Intellectual Output 1: Scoping Study

Contents

Introduction

There is currently no authoritative international publication or report that synthesises existing data about the educational use of interactive 360 video in general and in the university sector, in particular. This report (Intellectual Output 1: Scoping Study) addresses this gap and identifies the existing state of knowledge drawing from three different sources:

- A critical review of the academic published research literature (a Systematic Literature Review)
- A selected review of 'grey literature'" i./e. Unpublished and commercial information not found in academic publications
- Crowdsourced data about 360 video collected from social media

Part 1: Systematic Literature Review

1.1. Introduction

The purpose of this study is to examine the extent and nature of research in peer-reviewed research journal articles and conference papers in order to obtain an overview of current uses of 360 video in educational contexts, with a focus on possible application to the higher education field. We decided to adopt the methodological and analytical approach of the systematic literature review, in order to obtain comprehensive insights into a specific research domain, and also because it provides an objective, replicable and transparent approach for research synthesis, with the aim of minimizing bias. In order to minimize the subjectivity of the systematic literature review, to increase the intercoder reliability of the coding process and to ensure that all study reviewers worked uniformly, the process was undertaken by three researchers.

1.2. Research questions

The systematic literature review focuses on the use of 360 video in educational settings and tries to answer the following questions:

RQ1. How is 360 video currently used in different educational settings and context?
RQ2. What are the learning gains and benefits from the use of 360 video?
RQ3. What are the technical issues, barriers and opportunities around the use of 360 video?
RQ4. What training and support are educators likely to need to use 360 videos effectively?

These four research questions capture the broad scope of 360 videos and constrain the scope to educational applications.

1.3. Methods

A systematic literature review approach was applied in the review of the research journal articles and conference papers about the uses of 360 video in educational settings. Based on our results, we draw the

state of the art of the topic, providing an overview of current literature as for descriptive characteristics, educational contexts, possible learning gains, benefits/problems, thus identifying possible gaps to be covered in future research. The searches in databases were run on February 2020. First, we tried to find out if a systematic literature review on 360 video has already been carried out or is registered as an ongoing review. We did not find any systematic literature reviews on project research topics.

1.3.1. Inclusion criteria

Based on our emerging knowledge of the literature, during the first project transnational meeting the SEPA360 team formulated a list of inclusion criteria. The time frame of the research has considered the last ten years, with an overrun in 2020. The reason for the inclusion of the first two months of 2020 has been to consider the topic of research concerning an emerging technology and that research in databases it was run in late February 2020. We have included journal articles and conference papers about the search topic, in English language and that they present quantitative, qualitative, or mixed-method data.

1.3.2. Research tools

The corpus of the studies was collected through an extensive search using academic literature databases that were searched to obtain journal articles and published conference papers. These included: ACM Digital Library (Association for Computing and Machinery) <https://dl.acm.org/>, EBSCO*host* <https://search.ebscohost.com>, ERIC (Education Resource Information Center) <https://www.eric.ed.gov/>, IEEE Xplore Digital Library <https://ieeexplore.ieee.org/>, SCOPUS <https://www.scopus.com/>, Web of Science (Core collection) <http://www.webofknowledge.com/WOS>.

1.3.3. Search query

The developed search string was based on our research questions and preliminary searches. In order to find the relevant articles and papers in the database, the keywords that made up the search query were as follow: different ways of writing 360 videos (360 degree video, 360-degree video, 360° video), different educational contexts: education (preferred to educational because this term is still included in the search, as the suffix -al is an addition to the term education), university, school, professional development. We have not entered the terms in the plural form as they are automatically entered in the search for the singular form. In composing the expression of the search query we made use of the Boolean search operators AND and OR, and use parentheses to determine the order in which the commands are executed first:

> ("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)

1.3.4. PRISMA Flowchart and the review process

For the screening of the results obtained from the research we applied the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) <http://www.prisma-statement.org> as it is the statement most widely applicable across different research areas. Its methodological rigor and steps helps reviewers to improve the reporting of systematic literature reviews, for this we have used it for our systematic literature review.

The review process consisted of eighth steps, and it is summarized in the PRISMA flowchart (see Figure 1 below) .

