitable); 2 (the article is possibly suitable); and 3 (the article is suitable). Articles which were rated “1” were immediately rejected. The outcome of this procedure was a total of 17 articles from which data were extracted.

A data extraction sheet was used to record all the required information from the individual study reports. The extraction of data involved the various active learning approaches used in online training programs across different fields, the effectiveness of active learning approaches in online training by examining, to create a comprehensive understanding of the current state of knowledge regarding the use of active learning approaches in online training environments, and to formulate recommendations and directions for future research.

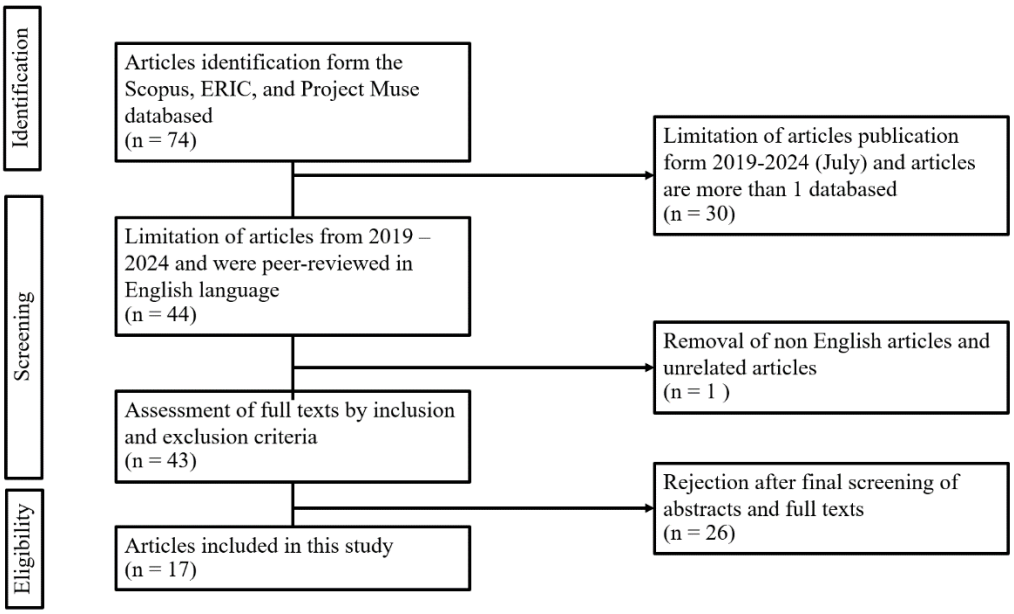

Figure 1. PRISMA Protocol Flow Diagram of the Systematic Literature Review (SLR) Process

Table 1. Keywords to search article from Scopus, ERIC and Project Muse

Databases	Keywords to search
Scopus	TITLE-ABS-KEY (“online training”) AND (“active learning”)
ERIC	"Online training" AND "Active learning"
Project Muse	"Online training" AND "Active learning"

Table 2. Screening criteria

Screening criteria	Details
Type of Publication	Articles
Language	English only
Timeframe	Five years (2019 – 2024 (July))
Accessibility	Full text
Focus of finding	Online training and active learning

4. Results

4.1 Description of Review Samples

The educational landscape is continually evolving, influenced by technological advancements and shifting pedagogical approaches. Recent research provides valuable insights into these trends. This study analyzes findings from a sample of research articles (2021-2024) to identify key focal areas within educational research.

Several studies have delved into the development of specific competences through online training programs. Adiego & Martin-Cruz (2021) created an online curriculum for higher education students that emphasizes transversal competences for smart city projects. This curriculum, which employs a project-based learning approach, provided interdisciplinary and multinational experiences, proving effective in the smart cities sector. Similarly, Chuang & Wu (2021) developed a training mechanism for SDN intrusion detection that combines self-training and active learning. Their approach enhanced the accuracy of identifying unknown attacks and outperformed existing systems, showcasing the potential of advanced online training in cybersecurity.

Online platforms for professional development have shown significant promise for educators and professionals. Fang et al. (2022) found that a five-day online professional development program substantially increased teachers' knowledge and capability to implement project-based learning (PBL). This program helped teachers gain a deeper understanding of PBL concepts and boosted their confidence in applying these methods across different educational settings. Moreover, Nguyen et al. (2024) revealed that short online pedagogical courses greatly improved university teachers' grasp of the importance of prior knowledge in the learning process and their ability to create engaging lectures. These improvements were especially pronounced among teachers who lacked prior pedagogical training.

Research has also focused on the effectiveness of various teaching methodologies and their impact on learner engagement in online settings. Bottini & Gillis (2021) compared web-delivered training with virtual role play to live training for teaching stimulus preference assessment (SPA) implementation. They discovered that both methods were equally effective, with the web-delivered training saving a considerable amount of trainer time, highlighting its efficiency in remote training contexts. James et al. (2022) emphasized the crucial role of active learning, effective communication, universal design, and backward design principles in successful online teaching. Their study highlighted the need for institutional support to enhance the effectiveness of online teaching and improve student engagement and learning outcomes.

The integration of technology in education has both facilitated and posed challenges to the learning process. Castro-Schez et al. (2020) examined the use of an intelligent tutoring system (ITS) for active learning in predictive parsing techniques. The ITS, named Proletool 3.0, significantly improved students' understanding and academic performance, demonstrating the benefits of technology-enhanced learning tools. Lynch & Miller (2023) focused on the use of hybrid and simplified technology in a community science project on pollinator visitation. They found that these technologies improved accessibility and participation, despite encountering challenges with data collection and technology use.

While online learning offers numerous advantages, it also presents challenges that need to be addressed. Pavlou (2022) explored the challenges and potentials of delivering museum education to pre-service teachers in an online environment. The study found that virtual museum visits and object-based learning promoted engagement

and active learning, although technical and logistical challenges were significant. Similarly, Krauthamer (2020) discussed the transformative impact of the COVID-19 pandemic on education, highlighting the benefits of remote learning for flexibility and student engagement. However, the study also pointed out challenges related to unequal access to technology and internet connectivity, which must be addressed to ensure effective remote learning for all students.

Collectively, the reviewed studies highlight the transformative potential of online training and education across various domains. From enhancing specific competences and professional development to improving teaching methodologies and integrating technology, online learning has demonstrated substantial benefits. However, challenges such as accessibility, technical issues, and the need for institutional support remain critical considerations. As education continues to evolve in the digital age, ongoing research and innovation will be crucial to maximizing the effectiveness and inclusivity of online learning.

