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Educational Innovation with Augmented Reality in the Teaching and Learning of History and Geography in Secondary Education: A Systematic Review

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Abstract. In secondary education, traditional lecture-based approaches in subjects such as history and geography often fail to engage students meaningfully, posing challenges for teachers seeking to foster motivation and deep learning. In this context, augmented reality (AR) has emerged as an innovative educational tool that enables students to interact with historical and geographical content through immersive digital environments. This systematic review aimed to analyze the trends in academic research on the use of AR in the teaching and learning of history and geography in secondary education, to identify the countries with the most research activity, and to examine the instructional methods and pedagogical models that are employed. Using the PRISMA methodology, a comprehensive literature search was conducted across major databases, including Scopus, Web of Science, ERIC, ScienceDirect, and Springer, focusing on publications from the last six years. A total of 13 relevant studies were selected and analyzed. The findings indicated that AR has a generally positive impact on student motivation, engagement, and academic achievement, offering new possibilities for instructional design that support both cognitive and emotional learning strategies. However, the review also identified barriers to implementation, particularly relating to teachers' limited training and experience with emerging technologies. This study contributes to the understanding of how AR can enhance history and geography education in secondary schools.

Keywords: augmented reality; educational technology; history education; geography education; secondary education

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1. Introduction

Augmented reality (AR) in the educational field has emerged as a tool with great potential (Delgado-Algarra et al., 2025). This innovative teaching resource enhances learning experiences by overlaying virtual images onto real-world contexts, thereby facilitating visualization and interaction, which can deepen understanding and engagement with academic content. Considering that one of the cross-curricular competencies in education is functioning in ICT-generated environments (Hayta et al., 2023), such environments can be enriched through collaborative virtual spaces (Yildirim & Kececi, 2024). In this sense, digital competence is essential for students in using and navigating information and communication technologies (ICTs) in educational settings effectively (Marsden, 1990). Developing this competence encompasses not only the ability to operate digital devices (Saripudin et al., 2022) but also the skills to retrieve and analyze information and use digital tools (Latif et al., 2023).

Numerous studies have shown that history and geography instruction continues to rely on a conventional model that restricts students from thinking independently and confines them to a passive role centered on memorizing factual knowledge (López-García et al., 2024). Therefore, teaching history and geography demands the integration of diverse digital technologies into pedagogical practices, moving beyond traditional textbooks and static visual materials. The growing need for intelligent learning has led to increased attention to AR in recent years (Delgado-Algarra et al., 2025). Implementation of AR enhances individual and collaborative participation and improves students' comprehension by providing interactive visual access to historical and geographical figures and events, thus making learning more engaging and personalized according to students’ abilities and interests (Bunari et al., 2024).

However, the integration of AR into history and geography education faces several challenges such as internet accessibility, lack of teacher training in digital resources, the financial costs of implementation, and the effectiveness of the learning environment when using AR (Vashisht & Sharma, 2024). Other authors highlight additional issues including technical difficulties, user-related concerns, AR content production, and curriculum adaptation (Bangkerd & Sangsawang, 2021), all of which may hinder the successful implementation and overall effectiveness of AR technologies in educational settings (Bangkerd & Sangsawang, 2021; Vashisht & Sharma, 2024).

Currently, AR is being used to achieve more innovative secondary education by bridging knowledge transmission with meaningful learning through the application of new technologies (Albar et al., 2021). Scientific literature shows growing interest in this field. According to Zhang et al. (2022), AR is considered an emerging technology with the potential to promote innovative and sustainable education. Similarly, the systematic review of Schmidt and Stumpe (2025) demonstrates that one of the main challenges in education today is the development of critical and active citizenship through mobile learning, with AR playing a key role in this objective. Consequently, the creation of educational AR applications in history and geography is on the rise.

This article explored the AR applications that are used in the teaching of history and geography, noting that scientific production on AR significantly increased in 2024, whereas a decrease was recorded in 2022. To date, no systematic review article has been identified that specifically addresses this topic, underscoring the relevance and novelty of the present study. Therefore, this article aimed to disseminate the most relevant educational applications and their contributions to promoting meaningful learning in these disciplines.

Regarding the gaps in empirical studies, it has been identified that AR applications require constant software updates. Therefore, it is essential to promote ongoing training for teachers and students in the proper use of such applications, ensure internet access for their use, and address the financial resources required for implementation. It is also important to stay up to date with educational methodologies (Tursinbaevna et al., 2023). To identify the advantages, barriers, applications in various subject areas, the countries where AR is most used, its motivational impact on students, and how it fosters critical thinking, a systematic literature review covering the past six years was conducted. This review contributes to analyzing the integration of AR in secondary education and how it enhances student engagement and supports meaningful learning, positioning AR as a valuable educational technology for improving learning outcomes.

In this context, the present article aimed to analyze the scientific literature published between 2019 and 2024 on the use of AR in the teaching of history and geography in secondary education. The objective was to identify its temporal evolution, geographical distribution, pedagogical approaches, employed educational resources, teacher-related barriers, and its impact on student motivation and critical thinking.
Based on the above, the following research questions were posed:

- RQ1: What is the temporal evolution of scientific publications on the use of augmented reality in the teaching of history and geography in secondary education?
- RQ2: Which countries demonstrate the highest scientific output on the use of augmented reality in teaching history and geography at the secondary level?
- RQ3: What learning models and/or methods are being implemented by teachers using AR for teaching history and geography in secondary education?
- RQ4: Which educational AR resources are used for learning history and geography through technological and/or didactic applications in secondary education?
- RQ5: What barriers do teachers face when incorporating augmented reality in the teaching of geography and history?
- RQ6: How does augmented reality influence student motivation and critical thinking in the learning of history and geography?

2. Literature Review

The literature review revealed that the application of AR systems in education is an unquestionable reality, with several tools and applications yielding highly positive results (Delgado-Algarra et al., 2025; López-García et al., 2024). Augmented reality is understood as the combination of virtual elements within the real world (Fernández García et al., 2024). Augmented reality is the technology that seeks to integrate and expand the user's physical environment or world in real time by adding layers of digital information (Arena et al., 2022). In Peru, the educational focus on history and geography transcends the mere transmission of factual content, aiming instead to foster the development of critical, reflective, and socially engaged citizens.