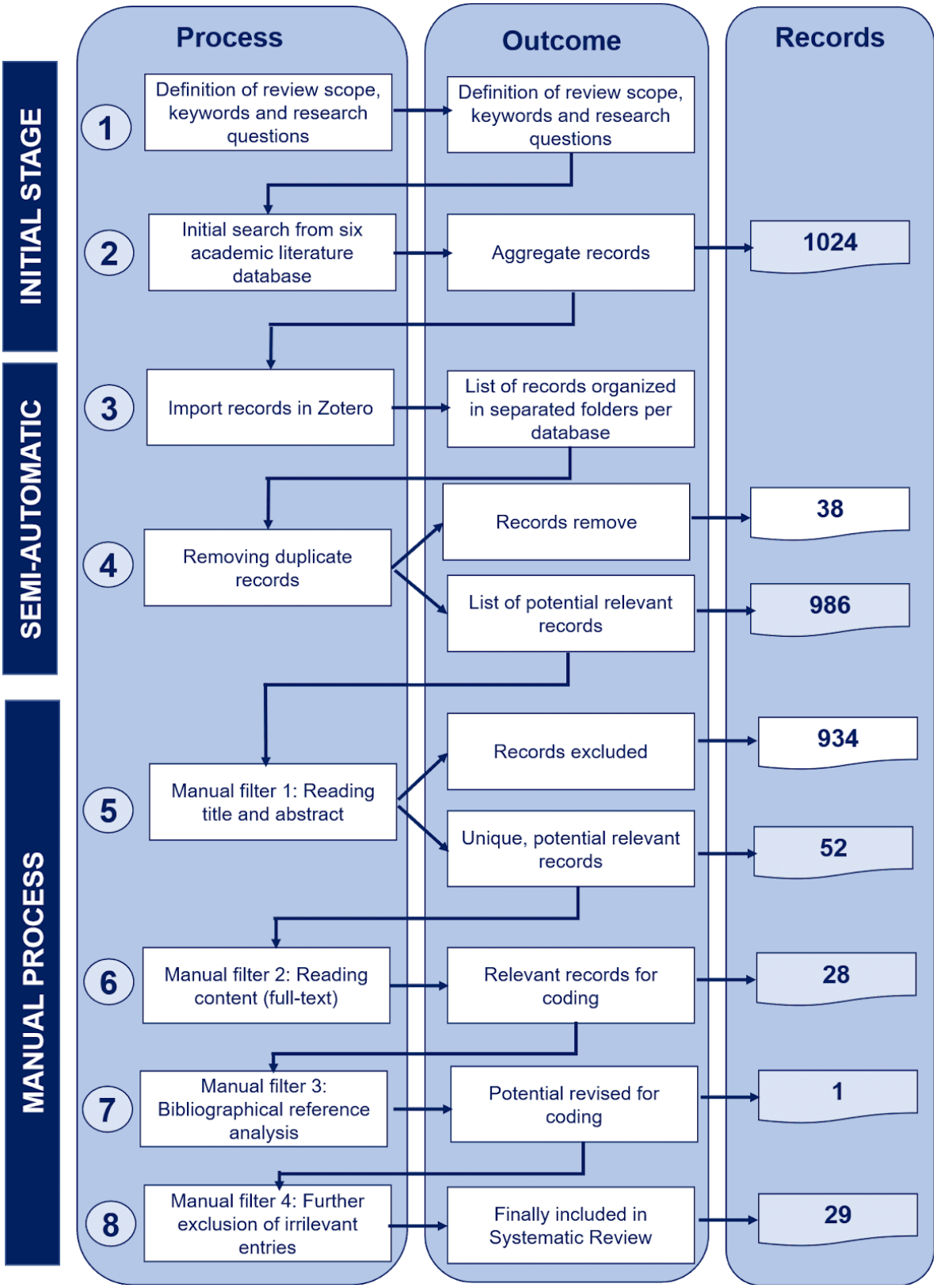

Figure 1: PRISMA flowchart

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

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

The 986 records left were screened applying exclusion criteria to the title, the keywords and the abstract of each record. At the end of this process, the remaining records were 52. In the next stage, full-text analysis was performed, allowing irrelevant articles to be further discarded. Each full-text was coded by three persons. Any discrepancies were discussed until we had a set of articles and papers with agreed coding categories ready. At the end of the whole screening process, the journal articles and conference papers that meet the inclusion criteria were selected to be part of our systematic literature review are 29, and are listed in the References section where they are marked with an asterisk.

1.3.5. Data analysis

The coding procedure started with the definition of the categories, characteristics and variables to be coded for each study. The five macro categories (*General document identity*, *Research design*, *Focus on 360 video*, *Results*, *Benefits and challenges of using 360 video in educational context*) and the sub categories were set up according to the research questions. Part of these categories are common and fairly typical in all systematic literature reviews, such as bibliographic metadata and the metadata that keep track of studies in terms of geographical area and research context, while others are specific to our field. Before proceeding to the review of studies we have refined the categories, and added the new categories, according to an iterative process .The final categories for coding are described in Table 2.

During the first phase of data analysis we tested them on three studies. After consolidating the categories, we built the matrix of coding in a spreadsheet, with these categories in the x axis, to organize the thematic information extracted from the coded articles in tabular form to better analyse the data. Each of the 29 studies included in the systematic literature review was read independently by the three reviewers and coded according to categories. Finally, the reviewers discussed their coding results until consensus was reached.

Table 2. Coding categories

	Fields	Description	Coding alternatives
General document	Authors	Authors in the publication	
	Title	Publication title	

identity	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, as indicated in the study.	
	Study research questions and/or hypotheses	Study research questions and/or hypotheses, as 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 analysis methodology was used in the study, (e.g. quantitative: descriptive statistics, inferential statistics: hypothesis of relationships between variables	

		and effect size) qualitative (e.g. coding in categories, thematic analysis; textual analysis of the occurrences of terms)	
	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	Lecture, 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	
	Limits of the study	Limits 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 gains	The learning gain in using 360 video	Attentiveness, Cognitive Skill, 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 support, Lack of time, Wider adoption
	Technical challenges	Technical Problems	

1.4. Results

In this section, we present the results – based on an explicit quantitative analysis and descriptive statistics of data collected – according to the main categories and criteria of analysis explained in the previous sections, combining the data in order to gain a better understanding of the findings. The term "data" is used here to mean any information about (or deriving from) a study, including details of methods, location or setting, context, interventions, outcomes, and results (Higgins et al., 2011).

1.4.1. Scope and nature of relevant studies

As a first step, we analysed the studies considering basic information such as year of publication, geographic area and document type. There are no relevant studies on 360 videos in the educational field before 2016 (see Figure 2), then, the trend reversed, reaching 12 studies in 2019.

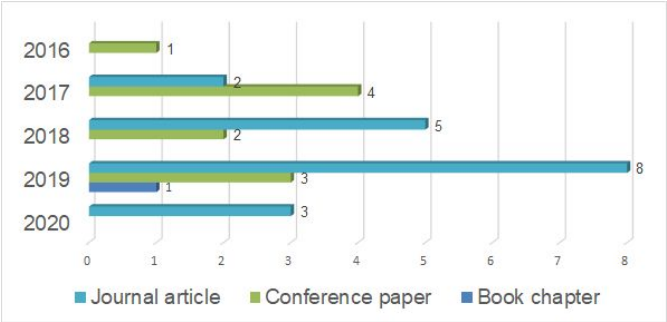

Figure 2: Number of publications per year divided by document type. The color shows the details of the document type.

A possible explanation of this trend can be found in the introduction of the upload, sharing and viewing of 360 video features in the main social network platforms: YouTube in March 2015, Facebook in September 2015 and Twitter in December 2016. In addition, the production and sharing of 360 videos goes in parallel with the development and 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. It emerges (Figure 3) that Europe is the geographical area with the highest number of publications (14/29), followed by North America (10/29).