4.2 Objective 1: The Various Active Learning Approaches Used in Online Training Programs across Different Fields

Project-Based Learning (PBL) emphasizes learning through the active exploration of real-world challenges and problems. Adiego & Martin-Cruz (2021) highlight the implementation of PBL and interdisciplinary teamwork in the context of smart cities and innovation management, focusing on higher education students and professionals aspiring to work in smart cities. Similarly, Fang et al. (2022) employed PBL in teacher training programs, engaging teachers in project designing, problem-solving, decision-making, and investigative activities. These approaches not only foster critical thinking but also enhance practical skills applicable in real-world scenarios.

Collaborative learning, particularly through virtual teams, has proven effective in online education. Darban (2021) discusses the use of collaborative learning to enhance team dynamics and leadership skills among university students. This approach promotes peer interaction and cooperative problem-solving. Almendingen et al. (2022) utilized breakout room discussions in health, social, and teacher education programs, facilitating interactive discussions and peer learning among university students. Additionally, Lynch & Miller (2023) combined interactive learning with outdoor practice in ecological research, engaging community scientists in hands-on projects that blend theoretical knowledge with practical application. Krauthamer (2020) further explored the use of technology-enhanced learning, collaborative learning, interactive workshops, and student presentations, emphasizing their importance in engaging college students and enhancing their learning experience.

Interactive learning techniques are also essential in enhancing the effectiveness of online teaching methodologies. James et al. (2022) incorporated various active learning strategies to improve the teaching experience for educators, emphasizing the importance of engagement and interaction in online learning environments. These methods help create a dynamic learning atmosphere that encourages student participation and retention.

Reflective tasks and self-directed learning are critical in promoting autonomous and deeper learning. Nguyen et al. (2024) combined engaging lectures with reflective tasks in higher education pedagogy, targeting university teachers and doctoral students. This approach encourages learners to reflect on their experiences and integrate new knowledge into their practice. Ram & Roy (2020) emphasized self-assessment during the COVID-19 pandemic, engaging university students in self-directed learning to adapt to remote education. Wang et al. (2022) focused on self-reflection assignments and interaction with learning materials in talent training for pharmaceutical sales, designed for medical sales representatives. Similarly, Chuang & Wu (2021) implemented self-training in network security and software-defined networking (SDN) intrusion detection, targeting workers in the field.

Game-Based Learning (GBL) and experiential learning approaches make education engaging and practical. Cantoia et al. (2023) applied GBL in teacher training programs, helping teachers design engaging educational activities that incorporate game mechanics. This method enhances motivation and retention by making learning enjoyable and interactive. Pavlou (2022) utilized experiential and collaborative learning, including object-based learning and virtual museum visits, in museum education for student teachers. These approaches provide hands-on experiences that connect theoretical knowledge with real-world applications.

Specific fields often require tailored active learning methods. Castro-Schez et al. (2020) emphasized learning through experimentation and the creation of exercises by learners in computer science, particularly in predictive parsing algorithms and compiler design, targeting university students. Bottini & Gillis (2021) used virtual role plays and interactive learning for behavioral interventions, engaging undergraduate students in realistic scenarios that develop practical skills. Gu et al. (2022) implemented flipped classrooms and active engagement in learning tasks for creativity training, involving university students in dynamic and interactive learning processes. Avci et

al. (2023) focused on student-centered active learning in social and financial leadership education for primary and secondary school teachers and students in Turkey, promoting leadership skills and active participation.

The diverse active learning approaches used in online training programs demonstrate the adaptability and effectiveness of these methods in enhancing educational experiences. By incorporating interactive techniques, online training programs foster critical thinking, practical skill development, and deeper understanding, ensuring that learners are well-prepared for their respective fields.

4.3 Objective 2: The Effectiveness of Active Learning Approaches in Online Training

Participation is a critical component of learner engagement. Adiego & Martin-Cruz (2021) emphasize the role of teamwork and project-based learning activities in enhancing student participation. Similarly, Bottini & Gillis (2021) highlight active engagement through virtual role plays, which are integral to their training programs. Darban (2021) discusses the enhancement of group collaboration and participation through shared leadership. Fang et al. (2022) and James et al. (2022) also underscore the importance of active participation in project-based learning and active learning strategies, respectively. Moreover, Nguyen et al. (2024) and Castro-Schez et al. (2020) describe the participation of teachers in collaborative learning activities, while Ram & Roy (2020) discuss student involvement in online classes. Almendingen et al. (2022) and Pavlou (2022) explore the use of breakout rooms and group activities to encourage participation. Lastly, Wang et al. (2022) and Avci et al. (2023) discuss the impact of active learning and interactive projects on learner participation. Krauthamer (2020) adds to this by highlighting various remote learning tools and strategies that facilitate student engagement and participation, such as interactive platforms and virtual collaboration.

Motivation is essential for sustained engagement and success in educational programs. Bottini & Gillis (2021) discuss how participants are motivated to perform well in role plays and assessments. Fang et al. (2022) highlight the increased motivation among students in project-based learning environments, while James et al. (2022) and Ram & Roy (2020) emphasize the role of active learning and good communication practices in enhancing learner motivation. Castro-Schez et al. (2020) discuss the promotion of learner independence and self-directed learning as motivational factors. Chuang & Wu (2021) and Almendingen et al. (2022) address motivation in the context of engaging learners through practical exercises and interactive group work. Finally, Pavlou (2022) and Avci et al. (2023) highlight motivation through relevant and engaging content, and Cantoia et al. (2023) focus on the innovation and engagement fostered by game-based learning activities. Krauthamer (2020) also underscores the importance of providing flexible learning environments and the use of technology to keep students motivated and engaged in their studies.

Satisfaction is a crucial indicator of the effectiveness of educational programs. Adiego & Martin-Cruz (2021) evaluate student satisfaction with course content and collaborative projects. Bottini & Gillis (2021) measure satisfaction through feedback on virtual role play experiences, while James et al. (2022) address satisfaction by highlighting regular feedback and supportive online communities. Ram & Roy (2020) and Pavlou (2022) discuss satisfaction levels based on survey responses and positive feedback from students and teachers. Almendingen et al. (2022) measure satisfaction through positive feedback on the use of breakout rooms, and Cantoia et al. (2023) assess satisfaction through teacher feedback on game-based learning activities. Lastly, Avci et al. (2023) report high levels of satisfaction with program content and delivery.

Knowledge acquisition is a fundamental outcome of any educational program. Bottini & Gillis (2021) discuss the effectiveness of virtual role plays in enhancing knowledge acquisition. Darban (2021) and James et al. (2022) highlight knowledge acquisition through shared leadership and active learning practices, respectively. Fang et al. (2022) and Almendingen et al. (2022) emphasize the positive impact of project-based learning and collaborative learning on knowledge acquisition. Chuang & Wu (2021) report improved understanding of SDN intrusion detection mechanisms, while Pavlou (2022) discusses interactive and experiential learning activities. Avci et al. (2023) highlight learning about social and financial leadership, and Cantoia et al. (2023) focus on teachers learning new strategies and tools for game-based learning. Krauthamer (2020) shows how remote learning platforms support knowledge acquisition through access to diverse resources and interactive content.

