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REVIEW ARTICLE

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If and how do 360° videos fit into education settings? Results from a scoping review of empirical research

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Abstract

Background: Over recent years, interest towards the use of immersive technologies has grown in parallel with the lowering of equipment costs: educators have started embedding them into their teaching practices at different levels of the educational system, from primary school to higher education. In general, immersive technologies are seen as suitable tools to live vicarious experiences, when the reality is hardly accessible, for instance due to safety issues.

Objectives: In this paper, we focus on 360° videos with the aim of developing a more systematic and evidence informed approach to the understanding of the educational uses of 360° in different educational contexts.

Methods: A scoping literature review approach has been adopted in order to obtain a comprehensive insight based on objective, replicable and transparent procedures.

Results and conclusions: The review includes studies published from 2016 onwards. According to the findings, 360° videos are more suitable for disciplines requiring careful observation of how knowledge is transferred into practice and where practical scenarios are involved: 360° videos have positive effects on learning, especially referring to motivation, attentiveness, information retention and transfer of knowledge. However, as for learners' reactions, physical discomfort is reported, mainly associated with the use of HMD. In addition, challenges, and barriers to the educational use of 360° video should be further analysed, since up to now logistical constraints have limited the studies to a very small sample population, without the possibility of providing suggestions for a wider adoption at organisation and institution level.

Implications: As 360° videos are reported to be promising in fostering learning processes, students' engagement, and information retention, further studies are recommend to cover the current gaps in the literature, particularly focusing on drawbacks and organizational challenges.

KEYWORDS
360° video, education, scoping literature review, virtual reality

1 | INTRODUCTION

Over recent years, interest towards the educational use of immersive technologies has grown (Pellas et al., 2021). Immersive technologies identify a series of digital tools and/or environments ranging from Virtual Reality (VR, i.e., completely reconstructed digital environments) (Freina & Ott, 2015), to Augmented Reality (AR, entailing an overlay of computer-generated content on the real world) (Azuma, 1997) and 360° video (Aguayo et al., 2017), where the real environment is captured through a camera. Although these technologies are not new, the increased commercialisation of tools supporting digitally immersive experiences (e.g., Oculus, HTC Vive, Valve), especially referring to 360° videos, has rekindled the interest and, today, a higher number of educators have started embedding them into their teaching practices at different levels of the education system, including primary school (e.g., Araiza-Alba et al., 2020), secondary school (e.g., Barreda-Ángeles et al., 2021; Ivars-Nicolás et al., 2020) and higher education (e.g., Kosko et al., 2020). In addition, the restrictions in the access to physical places due to the COVID-19 emergency highlighted how immersive technologies could complement the learning activity, providing students with the opportunity not only to hear about abstract contents but also to live vicarious experiences (e.g., Kang et al., 2020). This was particularly true for higher education since universities more than primary and secondary schools and colleges had to move their activities completely or almost fully online. As reported in several surveys on the lockdown impact on higher education (Bozkurt et al., 2020; Cirlan & Loukkola, 2021; Gaebel et al., 2021; Salmi, 2020), all institutions implemented some form of remote teaching, including online learning programmes, blended learning and hybrid teaching inducing decision-makers to look for new digital solutions, especially in light of the uncertain times we are living in. In this context, a systematic examination of the educational potential of immersive technologies, while also considering challenges and opportunities, would help decision-makers better understand the extent to which those technologies could contribute to overcoming certain limitations of face-to-face teaching, due to the difficulty or the impossibility of accessing the field. The limitations may be connected to emergency issues, or to the high number of the students in a class, or also to risky situations. In any case, their educational potential still needs investigation (Radianti et al., 2020). This paper intends to present and discuss the results of a scoping review of a specific immersive technology for educational use, namely the 360° video.

The focus on 360° videos was motivated by the fact that, in principle, the technical skills as well as the equipment needed to create and use them are less demanding than other immersive technologies. The scoping review has been undertaken within *Supporting Educators' Pedagogical Activities with 360° video* (SEPA360), a project funded under the Erasmus+ programme from the European Commission (EACEA), aiming at engaging lecturers, researchers and universities with the learning opportunities brought about by innovative 360° video cameras. Although SEPA was about higher education settings, the scoping review also took into account studies referring to other educational contexts, due to the limited number of articles available for higher education.

Prior to describing the methodology and the results of the scoping review, we provide the background of the study explaining how immersive technologies distinguish from other digital environments and describing what is generally claimed in the literature about the benefits and the challenges of 360° videos.

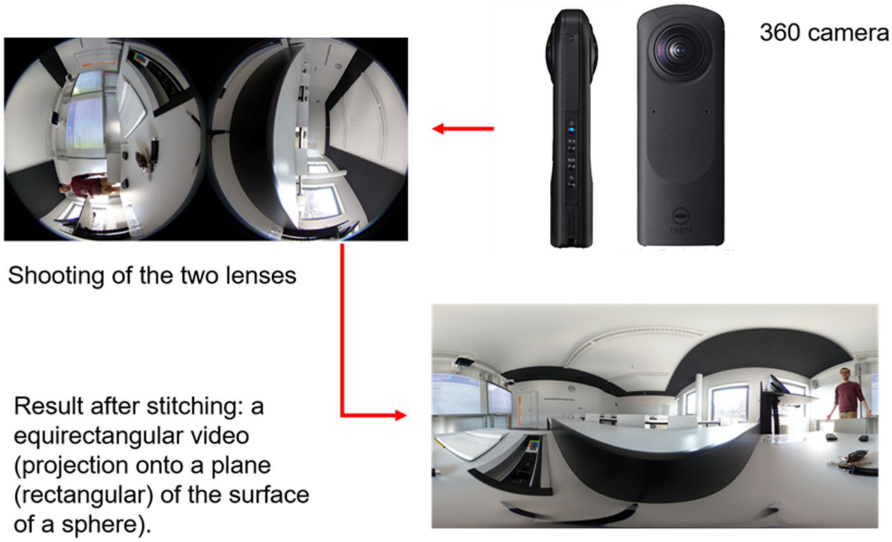
2 | CONCEPTUAL BACKGROUND

In research on virtual and augmented reality (Liberatore & Wagner, 2021; Nilsson et al., 2016), *immersion* is meant as the perception of being physically present in a non-physical world which is generated by surrounding the user of the VR system with images, sounds, or other sensorial stimuli. Through the integration of virtual content and real experience, the user engages naturally with the mixed reality, which refers to a combination of real and virtual environment (Freina & Ott, 2015). Within an immersive experience, the user perceives the virtual elements of the environment as a component of a whole, walking *through* and interacting *with* it. Immersion and sense of presence are experienced by wearing a Head Mounted Display (HMD) viewer and using a handle or a remote control so that the image of the digital content takes place in a virtual environment. The latest generation of HMD viewers, due to ergonomic improvements offering greater visual and acoustic isolation from the real environment, allows the wearer to live meaningful and engaging immersive experiences. This intense feeling of being present in an artificial world is what precisely distinguishes immersive technologies from other digital environments. 360° videos fit into this scenario as they offer enhanced realism and an increased sense of presence, when compared with 3D simulations, while becoming at the same time increasingly affordable (Aguayo et al., 2017).

Technically speaking, 360° videos are recorded with omnidirectional or multi-camera systems enabling to simultaneously capture all directions and perspectives. Videos are stitched together with software to produce a fully spherical field of view (Figure 1). During playback users can interact with the video through a mouse click, or by panning and tilting a mobile device to look in any direction within the video recording.

360° videos, enjoyed with an HDM, offer, then, not only a feeling of presence (Yoh, 2001) and a sense of 'embodiment' (Kilteni et al., 2012) but also something more than an authentic and realistic experience, when compared with other types of artificial environments, precisely because of the images of real environments. In recent years, support for 360° videos has been progressively integrated into popular social media and video sharing sites, starting with YouTube in March 2015, Facebook in September 2015, Twitter in December 2016, and later Vimeo in March 2017. This has contributed to improved ease of use for 360° video playback in addition to ubiquitous access to a growing collection of online 360° video contents. The field of educational 360° videos is emerging alongside the production and sharing of 360° videos and in parallel with the development and

FIGURE 1 360° video production



availability on the market, from 2016 onwards, of action cameras for 360° video shooting (e.g., the GoPro 7), increasingly versatile, easy to use, compact and low price, and viewers such as Google Cardboard, that reduce the cost barrier.