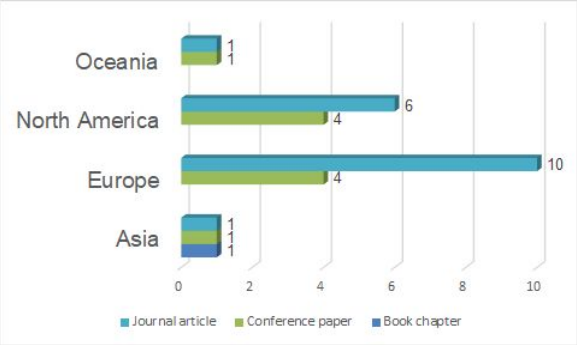

Figure 3: Number of publications per geographical area divided by document type. The color shows the details of the document type.

South America and Africa stand out for having none. As for number of publications (see Figure 3) these have increased in the past three years (2017 to 2019), both for conference proceedings (18/29) and for journal articles (10). This trend highlights and confirms that the interest and use of 360 video in education fields is on the rise.

1.4.1.1. Educational context and aims of the studies

Linger over to observe the educational context, it emerges, and it is common to all the studies analyzed, that the 360 video is used in the type of formal learning. So, also in adult learning, in the two research areas of *Commerce & Business*, and *Sport & physical education*, the educational context is formal.
The look at the educational level (Figure 4) shows that the most studies refer to *Higher education* (25/29).

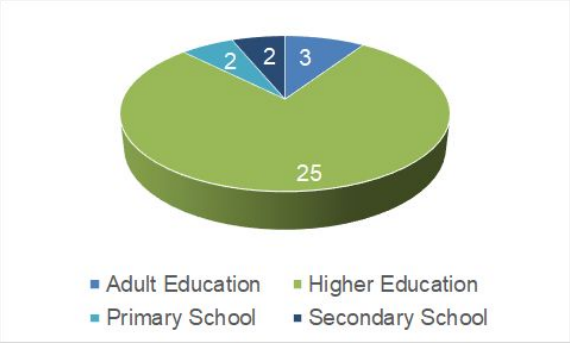

Figure 4. Educational level.

Continuing observation of the context, it is confirmed that the research area (Figure 5) that denotes remarkable interest in use of the 360 video is the scientific research area (11/29) – *Health Science* (8/29), then *Science* (3/29) and *Engineering* (1/29) – followed by *Education* (4) and *Teacher Education* (4).

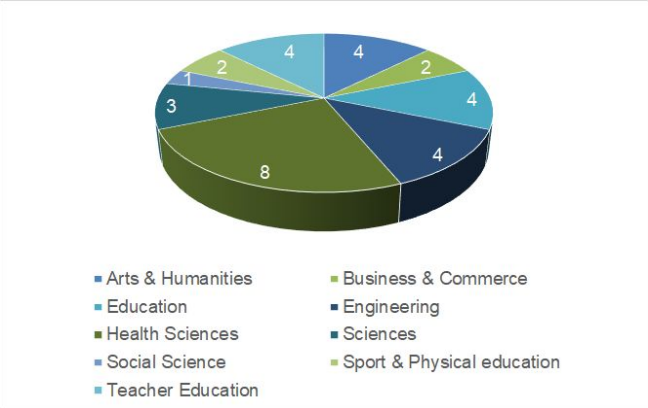

Figure 5. Research area.

In these areas, as also emerges from the reading of the aims (see Table 3), the 360 video is used in a profitable way to simulate, for example, operative procedures, laboratory experiments, and physical environment.

Table 3. Research area, aims of the study and technical equipment

Authors	Year	Title	Research area	Aims of the study	Technical equipment
Rupp et al.	2016	*The effects of immersiveness and future VR expectations on subjec-tive-experiences during an educational 360° video*	Education	To assess the impact of immersion manipulated by 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-degree video. And determine how these variables influence the amount of information retained following the simulation.	**Camera**: **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-degree-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 & 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	**Camera**: not specified **Device**: not specified

				evaluation. To create a field study combining a MOOC and face-to-face-teaching. To explore the use of 360 degree videos.	**Platform**: iMoox **Viewer**: not specified
Huber at 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 analyze 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 & 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**: note specified **Device**: smartphone **Platform**: Google Cardboard VR **Viewer**: Google Cardboard
Roche et al.	2017	*Using 360° video in Physical Education Teacher Education*	Sport & Physical education	To describe preservice teacher activity during workshop: their feelings, concerns, perceptions, emotions, and knowledge used and construct during viewing 360° video situations.	**Camera**: not specified **Device**: not specified **Platform**: YouTube **Viewer**: not specified
Tang et al.	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 & Humanities	To explore the possibilities of 360° video and chatbots for fostering language competencies by means of real world-like situations.	**Camera**: **Device**: smartphone **Platform**: YouTube, Facebook, Vimeo **Viewer**: Head Mounted Display

Harrington et al.	2018	*360° Operative Videos: A Randomised Cross-Over Study Evaluating Attentiveness and Information Retention*	Health Sciences	To produce high quality ,360 didactic operative videos augmented with educational material, using consumer available technologies. To assess the variance in attentiveness levels in a 360 video compared to the traditional (2D) format. Secondarily, to evaluate both video formats for variances in information retention and to achieve appraisals from the student population.	**Camera**: Go Pro **Device**: smartphone **Platform**: not specified **Viewer**: Gear VR Head Mounted Display
Johnson	2018	*Using virtual reality and 360-degree video in the religious studies classroom: An experiment*	Arts & 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 & 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 & Humanities	To employ enriched 360° videos displayed on the 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 et al.	2018	*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, standardised patient, video case study and 360-degree virtual reality video, and analysed 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 randomised 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 & Humanities	To compare the instructional effectiveness of immersive VRLE in increasing empathy and mastery learning, compared to a 360° video. And to analyze 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 degree video recordings with a cohort of PSTs at University of South Australia. To explores the affordances of 360 degree video in regard to the learning processes it might 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
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 into 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 Sciences	To report on the first two undergraduate courses that 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.	**Camera**: not specified **Device**: smartphone, tablet **Platform**: not specified **Viewer**: HMD, Google cardboard
Kosko	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	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 two degree 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‐degree videos combined with theoretical lectures in teacher education.	**Camera**: not specified **Device**: smartphone, tablet, laptop **Platform**: YouTube **Viewer**: Head Mounted Display
Ulrich	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 video, based on methodology of the Mayer's principles and on the Fredrick's construct of student engagement to measure the impact of the 360° video on the student.	**Camera**: not specified **Device**: not specified **Platform**: not specified **Viewer**: Head Mounted Display