Skill development is another critical outcome of educational programs. Adiego & Martin-Cruz (2021) cover the development of transversal competences and professional skills through project-based learning. Bottini & Gillis (2021) focus on developing skills related to preference assessment through practical exercises. James et al. (2022) describe the development of various skills, including technical and analytical skills, through active learning strategies. Castro-Schez et al. (2020) highlight skill development in predictive parsing techniques and other computer science skills. Chuang & Wu (2021) discuss skill development through hands-on training in SDN security techniques, and Almendingen et al. (2022) emphasize communication and teamwork skills through the

use of breakout rooms. Pavlou (2022) and Avci et al. (2023) discuss skill development in teaching, collaboration, leadership, financial literacy, and social responsibility. Cantoia et al. (2023) focus on enhancing instructional design and technology integration skills. Additionally, Krauthamer (2020) points out the importance of developing digital literacy and other skills necessary for successful remote learning.

Knowledge retention is crucial for long-term learning outcomes. Fang et al. (2022) discuss long-term knowledge retention and application as outcomes of project-based learning. James et al. (2022) examine how ongoing engagement and active learning techniques contribute to knowledge retention over time. Wang et al. (2022) also discuss the impact of active learning on knowledge retention through self-reflection and application to work tasks.

The diverse active learning approaches employed in online training programs across different fields highlight the potential of these methods to enhance engagement and learning outcomes. From project-based learning and virtual role plays to collaborative learning and game-based activities, each approach offers unique benefits tailored to specific educational contexts. As online education continues to evolve, the ongoing exploration and refinement of active learning strategies will be crucial in maximizing their effectiveness and inclusivity.

4.4 Objective 3: To Create a Comprehensive Understanding of the Current State of Knowledge Regarding the Use of Active Learning Approaches in Online Training Environments

Active learning involves instructional methods that engage students actively in the learning process, encouraging participation rather than passive absorption of information. Various studies have highlighted the effectiveness of these approaches in online training settings.

Adiego & Martin-Cruz (2021) highlight the importance of engaging students through interactive and practical learning activities in online programs. Their study reported positive outcomes, including the development of specific competencies related to smart city technologies and favorable feedback from participants regarding their engagement and learning experiences. Similarly, Bottini & Gillis (2021) demonstrated how virtual role play increases learner engagement by involving participants in interactive and realistic scenarios, leading to the acquisition of practical skills related to preference assessment.

The use of project-based learning (PBL) in online professional development, as discussed by Fang et al. (2022), enhances teacher engagement and participation. This approach has been shown to improve teacher competencies in implementing PBL and to enhance student outcomes in classrooms as a result of teacher training. Additionally, Castro-Schez et al. (2020) emphasized how active learning methods, supported by Intelligent Tutoring Systems (ITS), increase learner engagement by involving students in their learning processes and encouraging independence, ultimately leading to improved academic performance and higher grades.

Learner engagement is a critical factor in the success of online education. Active learning approaches have been found to significantly enhance engagement by making the learning process more interactive and participatory. James et al. (2022) found that active learning techniques, such as breakout rooms and interactive discussions, significantly increase learner engagement in online settings. These methods foster improved student engagement, better understanding of course material, and positive feedback from students. Krauthamer (2020) added that the shift to online learning increased student engagement by allowing flexibility in attending classes, using synchronous tools, and interactive activities. These improvements in student attendance, participation, and overall engagement are attributed to the enhanced interactivity and flexibility provided by online learning tools and methods.

Nguyen et al. (2024) also discussed how training courses improved teachers' conceptions of active learning and their ability to engage students during lectures, leading to increased awareness of the importance of prior knowledge and enhanced teaching practices. Darban (2021) highlighted how shared leadership enhances learner engagement by promoting active participation and collaboration among students. This study reported positive outcomes in terms of improved collaboration skills and knowledge acquisition through shared leadership and active learning. Similarly, Wang et al. (2022) demonstrated that active learning, through self-reflection assignments, significantly enhanced learner engagement by allowing learners to connect training content with their work tasks, thus fulfilling their need for autonomy.

The outcomes of active learning approaches in online training environments are overwhelmingly positive, with numerous studies reporting significant improvements in learning achievements and practical skills. Lynch & Miller (2023) found that active participation and engagement in online training programs lead to better learning outcomes, including knowledge retention and skill development. This finding is supported by the work of Wang et al. (2022), who reported that active learning significantly improved learning outcomes, including self-efficacy

and knowledge acquisition, compared to passive learning methods.

Ram & Roy (2020) conducted a survey indicating that online classes, when designed to be interactive and engaging, are considered necessary and useful by a significant portion of respondents. This engagement leads to positive learning outcomes and enhances the overall educational experience. Pavlou (2022) also reported positive student feedback, increased engagement, and a deeper understanding of museum education concepts as outcomes of active learning activities like 'Our Walks', where students led virtual tours and shared experiences.

Furthermore, Avci et al. (2023) highlighted how active learning processes and e-mentoring supported teacher engagement throughout the training, leading to significant improvements in teaching practices and positive impacts on student learning outcomes. Cantoia et al. (2023) reported that game-based learning (GBL) increased student engagement, motivation, and collaboration, leading to positive learning achievements, with students either maintaining or improving their grades.

The current state of knowledge regarding the use of active learning approaches in online training environments underscores their effectiveness in enhancing learner engagement and achieving positive educational outcomes. Studies consistently demonstrate that interactive and participatory methods foster deeper engagement, better understanding, and improved performance among learners. As online education continues to expand, incorporating active learning strategies will be crucial to ensuring that students remain engaged and achieve their full potential.

4.5 Objective 4: To Formulate Recommendations and Directions for Future Research

Effective online training design hinges on engaging, interactive, and practical learning activities. Adiego & Martin-Cruz (2021) emphasize the importance of integrating practical and interactive activities to keep students engaged. Similarly, Pavlou (2022) advocates for activities that promote active and experiential learning, such as virtual museum visits and object-based learning, to foster deep engagement. Krauthamer (2020) supports this by advising the use of interactive elements like synchronous tools to enhance engagement and learning outcomes.

Nguyen et al. (2024) highlight the necessity of considering target participants, duration, content, and cost in designing online pedagogical training. They recommend including reflective and interactive tasks, peer reviews, and ensuring accessibility and engagement through various digital tools. Moreover, Bottini & Gillis (2021) stress the importance of providing both live and online training materials to enhance trainee autonomy and accessibility.