According to the Ministry of Education, both subjects are intended to strengthen national identity and collective awareness by encouraging students to recognize their belonging to a community with a shared history and a common future (Ministerio de Educación, 2016). This pedagogical perspective aligns with the findings of the studies that were analyzed in this review, which emphasize the need to move beyond rote memorization. Instead, an active teaching approach is proposed – one that promotes understanding of the present through the analysis of the past and the geographic space while also preparing students to make meaningful commitments and to participate actively in the transformation of their social realities.

2.1 Advantages of Using AR in the Learning of History and Geography

The use of AR through educational applications enhances student engagement by allowing them to visualize historical events and geographical landscapes, significantly increasing their interest and motivation to learn (Albar et al., 2021; Vashisht & Sharma, 2024; Wahiddiyah et al., 2023). Interactive elements such as 3D projections of historical figures or events provide a richer context that improves information retention and recall (Bekas & Xinogalos, 2024; Wahiddiyah et al., 2023). This relationship between instructional design and the affordance of AR is illustrated in Figure 1, which demonstrates how the 3E model structures the teaching-learning process into three phases that enhance motivation, active exploration, and knowledge consolidation.

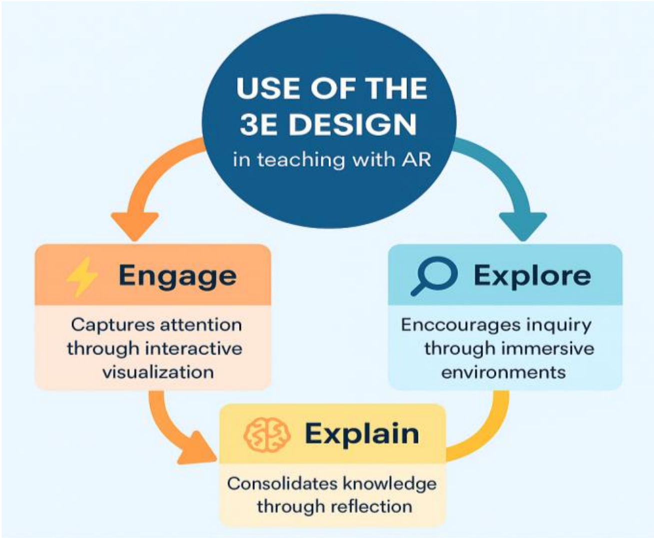

Figure 1: Application of the 3E instructional design model in the use of augmented reality for teaching history and geography

Several studies have identified key advantages of integrating AR into the teaching of history and geography. These benefits are primarily associated with improvements in student engagement, comprehension, and the personalization of learning experiences. The following table summarizes the main advantages reported by various authors and is based on empirical and theoretical research conducted in recent years.

Table 1: Advantages of augmented reality in learning history and geography

Author	Advantages
(Raghaw et al., 2018)	AR enhances the learning of history and geography by making the subjects interactive and engaging. It transforms traditional content into immersive experiences, capturing students' interest and improving comprehension through multimedia visualizations, thus addressing the monotony often associated with these subjects.
(Azhar et al., 2019)	AR provided interactive and engaging experiences. It allows users to visualize historical events and geographical locations, promoting better understanding and retention, especially among younger generations who often find traditional methods unappealing.
(Wahiddiyah et al., 2023)	AR improves the learning of history and geography by offering interactive visual experiences. This technology increases student engagement, enhances understanding of historical content, and personalizes learning, thus making it a vital tool in education.
(Xefteris et al., 2019)	AR enhances the learning of history and geography by blending physical and digital experiences, promoting critical thinking, engagement, and visual and kinesthetic learning, thereby enabling a deeper understanding of spatial relationships and historical contexts.
(Xiao et al., 2020)	AR has the potential to facilitate an ideal fusion between students and technological tools and to advance the reform of the current educational paradigm, aiming to improve the effectiveness of the learning process.

AR: Augmented reality

2.2 Competencies and Skills Developed Through the Use of Augmented Reality in the Teaching of History and Geography

The use of AR in the teaching of history and geography not only transforms the way information is presented but also fosters the development of competencies and skills. Various studies, including that of Fitria (2023), indicate that AR promotes competencies such as spatial awareness, critical thinking, and engagement in the learning process by allowing students to interact with 3D stories and the Earth's surface, thus facilitating a deep understanding of historical and geographical contexts.

Likewise, Vashisht and Sharma (2024) state that its use increases engagement, memorization, and understanding of historical events, enhancing active learning and adaptation to different learning styles while also strengthening the emotional and cognitive connection to the content and the development of analytical skills. Finally, according to Xefteris et al. (2019), AR fosters the development of spatial relationships, information retrieval, computational thinking, teamwork, and engagement while also providing an immersive and interactive experience that improves students' understanding of geographical features and historical contexts.

In summary, the identified competencies and skills are as follows:
1. Competencies: spatial awareness, critical thinking, engagement, active learning, spatial relationships, and teamwork
2. Skills: memorization, deep understanding, analytical skills, information retrieval, computational thinking, and engagement

The impact of AR on the development of these competencies and skills is better understood when linked to learning theories, models, and methods. For example, constructivist theory holds that learning is a process in which students construct knowledge using the tools and materials that are provided (Taber, 2019). In this framework, AR involves students actively participating in interpreting and evaluating content, helping them to construct their own knowledge through interaction (Nachtigall et al., 2024). Augmented Reality also supports the development of functional knowledge transfer, critical thinking, and collaboration skills through interactive digital content, contributing to an overall improvement in historical understanding (Baharuddin et al., 2020).

From the perspective of situated learning theory, the emphasis is on the interaction between learning and the real world where students face concrete situations that influence their actions and thoughts (Zhao et al., 2020). From this viewpoint, AR enables students to explore real-world contexts and deepen their understanding of historical and cultural content through interactive experiences (Azhar et al., 2019). Likewise, it creates authentic learning by exposing them to near-real risks where skills are enhanced (Arıkan et al., 2024). In geography, it improves learning competencies by increasing student engagement, enabling deeper conceptual understanding, and facilitating the effective visualization of geographical phenomena (Yulfa et al., 2022).

Cognitive load theory explains how learning environments should actively process relevant information to achieve meaningful learning. Therefore, it should be organized into a coherent model that integrates the student's prior knowledge (Nurjanah & Retnowati, 2024). Applied to AR, this allows students to reduce unnecessary mental effort, making the material content easier to assimilate (Ratmaningsih et al., 2024). Additionally, it improves the ability to experiment with and reinforce learning through different scenarios facilitated by technology, reducing the need for cognitive effort to recall or understand (Arıkan et al., 2024).