Walshe et al.	2019	*Developing reflective trainee teacher practice with 360-degree video*	Teacher education	To explore how the use of 360-degree video can support student teacher reflection. To address this significant gap within the literature by making empirical and methodological contributions.	**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-degree camera in a live classroom.	**Camera**: not specified **Device**: not specified **Platform**: YouTube **Viewer**: Head Mounted Display
Theelen	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-degree 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-degree video as part of an online experiment focused on inducing empathy among clinicians for understanding patient experience.	**Camera**: GoPro (Odyssey) **Device**: smartphone, tablet, laptop **Platform**: OmniVirt Premium **Viewer**: Google Cardboard

A brief summary of the research areas, aims of the study, technical equipments and year of publication can be found in Table 3. In terms of scope and nature of the studies (Table 3), four studies involved a comparison of educational 360 video with 2D video – a traditional video technology – or other technologies of Virtual Reality. For example in an interesting study from the field of surgical education (Harrington et al., 2017) the use of 360 video was compared to 2D video for teaching about operative surgical procedures. The results from this study highlight significantly higher levels of engagement and attentiveness for 360 video in comparison with 2D video. Hence, most studies comparing 360 video with 2D video estimated significant learning outcomes when 360 video was used. In fact, also another study

(Yoganathan et al., 2018) found significantly better results for surgical knot tying skill training with 360 video and compared to traditional 2D video. Another study (Lee et al., 2017) compare the view of 360 video with devices that have different levels of immersion. This study shows that the students who viewed 360 videos with HMDs rated their enjoyment and interest significantly higher than the flat screen group. While most studies compare only two viewing modes (e.g. Google Cardboard versus smartphone), one study (Rupp et al., 2019) compared as many as four viewing modes. The results of this study suggest that the educational 360 video experience may be improved when using higher quality device viewers that optimize sensory immersion as compared to lower-cost or less immersive technology.

1.4.1.2. Methodologies used in the studies

Looking at the studies in relation to the research methodology adopted (Figure 6) we observed that the majority (19/29) used a quantitative method, whilst 6 used a qualitative method and 4 a mixed-method approach.

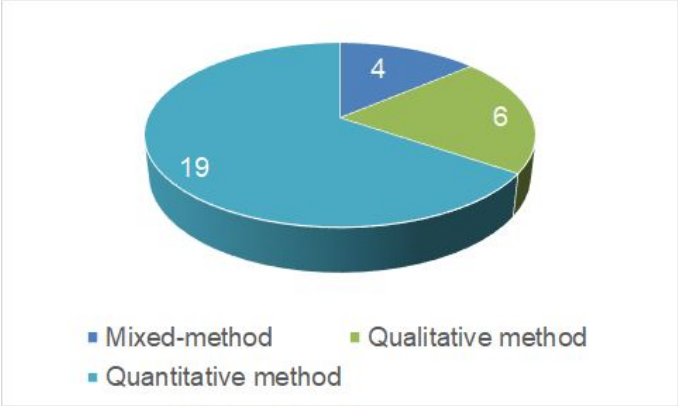

Figure 6: Research design and method.

It should be emphasized that the sample of students used in 20 studies is less than one hundred units (Figure 7), with only 7 studies that involved a sample of students larger than 100 participants.

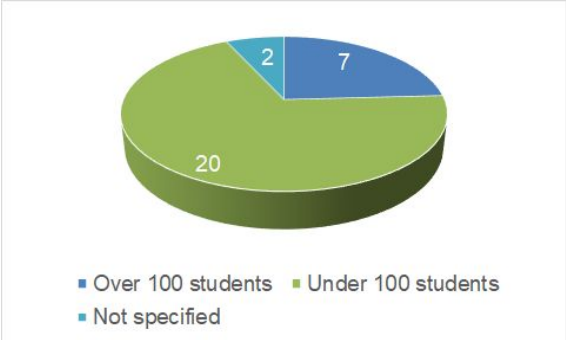

Figure 7: Study sample

Observing the sample by age group in line with what emerges from the educational levels (Figure 4) of the studies analyzed, the majority of learners were aged between 18 and 30 (i.e. young university students).

1.4.1.3. How to use the 360 video in educational context

A look at how 360 video is used in educational context highlights that there are three teaching methods (see Table 4) in which 360 video is used: *Lectures* (the 360 video is used in transmissive delivery lesson, it can make the learners understand complex subject theories or concepts of a discipline), *Modeling* (the 360 video is used to show the operative procedures and activities; it creates a powerful sense of space and realism and it allows you to see the procedure and activities in details from all angles or point of view), *Exploring* (the 360 video has the ability to transport learners to explore any place: natural landscape, internal environment or mixed environment internal and external, and it puts a learner in control and encourages discovery).

Table 4. How to use the 360 video in educational

Lectures			***Modeling***						***Exploration***		
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		

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

The 360 video is mainly used in Modeling (14/29) and in Exploration (10/29). The use of the 360 video in teacher education is attested in six studies and could be a good example of the *Modeling* modality (Roche et al., 2017, Balzaretti et al., 2019; Kosko, 2019; Theelen et al., 2019; Walshe et al., 2019; Theelen, 2020). The 360 video has proven very useful in teacher self-reflection on their pedagogical practice. The investigation of 360 video use in teaching sport (Gänsluckner et al., 2017) demonstrates and confirms once again how its main characteristics – sense of immersion and presence, multiple angle view that allows you to see the scene in every direction and observe the movements – are effective.

About the use of 360 video in the *Lectures*, its effectiveness emerges, as we will see in the next section, in terms of learning, engagement, information retention, and "positive attitude towards discipline [Science] (Boda et al., 2019, 16) or "improvement of the vocabulary [in language learning]" (Repetto et al., 2018, pg. 62). Also, we observe that the most of the studies have focused on aspects related to learning with 360 video but not which aspects to evaluate and how to structure a lesson when a teacher decides to implement 360 video technology in the classroom. For this, we point out the reference that emerged in Frisby's study on which aspects teachers must consider when deciding to implement 360 video in their classes, "it is vital that they: research the technology; practice with the technology before introducing it to their students; plan how to strategically implement it into the course, and reflect on the integration of the technology." (Frisby et al., 2020, pg. 13).