Moving to the pedagogical aspects, though research on the educational benefits of 360° videos is still in its infancy, studies on immersive technologies generally point out that they have a positive influence on remembering and understanding visual and spatial dimensions (cognitive skills), on visual scanning or observational skills (psychomotor skills) as well as on controlling emotional response to stressful or difficult situations (affective skills) (Jensen & Konradsen, 2018). All circumstances where the (real or virtual) experience plays an important role in supporting learners' advancement in knowledge and skills seem to benefit from the use of HMD viewers and 3D interactive videos. Although disputed for some simplification of the way we learn (Seaman, 2008), the Kolb's (1984) theory of experiential learning may help catch the pedagogical affordances of immersive digital environments. This theory, indeed, emphasizes the role of the experience in the learning process arguing that 'knowledge is created through the transformation of experience' (Kolb, 1984) which occurs through a cycle of four stages starting with (1) having a concrete experience followed by (2) observation of and reflection on that experience which leads to (3) the creation of abstract concepts and generalizations which are then (4) used to test a hypothesis in future situations, generating new experiences. 360° videos may support the learning process by offering an immersive experience, even when access to the reality is limited.

Further theories useful to conceptually frame the educational potential of 360° videos are linked to the notion of situated learning, also known as situated cognition (Brown et al., 1989; Leave & Wenger, 1991). As it is well-known, situated learning is a socio-constructivist perspective which, while questioning the traditional separation between knowledge and practice, stresses that knowledge construction processes are inherently related to the context of practice where they take place. Learning does not occur in abstract settings but in situational contexts: students develop their knowledge from observing others and practicing themselves, therefore becoming 'cognitive apprentices' within the community (Wenger, 1998). However, along with these pedagogical benefits, there are also disadvantages which can be due to physical discomfort (Huber et al., 2017; Rupp et al., 2016; Taylor & Layland, 2019), or a lack of good practices to be shared among the teachers to inspire their practices (Frisby et al., 2020).

3 | RESEARCH QUESTIONS

With the aim of developing a more systematic and evidence informed approach to the understanding of the educational uses of 360° videos, a comprehensive scoping review has been carried out focusing on the following research questions:

> **RQ1.** *What are the main characteristics, including aims, methods, and contexts, of studies on 360° video in education?*

> **RQ2.** *How are 360° videos currently used in different educational settings?*

> **RQ3.** *What type of benefits and barriers to wide adoption of 360° videos are reported in the literature?*

4 | METHODOLOGY

A scoping literature review approach was adopted to answer the research questions outlined above. This methodological strategy allows researchers to obtain a comprehensive insight into a specific research domain, and is based an objective, replicable and transparent procedures for research synthesis to minimize bias (Cooper et al., 2019). To increase reliability, the review process was undertaken by three researchers who searched, selected and examined all relevant studies, while comparing and discussing their results throughout the process. Before starting the review in February 2020, a search for pre-existing systematic literature reviews on the same topic was undertaken, but no studies were found. The research was updated during the editorial process of the current paper in 2021, founding new review articles (Ranieri et al., 2020; Shadiev et al., 2021; Snelson & Hsu, 2019). However, if compared with Snelson and Hsu (2019), the present study considers a higher number of papers and, differently from Shadiev et al. (2021), it only takes into account empirical research studies. As far as Ranieri et al. (2020) is concerned, it was just a preliminary descriptive presentation of data with no critical analysis of findings. After this preliminary examination and adopting the PRISMA guidelines (Moher et al., 2009) to identify and select the studies, the research has been carried out through the definition of inclusion and exclusion criteria as better explained in the following paragraphs.

4.1 | Inclusion criteria

Based on the knowledge of the emerging literature in the field, during the first project transnational meeting the research team identified specific inclusion criteria to address the research questions of the review and clearly define the boundaries of the scoping study. The inclusion criteria include:

- Year of publication: from January 2009 to February 2020;
- Type of publication: peer-reviewed empirical journal articles and conference papers including a clear presentation of research questions, methodology (quantitative, qualitative or mixed-method strategies) and interpretations based on theory and evidence (Freeman et al., 2007);
- Language: English;
- Geographical areas: all countries;
- Subject: studies that have specifically investigated the educational uses of 360° videos in different settings, including findings on teaching and learning opportunities and barriers as well as organizational or technical issues.

Unpublished manuscripts, research abstracts and doctoral dissertations were excluded. Although this type of publications may provide interesting results, peer-reviewed studies were privileged to ensure a higher quality. Moreover, conceptual papers and review articles were not considered in the review. Even publications with a wider focus on immersive technologies such as simulations or VR, or also studies mainly dealing with technical aspects were ignored in order to keep the attention on the educational affordances and barriers of 360° videos.

4.2 | Search strategy

Six scientific databases were identified to assure a broad coverage of academic peer-reviewed studies:

1. ACM Digital Library (Association for Computing and Machinery) <https://dl.acm.org/>;
2. EBSCOhost <https://search.ebscohost.com>:
   a. eBook Collection,
   b. Education source;
3. ERIC (Education Resource Information Center) <https://www.eric.ed.gov/>;
4. IEEE Xplore Digital Library <https://ieeexplore.ieee.org/>;
5. SCOPUS <https://www.scopus.com/>;
6. Web of Science (Core collection) <http://www.webofknowledge.com/WOS>.

The search string adopted for searching the databases referred to the following keywords: different wording for 360° videos (i.e., 360° degree video, 360-degree video, 360° video); different educational settings (i.e., higher education, university, school, professional development). Terms in the plural form were not entered into the search string since they are automatically changed into the singular form. In composing the search string, the Boolean search operators AND and OR were used, while parentheses were introduced to order the search execution: ('360 video' OR '360 degree video' OR '360-degree video' OR '360° video') AND (education OR university OR 'higher education' OR 'professional development' OR school).

4.3 | Identification of relevant papers

The total number of records found through the search was 1024 (see Table 1). They were imported into Zotero <https://www.zotero.org/> and duplicate records (38) were removed through the automatic feature of the software.

The remaining 986 records were screened according to the established inclusion criteria looking through the titles, the keywords and the abstracts. Following this first analysis, 52 studies were selected. In the next stage, full-text examination—including an analysis of the papers' references—was performed by the researchers to further identify pertinent articles and discard the irrelevant ones. Individual results were compared and discussed: at the end of the whole screening process, 29 journal articles and conference papers were selected for the scoping literature review. All of them are listed in the References with an asterisk as a marker. The following PRISMA

TABLE 1 Results of the search for each database

Database	Results
ACM digital library	331
EBSCO (eBook collection education source)	16
ERIC	12
IEEE Xplore	11
SCOPUS	639
Web of Science (core collection)	15
TOTAL	1024