Several studies underscore the need for adaptive learning systems. Castro-Schez et al. (2020) recommend designing online training systems that support active learning through interactive features and personalized feedback. Similarly, Gu et al. (2022) suggest tailoring online training to individual cognitive styles, with active strategies being particularly beneficial for Field Dependent learners.

Effective implementation strategies are crucial for the success of online training programs. Bottini and Gillis (2021) recommend offering both live and online training to accommodate trainee preferences and maximize engagement. James et al. (2022) emphasize the importance of institutional support, including professional development for faculty, student support through training modules, and technological support. Krauthamer (2020) adds that implementing online training with various virtual conferencing tools and recording sessions ensures access for all students, including those who cannot attend live sessions.

Interactive and collaborative elements are vital for engaging learners. Ram & Roy (2020) suggest that online classes should be engaging and interactive, with tools to keep students active. Almendingen et al. (2022) recommend using structured collaborative activities and breakout rooms to enhance engagement and collaboration in online learning environments. Providing immediate feedback and supporting both individual and collaborative learning are also emphasized. Nguyen et al. (2024) advocate for incorporating elements like interactive tasks, peer reviews, and regular content updates to enhance online course effectiveness. Avci et al. (2023) outline an implementation process involving regular meetings, feedback sessions, and structured training sessions to ensure effective learning outcomes.

Future research should focus on various aspects of online training to further enhance its effectiveness and accessibility. Bottini & Gillis (2021) suggest investigating the cost-benefit analysis of saving trainer time versus trainee time and the effectiveness of virtual role-play in online training. Darban (2021) recommends comparing vertical versus shared leadership and examining other team-level constructs to understand their impacts in virtual team learning contexts.

Nguyen et al. (2024) call for future research with larger sample sizes and control groups to draw stronger conclusions. They also recommend conducting observations to detect changes in teaching practices and

follow-up surveys to assess how knowledge is applied in practice. Fang et al. (2022) emphasize the need for larger teacher samples across various age and experience levels to examine the sustainability of training methods.

Exploring the impact of intelligent tutoring systems on learning outcomes is another research direction. Castro-Schez et al. (2020) suggest investigating the effectiveness of different active learning strategies within these systems. Additionally, Wang et al. (2022) recommend further investigation into the underlying mechanisms between active learning and the need for autonomy, as well as exploring different operationalizations of active learning.

The potential of blended learning strategies and the use of 'living inquiry' in online museum education are areas for future exploration, as suggested by Pavlou (2022). Lastly, Avci et al. (2023) call for studies to explore the impact of student-centered education practices in different educational environments and among various groups of students.

The synthesis of recommendations and future research directions from recent studies provides a comprehensive framework for enhancing online training design and implementation. By focusing on interactive, practical, and adaptive learning strategies, and by addressing diverse learner needs and preferences, online training programs can achieve greater effectiveness and engagement. Future research will play a crucial role in refining these strategies and exploring new avenues to further optimize online learning experiences.

5. Conclusion

The findings from the reviewed studies underscore the significant impact of active learning approaches in online training programs across various fields. These methods, which include project-based learning, virtual role plays, collaborative learning, game-based learning, and more, have consistently demonstrated their effectiveness in enhancing learner engagement, motivation, satisfaction, knowledge acquisition, skill development, and knowledge retention. For instance, studies by Adiego & Martin-Cruz (2021) and Fang et al. (2022) highlight how project-based learning fosters critical thinking and practical skills through real-world applications. Similarly, the work of Bottini & Gillis (2021) and James et al. (2022) illustrates that virtual role plays and interactive learning techniques not only engage students but also save valuable instructional time.

However, these benefits do not come without challenges. The integration of technology, while facilitating active learning, also poses significant hurdles. Studies by Castro-Schez et al. (2020) and Lynch & Miller (2023) reveal that technical issues and data collection challenges can hinder the effectiveness of online learning tools. Moreover, the need for comprehensive institutional support, as emphasized by James et al. (2022) and Krauthamer (2020), remains critical to overcoming these barriers. Ensuring accessibility, providing professional development for educators, and supporting students with adequate technological resources are essential to fully harness the potential of online education. As the digital age continues to evolve, addressing these challenges through ongoing research and innovation will be crucial for maximizing the effectiveness and inclusivity of online learning environments.

6. Discussion

The transformative impact of active learning approaches in online education is evident from the reviewed studies, yet it also brings to light several critical considerations that need to be addressed to optimize these strategies. Active learning techniques, such as project-based learning (PBL), virtual role plays, collaborative learning, and game-based learning, have been shown to significantly enhance student engagement, knowledge acquisition, and skill development. These methods foster an interactive and participatory learning environment that is crucial for maintaining student interest and motivation in an online setting. However, their implementation is not without challenges.

One of the most pressing issues is the technological barrier that still exists for many learners and educators. Studies by Castro-Schez et al. (2020) and Lynch & Miller (2023) illustrate that while technology can greatly enhance learning through tools like intelligent tutoring systems and hybrid technologies, technical issues and data collection challenges can impede their effectiveness. Additionally, unequal access to technology and reliable internet connectivity, as highlighted by Pavlou (2022) and Krauthamer (2020), remains a significant obstacle. This digital divide can exacerbate educational inequalities, making it imperative to address these infrastructural gaps to ensure equitable access to quality online education.

Furthermore, the need for comprehensive institutional support cannot be overstated. Effective online learning environments require more than just technological tools; they necessitate robust support systems for both educators and students. James et al. (2022) and Krauthamer (2020) emphasize the importance of professional

development for educators to equip them with the necessary skills to facilitate active learning online. Equally important is the provision of student support services, including technical assistance and access to learning resources. Institutions must also foster a culture of continuous improvement and feedback, as suggested by Nguyen et al. (2024), to refine and adapt teaching practices based on student needs and learning outcomes.

Another critical aspect is the customization of learning experiences to cater to individual learner needs. Adaptive learning systems, as recommended by Castro-Schez et al. (2020) and Gu et al. (2022), can play a pivotal role in this regard by providing personalized feedback and tailored learning paths. Such systems can help address the diverse cognitive styles of learners, thereby enhancing the overall effectiveness of online education. However, the development and implementation of these systems require significant investment and research to ensure they are scalable and effective across different educational contexts.

7. Recommendation

Future research should prioritize developing strategies to bridge the digital divide, which remains a significant barrier to equitable online education. This involves investigating affordable and scalable solutions for providing reliable internet access and technological tools to underserved communities. Researchers should explore the impact of such interventions on reducing educational inequalities and improving learning outcomes, ensuring that all students have equal opportunities to benefit from online learning innovations.