Regarding learning models, AR is closely linked to experiential learning, developed by Kolb (1984), which defines learning as a process in which knowledge is created through the transformation of experience. Therefore, interaction with three-dimensional content strengthens deep understanding and analytical skills. The Self-Regulated Learning Model allows students to self-regulate, progress address their own needs, progress at their own pace, and set personal goals (Zimmerman, 2002).

In contrast, the Collaborative Learning Model, according to Nachtigall et al. (2024), promotes teamwork, participation, and engagement through joint activities in immersive environments. These models not only revolutionize the methodologies used in teaching history and geography but also promote quality teaching by facilitating an educational experience that addresses students' needs and learning pace (Mena et al., 2023).

The learning methods that enhance the use of AR include learning by doing, which fosters active learning through action and game-based learning, which combined with AR tools through role-playing games allows users to create their own virtual objects and place them in a specific real-world location within the application, enabling problem-solving (Amanatidis, 2022; Lee, 2012). The learning methods also include inquiry-based learning, which promotes autonomous exploration and the development of critical thinking about historical and geographical facts (McNerney et al., 2023).

3. Methodology

This study was conducted using a search strategy based on the PICO model, which served as the foundation for a systematic literature review—understood to be a thorough and structured examination of relevant academic sources on a specific topic. This methodology enables researchers to demonstrate knowledge and understanding of previous research, critically analyze relationships between studies, synthesize findings, and identify gaps in the existing literature (Mourão et al., 2020). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 protocol was adopted because of its methodological rigor and international recognition.

The literature search was carried out across five specialized databases: Scopus, Educational Resources Information Center (ERIC), SpringerLink, ScienceDirect, and Web of Science. Articles were identified using keyword combinations specific to each database, as detailed in Table 2. Initially, documents were selected based on their titles, abstracts, and associated keywords. In this first phase, a total of 804 records were retrieved and managed using EndNote 23 software to remove duplicates. Subsequently, Publish or Perish 8 was used to generate a data matrix in Excel, which facilitated the organization and analysis of the articles.

Table 2: Search strings

Database	Search String
Scopus	TITLE-ABS-KEY ("Augmented reality" AND learning AND secondary AND history OR geography AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar")))
ERIC	("Augmented reality" AND learning AND secondary AND history OR geography)
SpringerLink	("Augmented reality" AND learning AND secondary AND history AND geography)
ScienceDirect	("Augmented reality" AND learning AND secondary AND history AND geography)
Web of Science	ALL= (Augmented reality AND learning AND secondary AND (history OR geography))

Thereafter, inclusion and exclusion criteria were applied (see Table 3) in order to select the studies that were most relevant to the research objective. In the final selection, 13 scientific articles were included for in-depth analysis during the critical reading phase.

Table 3: Inclusion and exclusion criteria for the review

Criteria	Inclusion	Exclusion
Document Type	Article	• Proceedings • Theses • Conference papers • Instruments
Time Period	2019–2024	• Outside the specified range
Population	Secondary school students	• Students with special educational needs • Students from other levels
Subject Area	History and geography	• Other subject areas

The selection of studies was conducted through an independent evaluation process by the authors who carried out a systematic screening of the articles in different stages (title, abstract, and full text). At each stage, thematic and methodological aspects were considered to ensure that the studies were relevant to educational innovation with AR in history and geography and met the basic methodological quality criteria. The method employed was PRISMA, which is designed to demonstrate that study selection is carried out objectively by describing the entire selection process (Page et al., 2021). See Figure 2.