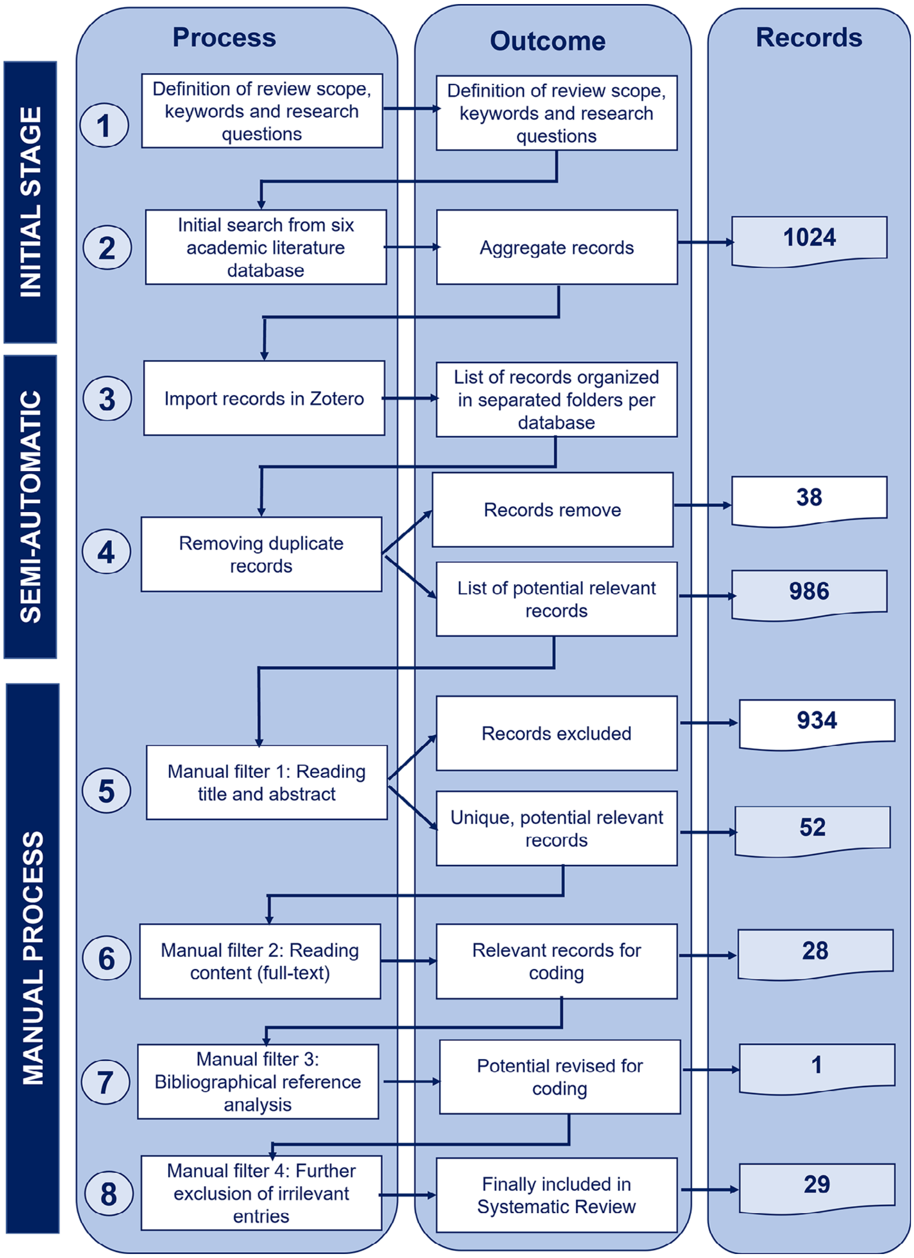


FIGURE 2 The PRISMA flowchart (*Source*: model adapted from Radianti et al., 2020, p. 8)

flowchart (Figure 2) summarizes the overall research strategy also showing the number of relevant papers identified at each stage.

4.4 | Data analysis

The coding procedure started with the definition of the categories to be used for describing each study. Five macro-categories (i.e., 'Publication type', 'Research design', 'Focus on 360° video', 'Results', 'Benefits and Challenges' to the use of 360° videos in educational contexts) and 29 related sub-categories were set up according to the research questions. Some of the coding categories are typically adopted for scoping reviews, including for example bibliographic metadata and metadata related to the geographical area and the research context.

Other categories such as 'Type of instructional design 360° video', 'Type of 360° video', 'Technical equipment' were specific to the field and suggested by a panel of experts involved in the project. However, prior to undertaking the actual review process, the categories were revised or also integrated with new categories, following an iterative process of making hypotheses, application, and revision, as usually happens in qualitative research (Denzin et al., 2005). Furthermore, to improve the intercoder reliability of the coding process and to ensure uniformity, all researchers participated in a coding test with five selected papers.

Results were compared and all coding discrepancies were discussed until reaching consensus, instead of calculating the discrepancies quantitatively as suggested by Krippendorff (2004) or Holsti (1969). The final coding categories are described in Table A1.

Once the categories were consolidated, a matrix for coding was built up to facilitate the procedure of information extraction. All the full-text of the 29 studies included in the review were read independently by the reviewers and coded. At the end of the coding process, the level of agreement among reviewers has been measured through the calculation of the percent agreement which resulted in the acceptable outcome of 0.82 (Capozzoli et al., 1999). Disagreements were resolved by consensus-based discussions.

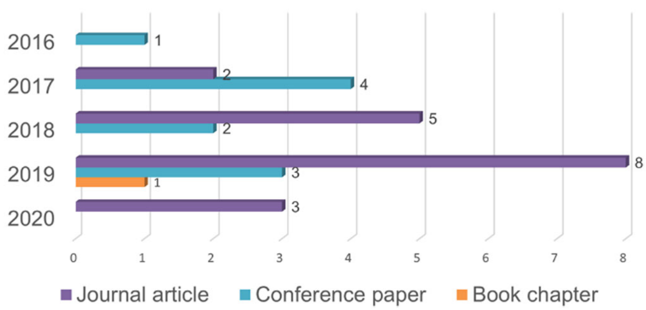
5 | RESULTS

5.1 | Scope and nature of relevant studies

To answer the first research question *What are the main characteristics, including aims, methods and contexts, of studies on 360° video in education?* studies were coded considering basic information such as year of publication, geographic area and publication type. A look at the time span under scrutiny, namely 2009–2020, reveals how the publications' trend has grown since 2016 onwards. No relevant studies of 360° videos in education were published before 2016 (Graph 1), instead as a reversed trend 12 studies were released in 2019. More specifically, most publications concentrate in the last 3 years, including conference proceedings (18) and journal articles (10).

This phenomenon is due to different surrounding circumstances. First, the commercial availability of 360° cameras for the consumer segment from 2014/2015 must be mentioned (Martín-Gutiérrez et al., 2016) together with the introduction of the uploading, sharing and viewing of 360° video features on the main social media platforms, including YouTube, Facebook and Twitter between 2015 and 2016. Moreover, as previously noted, from 2016 onwards more flexible, easy to use and low-price action cameras for 360° video shooting (e.g., the GoPro 7) become available on the market.

As shown in Graph 2, Europe is the geographical area with the highest number of publications (14), followed by Northern America (10). South America and Africa stand out for having none.

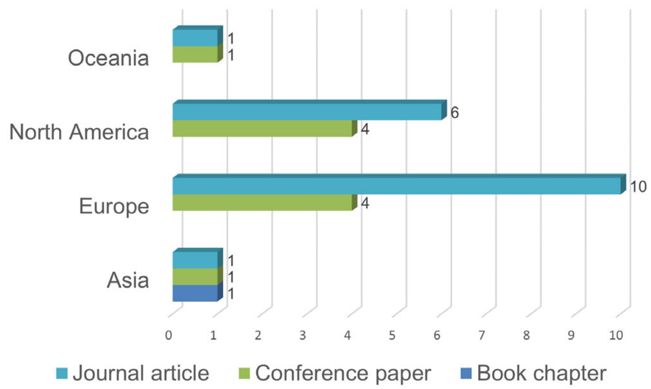


GRAPH 1 Number of publications per year distributed per publication type. The colour indicates the publication type.

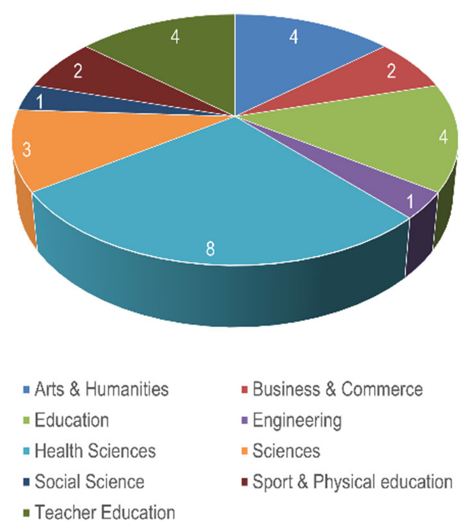
5.2 | Educational contexts and aims of the studies

When moving to the educational contexts, science is the most common domain (12)—*Health Science* (8), then *Science* (3) and *Engineering* (1)—followed by *Education* (4) and *Teacher Education* (4) (Graph 3). A reason for the higher number of studies in the scientific area could be that 360° videos are particularly suitable for simulating procedures, laboratory experiments and physical environments (Table 2). As far as the educational level is concerned (Graph 4), 360° videos are mostly used in formal settings. In fact, almost all studies refer to *Higher education* (25), while very few studies focus on primary or secondary education (respectively 2 and 2). Even the two studies on adult education in the areas of *Commerce & Business* and *Sport & physical education* were conducted in a formal context.

Focusing on the aims of the studies (Table 2), four articles entailed a comparison between educational 360° videos and 2D videos, or VR. While most studies compared only two viewing modes (e.g., Google Cardboard vs. smartphone), one study (Rupp et al., 2019) made a



GRAPH 2 Number of publications per geographical area distributed per publication type. The colour indicates the publication type.