Additionally, there is a critical need to enhance the integration of advanced technologies in online education. Future studies should focus on optimizing intelligent tutoring systems, adaptive learning platforms, and other technological tools to cater to diverse learning environments. Researchers should evaluate the long-term effectiveness of these technologies in enhancing student engagement, motivation, and academic performance. By understanding how these tools can be best utilized, educators can create more personalized and effective online learning experiences.

Lastly, comprehensive research is needed on the effectiveness of professional development programs for educators in online settings. These studies should assess various training models, their impact on teaching practices, and the subsequent effects on student learning outcomes. Additionally, future research should examine the role of institutional support systems, including technical assistance and access to learning resources, in fostering a supportive and engaging online learning environment. By addressing these areas, future studies can provide valuable insights into improving the design and implementation of online training programs, ensuring they are effective and inclusive for all learners.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The Publication Ethics Committee of the Canadian Center of Science and Education.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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No additional data are available.

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Appendix

Appendix A

The List of selected articles for Systematic Literature Review

Table A1. Article lists and details

Article	Athor(s)	databased	Main Findings
Training competences in smart cities: an online program for higher education students	Adiego & Martin-Cruz, 2021	ERIC	The study developed an online training curriculum aimed at equipping students with transversal competences necessary for working on smart cities projects. The curriculum employed a project-based learning approach and demonstrated effectiveness in providing interdisciplinary and multinational learning experiences, essential for the smart cities sector.
Use of an Online Training with Virtual Role Play to Teach Preference Assessment Implementation	Bottini & Gillis, 2021	ERIC	The study found that web-delivered training with virtual role play was as effective as live training for teaching stimulus preference assessment (SPA) implementation to undergraduates. Both methods required in-person role-play and feedback to achieve high performance. The web-delivered training saved approximately 25 minutes of trainer time per participant, indicating its efficiency and potential usefulness in remote training settings.
Learning in virtual student teams: an examination of shared leadership	Darban, 2021	ERIC	The study found that team empowerment and perceived virtuality positively influence the formation of shared leadership in virtual student teams. Shared leadership, in turn, significantly enhances team members' perceived knowledge update and intention to learn. This research highlights the importance of shared leadership for effective knowledge acquisition and team learning in online project-based settings.
Can online professional development increase teachers'success in implementing project-based learning in south China?	Fang et al., 2022	ERIC	The study demonstrated that a five-day online professional development program effectively increased teachers' knowledge of and ability to implement project-based learning (PBL) in their classrooms. The training led to a shift from a superficial to a deeper understanding of PBL concepts and increased teachers' comfort level in planning and implementing PBL projects across various grade levels and subjects.
Effective online teaching: Voices of experience	James et al., 2022	ERIC	The study highlights the importance of active learning, effective communication, universal design, and backward design principles in successful online teaching. It emphasizes the need for institutional support, including professional development and technological resources, to enhance online teaching effectiveness. Experienced instructors shared best practices, demonstrating that these strategies can significantly improve student engagement and learning outcomes in online courses.
The Effects of Short Online Pedagogical Courses on University Teachers' Conceptions of Learning and Engaging Students During Lectures	Nguyen et al., 2024	ERIC	The study found that short online pedagogical training courses significantly improved university teachers' understanding of the importance of prior knowledge in the learning process and their ability to create engaging lectures. These improvements were more pronounced in teachers without prior pedagogical training, highlighting the effectiveness of short courses in enhancing pedagogical skills, especially for novice educators.
An intelligent tutoring system for supporting active learning: A case study on predictive parsing learning	Castro-Schez et al., 2020	Scopus	The study found that an intelligent tutoring system (ITS) designed for active learning in predictive parsing techniques significantly improved students' learning outcomes. The ITS, called Proletool 3.0, allowed students to create and solve exercises independently, provided automated feedback and guidance, and facilitated learning through experimentation. Students using the system demonstrated better understanding and higher academic performance in predictive parsing compared to those who did not use it.
Perception On Online Classes - A Questionnaire Survey	Ram & Roy, 2020	Scopus	The survey concluded that online classes are perceived as necessary and useful by students and parents, with 52% of respondents affirming their necessity. However, contact classes were preferred over online classes. The study also highlighted that while online classes are seen as beneficial for improving knowledge, they can cause stress and health issues for some students. Additionally, there was no significant gender difference in perceptions of the usefulness and impact of online classes.
Employing On-Line Training in SDN Intrusion Detection	Chuang & Wu, 2021	Scopus	The study presents a new training and learning mechanism for SDN intrusion detection that combines self-training and active learning. This mechanism improves identification accuracy of unknown attacks by incorporating high-confidence malicious samples and using faster clustering methods for active learning. Parallel training ensures continuous classifier operation without service interruption. The proposed method outperforms existing active learning intrusion detection systems (ALIDS) in terms of accuracy and efficiency, effectively preventing unknown attacks with minimal time cost.
Breakout Rooms Serve as a Suitable Tool for Interprofessional Pre-Service Online Training among Students within Health, Social, and Education Study Programs	Almendingen et al., 2022	Scopus	The study found that breakout rooms are an effective tool for interprofessional pre-service online training among students in health, social, and education programs. Breakout rooms provided a suitable platform for students to learn about, from, and with each other, especially in discussing sensitive topics and practicing interprofessional collaboration (IPC). Students reported that breakout rooms created a safe and supportive online environment for learning and practicing IPC skills.
Active versus Passive Strategy in Online Creativity Training: How to Best Promote Creativity of Students with Different Cognitive Styles?	Gu et al., 2022	Scopus	The study found that active learning strategies in online creativity training significantly improve creative performance for field-dependent (FD) learners, particularly in tasks involving alternative uses and design problems. In contrast, field-independent (FI) learners did not show significant improvement with active learning strategies compared to passive ones. This suggests that the effectiveness of online creativity training varies based on cognitive styles, highlighting the need to tailor training approaches to individual learner differences.
Museum education for pre-service teachers in an online environment: Challenges and potentials	Pavlou, 2022	ERIC & Scopus	The study highlights the challenges and potentials of delivering museum education to pre-service teachers in an online environment during the COVID-19 pandemic. It found that experiential and collaborative learning can be effectively promoted through innovative online activities such as virtual museum visits and object-based learning. These activities fostered engagement, active learning, and the development of positive attitudes towards museums, showing that remote museum education can be a valuable component of teacher training programs.
Active learning and instructor accessibility in online talent training: a field experiment in China during COVID-19	Wang et al., 2022	Scopus	The study found that online training programs significantly improved participants' self-efficacy and learning outcomes across all conditions. The active learning condition had the strongest impact on learning outcomes, followed by the instructor accessibility condition, and lastly the control condition. Active learning, which involved self-reflection assignments, was a stronger predictor of improved learning outcomes than instructor