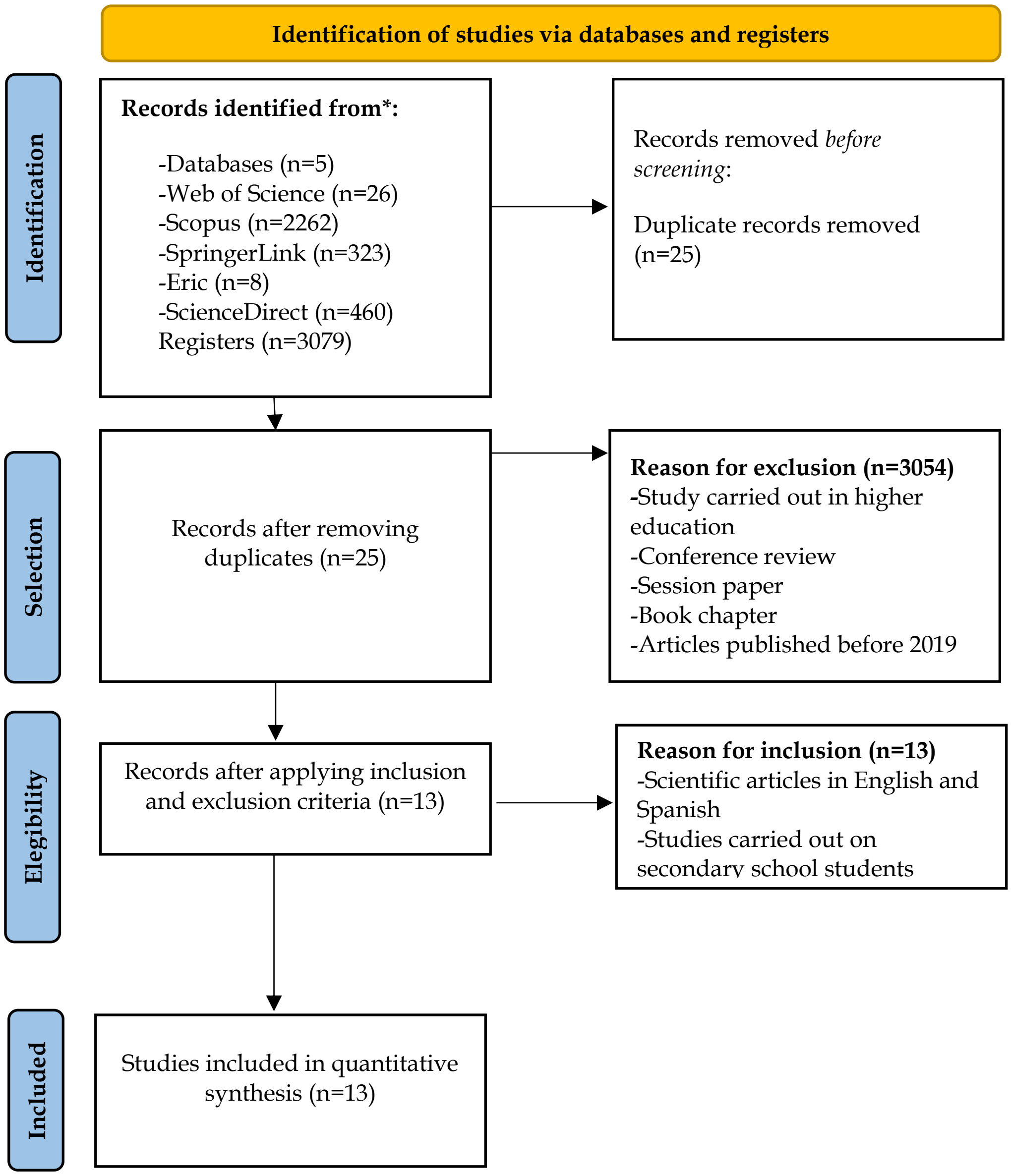

Figure 2: Article search and selection process – PRISMA flow diagram

4. Results

Certain bibliometric parameters or indicators – such as year of publication and country – were examined to assess the scientific relevance of the sample. The following results were obtained based on the indicators proposed in the methodology:

RQ1: What is the temporal evolution of scientific publications on the use of augmented reality for the learning of geography and history in secondary education?

The results shown in Figure 3 reveal the publication periods related to the use of AR in teaching history and geography in secondary education from 2019 to 2024. The chart illustrates the distribution of publications on the use of AR in history and geography learning over the past years. A noticeable increase in scientific output is observed in 2024 with a total of six publications, thus reflecting growing interest in the topic (Bekas & Xinogalos, 2024). In contrast, previous years show more limited output: two publications in 2021 and 2023 each and none in 2022. In 2019, only one publication was recorded.

These findings suggest that AR as an educational tool has gained relevance in recent years, possibly due to technological advancements and the increasing need for innovative teaching methodologies (Bunari et al., 2024). The recent surge in publications may be linked to greater recognition of the benefits of AR in promoting meaningful learning in disciplines such as history and geography, which demand visual and contextual strategies to enhance understanding.

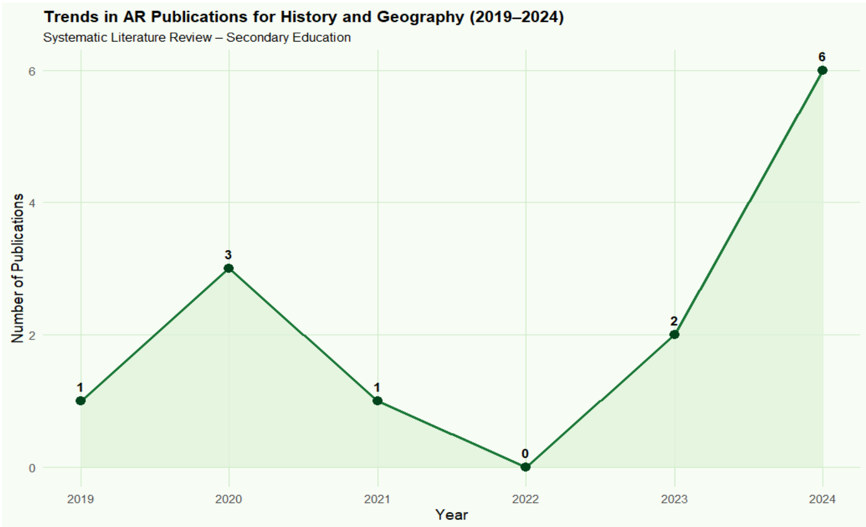

Figure 3: Publications by year

RQ2: Which countries demonstrate the highest scientific output on the use of augmented reality in teaching history and geography at the secondary level?

The results presented in Figure 4 highlight the publication trends by country regarding the use of AR in teaching history and geography in secondary education from 2019 to 2024. Figure 4 displays the distribution of publications by countries based on where the research was conducted. Spain has the most publications with four, representing 31% of the total studies. Following Spain, countries such as Germany, the United States, Greece, Italy, Switzerland, Ireland, Türkiye, Indonesia, and China each contributed a single publication, accounting for 8% per country.

This distribution indicates that although the topic has international reach, research is still fragmented and less concentrated outside Europe. It is worth noting that the most represented countries are located in Europe, indicating a geographical concentration of interest in the implementation of AR in history and geography education. While some geographical diversity exists, it is limited; only one non-European country (the United States) appears on the list.

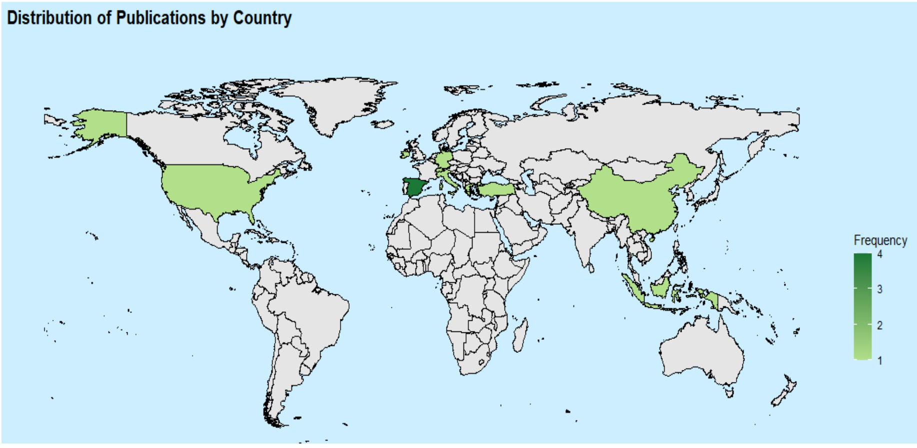

Figure 4: Publications by country

RQ3: Which learning models and/or methods are being implemented by teachers using AR for teaching history and geography in secondary education?
The results presented in Table 4 show that teachers employ three learning models that incorporate AR as a teaching resource in their teaching of history and geography: experiential learning, self-regulated learning, and collaborative learning. These models position the student as an active agent in the meaningful construction of knowledge. Both AR and virtual reality offer the possibility of creating immersive environments that support students in practical exploration and their understanding of complex concepts (Tene et al., 2024). They also represent technological tools that can be effectively applied within this framework (Criollo-C et al., 2024).