We also investigated (Table 5) how the 360 video is viewed: in which places (classroom, laboratory or at home) and if individually, in a couple or in a group. In fact, a key aspect of 360 video immersion is the freedom to explore the scene on your own.

Table 5. Delivery of 360 video: place/how

Classroom/ Individually	Classroom/ Group	Home/Individually	Laboratory/ Individually	Laboratory/ Individually	Not specified
16	1	4	5	1	2

It offers new features to communicate and view content, such as self directed control of view direction and immersion, which both influence the feeling of presence. Also, as we see in some studies (e.g. Lee et al., 2017; Tang et al., 2017) , the user does not necessarily need a Head Mounted Display (HMD) to view a 360 video, a web based video player, as tablet or smartphone, may suffice, because it supports drag and drop in order to pan and zoom around the video.
This type of viewing a 360 video with HMD, with an high level of immersion, is appropriate (Table 5), of course, 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, but this type of "solo" viewing is also common in viewing via a web based video player. This is also confirmed in the studies, in fact, the environmental context (Table 5) in which the 360 video is viewed for most studies is individually whether the 360 video is watched in the classroom (15/29), in the laboratory (5/29) at home (4/29).
Only one study (Tang et al., 2017) investigates the possibility of using 360 video collaboratively with a pair using one tablet, via a web based video player. This study identifies communication as the main problem of viewing 360 videos: "understanding what they are looking at in relation to conversation" (Tang et al., 2017, pg. 4504), 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 et al., 2017, pg. 4504).

1.4.2. Benefits and challenges of using 360 video in educational contexts

In the studies analysed, we investigated the advantages and problems for students in viewing 360 videos. We also explored these issues from the perspective of the organization, investigating the advantages, barriers and challenges in the use of 360 videos in teaching. We discovered relatively little data relating to topics such as *the benefits, challenges and barriers for organizations*, because most of the studies focused primarily on the use of 360 videos by individual learners, not organizations. Only one study (Ulrich. 2019) explicitly investigated the benefits for the institution, focusing on learning satisfaction and positive emotion about 360 video. This study concluded that 360 video should be an attractive option to many teaching institutions because the production costs are similar to those of a "regular" video, whilst the benefits exceed those of traditional video. In another study Harrington et al. (2017) presents a cost assessment of creating and using 360 video. They came to the conclusion that despite the ease of camera setup and fast editing procedure 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., 2017, pg. 999). Regarding *Challenges and barriers*, it should be noted that two studies reveal a lack of availability of 360 videos to be attributed to different factors: a poor availability on the YouTube platform (Johnson, 2018), and, despite the ease of production, as mentioned above, not many 360 videos are made on specialist areas or on procedures (e.g. in the medical surgical field) (Harrington et al., 2017).

1.4.2.1. Learning gains

One notable trend pertaining to benefits was the positive experience of learning with the 360 video. Across multiple studies (Table 6), participants indicate high levels of:

- engagement attested in nine studies (Assimila et al., 2017; Gänsluckner et al., 2017; Hodgson et al., 2019; Lee et al., 2017; Harrington et al., 2018; Johnson, 2018; Abadia et al., 2019; Gilmartin et al., 2019; Rupp, 2019; Violante et al., 2019);
- attentiveness attested in six studies (Huber et al., 2017; Lau et al., 2018; Boda & Brown, 2019; Rupp 2019; Taubert et al., 2019; Zulkiewicz et al. 2020);
- information retention attested in six studies (Rupp et al., 2016; Berns et al., 2018; Harrington et al., 2018; Yoganathan et al., 2018; Rupp 2019; Frisby et al., 2020);
- transfer of knowledge attested in six studies (Lee et al., 2017; Berns et al., 2018; Yoganathan et al., 2018; Hodgson et al., 2019; Kosko 2019; Ulrich 2019; Walshe et al., 2019)

Table 6. Learning gains

Attentiveness	Cognitive skill	Engagement	Information retention	New learning behaviors	Reflective activities	Technical skill	Transfer of knowledge	Not specified
6	2	10	6	1	2	1	7	5

The total number of items may be more than 28 as the same study could have been classified in more than one subcategory.

1.4.2.2. Learner's reaction to the use of 360 video

Closely related to learning gains (Table 7), many studies (14/29) report high levels of enjoyment by the learners in viewing 360 video. For example: "360° video offers something new compared to VR and regular video, namely, the positive emotional attributes" (Ulrich, 2019, pg. 9).

Table 7. Learners reactions

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

The total number of items may be more than 28 as the same study could have been classified in more than one subcategory.

In addition to these positive gains, some studies reported minor problems (Table 7) in viewing 360 video including distraction or poor concentration (Huber et al, 2017; Johnson 2018), physical discomfort was reported in 9 studies – such as motion or cyber sickness, low nausea, dizziness lost sense of time, anxiety for interaction or reject – but there are isolated cases and numerically small. Motion or cyber sickness is the object of investigation by four of the studies identified in this review. Three of these studies (Rupp, et al., 2016; Huber et al. 2017, Taylor et al., 2018;) reported no physical discomfort. Only one study (Rupp, 2019) found that 7 out of 28 learners who used Google cardboard had low motion sickness; while the other 108 who use the smartphone, Oculus Rift DK2 or Oculus CV1 showed no physical discomfort.