			accessibility during the COVID-19 pandemic.
Contribution of the Social and Financial Leadership Education Program to Students and Teachers	Avci et al., 2023	ERIC & Scopus	The Social and Financial Leadership Education Program in Turkey significantly improved both students' and teachers' knowledge and attitudes towards social and financial leadership. The program also enhanced teachers' use of student-centered teaching methods. The training program was effective across various regions in Turkey, indicating its broad applicability and success in fostering essential leadership skills and financial literacy among participants.
Training Teachers to Design Game-Based Learning Activities: Evidence from a Pilot Project	Cantoia et al., 2023	Scopus	Teachers recognize the potential of game-based learning (GBL) for enhancing student engagement and motivation but face challenges in integrating it into the curriculum due to high costs, lack of resources, and insufficient guidance on GBL implementation. The study found that after a four-month online training, teachers developed more insightful opinions and expectations about GBL, and their methodological choices and skills in implementing GBL activities improved, promoting active learning strategies in both face-to-face and distance education settings.
Accessibility of Participation in a Pollinator-Focused Community Science Project	Lynch & Miller, 2023	Scopus	The study found that the use of hybrid and simplified technology in training programs for a community science project on pollinator visitation significantly improved accessibility and participation. Despite encountering barriers such as difficulty with data collection, technology use, and access, the project successfully engaged participants by employing strategies like active learning and flexible data submission methods.
It's Time: Embracing Remote Learning	Krauthamer, 2020	Project Muse	The study highlights the transformative impact of the COVID-19 pandemic on education, demonstrating the significant benefits of remote learning. The pandemic accelerated the adoption of online teaching methods, revealing their potential to provide flexibility and increase student engagement. Despite initial resistance, educators and students found value in the virtual classroom environment, particularly in terms of active learning and accessibility. However, the article also emphasizes the need to address challenges related to unequal access to technology and internet connectivity to ensure the effectiveness of remote learning for all students.

Appendix B

The details align with the research goals

Table B1. Objective 1: To identify and categorize the various active learning approaches used in online training programs across different fields

Articles	Active Learning		
	Types	Field of Study	Learner
Adiego & Martin-Cruz, 2021	Project-based learning (PBL) and interdisciplinary teamwork	Smart cities and innovation management	Higher education students and professionals aiming to work in smart cities
Bottini & Gillis, 2021	Virtual role plays and interactive learning	Behavioral interventions	Undergraduate students
Darban, 2021	Collaborative learning through virtual teams	Not explicitly mentioned, but relates to team dynamics and leadership	University students
Fang et al., 2022	Project-Based Learning (PBL), which includes project designing, problem-solving, decision making, and investigative activities	Teacher training for implementing PBL	Teachers
James et al., 2022	Incorporating active learning techniques	Online teaching methodologies	Teachers and educators
Nguyen et al., 2024	Engaging lectures and reflective tasks	Higher education pedagogy	University teachers and doctoral students
Castro-Schez et al., 2020	Learning through experimentation and creation of exercises by learners	Computer Science (specifically, predictive parsing algorithms and compiler design)	University students in Computer Science programs
Ram & Roy, 2020	Self-assessment	General education during the COVID-19 pandemic	University students
Chuang & Wu, 2021	Self-training	Network security and software-defined networking (SDN) intrusion detection	Worker
Almendingen et al., 2022	Breakout room discussions	Health, social, and teacher education programs	University students in health, social, and teacher education programs.
Gu et al., 2022	Flipped classroom and active engagement in learning tasks	Creativity training	University students
Pavlou, 2022	Experiential and collaborative learning, object-based learning, and virtual museum visits	Museum education within initial teacher training	Student teachers
Wang et al., 2022	Self-reflection assignments and interaction with learning materials	Talent training in pharmaceutical sales	Medical sales representatives
Avci et al., 2023	Student-centered active learning approach	Social and financial leadership education.	Primary and secondary school teachers and students in Turkey
Cantoia et al., 2023	Game-Based Learning (GBL)	Teacher training for designing GBL activities	Teachers
Lynch & Miller, 2023	Interactive learning and outdoor practice	Ecological research, education, and community	Scientists
Krauthamer, 2020	Technology-enhanced Learning, Collaborative Learning, Interactive Workshops and Student Presentations	General educational	College Students

Table B2. To analyze the existing research on the effectiveness of active learning approaches in online training: impact on learner engagement, and learning outcomes

Articles	Learner Engagement			Outcomes		
	Participation	Motivation	Satisfaction	knowledge acquisition	skill development	knowledge retention
Adiego & Martin-Cruz, 2021	The engagement of students in teamwork and project-based learning activities	Not Given	Evaluates student satisfaction with course content and collaborative projects	Not Given	The development of transversal competences and professional skills	Not Given
Bottini & Gillis, 2021	Involves participants actively engaging in virtual role plays as part of their training	Participants are driven to perform well in role plays and assessments	Participants' feedback on the virtual role play experience	The effectiveness of virtual role plays in enhancing knowledge acquisition is discussed	The training focuses on developing specific skills through practical exercises	Not Given
Darban, 2021	The role of shared leadership in enhancing group collaboration and participation	Not Given	Not Given	The knowledge acquisition through shared leadership and collaborative learning	Not Given	Not Given
Fang et al., 2022	The importance of active participation in project-based learning environments	The higher degree of motivation among students engaging in project-based learning	Not Given	The positive impact of project-based learning on knowledge acquisition	The development of critical-thinking and problem-solving skills through PBL	Long-term knowledge retention and application as outcomes of project-based learning
James et al., 2022	The various strategies to enhance participation	Active learning and good communication practices can enhance learner motivation	The importance of regular feedback, clear communication, and supportive online communities	Active learning and effective online teaching practices contribute to knowledge acquisition	Different active learning strategies help in developing various skills, including technical and analytical skills	Ongoing engagement and active learning techniques can help in retaining knowledge over time
Nguyen et al., 2024	The participation of teachers in collaborative learning activities and teamwork	Engaging lectures can nourish students' motivation to learn	Not Given	Not Given	Not Given	Not Given
Castro-Schez et al., 2020	The system encourages active participation by involving students in their learning process through interactive components	The system promotes learner independence and self-directed learning	Not Given	Knowledge acquisition is achieved through the system's support of active learning and interactive tasks	Skill development is a key outcome, particularly in predictive parsing techniques and other computer science skills	Not Given
Ram & Roy, 2020	The student involvement in online classes	The perceived usefulness and engagement of online classes	The effectiveness and enjoyment of online classes	Benefit of online classes	Not Given	Not Given
Chuang & Wu, 2021	Active learning components	Engaging learners through active learning and practical exercises	Not Given	Improved understanding of SDN intrusion detection mechanisms	Hands-on training and practical application of SDN security techniques	Not Given
Almendingen et al., 2022	The use of breakout rooms encourages active participation among learners by providing opportunities for smaller group discussions and activities	An engaging environment through interactive group work in breakout rooms	The positive feedback from students on the interactive and collaborative nature of breakout rooms	The collaborative learning and discussions in breakout rooms	Skills development, particularly in communication and teamwork, is a key outcome of using breakout rooms for interprofessional education	Not Given
Gu et al., 2022	Active learning strategies can lead to higher levels of participation	Active learning on increasing students' motivation	Different learning strategies affect learner satisfaction	Compares the effectiveness of active and passive learning	Not Given	Not Given
Pavlou, 2022	Group activities and interactive tasks	Making the content personally relevant and engaging for learners	The positive feedback and comments from student teachers regarding the course	The interactive and experiential learning activities	Skill development, particularly in teaching and collaboration, is a significant outcome of the program	Not Given
Wang et al., 2022	The impact of active learning and instructor accessibility on learner participation during the COVID-19 pandemic.	Active learning approaches can enhance learner motivation	Learner satisfaction as part of the engagement strategy	The impact of active learning on knowledge acquisition	Skill development as a result of active learning and self-reflection	Active learning contributes to knowledge retention through self-reflection and