Regarding the methods, learning by doing, game-based learning, and inquiry-based learning were identified. These show that AR is not only used as a resource but also as a pedagogical tool to promote motivation and critical thinking. Augmented and virtual reality can immerse students in the learning process, stimulating their curiosity and motivation (Bikar et al., 2022; Skulmowski & Xu, 2022). For example, in a history class, AR could allow students to 'visit' ancient civilizations and interact with cultural elements, helping them connect theory with practice (Soelistya et al., 2023). These findings suggest that through combining models that foster experience, autonomy, and collaboration with active and participatory methods, AR can enhance deeper, more meaningful, and contextualized learning in the teaching of history and geography.

Table 4: Learning models using augmented reality by secondary school teachers for teaching history and geography

Category	Name	Article from the selection	Description
Models	**Experiential Learning**	(Boboc et al., 2019)	In the Starry Sky Exploration - Eight Planets in the Solar System application, students interact with 3D representations of planets, manipulating them with gestures and exploring contextualized immersive content. The use of micro-videos, graphics, mind maps, and interactive games fosters knowledge construction through direct interaction and reflection, maintaining interest and engagement.
	Self-Regulated Learning	(Nachtigall et al., 2024)	In the use of 360° videos, techniques such as critical content analysis, evaluation of visual representation, and emotional regulation strategies were applied, promoting reflective and controlled student participation. These strategies also enable students to manage their performance in immersive environments autonomously and consciously.
	Collaborative Learning	(Masneri et al., 2024; Nachtigall et al., 2024; Schnürer et al., 2020; Carrascosa et al., 2022)	In the Around the World application, interaction is encouraged by allowing students to support each other with hints and feedback while solving questions. In contrast, in 360° videos, students develop and synthesize strategies for video analysis. In the AR model developed by Schnürer et al. (2020), students can create engaging experiences that promote collaboration through the understanding, analysis, and correct evaluation of maps in geography courses. In the TILAR dynamic, groups of four to six players are formed to solve technological tasks and challenges.
Methods	**Learning by Doing**	(Nachtigall et al., 2024; Ratmaningsih et al., 2024; López-García et al., 2024; Kleftodimos et al., 2023; Jung et al., 2020; Boboc et al., 2019; Lázaro Carrascosa et al., 2024; Remolar et al., 2021)	In the Around the World application, students interact directly with a 3D globe and respond by placing a pin on the map, combining active resource manipulation with the exchange of hints and suggestions between peers. In AR Books, students view and interact with history and geography content. In World War II AR, they design and visualize narratives such as Hitler's story told in the first person, choose stages, and access related resources. In contrast, Doltso encourages exploration and discovery of environments, complemented by a virtual tour in Google Earth. PalmitoAR allows experiencing battles without being physically present at the site to understand historical events. OvidAR enables exploration of 3D scenes, manipulation of environments, and autonomous discovery of historical and cultural elements. TILAR allows students to interact with physical cards and AR elements to obtain information and play games relating to Ancient Rome, to design and explore Roman cities, and to interact with historical buildings and characters.

	Game-Based Learning	(Kleftodimos et al., 2023; McNerney et al., 2023; Lázaro Carrascosa et al., 2024)	The Doltso app gamifies learning through points, rewards, and progressive roles (tourist, architect, local resident, and active citizen), each with specific goals and challenges linked to cultural heritage. SatéliteSkill5 presents challenges requiring data interpretation and the development of various skills, awarding digital trophies for each completed challenge. Likewise, TILAR uses the Timeline board game, providing a playful context where students place cards in chronological order and face challenges with immediate consequences.
	Inquiry-Based Learning	(McNerney et al., 2023)	The SatéliteSkill5 app enables students to formulate scientific arguments, identify relevant patterns, participate in reports and monitor environmental monitoring, positioning them as 'citizen scientists'.

To provide a visual synthesis of these relationships, a conceptual framework diagram has been developed (Figure 5). This model illustrates how AR interacts with teaching methods and learning outcomes, highlighting the connections between experiential, self-regulated, and collaborative learning models and active teaching methods such as learning by doing, game-based, and inquiry-based learning.

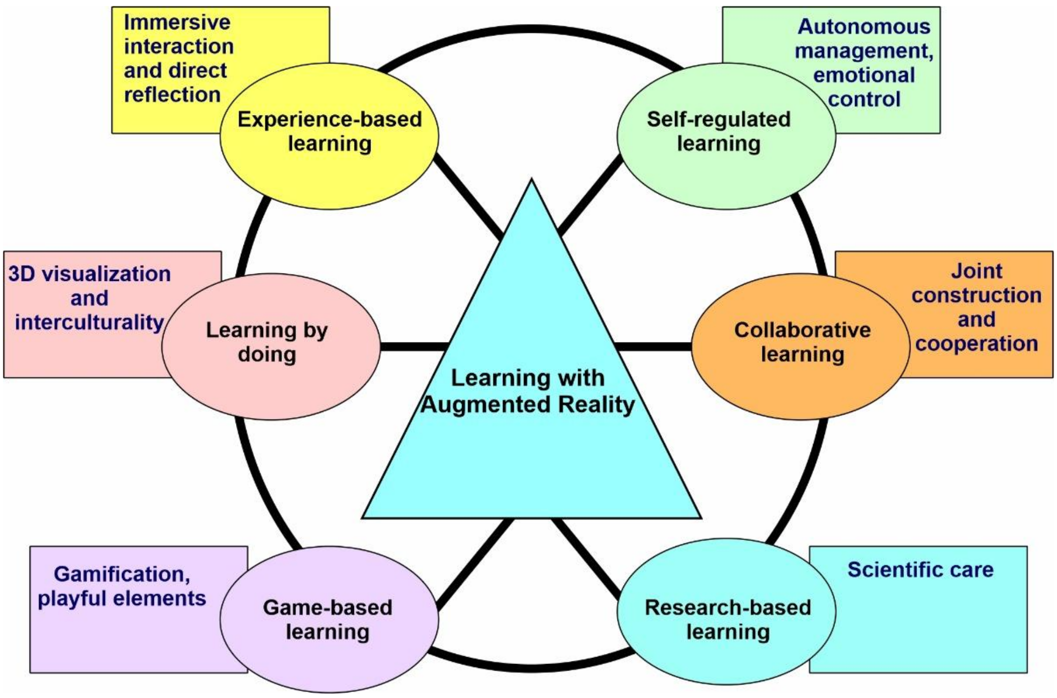

Figure 5: Conceptual framework illustrating the relationships between augmented reality, teaching methods, and learning outcomes

Note: Elaboration by the authors

RQ4: Which educational AR resources are used for learning history and geography through technological and/or didactic applications in secondary education?