GRAPH 3 Research areas

TABLE 2 How to use the 360° video in education

Lectures			Modelling						Exploring		
Health (4)	History (1)	Science (1)	Climbing and sports (2)	Maritime (1)	Public speaking (1)	Retailing (1)	Surgical (3)	Teacher education (6)	Internal environment (5)	Natural landscape and sites (3)	Mixed environment (internal and external) (2)
6			14						10		

Note: The total number of items may exceed 29 as the same study could have been coded in more than one subcategory.

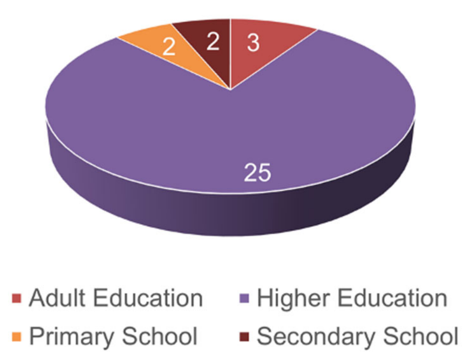
comparison between four viewing modes (smartphone, Google Cardboard, Oculus Rift Development Kit 2 or Oculus Consumer Version 1). Five studies specifically investigated whether the use of 360° videos could generate physical discomfort in the students. The physical distress under examination was cybersickness or motion sickness. Furthermore, it must be noted that, though many studies dealt with aspects related to learning within immersive environments, poor attention was devoted to clarifying what educational elements are relevant for positive experiences and how to design teaching based on the use of 360° videos.

5.3 | Technical equipment

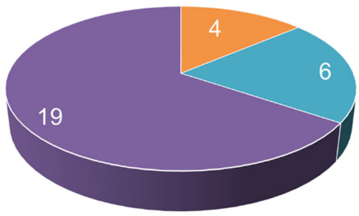
Coming to *Technical equipment* (Table A2) all the tools involved in different phases of the study were coded: from the video production phase, including the camera or the brand and type of 360° videos camera, to the viewing phase where different types of devices were distinguished based on the diverse levels of immersion. Notebooks, tablets, and smartphones were included among the devices entailing low level of immersion, while viewers such as the HMD, that are specifically designed for immersive viewing of 360° video, were put on the side of devices entailing a high level of immersion. Platforms such as YouTube or Vimeo were also considered since they allow users to upload and view 360° videos. As shown in Table A2, information about the type of camera is not present in most of the studies with only four articles specifying which type of camera was used (2 GoPro, 1 Insta 360 Nano and 1 Samsung Gears 360). The most common device employed to watch 3D video contents is the smartphone (16) in combination with a cardboard headset (8) or with the more advanced version of a plastic viewer (3); 7 studies report generic HMD, 3 Oculus Rift, 1 Oculus Go and 1 Oculus VR. As far as the platforms are concerned, 5 studies document the use of proprietary platforms, while 8 studies refer to social media such as YouTube (6), Facebook (1) and Vimeo (1).

5.4 | Methodologies used in the studies

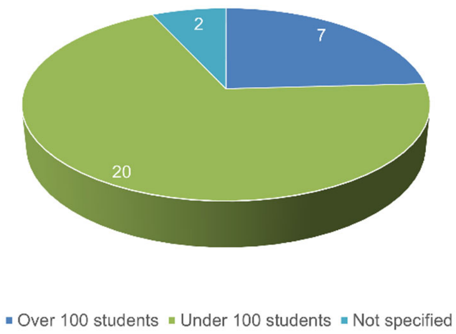
Looking at the research strategies of the selected studies, most of them are based on quantitative methods (19), while six adopted qualitative methods and four a mixed-method approach (Graph 5).



GRAPH 4 Educational levels



GRAPH 5 Research design and methods



GRAPH 6 Study sample

The student sample population is generally limited in number: the sample is less than 100 units in 20 studies, with only 7 studies involving more than 100 participants (Graph 6). The relatively limited sampling is basically due to logistical constraints (e.g., lab scheduling, time intensive practice sessions involving one-on-one feedback, device availability) or external causes (e.g., learners who would not allow their data to be collected). Furthermore, most learners were aged between 18 and 30 (i.e., young university students).

6 | EDUCATIONAL USES OF 360° VIDEO

To answer the second research question *How are 360° videos currently used in different educational settings?*, studies were coded trying to identify how the videos were designed and delivered according to different learning principles.

6.1 | Instructional approaches

From the analysis of the literature, it emerged that educational 360° videos can be designed according to three teaching methods (Table 2):

- **Lecturing**: the 360° videos are used to represent a traditional transmissive lecture taking place in a typical teaching situation with a focus on the teacher within a formal context such as a classroom or a conference hall (six studies: Abadia et al., 2019; Boda & Brown, 2019; Hodgson et al., 2019; Taubert et al., 2019; Ulrich et al., 2019; Zulkiewicz et al., 2020).
- **Modelling**: the 360° videos are used to show concrete procedures and activities; they generate a powerful sense of space, augmented and enhanced by the opportunity to deeply examine the environment and look at it from all angles, with a high sense of realism, also useful to arouse an emotional reaction (13 studies: Balzaretti et al., 2019; Frisby et al., 2020; Gänsluckner et al., 2017; Gilmartin et al., 2019; Harrington et al., 2018; Huber et al., 2017; Kosko et al., 2019; Lau et al., 2018; Roche & Gal-Petitfaux, 2017; Theelen et al., 2019; Theelen et al., 2020; Walshe & Driver, 2019; Yoganathan et al., 2018).
- **Exploring**: the 360° videos can, in principle, bring learners everywhere and make them able to explore any place: natural landscape, internal environment or mixed environment (internal and external). They increase the learners' control of the learning process, while encouraging curiosity and discovery (10 studies: Abadia et al., 2019; Berns et al., 2018; Johnson, 2018; Lee et al., 2017; Repetto et al., 2018; Rupp et al., 2019; Rupp et al., 2016; Tang & Fakourfar, 2017; Taylor & Layland, 2019; Violante et al., 2019).

In the *Lecturing* approach, 360° videos are supposed to favour learners' understanding of theories or concepts related to a specific subject topic, especially when compared with traditional teaching or 2D videos. In this regard, the review found contrasting evidence. For example, Ulrich et al. (2019) conducted an experimental study on the impact of different educational technologies, based on the delivery of the same lecture through three different channels, that is, 360° videos, 2D videos and traditional teaching, addressing three different treatment groups. Results indicate that the effectiveness of 360° videos was the same as 2D videos and traditional teaching. Other scholars, instead, reported that the immersive nature of 360° video facilitated students' concentration on the content (Taubert et al., 2019), with positive effects in terms of engagement, information retention, and 'positive attitude towards discipline [Science]' (Boda & Brown, 2019, p. 16).

When coming to *Modelling*, it must be observed that this approach is adopted in all studies on teacher education (Balzaretti et al., 2019; Kosko et al., 2019; Roche & Gal-Petitfaux, 2017; Theelen et al., 2019; Theelen et al., 2020; Walshe & Driver, 2019). In this area, 360° videos proved to be successful to stimulate teachers' self-reflection or future teachers' understanding of pedagogical practices. In Walshe and Driver (2019), education students were individually video recorded when teaching and by re-watching their own 360° videos they re-experienced their teaching, thus being solicited reflecting on their practices. Theelen et al. (2019), instead, report on a study where future teachers were invited to watch 360° videos of expert teachers to get a richer comprehension of possible teaching situations, before entering the classroom. For teacher education, 360° video affordances are particularly useful as the omnidirectional view allow student teachers to observe in any direction and 'develop a more nuanced understanding of what was taking place at different points during the lesson' (Walshe & Driver, 2019, p. 101), in addition to acquiring self-efficacy towards teaching. Moreover, 360° videos are highly appreciated by future teachers because they give 'the possibility of exploring the whole situation and of understanding all the different aspects. […] The possibility of moving in the video allows [them] to understand the context' (Roche & Gal-Petitfaux, 2017, p. 4). And also, 'the 360-degree videos, added with theoretical knowledge, increased PSTs' [Preservice Teachers'] professional vision when noticing relevant classroom events.' (Theelen et al., 2019, p. 9).

360° videos are even used to teach sports, including the most extreme ones such as climbing (Gänsluckner et al., 2017): the sense of immersion and multiple-angle views allow the viewer to see the scene from all directions and better observe body movements: 'The usage of 360-degree video in the course is better, compared to traditional video. Specially the video about climbing techniques turned out to enable new viewing angles and learning scenarios that would not be possible without 360° video techniques' (Gänsluckner et al., 2017, p. 48).