1.5. Recommendations

1. The 360 video is particularly effective for practice based disciplines such as teaching, health science, engineering, sciences, physical education and sports, language learning and all those disciplines where students need to observe carefully how knowledge is transferred into practice in order to identify details or apply theory and simulate operative procedures or laboratory experiments.
2. Compared to other technologies such as 2D videos, 360 videos are more appropriate for practice-based learning since they are more engaging, they better promote information retention, attentiveness and transfer of knowledge.
3. The educational experience of 360 videos may be enhanced by the use of Head Mounted display and higher quality device viewers that optimize sensory immersion as compared to lower-cost or less immersive technologies.
4. When designing and implementing 360 videos as pedagogical resources in educational contexts, it is recommended to pay attention to technological familiarization and careful planing, namely: involve students into the practice with this technology before introducing it to them for educational purposes, plan how to strategically implement it into the curriculum, and reflect on the integration of this technology to improve the educational experience.
5. To encourage the use of 360 videos in educational contexts, it is advised to minimize the devices' cost, to advance in the development of user-friendly softwares,to simplify the video production process and increase the availability of free online 360 videos on video platforms such as YouTube, Vimeo, Facebook, etc.

Part 2: ‘Grey Literature’ on 360 video in Higher Education

1.1 What is ‘Grey Literature’

This section of the report draws upon a range of documents and data that has not been produced or controlled by commercial publishing organisations. This is often referred to as ‘grey literature’. This is an important source of information because the use of 360 video in Higher Education is a relatively new field and much of the existing knowledge base about it does not yet exist in peer reviewed publications covered by the SLR. Typically this kind of information includes: conference proceedings; policy statements and government reports; White papers; academic theses and dissertations; unpublished research reports; newsletters, newspapers and other magazines.

1.2. Research questions

The ‘grey literature review is broadly similar in terms of research questions as the SLR and includes:

- RQ1: How is the use of 360 video in educational settings and contexts reported in the ‘grey literature’?
- RQ2: What learning gains and benefits from the use of 360 video are reported in the ‘grey literature’?
- RQ3. What are the technical issues, barriers and opportunities around the use of 360 video reported in the ‘grey literature’?
- RQ4. What training and support are educators likely to need to use 360 videos effectively, as reported in the ‘grey literature’?

2.1 Methodology

The methodology broadly followed that set out in the SLR (insert page reference) including the following search string: (("360 video") OR ("360 degree video") OR ("360-degree video") OR ("360° video")) AND ((education) OR (university) OR ("higher education") OR ("professional development")). For consistency purposes we adopted broadly the same inclusion criteria as for the main SLR. These are: Year of publication(2009 to 2020); Nations: (all); Languages: English; Topic: (How 360 video is currently used in different educational settings and contexts); Empirical studies. We used the University of Hull’s database SUMMON to undertake the search. The initial search identified 9,237 results which was subsequently reduced to 103 by refining the discipline parameters. All of these were read manually leading to the exclusion of a further 80 results, leaving just 23 studies. After a careful reading of all 23 outputs only four were identified as fully relevant to the ‘grey literature’ review as shown in Table 8.

Table 8: Final outputs selected for inclusion

#	Author/s	Year	Title	Source	Aim of the study	Focus on 360 video
4	Skiles, Steven, and Bill Shafer.	2018	"The Future of Onboarding Is Here ... Now! VR 360 videos provide immersive experiences that have a physiological effect on the body, allowing users to connect with content in a deeper way."	Training Volume 55, no. 4, (https://link.gale.com/apps/doc/A549157512/ITOF?u=unihull&sid=ITOF&xid=b7968a1f)	This study describes how a company based in the USA used 360 video to take all of its employees on a virtual expedition to the Samsung’s Innovation Museum in Korea as part of an annual professional development and training exercise. The study focuses on the reaction and impact of this novel form of professional training on the employees and also discusses the issues and design decisions involved in making effect 360 video vignettes for this purpose.	Samsung Gear 360 4K camera

					The company used the Samsung Gear 360 4K camera to film what they refer to as 'video stories' and the study notes the value of populating the stories with relevant cultural anecdotes and insights, such as the etiquette involved in eating at a traditional Korean BBQ restaurant, to help viewers develop greater empathy with the subject matter. The company organised their own evaluation of the exercise and found that 96 percent of participants agreed (60 percent strongly agreed) that using the Gear VR equipment enhanced their learning experience positively. Additionally, 73 percent stated that using this tool increased their effectiveness in their role by more than 50 percent. The study found higher levels of engagement and empathy from its employees than was normal and also discovered that participants in the research also experienced physiological effects that allowed them to engage more deeply with the content they were shown: " It transports users into experiences that trick the brain into thinking it is actually there. It is these tricks that make the experience more memorable and impactful." The study concluded with discussion about the production process associated with making effective 360 video stories and some recommendations for users who wanted to undertake this (see: https://techlearnconference.com/2019/index.cfm)	

11	Matthews, David	2017	VR: A new dimension in learning.	Times Higher Education, Retrieved from https://search.proquest.com/docview/1869132749?accountid=11528	Although the focus of this article is about the use of Virtual Reality (VR) in Higher Education contexts in the UK, it also devotes some specific attention to the use of 360 video, mainly from the context of its use in modern journalism courses and specifically at the Immersive Lab in Coventry University. In the case of the Immersive Lab in Coventry University students are using 360 video on a number of vocational and practical study programmes, most noticeable journalism and paramedics. 360 video is being used in the journalism degree to explore a new form of narrative and news reporting that the lead academic - Dr. Sarah Jones - refers to as 'storytelling'. (see https://www.journalism.co.uk/news/how-to-get-involved-in-the-rise-of-360-degree-video-/s2/a611715/ The study focused on the issues of cyber sickness when using 360 video but found no appreciable different between students who used 360 video (with and without headsets) and those who watched the same content in VR (see https://pureportal.coventry.ac.uk/en/publications/comparison-study-of-the-use-of-360-degree-video-and-non-360-degre).	360 equipment
21	Fine, Ariana.	2018	"Visiting the VR farm."	District Administration, vol. 54, no. 6,	This study investigates the use of 360 video in New York by children in primary schools who use it to visit a virtual farm (the Farm Sanctuary). The purpose is to help	