Table 5 presents 13 AR applications used in teaching history and geography to secondary school students, including Around the World, AR Book, Doltso, PalmitoAR, OvidAR, the Rome Game, TILAR, SatelliteSkill5, and 360° videos. These applications show significant differences in their features and technological requirements. For example, Around the World and the Rome Game incorporate gamification elements that enhance student motivation, while Doltso is based on location-based AR and requires Android tablets with GPS (Kleftodimos et al., 2023). PalmitoAR uses 3D models that are accessible through browsers that are compatible with WebGL, as does OvidAR, which also allows the creation of customized content.

In terms of effectiveness, PalmitoAR has demonstrated a positive impact on the understanding of historical content (Jung et al., 2020), whereas OvidAR is noted for its flexibility in creating experiences tailored to student needs. Applications with higher levels of interactivity and gamification boost motivation and retention of complex content, while those focused on passive visualization (such as 360° videos) require greater teacher support.

Table 5: Augmented reality educational content in secondary education for learning history and geography

Article	Subject	Augmented reality	Description	Tools and/or development software	Results
(Masneri et al., 2024)	Geography	Around the World Geography Game	A collaborative geography quiz in which students answer teacher-prepared questions	Unity (with AR Foundation), Typescript, Three.js	Positive correlation between engagement and performance (r=.37, p=.044).
(Nachtigall et al., 2024)	History	360° videos	Enhances cognitive and critical processing in history learning through immersive visualizations	YouTube 360° videos, headsets, smartphones, Word for analysis	Significant effect of training on video processing ($F(4,137)=3.29$, $p=0.01$, $\eta^2=0.09$).
(Ratmaningsih et al., 2024)	History	AR Book	Visualizes abstract content using mobile cameras and overlays 3D objects/animations	Vuforia, Adobe Illustrator	Most curricular and design components were rated as high quality.
(López-García et al., 2024)	History	World War II AR	Active learning scenarios mediated by AR and historical thinking skills	Kotlin, Metaverse app	Experimental group scored significantly higher post-test (M=6.44) vs. control (M=4.34).
(Arıkan et al., 2024)	Geography	360° videos	Make disaster education more interactive and engaging	YouTube	$KR\text{-}20$=0.819, test considered reliable and valid.
(Kleftodimos et al., 2023)	History	Doltso	Location-based app for heritage education focused on Doltso district, Greece	Taleblazer (MIT)	Positive influence of challenge and interaction on

Article	Subject	Augmented reality	Description	Tools and/or development software	Results
					educational value and reuse intention.
(Schnürer et al., 2020)	Geography	Prototype AR App for Tablets	Combines 3D visualization with traditional printed atlases	Vuforia Engine, Unity	Improved spatial orientation ($t(54)=-2.11$, $p<.05$, $d=.56$); interest showed no significant change.
(Jung et al., 2020)	History	PalmitoAR	Allows intuitive observation of the Palmito Ranch Civil War battle	JavaScript libraries (ARToolkit, A-Frame), Blender 3D	Visual design significantly influenced task-technology fit (β = 0.662, 95% CI = .274–.867).
(Boboc et al., 2019)	History	OvidAR	Recreates scenes from Ovid's life in Sulmona, Rome, and Constanța	3DS Max, MakeHuman, Blender, Unity	App usability and interaction were rated as satisfactory.
(McNerney et al., 2023)	Geography	SatelliteSkill5	Teaches remote sensing and SDGs through AR and gamification	Unity (2019–2022.3), ARCore, ARKit	Successfully introduced satellite data and SDGs in an engaging way.
(Remolar et al., 2021)	History	Game about Ancient Rome	'Learning by doing' approach with interactive experiences	Unity (2018.3.8f1), Vuforia Plugin	48% of students answered nearly all questions correctly.
(Carrascosa et al., 2022)	History	TILAR	AR clues about event chronology via card scanning in Timeline board game	Kotlin	Improved understanding of historical facts; enhanced learning with gamified AR.
(Xiao et al., 2020)	Geography	Starry Sky Exploration – Eight Planets	Allows gesture-based interaction with 3D models of the solar system	Unity, AR Foundation	78% reported satisfaction; most want to continue using the tool.

AR: Augmented reality; SDGs: Sustainable Development Goals

RQ5: What barriers do teachers face when incorporating augmented reality in the teaching of geography and history?

Despite the growing interest in using AR as a pedagogical resource, several challenges hinder its integration into secondary education. Table 6 outlines the main barriers reported in the literature, including technological limitations, lack of teacher training, infrastructural issues, resistance to change, and curricular integration difficulties. These findings reflect the need for institutional support, teacher preparation, and equitable access to ensure the effective implementation of AR in the teaching of history and geography.

Table 6: Barriers faced by teachers when integrating augmented reality into secondary education for teaching history and geography

Authors	Barrier	Summary description	Subject areas (History/ Geography)
(Masneri et al., 2024; Nachtigall et al., 2024; Ratmaningsih et al., 2024; López-García et al., 2024; Arıkan et al., 2024; Boboc et al., 2019)	Lack of Training and Professional Development	Limited technical and pedagogical training in AR (e.g., programming, content design, ICT skills)	History and Geography
(Xiao et al., 2020; Nachtigall et al., 2024; Jung et al., 2020; Boboc et al., 2019; McNerney et al., 2023; Remolar et al., 2021)	Technological and Infrastructure Limitations	Deficient equipment (devices, electricity, furniture) and school readiness for AR integration	History and Geography
(Carrascosa et al., 2022; Kleftodimos et al., 2023; McNerney et al., 2023)	Limited Access and Connectivity	Unequal access to devices and reliable internet, which restricts the AR experience	History and Geography
(López-García et al., 2024; Kleftodimos et al., 2023; Arıkan et al., 2024; Ratmaningsih et al., 2024; Boboc et al., 2019; Remolar et al., 2021)	Resistance to Change	Preference for traditional methods, skepticism toward AR due to lack of familiarity or evidence	History and Geography
(Nachtigall et al., 2024; López-García et al., 2024; Jung et al., 2020; McNerney et al., 2023; Remolar et al., 2021; Zhao et al., 2020; Masneri et al., 2024)	Curricular Integration	Challenges in aligning AR with the curriculum and adapting content within limited instructional time	History and Geography
(Schnürer et al., 2020; Boboc et al., 2019; Arıkan et al., 2024; Remolar et al., 2021)	Costs and Financial Resources	High costs of implementation, maintenance, licenses, and teacher training in AR technologies	History and Geography
(Schnürer et al., 2020)	Technical Limitations in Map Recognition	Visual recognition issues in AR such as instability or poor rendering due to angle limitations	Geography
(Jung et al., 2020)	Time and Complexity in Creating 3D Content	3D content creation requires technical skills and faces compatibility challenges across formats and devices	History

RQ6: How does augmented reality influence student motivation and critical thinking in the learning of history and geography?