As for *Exploring*, 360° videos provide the viewer with the possibility of exploring different environments, providing a higher level of reality in comparison with virtual reconstructed spaces. From this point of view, '360° videos have opened up an entirely new way for people to immerse themselves in new places and experiences' (Tang & Fakourfar, 2017), even when located thousands of kilometres away. For example, the 360° video of the International Space Station (Rupp et al., 2016) consists of a guided tour from the perspective of an astronaut floating alongside the space station, while the audio track provides explanations and information about the different aspects of the station. As also attested in a subsequent study by Rupp (2019, p. 264), 'participants who experienced greater place illusion had greater post simulation increases in interest for learning more about space and the ISS'. Among the three teaching strategies identified within the selected studies, *Modelling* and *Exploring* are more common than *Lecturing*: this is not particularly surprising in so far as while *Lecturing* is mainly centred on content transmission or, in other words, on 'telling, showing and listening to', *Modelling* and *Exploring* on 'showing and doing': if 'telling, showing and listening to' are consistent with traditional 2D videos, 'showing and doing' are emphasized by immersive environments.

Along with these positive examples, we observed a lack of studies on how teachers can implement the video, or structure the lesson, or evaluate the learning outcomes. Only one study (Frisby et al., 2020) focuses on instructional conditions for effective adoption, leading to consider the following aspects: (a) identify appropriate technological tools; (b) practice with them before introducing them to the students; (c) design how implementing them into the course; and (d) reflect on the consequences related to their integration into the curriculum.

6.2 | Delivery mode

In the analysis of the literature, we also investigated how the 360° video is delivered, which means in what context and type of room (classroom, laboratory or at home) and if individually, in a couple or in a group (Table 3). Indeed, the delivery mode is a variable that can also affect the level of immersion and the feeling of presence, as it influences the way of viewing contents, such as self-directed control of view direction. In addition, as emerged from some studies (e.g., Lee et al., 2017; Tang & Fakourfar, 2017), the user does not necessarily need a HMD to view a 360° video: a web-based video player, such as a tablet or smartphone, may be sufficient to watch the video, since it supports drag and drop. Watching a 360° video with HMD brings a higher level of immersion, but is appropriate only for a single user experience, as this device isolates the individual from the real surrounding environment to immerse him or her in the virtual one. On the other hand, this type of 'solo' viewing is also common in viewing via a web-based video player. In fact, in most studies the delivery mode is individual either the 360° video is watched in the classroom (16), in the laboratory (5) or at home (4).

Only one study (Tang & Fakourfar, 2017) investigates the collaborative use of 360° video using a tablet via a web-based video player. This study identifies communication as the main problem of viewing 360° video because 'as we scale up to larger groups or heterogeneous groups (e.g., educational contexts where a teacher guides a group), we need to consider how to give people the freedom to explore, and then to come back to the views of others' (Tang & Fakourfar, 2017, p. 4504).

7 | BENEFITS, CHALLENGES AND BARRIERS

To answer the third research question: *What type of benefits and barriers to wide adoption of 360° videos are reported in the literature?*, studies were coded trying to identify learning factors and gains, students' reactions, and challenges with related constraints.

7.1 | Learning factors and gains

They were analyzed through nine subcategories, including *attentiveness*, *cognitive skills*, *engagement*, *information retention*, *new learning behaviours*, *reflective activities*, *technical skills*, *transfer of knowledge*, and other. As shown in Table 4, participants generally reported high levels of:

TABLE 3 Delivery of 360° video: Place/how

Classroom/individually	Classroom/group	Home/individually	Laboratory/individually	Laboratory/individually	Not specified
16	1	4	5	1	2

TABLE 4 Learning factors and gains

Attentive-ness	Cognitive skills	Engagement	Information retention	New learning behaviours	Reflective activities	Technical skills	Transfer of knowledge	Not specified
7	2	10	5	1	2	1	7	5

Note: The total number of items may exceed 29 as the same study could have been coded in more than one subcategory.

- **Engagement** documented in ten studies (Abadia et al., 2019; Assilmia et al., 2017; Gänsluckner et al., 2017; Gilmartin et al., 2019; Harrington et al., 2018; Hodgson et al., 2019; Johnson, 2018; Lee et al., 2017; Rupp et al., 2019; Violante et al., 2019).
- **Attentiveness** reported in seven studies (Boda & Brown, 2019; Harrington et al., 2018; Huber et al., 2017; Lau et al., 2018; Rupp et al., 2019; Taubert et al., 2019; Zulkiewicz et al., 2020).
- **Information retention** acknowledged in five studies (Berns et al., 2018; Frisby et al., 2020; Rupp et al., 2016; Rupp et al., 2019; Yoganathan et al., 2018).
- **Transfer of knowledge** described in seven studies (Berns et al., 2018; Hodgson et al., 2019; Kosko et al., 2019; Lee et al., 2017; Ulrich et al., 2019; Walshe & Driver, 2019; Yoganathan et al., 2018).

Generally speaking, from the studies included in the current review, it emerges that the use of 360° video promotes and increases interest and students' engagement. Engagement refers to the level of curiosity, interest, optimism and passion that students show, when they are learning or being taught, which also influences learners' motivation and retention. It includes three conceptual components (Fredricks et al., 2004), that is: emotional engagement, behavioural engagement and cognitive engagement. Emotional engagement envisages the feelings of learners during their learning experience, such as interest, frustration or boredom and their social connection with others at school or university. Behavioural or physical engagement includes the idea of being involved in an activity and the related effort. Cognitive engagement refers to the learner's effort to understand what has been explained, including metacognitive behaviours and self-regulation. All three types of engagement are dynamically interrelated within the individual and not isolated processes, and were found as associated to the use of 360° videos: for example, Harrington et al. (2018), p. 997) underline that 'higher engagement and attentiveness [are] associated with the 360° format', while Johnson (2018, p. 235) argues that '360° video can be used for innovative and engaging assignments that further learning outcomes and have significant pedagogical potential' and Rupp (2019, p. 266) concludes that 'immersive experiences would increase learner engagement and improve learning outcomes'.

Moving to attention, Violante et al. (2019) highlighted that, since 360° videos significantly increase learners' involvement, their use mitigates the risk of distraction favouring higher levels of attentiveness, including processes such as filtering and balancing multiple perceptions as well as attributing emotional meanings to them. There are two major forms of attention: passive and active. 360° videos mainly impact on active attention, which is a multidimensional cognitive process that includes the ability to select and focus on what is important at any given moment, the ability to continuously maintain the mental effort, while performing tasks that require mental energy, and the ability to inhibit action or thought, while previewing alternative actions or thoughts.

As far as information retention is concerned, it refers to the process through which new information is transferred from short-term to long-term memory. Overall, the evidence collected shows that higher levels of immersion positively impact on memorisation processes and information retention. For example, improvements were found in content learning related to languages (e.g., Berns et al., 2018) or surgical education (e.g., Yoganathan et al., 2018). Even Rupp et al. (2019), who compared two different conditions of immersion (i.e., low and high), found that participants in the most immersive condition received higher scores than the less immersive condition indicating that they remembered more information. However, while this was true for auditory information, it was less significant for visual information. Similarly, Harrington et al. (2018) could find no significant added value of 360° videos for visual information retention. However, to some extent this topic needs further investigation.

Another benefit is linked to the *transfer of knowledge*. 'Knowledge transfer' is a cognitive process whereby the learner's mastery of knowledge or skills in one context enables him/her to apply it or them to different context. Among the studies highlighting the value of 360° video in this regard, one can mention those related to professional learning such as Kosko et al. (2019) and Walshe and Driver (2019). Focusing on teacher education, Kosko et al. (2019) investigated the influence of 360° video on pre-service teachers' professional noticing in the area of mathematics, finding that a higher level of immersion, due to the use of a virtual reality headset, was associated with improved situational awareness. Similarly, Walshe and Driver (2019) explored how the use of 360° videos can support student-teacher reflection and found that embodied experience of reflecting can favour a more nuanced understanding of microteaching practice, and student-teachers' self-efficacy towards teaching.

7.2 | Learners' reactions

Both positive and negative reactions from the students are reported in the literature (Table 5). Closely associated with learning gains, many studies (14) indicate high levels of enjoyment by the learners in viewing 360° video. For example, Lee et al. (2017, p. 157) observe that 'VR has the potential to make learning more enjoyable by allowing students to translate their personal experiences, emotions and memories to the virtual environment', while Ulrich (2019, p. 9) states that

TABLE 5 Learners reactions

Enjoyable experience	Experienced technical hindrances	Physical discomfort	Not specified
14	2	9	10

Note: The total number of items may exceed 29 as the same study could have been classified in more than one subcategory.