				https://link.gale.com/apps/doc/A541890908/ITOF?u=unihull&sid=ITOF&xid=e00a9b48	students understand the issues and debates associated with intensive farming in the USA and to help them develop a greater sense of compassion for animal. The 360 video was shot using drones to give an aerial perspective but little detail is provided about the impact or its effects on learners.	
22	Weinstein, M.	2017	Winning Trends In Games & Simulations.	Training, 54(5), 36-39. https://search.proquest.com/docview/1940841402?accountid=11528	This study reports the outcomes of a training exercise for employees at Sberbank, the largest bank in Central and Eastern Europe. In 2017 the Sberbank Corporate University created Skill Hub VR to develop their staff's soft skills in handing customers in an efficient way that allowed them to practice in situations as close to real life as possible. The Skill Hub VR allows companies to train, evaluate, and manage their employees' soft skills using realistic VR simulations, including the use of 360 video. . One of the more popular elements of the Skill Hub VR training programme was the module featuring 360 video, designed to encourage employees to have greater empathy and compassion for their customers, particularly those of an older age. Three hundred volunteers took part in the study using VR headsets to view a selection fo 360 videos filmed from the perspective of older customers visiting the bank. 97 percent of users in the study described having an intense feeling of empathy-of a kind they never felt before. The company plan to roll out the 360 video experience to all of	

					their workers across Russia and believe it will play a significant role in helping them to be more responsive to their customers needs and problems.	

Given the small number of studies identified as suitable for this review a decision was made to expand the results manually by searching for relevant research based studies that had slipped through the search strategy described above. This resulted in an additional five studies that were deemed suitable for inclusion as they met the original inclusion criteria. These are outlined briefly in table 9.

Table 9: Additional studies identified manually

No.	Author/s	Year	Title	Source	Aim of the study	**Focus on 360 video**
1		2016	Coventry Journalism course: https://www.journalism.co.uk/news/how-to-get-involved-in-the-rise-of-360-degree-video-/s2/a611715/	Vimeo interview	The Immersive Lab was founded by Dr. Sarah Jones and is based in Coventry University. One of its many projects explores the changing face of journalism in the light of new technologies such as VR, AR and in this case, 360 Video. The Lab was established in 2016 and as its co-founder, Dr. Sarah Jones is exploring both the impact of 360 video on readers but also the design	Ricoh Theta S

					and production process that journalists need to understand and use in order to create effective 360 video stories. In a video interview with Dr Jones recorded towards the end of 2016 she explains the work she is undertaking with 360 video and the lessons she has learned in preparing trainee journalists to use it (see https://vimeo.com/155689275). She notes the impact that Google Cardboard, released in 2014, has had on the use of 360 video and the decision by the New York Times in 2016 to send out 1.2m cardboard headsets to their viewers. This is the basis of immersive journalism. She notes the current debates (as in 2016) around the value of 360 and other VR technologies but personally believes these are 'empathy' machines that drive greater engagement and connection with the subject matter (Note the contrary view offered by David xxxxx below). She notes how this sense of engagement and empathy works best when the narrative or storyline is character driven, not driven by an	

					external narrator. This gives the viewer the perspective of the character, not the second hand reporting perspective of the journalist. This, she believes, builds a much stronger emotional connection to the story. Although 360 video is superficially simple to use and film, in reality, argues Sarah, it is far more complicated and requires considerable pre-planning and thought. She categories the use of 360 video in journalism into two camps. Very simple footage, which she describes as 'social 360,' using simple cameras like the Ricoh Theta to produce relatively short (30-60 seconds) videos or news vignettes. These work best for events like flooding (in the York, UK in 2016), natural disasters and other events where the public want to have a quick look around. Full stories are more complicated using complex 360 rigs (multiple cameras). These tend to be feature led such as the refugee crisis or the migrant camps which are unlikely to date quickly. These are narrator led, not character based. Viewing angles and length of shots	

					are critical on these shots. Believes this is still an evolving field and a lot more needs to be done and understood about how to tell a story using this medium.	

2	The Centre for Innovation, Leiden University, Netherlands		Leiden University, Centre for Innovation 360 pilot (2017-2019) • (https://www.centre4innovation.org/stories/innovation-pilot-exploring-the-potential-of-360-vr-at-leiden-university/)		Various universities around the world have reported their use and experimentation with 360 video for teaching and learning purposes. One of the most notable is Leiden University in the Netherlands who have conducted an extensive pilot project with six different discipline areas to explore its benefits in teaching and learning. The study included a range of academic disciplines and support staff. In many cases students were also included as co-authors of the projects. Although none of the projects has yet to be formally evaluated for their impacts on learning and teaching (as of June 2019), some of the emerging findings include greater student motivation and enthusiasm and some evidence to show students found the resources helpful in translating theoretical aspects of their course into practical settings. Many projects reported such benefits in helping students to bridge the gap between theory and practice such as trainee teachers learning to understand how to observe classrooms effectively and archaeology students learning how to develop their skills on site. Every project reported positive benefits in	Link to full notes on use of 360 video in Leiden University

					allowing their students to visit a site or place of study virtually, before actually visiting the site physically. In some cases, such as bad weather conditions, this was essential in allowing students to continue their studies. It was also apparent these pilot studies that academics need support from a range of non-academic staff such as project managers and filmmakers to produce high quality video vignettes for use in teaching and learning.	
3	The University of Cambridge (Dr. Paul Driver,)	2018	Blog page: A Tour of VR resources and content creation tools: https://www.cambridge.org/elt/bl		Video interview/presentation by Paul Driver: https://www.youtube.com/watch?time_continue=902&v=DXDCUTLi6WY&feature=emb_logo Link to Youtube 360 channel:	

			og/2018/03/16/virtual-reality-resources/		https://www.youtube.com/channel/UCzuqhhs6NWbgTzMuM09WKDQ Need to make notes here from his blog and experiences of using 360 video in teaching ESL students	
4			Dan Archer, 'Dismantling the Metrics of Empathy (in 360 Video)', Immerse, 19 May 2018, https://immerse.news/dismantling-the-metrics-of-empathy-in-360-video-b03d013123ae , accessed 25 October 2018		Source: IMMERSE (MIT Open DocLab and The Fledgling Fund) - May 2018 http://opendoclab.mit.edu/?s=360+video Very interested study carried out in the USA using an empathy questionnaire to measure empathy. Used the following sub-elements: ● perception, emotion, and motivation: ● a user's self-reported sense of presence, ● their ability to perspective-take, ● their likelihood of taking action based on their experience. Would be worth following up to find the tool if we want to do a similar study at the end of our project Used three formats to present the	