						application to work tasks
Avci et al., 2023	The students and teachers actively participate in the program through various interactive activities and projects.	The program aims to inspire and engage students through real-world applications and leadership opportunities.	The feedback from participants, indicating high levels of satisfaction with the program's content and delivery.	A key outcome, with students learning about social and financial leadership.	The program emphasizes skill development, particularly in leadership, financial literacy, and social responsibility.	Not Given
Cantoia et al., 2023	Teachers actively participate in designing and implementing game-based learning activities	Motivation is addressed as teachers are encouraged to innovate and engage students through game-based learning	Satisfaction is measured through teacher feedback on the effectiveness and enjoyment of game-based learning activities	Knowledge acquisition is discussed as teachers learn new strategies and tools for game-based learning	Skill development is a significant outcome, with teachers enhancing their instructional design and technology integration skills	Not Given
Lynch & Miller, 2023	The participation in the project through community science activities and data collection	The participants are driven by the opportunity to engage with nature and contribute to scientific research	The participant feedback, indicating a positive experience with the project	The participants learn about pollinators and ecological research methods	Skill development is a key outcome, particularly in data collection, identification, and scientific observation	Not Given
Krauthamer, 2020	The various remote learning tools and strategies that facilitate student engagement and participation, such as interactive platforms and virtual collaboration	Providing flexible learning environments and the use of technology to keep students motivated and engaged in their studies	Not Given	Remote learning platforms are shown to support knowledge acquisition through access to diverse resources and interactive content	The development of digital literacy and other skills necessary for successful remote learning	Not Given

Table B3. To synthesize the findings from the reviewed studies to create a comprehensive understanding of the current state of knowledge regarding the use of active learning approaches in online training environments

Articles	Effectiveness of active learning in online training	
	Learner Engagement	Outcomes
Adiego & Martin-Cruz, 2021	The program's design emphasizes engaging students through interactive and practical learning activities.	The development of specific competencies related to smart city technologies and positive feedback from participants regarding their engagement and learning experience.
Bottini & Gillis, 2021	The virtual role-play increases learner engagement by involving participants in interactive and realistic scenarios.	The outcomes focus on the acquisition of practical skills related to preference assessment and positive feedback on the training's engagement level.
Darban, 2021	Shared leadership enhances learner engagement by promoting active participation and collaboration among students.	Improved collaboration skills and knowledge acquisition through shared leadership and active learning.
Fang et al., 2022	Project-based learning in online professional development enhances teacher engagement and participation.	Improved teacher competencies in implementing project-based learning and enhanced student outcomes in classrooms as a result of teacher training.
James et al., 2022	Active learning techniques, such as breakout rooms and interactive discussions, increase learner engagement in online settings.	Improved student engagement, better understanding of course material, and positive feedback from students regarding their learning experiences.
Nguyen et al., 2024	The training courses improved teachers' conceptions of active learning and their ability to engage students during lectures.	Increased awareness of the importance of prior knowledge, enhanced teaching practices, and improved student engagement in lectures.
Castro-Schez et al., 2020	Active learning methods increase learner engagement by involving students in their own learning process and encouraging their independence. The use of an Intelligent Tutoring System (ITS) is noted as a means to promote active participation and engagement.	Improved academic performance and higher grades for students who used the active learning tools compared to those who did not.
Ram & Roy, 2020	Online learning can motivate students and increase their engagement compared to traditional methods.	The survey indicates that online classes are considered necessary and useful by a significant portion of respondents, showing positive outcomes from engaging in active online learning.
Chuang & Wu, 2021	Active learning reduces the workload for network security analysts and adapts to data changes, ensuring more accurate labeling of data and improving the training set's effectiveness, which leads to better engagement in the training process.	The new training mechanism involving active learning led to better identification accuracy and effective prevention of unknown attacks, demonstrating positive outcomes of active learning in this context.
Almendingen et al., 2022	Breakout rooms facilitated active participation and engagement among learners, improving their collaborative skills and interaction	Breakout rooms were effective in developing collaborative skills and enhancing knowledge retention through active discussions and teamwork
Gu et al., 2022	Active training was found to significantly improve engagement by involving participants in interactive tasks and promoting higher-order thinking	Active learning leads to better knowledge acquisition and skill development in creativity, particularly for FD participants
Pavlou, 2022	The various activities like 'Our Walks', where students led virtual tours and shared experiences. These activities fostered engagement and active participation, demonstrating the effectiveness of active learning in keeping	The outcomes mentioned include positive student feedback, increased engagement, and deeper understanding of museum education concepts. Students reported enjoying the course and expressing a newfound appreciation for museums, indicating successful

	students engaged in an online environment	learning outcomes from active learning methods
Wang et al., 2022	Active learning, through self-reflection assignments, significantly enhanced learner engagement by allowing learners to connect training content with their work tasks, thus fulfilling their need for autonomy	Active learning significantly improved learning outcomes, including self-efficacy and knowledge acquisition, compared to passive learning methods
Avci et al., 2023	Active learning processes and e-mentoring supported teacher engagement throughout the training. Teachers were actively involved in the learning process, which increased their engagement and participation	The training led to significant improvements in teachers' teaching practices, making them more student-centered. Teachers also applied the skills they learned to their classrooms, which positively impacted student learning outcomes and engagement
Cantoia et al., 2023	Teachers reported that GBL increased student engagement, motivation, and collaboration. The training allowed teachers to observe higher levels of student involvement and participation, demonstrating the effectiveness of active learning for engagement	The outcomes included positive learning achievements, with students either maintaining or improving their grades. Teachers also felt more competent and motivated to use GBL in their teaching, indicating successful outcomes from the training
Lynch & Miller, 2023	The role of active learning in enhancing engagement through accessible and participatory training programs	The active participation and engagement in online training programs lead to better learning outcomes, including knowledge retention and skill development
Krauthamer, 2020	The shift to online learning increased student engagement by allowing flexibility in attending classes, using synchronous tools, and interactive activities.	The improvements in student attendance, participation, and overall engagement in online learning environments. These outcomes are attributed to the enhanced interactivity and flexibility provided by online learning tools and methods