'360° video offers something new compared to VR and regular video, namely, the positive emotional attributes'.

Besides these positive effects, a few studies found some drawbacks (Table 5). In particular, physical discomfort such as motion or cybersickness, slight nausea, dizziness, lost sense of time, and anxiety for interaction or rejection, was reported in nine studies, though they refer to isolated cases involving numerically small samples. Four studies investigate motion or cybersickness with three of them (Huber et al., 2017; Rupp et al., 2016; Taylor & Layland, 2019) reporting no physical discomfort. Rupp et al. (2016, p. 211) make the point that 'No significant differences were found for simulation sickness, positive or negative affect, or information recalled' and this view is also supported by Huber et al. (2017, p. 4474) who comment that 'The results of the motion sickness questionnaire revealed no sign of nausea for any of the participants at any time during the IVR session. The lack of motion sickness during the IVR sessions may be explained by the low rate of head movements during a laparoscopic surgery'. Only one study (Rupp et al., 2019) found that 7 out of 28 learners who used Google Cardboard had slight motion sickness; while the other 108 who used a smartphone, Oculus Rift DK2 or Oculus CV1 showed no physical discomfort.

7.3 | Opportunities and obstacles to adoption

Only one study by Ulrich et al. (2019) explicitly investigated the benefits of educational use of 360° video for institutions. This study concluded that 360° video should be an attractive option for many teaching institutions because the production costs are similar to those of a 'regular' video, while the benefits exceed those of traditional videos. Moreover, Ulrich (2019, p. 10) underlines that 'the implication of combining cost-effectiveness with positive emotions is a good indicator for the acceptance and adoption of 360° video'.

Further elements explored through the review were barriers to the educational use of 360° video from the point of view of organizations and institutions. In this regard, it must be noted that only a few studies focused on this topic, since most of them mainly concerned individual learners. Obstacles to the wide adoption and implementation of 360° video in educational organizations are brought back to a general lack of video resources on the YouTube platform (Johnson, 2018) and the deficiency of specialized video resources for specific domains or on specific procedures (e.g., in the medical surgical field) (Harrington et al., 2018). In addition, Harrington and colleagues (2017) made an evaluation of the costs connected to the production and use of 360° video, and came to the conclusion that, despite the ease of camera setup and fast editing procedures associated with 360° video, the 'increased expenses relative to traditional video recordings, and the cost-effectiveness of this new technology is open to debate' (Harrington et al., 2018, p. 999).

8 | DISCUSSION

The current scoping review aimed at investigating the potential of 360° video in education and systematizing the main research findings in the field through a comprehensive approach to the analysis of the empirical literature. The main findings of the review can be summaried as follows.

Firstly, and most importantly, in the considered literature, the use of 360° video is widely reported as particularly effective especially for practice-based disciplines such as student teaching, health science, engineering, sciences, physical education and sports and language learning. In general 360° videos are recognized as particularly suitable for disciplines requiring careful observation of how knowledge is transferred into practice and where practical scenarios are involved. Relevant examples of meaningful use come from scientific disciplines and teaching sports (Gänsluckner et al., 2017) since 360° videos represent real environments which are fully explorable in a safe way. From this perspective, their effectiveness especially emerges with those teaching strategies (Modelling, Exploring) which allow the learner a more complete experience of all aspects of the practical scenarios (Roche & Gal-Petitfaux, 2017; Theelen et al., 2019; Walshe & Driver, 2019). This finding is consistent with the theoretical assumptions of the experiential learning model (Kolb, 1984) and highlights the potential of 360° videos as a powerful educational tool.

A second important finding is related to learning factors and gains. According to the reviewed literature (see e.g., Gänsluckner et al., 2017; Lee et al., 2017), 360° videos are appropriate to practice-based learning for promoting engagement, attentiveness, information retention, and transfer of knowledge. In particular, more than a half of the selected studies focusing on the enabling factors of learning indicated that the use of 360° videos increases students' interest, attention and concentration in the learning activity, while also involving them from an emotional and behavioural point of view (Ulrich et al., 2019). Fewer papers, one-third out of the total, deal instead with information retention and transfer of knowledge: this is likely due to the lack of studies comparing these learning gains with and without the use of 360° videos.

Still keeping to the role of immersion in the learning experience, the third finding is that the educational experience of 360° videos may be enhanced through the use of HMD and remote control to improve the feeling of 'immersiveness' and interaction (e.g., Rupp et al., 2016), although the Cost–Benefit Ratio of using fully immersive devices is still debated. In fact, while all the selected studies identified one or more positive effect of 360° videos in terms of learning factors and gains, some drawbacks have been also highlighted. In particular, motion sickness is the most reported issue, which is likely due to a long stay in the immersive experience, although research shows that it also relies on subjective responses and on the type of video (Huber et al., 2017).

The fourth finding concerns the 360° videos design and implementation as educational resources. One study (Frisby et al., 2020) recommends paying attention to technological familiarization by involving the students in practicing these immersive technologies before introducing them for educational purposes. It is also advised to carefully planning the implementation of the 360° videos in the curriculum to maximize their effectiveness for the educational experience.

The fifth finding refers to the barriers which still prevent a wider adoption of 360° videos. The main limitation is a lack of availability of educational 360° videos as reported by two studies (Harrington et al., 2018; Johnson, 2018). In fact, despite the increased interest in 360° videos and the greater commercial availability of devices with relative ease of production (i.e., camera setup and fast editing procedure), few 360° videos have been created on specific knowledge or procedures (e.g., in the medical surgical field) leading to a poor availability of resources on social media platforms. Furthermore, logistical constraints (e.g., lab scheduling, time intensive practice sessions involving one-on-one feedback, and device availability) have been found in many studies as a key issue to be addressed for a scalable adoption. In conclusion, despite some clear advantages of 360° videos, their cost-effectiveness is still under scrutiny (Harrington et al., 2018).

The literature examined, also considering that 360° videos have not reached full maturity yet, offers a broad and articulate view on their use in different research areas, at different educational levels and with different teaching methods. However, some aspects are not wholly explored yet, while deserving to be contemplated for future research developments. Among them, one of the most relevant shortcomings in the reviewed literature is the low attention paid to disadvantaged or impaired students. In fact, no student with reduced ability is reported in the studies, despite the sensitive matter of inclusion and accessibility when using educational technologies in the curriculum, so we can say that an effective use of 360° videos cannot escape the challenges of fitting the needs of special education. Another emerging shortcoming to be addressed is the scarce attention given to the 'teaching process', particularly referring to how the teachers should approach 360° videos as producers. Indeed, while the role of the teachers as users of existing videos is relatively tackled, his/her role as designer and producer of new, original videos should be considered to nurture the regular and effective adoption of 360° videos into the curriculum.

As mentioned earlier, barriers to the wider adoption have not been fully examined by the selected literature. It may be due to the relative novelty of 360° videos, especially in the education domain, which may have led to focusing on the opportunities and benefits more than on barriers and drawbacks. In particular, the actual cost-effectiveness ratio for organizations was explicitly addressed by only two studies (Harrington et al., 2018; Hodgson et al., 2019) and no specific investigation has been made about the production costs, the conduction of a 360° video lesson in the classrooms, and the adaption and re-use of the produced materials. These aspects should be the object of analysis, when comparing 360° videos to 2D traditional videos, also in terms of the educational benefits. Indeed, at present, also considering most recent literature reviews (Ranieri et al., 2020; Shadiev et al., 2021; Snelson & Hsu, 2019), little attention is paid to this aspect, while it should be carefully taken into consideration, since the introduction of 360° videos within organizations may have several implications, especially in terms of sustainability of the investments in hardware and equipment due to fast changing landscape and consequent technological obsolescence.

The greater availability, in the consumer segment, of the equipment needed for shooting the 360° videos and the improved ease of use of software for their post-production suggest that, in the next years, the production of 360° videos will increase and help in overcoming an important barrier, such as the scarce availability of 360° educational resources, that currently seems to be the most limiting factors reported in the literature (Harrington et al., 2018; Johnson, 2018).