To demonstrate the pedagogical impact of AR on secondary education, Table 7 summarizes the evidence that was reported in the selected studies regarding two core competencies: student motivation and critical thinking. These competencies are essential for promoting meaningful learning in history and geography, as they foster engagement, reflection, and intellectual autonomy. The reviewed literature highlights a variety of cognitive and emotional mechanisms triggered by immersive AR experiences, ranging from enhanced self-efficacy and curiosity to the development of analysis, reasoning, and argumentation skills.

Table 7: Influence of augmented reality on students' motivation and critical thinking in history and geography learning in secondary education

Author(s)	Motivation	Critical thinking
(Masneri et al., 2024)	Immersive interaction (3D models, progressive feedback, peer participation) sparks autonomous interest and a spontaneous desire to explore content.	Team-based decision-making and real-time information assessment foster critical reflection and idea comparison.
(Nachtigall et al., 2024)	Vivid emotional experiences (360° videos, realistic scenarios) create a meaningful personal connection, generating emotional engagement without external rewards.	Students develop skills in visual analysis, contextual interpretation, and drawing conclusions based on multisensory experiences.
(Ratmaningsih et al., 2024)	Understanding complex content through visual and auditory resources stimulates a sense of competence, sustaining intrinsic motivation.	Encourages problem-solving of social or spatial issues through abstract reasoning and real-world application of concepts.
(López-García et al., 2024)	Media editing, debates, and interactive exercises enhance motivation through self-expression and active participation in historical contexts.	Students interpret, contextualize, and debate historical processes, fostering analysis of causes, consequences, and social change.
(Arıkan et al., 2024)	Natural curiosity is activated through novel technologies (VR, drones, simulators), motivating learning through spontaneous exploration.	Learners build knowledge through analysis, experimentation, and critical debate on real or simulated geographic scenarios.
(Kleftodimos et al., 2023)	Gamification elements (roles, challenges, rewards) enhance personal achievement, internal satisfaction, and enthusiasm for learning.	Taking on multiple perspectives fosters flexible thinking, situational analysis, and argumentation in civic or cultural contexts.
(Remolar et al., 2021)	Free exploration of reconstructed historical environments generates excitement and intellectual pleasure, motivating continued historical inquiry.	Promotes strategic thinking and conscious planning, applying analytical skills to create and evaluate historical spaces.
(Schnürer et al., 2020)	Visualization of complex 3D data, use of VR headsets, drones, and digital games trigger positive emotions such as awe and cognitive satisfaction, motivating deeper engagement.	Manipulating spatial variables enables critical judgment of geographic phenomena, fostering the ability to evaluate complex facts.
(Jung et al., 2020)	Simulated historical events with active interaction (rewards, points, leaderboards) inspire interest in reliving meaningful experiences and drive autonomous exploration.	Enhances comprehension of complex historical narratives through observation and analysis of processes from a critical perspective.
(Boboc et al., 2019)	Animated, detailed depictions of historical figures create emotional connections with the past, motivating a deeper desire to learn.	Supports temporal and spatial contextualization of historical events, fostering critical understanding of their significance.
(McNerney et al., 2023)	Engagement with real-world issues and SDGs, combined with digital rewards, motivates students to act as active agents in their environment.	Critical thinking is stimulated by assuming citizen-scientist roles, applying technical and ethical reasoning in environmental decision-making.
(Carrascosa et al., 2022)	Playful activities such as digital timelines generate enjoyment and autonomous engagement, turning learning into a motivating experience.	Chronological analysis and error correction enhance logical evaluation, sequential reasoning, and synthesis skills.

Author(s)	Motivation	Critical thinking
(Xiao et al., 2020)	Use of interactive 3D images with games and micro-videos encourages spontaneous exploration and personal satisfaction in understanding.	Strengthens analytical comprehension through detailed observation and cross-referencing of visual and textual data to interpret astronomical phenomena.

VR: Virtual reality; SDGs: Sustainable Development Goals

5. Discussion

The systematic analysis of the selected articles reveals the potential of AR as an innovative pedagogical tool in transforming the teaching and learning process into history and geography. The review demonstrates the notable evolution of AR applications designed as didactic strategies that facilitate the understanding of complex content and promote active, immersive learning by engaging students in realistic scenarios that allow the interactive exploration of historical events and geographical landscapes (Dhaas, 2024). As illustrated by the reviewed studies, the application developed by Xiao et al. (2020), for example, enabled interaction with three-dimensional planetary models, enhancing students' spatial understanding. In contrast, Nachtigall et al. (2024) implemented an application using 360° videos to recreate historical contexts, fostering deeper and more contextualized analysis of historical facts.

These applications contribute to various learning objectives in history and geography. At the factual level, AR reinforces memorization and information retrieval by offering visual and manipulable representations that enrich the cognitive experience. For example, the application developed by Boboc et al. (2019) promotes contextualized understanding and goes beyond superficial memorization by recreating and enabling interaction with three-dimensional scenes from the life of Ovid.

At the conceptual level, AR facilitates the understanding of spatial relationships and historical processes through immersive representations; for instance, the application by Xiao et al. (2020) allows interaction with three-dimensional planetary models, thereby improving students' spatial comprehension. At the procedural level, AR develops practical skills such as map interpretation and problem-solving in simulated contexts.

The effectiveness of these applications is closely linked to the learning models employed by educators who recognize AR as a means to enhance experiential learning and integrate technological tools (Scott & Cong, 2007). These models align technology with historical and geographical content, transforming traditional practices. The COVID-19 pandemic further accelerated this transformation by necessitating a shift from traditional in-person learning to e-learning methodologies (Kumar & Kumari, 2024).