Table B4. To formulate recommendations and directions for future research

Articles	Recommendations		
	Online Training Design	Online Training Implementation	Future Study
Adiego & Martin-Cruz, 2021	Emphasizes the importance of engaging students through interactive and practical learning activities.	Provides guidelines for integrating practical and interactive activities to engage students effectively.	Not Given
Bottini & Gillis, 2021	The importance of providing both live and online training materials to give trainees more autonomy and better access to training.	Recommends offering both live and online training to accommodate trainee preferences and maximize engagement.	Suggests further research into the cost-benefit analysis of saving trainer time versus trainee time and the effectiveness of virtual role-play in online training.
Darban, 2021	Not Given	Not Given	Future studies should compare vertical versus shared leadership and examine other team-level constructs to better understand the impacts in virtual team learning contexts.
Fang et al., 2022	Not Given	Not Given	Future research should focus on larger teacher samples across various age and experience levels, and examine the sustainability of training methods.
James et al., 2022	Using various online learning modalities, ensuring universal design and backward design principles, and creating a Community of Inquiry (CoI) to support student learning outcomes.	Emphasizes the importance of institutional support, including professional development for faculty, student support through training modules and technological support, and facilities such as testing centers.	Not Given
Nguyen et al., 2024	To design effective online pedagogical training, it is important to consider target participants, duration, content, and cost. Courses should include various learning activities such as reflective and interactive tasks, peer-reviewing tasks, and should ensure accessibility and engagement through a variety of digital tools.	Implementing online courses should ensure immediate feedback for learners and support both individual and collaborative learning. Incorporating elements like interactive tasks, peer reviews, and regular updates to content is recommended to enhance effectiveness.	Future research should include larger sample sizes and control groups to draw stronger conclusions. Observations to detect changes in teaching practices and follow-up surveys to assess how knowledge is applied in practice are also recommended.
Castro-Schez et al., 2020	Designing online training systems that support active learning through interactive features and personalized feedback.	The importance of implementing intelligent tutoring systems that can adapt to learners' needs and provide immediate feedback to enhance learning outcomes.	The further research on the impact of intelligent tutoring systems on various learning outcomes and the effectiveness of different active learning strategies.
Ram & Roy, 2020	The need for diverse learning styles and the importance of mixed media to cater to different learners. It emphasizes active learner-centered approaches over passive learning.	The online classes should be engaging and interactive, with tools that keep students active and participating. It also mentions the need for appropriate class duration and preferred methods of delivery (e.g., video calls).	The larger sample sizes for future research and exploring various online tools and strategies to improve online education effectiveness.
Chuang & Wu, 2021	The use of a semi-supervised learning mechanism that combines self-training and active learning to improve the accuracy of intrusion detection systems. It suggests incorporating high-confidence samples and using clustering methods to enhance training efficiency.	The parallel training to maintain the classifier's constant service without interruption and using faster clustering methods to reduce operation time during active learning.	The further research to improve the training mechanism, particularly in reducing identification errors and enhancing the classifier's ability to detect unknown attacks.
Almendingen et al., 2022	Using breakout rooms to enhance engagement and collaboration in online learning environments. It emphasizes structured and interactive approaches.	The article suggests structured collaborative activities and addressing the social learning environment in breakout rooms for effective training.	The future research to use open-ended responses in qualitative interviews to better understand the optimal online learning environment for breakout rooms.
Gu et al., 2022	The online training should consider individual cognitive	Implementing active learning strategies that	The future research to explore longer training

	styles. Active training strategies are more beneficial for Field Dependent (FD) learners, while a balanced approach might benefit Field Independent (FI) learners.	require participants to practice and apply techniques actively, especially for FD learners. It also emphasizes structured guidance and social support for FD individuals.	durations, investigate the cognitive mechanisms underlying different training strategies, and use neuroscience techniques to understand creativity-related brain areas.
Pavlou, 2022	The article emphasizes designing activities that promote active and experiential learning, such as object-based learning and virtual museum visits. It also suggests scaffolding engagement through activities like 'Our walks' to foster a sense of presence and deep engagement in online courses.	Implementing structured and interactive online activities, such as using Google Maps and the Art Project for virtual museum tours, and collaborative tasks to engage students in an online environment.	The article calls for further research on the potential of 'living inquiry' and a/r/tography practices in online museum education. It suggests exploring blended learning strategies and understanding tutors' needs to design effective online learning environments.
Wang et al., 2022	Designing online training programs that emphasize active learning strategies, such as self-reflection assignments, to improve learning outcomes.	Implementing active learning and ensuring instructor accessibility to enhance learning outcomes during crises like COVID-19.	Investigation into the underlying mechanisms between active learning and the need for autonomy, as well as exploring different operationalizations of active learning in future research.
Avci et al., 2023	The use of a student-centered active learning approach and highlights the importance of training mentors on e-mentoring and active learning methods for effective online training design.	The implementation process, including regular meetings, feedback sessions, and structured training for teachers over 12 sessions of 2 hours each. It also describes the student training, which lasted for five months and incorporated active learning methods and family involvement.	To explore the impact of student-centered education practices in different educational environments and among different groups of students. It also calls for examining the long-term effects of such programs on both teachers and students.
Cantoia et al., 2023	Designing online training for teachers to create game-based learning activities, emphasizing the importance of aligning training objectives with instructional goals and incorporating interactive elements to enhance engagement and learning outcomes.	The implementation strategies for the training program, including the use of pilot projects to test and refine the training materials, as well as continuous support and feedback mechanisms for teachers during the training process.	To to evaluate the long-term impact of game-based learning activities on student outcomes and to explore the scalability of the training program to different educational contexts and larger groups of teachers.
Lynch & Miller, 2023	Designing online training programs that are accessible and consider the technological barriers faced by participants.	Implementing hybrid training formats and simplified technology to enhance participation and engagement.	Exploring different ways to improve accessibility and engagement in online community science projects.
Krauthamer, 2020	The document advises designing online training with interactive elements like synchronous tools (e.g., Blackboard Collaborate Ultra), PowerPoint presentations, and student presentations to enhance engagement and learning outcomes.	Implementing online training by using various virtual conferencing tools, making the sessions interactive, and recording classes to ensure total access for all students, including those who cannot attend live sessions.	Not Given