9 | LIMITATIONS

Although the object of the present study is relatively new, a meaningful number of papers have been found providing the ground for a comprehensive analysis. Yet some limitations can be found, mainly due to the novelty of the topic. First, only literature published in English has been included in the review, while there could be exploratory studies in other languages that, as the research topic will be more established, will reach a wider audience through international journals. Another limitation is linked to the number of students involved in the studies. The sample population is, in fact, generally small (less than 100 students), especially because of the logistical constraints examined in the previous sections. Moreover, the selected studies are often based on convenience sampling procedures of local participants, who can more easily be involved in the study. These limitations prevent one from generalizing the findings. In addition, one can also assume that with greater and more representative samples certain topics such as the negative side-effects of immersive technologies and their mitigation, can find higher consideration. Nonetheless, the convergence of the literature results ensures reasonable confidence in the following conclusions.

10 | CONCLUSIONS

This scoping review intended to analyse the emerging results from the research literature on the educational use of 360° videos, as a specific strand of immersive technologies. A peculiarity of 360° videos is that they provide a real—not virtual—representation of concrete scenarios, while being relatively affordable in terms of equipment and accessible as for using and producing such type of videos. Although the pedagogical use of 360° videos is still at the beginning, through the review of the selected studies, a general agreement was found on the potential of 360° videos to foster the effectiveness of the learning process, students' engagement, and information retention, especially through *Modelling* and *Exploring*, mainly within the scientific domains (Health Science, Science and Engineering), but also in Social Science (Education and Teacher Education).

While the higher effectiveness of 360° videos, with respect to the 2D traditional ones, is widely acknowledged by the existing literature, still some drawbacks are reported among which a few cases of motion sickness. However, since only a few papers focused on barriers, it is hardly possible to draw any general conclusions about the motion sickness relevance for educational purposes. Another limitation to 360° video adoption can be the scarce availability, on social platforms, of 360° videos on specialized domains to be used for educational purposes.

From the existing literature, other aspects have been identified as worthy of further investigation. The first one refers to the challenge of adopting immersive technologies with disadvantaged or impaired students: since learning must be for all, the introduction of inaccessible technologies risks dramatically reducing the inclusiveness of the teaching and learning processes. The second one concerns the role of teachers as designers and producers of new videos, including the understanding of how those videos can be consistently integrated by the teacher within the curriculum. Last, but not least, so far, the benefits and barriers for the adoption of 360° videos in organizations are not fully addressed. Indeed, if one strength of the 360° video is the affordability of the devices (both cameras and headsets), its scalability for their full adoption in a programme still needs to be carefully considered.

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Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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APPENDIX A

Table A1 and Table A2

TABLE A1 Coding categories

Category	Field	Description	Subfield
General document identity	Authors	Authors in the publication	
	Title	Publication title	
	Year	Year of publication	
	Source Title	Journal, conference or other information indicating the type and context of publication	
	Document type	Type of publication	Journal article, Conference paper
	Geographical Area	Geographical area of the study	Africa, Asia, Europe, North America, South America
	Abstract	Synthesis of the research, as provided by the authors	
	Keywords	Specific words describing the content/focus of the research	
Research design	Research area	The overarching disciplinary field where the research can be placed	Arts & Humanities, Business & Commerce, Education, Engineering, Health Sciences, Science, Social Science, Sport & Physical education, Teacher education
	Educational level	Characterization of the educational level	Adult learning, higher education, primary school, secondary school
	Type of learning	Characterization of the learning processes according to their structure, from more structured and institutionalized, to more open and unacknowledged by the participants	Formal, informal, non-formal
	Aims of the study	Expresses the intention or an aspiration of the study, it is extracted from those indicated in the study.	
	Study research questions and/or hypotheses	Study research questions and/or hypotheses, it is extracted from those indicated in the study	
	Type of study design	Methodological choices made by the authors	Mixed-method, qualitative, quantitative
	Type of data collected	Type of data collected paying attention to the size, to what is provided before and after	
	Data analysis method	Description of the type of methods used in the study to analyze data, i.e. quantitative (e.g., descriptive statistics, inferential statistics: hypothesis of relationships between variables and effect size) or qualitative (e.g., coding in categories, thematic analysis; textual analysis of the occurrences of terms)	

TABLE A1 (Continued)

Category	Field	Description	Subfield
	Sample	The sample object of the study	Number, Gender, Age, Previous experience
Focus on 360° video	Type of instructional design of 360° video	How 360° video is mainly employed	Lecturing, Modelling, Exploration
	Type of delivery of 360° video	In which context the 360° video is viewed	Home, classroom, individually, laboratory
	Type of 360° videos	Information on the duration, points of view and topic of the 360° video	
	Technical equipment	Technical equipment: camera, viewer, software, device, platform	
Results	Result/Findings	Research results illustrated in the publication	
	Limitations of the study	Limitations of the study described in the publication	
	Implications for policy and practices	Policy implications, practices and guidelines in the production and use of 360° video	
Benefits and challenges of using 360° video in educational context	Learning factors and gains	The learning factors and gain in using 360° video	Attentiveness, cognitive skills, engagement, information retention, reflective activities, transfer of knowledge
	Learners' reactions	Positive and negative experiences, emotional or physical, in the use of 360° video	Enjoyable experience, experienced technical hindrance, physical discomfort
	Benefits (general, organization)	Advantages for the organization in terms of costs, time, ease of production, inclusion, scalability	Cost, scalability, time
	Challenges and barriers	Challenges and barriers in implementing and using 360° video	Classroom size, type of disciplinary content, teachers' resistance, lack of institutional support, lack of recognition, lack of time, wider adoption
	Technical challenges	Technical problems	

TABLE A2 Main features of the selected studies

Authors, year and title	Research area	Aims of the study	Technical equipment
Rupp et al., 2016. *The effects of immersiveness and future VR expectations on subjective experiences during an educational 360° video*	Education	To assess the impact of immersion manipulated by the type of VR device used as well as how participant's prior expectations about and interest in VR may influence their feelings of presence, positive/negative affect, and motion (simulator) sickness experienced while watching a 360° video. To determine how these variables influence the amount of information retained following the simulation.	Camera: not specified Device: smartphone Platform: not specified Viewer: Google Cardboard/Oculus Rift Head Mounted Display
Assilmia et al., 2017. *IN360: A 360-degree-video platform to change students preconceived notions on their career*	Education	To create a sustainable system or model for career education content using 360° video format and to deliver it through a digital platform.	Camera: non specified Device: smartphone Platform: IN360 (website) Viewer: Google Cardboard
Gänsluckner et al., 2017. *360-degree videos within a climbing MOOC*	Sport and physical education	To present the background of the Climbing MOOC (Klettern mit 360° videos) course, the course concept, the course itself and the results of the evaluation. To create a field study combining a MOOC and face-to-face-teaching. To explore the use of 360° videos.	Camera: not specified Device: not specified Platform: iMoox Viewer: not specified
Huber et al., 2017. *New dimensions in surgical training: immersive virtual reality laparoscopic simulation exhilarates surgical staff*	Health science	To develop a new combined highly IVR laparoscopy setup and to analyse first experiences regarding the degree of immersion, motion sickness and performance measurements.	Camera: Samsung Gear 360 Device: laptop Platform: non specified Viewer: Head Mounted Display
Lee et al., 2017. *Assessing Google Cardboard virtual reality as a content delivery system in business classrooms*	Business and commerce	To examine the potential for using Google Cardboard VR in business classrooms as a content delivery platform. To investigate how VR (viewing a 3-dimensional, 360° video) differs from the traditional flat-screen format as a teaching tool to deliver video-based content.	Camera: not specified Device: smartphone Platform: Google Cardboard VR Viewer: Google Cardboard
Roche & Gal-petitfaux, 2017. *using 360° video in physical education teacher education*	Sport and physical education	To describe preservice teacher activity during the workshop: their feelings, concerns, perceptions, emotions, and knowledge used and constructed during viewing 360° video situations.	Camera: not specified Device: not specified Platform: YouTube Viewer: not specified
Tang & Fakourfar, 2017. *Watching 360° videos together*	Education	To contribute the first study of collaborative 360° video viewing and based on the findings of the study, to contribute a set of design implications for 360° video players.	Camera: not specified Device: tablet Platform: not specified Viewer: not specified
Berns et al., 2018. *Exploring the potential of a 360° video application for foreign language learning*	Arts and humanities	To explore the possibilities of 360° video and chatbots for fostering language competencies by means of real world-like situations.	Camera: not specified Device: smartphone Platform: YouTube, Facebook, Vimeo Viewer: Head Mounted Display
Harrington et al., 2018. *360° operative videos: A randomized cross-over study evaluating attentiveness and information retention*	Health Sciences	To produce high quality, 360° teaching operative videos augmented with educational material, using available consumer technologies. To assess the variance in attentiveness levels in a 360° video compared with the traditional (2D) format.	Camera: Go Pro Device: smartphone Platform: not specified Viewer: Gear VR Head Mounted Display