Based on our analysis, collaborative learning emerges as a dominant approach in AR-based applications. These experiences allow students to assume differentiated roles, exchange ideas, solve problems as a team, and make joint decisions (Masneri et al., 2024). Such interactions not only foster high emotional engagement but also promote deeper, more reasonable comprehension of historical and geographical content. Moreover, immersive AR technology strengthens students' cognitive skills in authentic learning environments. The most effective learning models that incorporate AR in education include interactive learning, game-based learning, and collaborative learning, all of which enhance participation and knowledge construction. The most effective learning methods that incorporate AR in education include learning by doing and game-based learning; these enhance engagement and knowledge construction.

However, it is essential to consider that the effectiveness of these practices may depend on factors such as instructional design, teacher training, and technological accessibility. In this regard, teacher training should encompass not only AR literacy and knowledge of technological tools and resources but also skills to design and adapt interactive content and set positive attitudes toward innovation and continuous learning (Castaño-Calle et al., 2022; Nikou et al., 2025; Salehi, 2025).

A key finding was the strong leadership of European countries in implementing AR in history and geography education, as evidenced by the volume of published research and the diversity of applications developed in recent years. In contrast, a second finding highlighted a significant gap in scientific production and AR implementation in South American countries. This gap stems from a set of interrelated barriers that limit its adoption in the teaching of history and geography, for example, teachers' limited training in the use of AR, the persistence of traditional methods focused on memorization and the excessive use of textbooks, the lack of technological skills, and uncertainty about the effectiveness of AR (López-García et al., 2024; Masneri et al., 2024).

Additional challenges include the difficulty of incorporating AR into rigid curricula, technical limitations in the recognition of geographic maps (Schnürer et al., 2020), and the complexity of developing three-dimensional content, which requires specialized technical knowledge (Jung et al., 2020). Finally, inequality in access to technological devices, connectivity, and adequate infrastructure—especially in rural or low-resource areas—constitutes a structural barrier that exacerbates the technological and educational gap (Carrascosa et al., 2022; Nachtigall et al., 2024).

Moreover, teachers face challenges such as the scarcity of suitable AR educational applications, the high cost of equipment, and insufficient infrastructure, which hinder implementation and particularly affect students from disadvantaged socioeconomic backgrounds or with limited access to technology (Oralkul et al., 2025; Perifanou et al., 2023). Therefore, educational policies and institutional support should address these inequalities through ongoing training programs and the provision of adequate resources (Ewais et al., 2025; Perifanou et al., 2023).

These findings highlight the need for educational policies and curriculum standards to adapt and ensure that assessment practices, teacher training, and institutional support effectively facilitate the integration of AR in history and geography classrooms.

A third finding underscored the role of AR in stimulating intrinsic motivation and enhancing students' critical thinking skills. Several of the analyzed studies report that AR fosters meaningful learning by facilitating exploration of historical and geographical content in three-dimensional environments, which sparks students' interest and curiosity (Masneri et al., 2024). This motivation is reinforced by immersive experiences that integrate realistic task representations and technological considerations, ensuring students' deep and meaningful engagement in educational activities (Mystakidis & Lympouridis, 2023).

Regarding critical thinking, AR supports collaborative environments where students engage in analysis, group discussion, and the confrontation of ideas to achieve a deeper understanding of historical and geographical phenomena (Christopoulos et al., 2024). For instance, in the study of Shonima and Sowmya (2024), students demonstrated the ability to integrate complex concepts critically and reflectively.

A limitation of this study is the lack of AR applications developed in South American contexts, which restricts the generalizability of the findings to educational settings with different cultural, curricular, and technological frameworks in European and Asian countries. While European countries may lead AR research with an ecosystem that fosters innovation, clear policies, and a culture of experimentation, South American educational contexts face barriers such as a gap in usage, resistance to pedagogical change, insufficient teacher training, and a limited focus on technological creation (Revuelta-Domínguez, 2014). Overcoming these challenges requires a comprehensive and collaborative approach that promotes profound change in education. This gap highlights the urgent need to increase scientific production in South America to generate contextualized and relevant evidence.

In this regard, it is suggested that future studies not only design or implement AR applications adapted to a single context but are also carried out in collaboration with teachers, students, and developers to ensure greater educational integration. It is imperative to invest in comprehensive teacher training and develop curricula that integrate AR in a pedagogically sound manner, taking as a reference projects such as Hello Ruby, which helps establish mechanisms to fund educational initiatives (Revuelta-Domínguez, 2014).

Moreover, although collaborative learning is often promoted by AR applications, this was not sufficiently explored or systematically addressed in the studies that were analyzed (Nachtigall et al., 2024). This reveals a gap in understanding how such learning is generated, sustained, and assessed in AR environments. Likewise, there is a recognized need for future research to develop studies on assessment approaches that are applicable in these contexts and that consider both traditional and innovative methods to measure learning outcomes.

In this regard, future research should incorporate quasi-experimental and experimental designs to establish causal relationships between the use of AR and the development of historical and geographical competencies and longitudinal studies to assess the sustainability of the effects of AR and its impact on teaching practice (Abualrob et al., 2025; Perifanou et al., 2023; Salehi, 2025). Comparative analyses between institutions with different levels of technological infrastructure would also be valuable to propose strategies adapted to low-resource schools.

6. Conclusion

This study demonstrates that AR enhances learning in history and geography by facilitating the understanding of complex content through immersive, interactive, playful, and contextualized experiences that promote active participation and strengthen both cognitive and emotional strategies. Based on the systematic literature review, three learning models that support the use of these technologies were identified: the Experiential Learning Model, the Self-Regulated Learning Model, and the Collaborative Learning Model. The contribution of this study lies in the analysis of these approaches that enable students to construct contextualized knowledge through critical interaction with meaningful experiences using interactive technological tools that foster collective reflection and reinforce self-regulated learning through motivation, engagement, and academic performance.

The study also revealed that Spain is the leading country in producing research articles on this topic. This is in contrast to Latin America, where scientific evidence on AR in these curricular areas remains limited. Therefore, it is recommended to promote the development of AR applications within Latin American contexts that respond to the curricular diversity of history and geography education through intentional instructional design that allows for personalized learning experiences. For this reason, it is essential to promote comprehensive digital training not only for students and education science pre-service teachers but also for in-service educators, ensuring the effective integration of new methodologies and emerging technologies into educational processes.

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