TABLE A2 (Continued)

Authors, year and title	Research area	Aims of the study	Technical equipment
		Secondarily, to evaluate both video formats for variances in information retention and to achieve appraisals from the student population.	
Johnson, 2018. *Using virtual reality and 360-degree video in the religious studies classroom: An experiment*	Arts and humanities	To describe and reflect on the experimental incorporation of these technologies in two sections of an introductory religious studies course at a small two-year campus in the University of Wisconsin System.	Camera: not specified Device: smartphone Platform: YouTube Viewer: Google Cardboard
Lau et al., 2018. *360- degree immersive videos: a way to improve organizational learning practices*	Business and commerce	To involve employees in an advanced situated-training program on Omni-channel retailing. Using designed 360-degree videos (with Oculus system), to develop their professional knowledge and problem-solving skills.	Camera: not specified Device: smartphone Platform: not specified Viewer: Oculus VR
Repetto et al., 2018. *Learning into the wild: A protocol for the use of 360° video for foreign language learning*	Arts and humanities	To employ enriched 360° videos displayed on a smartphone and experienced immersively by means of a cardboard headset, to improve second language learning in high school students.	Camera: not specified Device: smartphone Platform: not specified Viewer: Google Cardboard
Taylor & Layland, 2019. *Comparison study of the use of 360-degree video and non-360-degree video simulation and cybersickness symptoms in undergraduate healthcare curricula*	Health science	To compare four common simulation tools, high fidelity manikin, standardized patient, video case study and 360° virtual reality video, and analyzed the self-reported cybersickness symptoms.	Camera: not specified Device: smartphone Platform: not specified Viewer: Samsung Gear
Yoganathan et al., 2018. *360° virtual reality video for the acquisition of knot tying skills: A randomized controlled trial*	Health sciences	To determine whether a 360° VR video improved knot tying skills when compared with conventional 2-dimensional (2D) video teaching. No previous study has evaluated the use of VR video in basic surgical training.	Camera: Ista360 Nano Device: smartphone Platform: not specified Viewer: Head Mounted Display
Abadia et al., 2019. *Effectiveness of using an immersive and interactive virtual reality learning environment to empower students in strengthening empathy and mastery learning*	Arts and humanities	To compare the instructional effectiveness of immersive VRLE in increasing empathy and mastery learning, compared with a 360° video. To analyse the relationship of increased empathy to student's mastery learning.	Camera: not specified Device: not specified Platform: Kokoda VR Viewer: not specified
Balzaretti et al., 2019. *Unpacking the potential of 360-degree video to support pre-service teacher development*	Teacher education	To present a summary overview of the initial exploration of the use of 360° video recordings with a cohort of PSTs at the University of South Australia. To explore the affordances of 360° videos with regard to the learning processes they may foster and develop.	Camera: not specified Device: not specified Platform: not specified Viewer: not specified
Boda & Brown, 2019. *Priming urban learners' attitudes toward the relevancy of science: A mixed-methods study testing the importance of context*	Science	To investigate the immersive nature of 360° virtual reality videos for a better science learning experience in urban elementary students (K-12).	Camera: not specified Device: smartphone Platform: not specified Viewer: Google Cardboard

(Continues)

TABLE A2 (Continued)

Authors, year and title	Research area	Aims of the study	Technical equipment
Gilmartin et al., 2019. *VR training videos: Using immersive technologies to support experiential learning methods in maritime education*	Sciences	To discuss the pedagogy and research-based foundation behind a proposed course design using these VR Training Videos as a part of an experiential learning process. To discuss the steps which SUNY Maritime College has undergone to implement this technology and course design in the classroom along with some of the initial findings of this project.	Camera: not specified Device: not specified Platform: VR Training Videos Viewer: Head Mounted Display
Hodgson et al., 2019. *Immersive virtual reality (IVR) in higher education; development and implementation*	Health science	To report the first two undergraduate courses those have adopted both VR and IVR modes for classroom learning: 'Pharmacology and Therapeutics' and 'Understanding Ecotourism'. The 360° videos have undergone a complete cycle of design, development, implementation and evaluation. These video captures can transcend physical boundaries in both clinical cases simulating a hospital ward and natural countryside landmarks.	Camera: not specified Device: laptop, tablet Platform: not specified Viewer: Head Mounted Display
Kosko et al., 2019. *Preservice teacher's noticing in the context of 360° video*	Science	To examine the specificity of mathematics noticed by PSTs in the context of perceptual capacity and embodied interaction.	Camera: not specified Device: laptop Platform: not specified Viewer: Oculus Go
Rupp et al., 2019. *Investigating learning outcomes and subjective experiences in 360-degree videos.*	Education	To test the effectiveness of a 360° video learning experience to facilitate learning of declarative knowledge, and to test four devices of varying degrees of immersion to determine how well each would support learning.	Camera: not specified Device: smartphone Platform: YouTube Viewer: Oculus Rift, Oculus Consumer Version, Google Cardboard
Taubert et al., 2019. *Virtual reality videos used in undergraduate palliative and oncology medical teaching: Results of a pilot study*	Health sciences	To evaluate whether VR is an effective and acceptable teaching environment. To evaluate the views of undergraduate medical students experiencing a 27 min VR lecture on nausea and vomiting management, and 2D videos were filmed and edited.	Camera: not specified Device: laptop, smartphone Platform: not specified Viewer: Oculus Rift
Theelen et al., 2019. *Using 360-degree videos in teacher education to improve preservice teachers' professional interpersonal vision*	Teacher education	To present a mixed-method study about a classroom simulation using 360° videos combined with theoretical lectures in teacher education.	Camera: not specified Device: smartphone, tablet, laptop Platform: YouTube Viewer: Head Mounted Display
Ulrich et al., 2019. *Learning effectiveness of 360° video: experiences from a controlled experiment in healthcare education*	Health sciences	To explore the learning effectiveness of 360° video when used as e-learning for healthcare students and whether the technology is a good IT-investment for education institutions.	Camera: not specified Device: laptop, smartphone Platform: not specified Viewer: Samsung Gear
Violante et al., 2019. *Interactive virtual technologies in engineering education: Why not 360° videos?*	Engineering	To design effective 360° interactive learning videos, based on the methodology of Mayer's principles and on Fredrick's construct of student engagement to measure the impact of 360° videos on the student.	Camera: not specified Device: not specified Platform: not specified Viewer: Head Mounted Display

TABLE A2 (Continued)

Authors, year and title	Research area	Aims of the study	Technical equipment
Walshe & Driver, 2019. *Developing reflective trainee teacher practice with 360-degree video*	Teacher education	To explore how the use of 360° videos can support student teacher reflection. To address this significant gap within the literature through empirical and methodological contribution.	Camera: not specified Device: smartphone Platform: not specified Viewer: Head Mounted Display
Frisby et al., 2020. *Using virtual reality for speech rehearsals: an innovative instructor approach to enhance student public speaking efficacy*	Social science	To explore the use of Virtual Reality speaking rehearsals as one technology that instructors can adopt to enhance students' public speaking efficacy. The virtual reality stimulus video was recorded using a 360° camera in a live classroom.	Camera: not specified Device: not specified Platform: YouTube Viewer: Head Mounted Display
Theelen et al., 2020. *Developing preservice teachers' interpersonal knowledge with 360-degree videos in teacher education*	Teacher education	To investigate the development of PSTs' interpersonal knowledge structures and the content of PSTs' interpersonal knowledge after watching 360° videos combined with theoretical lectures.	Camera: not specified Device: smartphone Platform: YouTube Viewer: Head Mounted Display
Zulkiewicz et al., 2020. *Using 360-degree video as a research stimulus in digital health studies: Lessons learned*	Health Sciences	To describe the challenges and lessons learned in designing and implementing a 360° video as part of an online experiment focused on inducing empathy among clinicians to understand patient experience.	Camera: GoPro (Odyssey) Device: smartphone, tablet, laptop Platform: OmniVirt Premium Viewer: Google Cardboard