					story ● VR on a headset ● 360 video on a laptop ● Newspaper 360 videos included: The three 360 videos chosen were all produced by HuffPo RYOT and all were around 5 minutes in duration. Growing Up Girl was told by one young female protagonist and focuses on gender equality in Sub-Saharan Africa; Seeking Home (see below) chronicled the lives of several refugees in the Calais Jungle camp; and Act in Paris was told purely in voice-over, without any central character. Very useful for designing 360 video: ● Stories with a clear protagonis consistently found to be more enjoyable VR triggered a higher emotional response than the newspaper. Also VR experience more likely to be motivated to want to find out more about the subject. Noted little difference in the levels of engagement between the VR headset	

					and the 360 laptop experience Argues that story is still the key ingredient in engaging readers - from a journalistic point of view Plans to do more research including capturing more physiological feedback (e.g. heartbeat, blood pressure, etc) - worth following up!!!!	

3.1 Discussion and analysis

3.2. RQ1: How is the use of 360 video in educational settings and contexts reported in the 'grey literature'?

The grey literature identified a multitude of educational contexts in which 360 video was found to be effective. For example, a study in Leiden University identified six different disciplines in which 360 video was seen to be useful, including archaeology, health care and nursing, environmental studies, science, anthropology and initial teacher education. Other contexts for using 360 video include journalism (see Coventry University) and English (see Cambridge University, Paul Driver).

A second feature revealed in the grey literature is the wide variety of different pedagogical purposes to which 360 video has been applied in universities. These include providing access to experiences and spaces that would otherwise be too dangerous to visit(e.g. a hazardous laboratory), or too inaccessible to be feasible (e.g. a visit Antarctica or an archaeology excavation during periods of inclement weather). Another purpose of 360 video is to provide practice opportunities in a relatively low risk environment, unhindered by the immediate effects of decision-making. Good examples include teaching in which trainee students are able to practice their observational and decision making skills; surgical and nursing settings (e.g. an operating theatre), sports management (e.g. referring decisions) and many science related scenarios where decision-making is essential but also high-risk.

3.3. RQ2: What learning gains and benefits from the use of 360 video are reported in the 'grey literature'?

Most of the studies reported in the grey literature identified 360 video as popular, engaging and motivational for students. Many highlighted an increased sense of empathy, often associated with a greater sense of presence. For example the Russian bank Skerbank, reported that employees who used 360 video were moved to tears by the experience with 97% of users (n=300) experiencing an intense feeling of empathy of a kind they had never previously experienced. In the case of journalism training, the adoption of 360 video to supplement traditional print based media (see for example the New York Times 360 library) is seen as a landmark event by some experts who are talking about a new form of news report or narrative.

However these claims around the empathetic value of 360 video, and indeed VR as a whole, are contested by some who argue the 'empathy machine' narrative is only part of a much more complex and little understood story that needs better understanding.

3.4. RQ3. What are the technical issues, barriers and opportunities around the use of 360 video reported in the 'grey literature'?

The studies in this review point to the need for careful pre-planning and design in order to produce a quality teaching and learning resource. 360 video cameras can be used to produce instant, in the round, accounts of an event such as the recent floods in the UK (2016) when many members of the public used their own smartphone to record short 360 video clips, however, the production of a genuine teaching scenario, which features in many of the cases listed in this review, requires considerably more time, planning, design and resources than a 'social 360' video and this may be a barrier.

There are also a number of critical design decisions that need to be understood to create effective 360 videos and many of these have only emerged by a process of trial and error from the early adopters featured in this report. In the case of journalism, for example, students and tutors at the Immersive Lab in Coventry, UK have discovered the importance of creating storylines and narratives that are character driven rather than the traditional journalistic approach that is driven by the narrator from a second hand reporting perspective. This reinforces the findings from MIT's Immerse study which found video stories such as the 'Calais Jungle,' which details the plight of refugees in the Calais refugee camp, to be less emotionally engaging than stories which focus on the perspective of an individual. Indeed, some argue that 360 video needs to be driven by a strong protagonist (see Merrimen article) if empathetic engagement is its principal purpose.

Navigation and direction through a 360 video is also a challenge that has emerged from these different studies since, unlike traditional video narrative which is linear in fashion starting at one point and moving through to a finale, 360 video can appear directionless and viewers can be confused or uncertain about what to view when confronted with 360 degree choices. To address this challenge different strategies have been adopted which might be labelled 'navigation aids'. One of these is to place actual visual markers within the video to signpost points of interest and draw attention to these for viewers.

In some instances, however, too much extraneous information can be a design fault in a 360 video and can diminish the engagement and immersion that users experience in these environments. Similarly, screen clutter, such as additional maps to help navigate around a particular site or space may seem a useful tool but can often distract the user from the more immersive elements of the storyline.

RQ4. What training and support are educators likely to need to use 360 videos effectively, as reported in the 'grey literature'?

Many of the training and support issues that educators need to consider in order to use and create 360 video effectively have been covered in the previous three sections and do not need much further elaboration here. Both the Samsung and Skerbank examples from Russia focused on the professional development of staff working in commercial settings. Although these are not set in higher education context themselves there are lessons that might be transferable into the university context. One of these is cost savings and financial benefits associated with virtual visits compared to physical face-to-face excursions. This has particular resonance at the current time when faced with a pandemic that is worldwide, many universities are unable to undertake the kind of external visits and meetings they would normally expect their students to experience.

Although none of the studies reported in this section provided much detail about issues regarding training and the preparation of staff for the use of 360 video, most of them hinted at the issues we should be considering such as the need to think through a design based perspective when planning such video narratives, the need to plan and design these activities carefully rather than randomly, and the need to think about the pedagogical purpose of these resources and what they add over and above traditional media or existing technologies. These are likely to be a few of the issues and agendas that need to be better understood if 360 video is to become more widely embedded in higher education contexts.

4. Recommendations

1. Be aware of the applicability and usefulness of 360 video across the entire range of university disciplines
2. 360 video is particularly effective for practice based disciplines such as teaching, nursing and archaeology where students need to observe carefully to identify details or apply theory
3. Use 360 video in settings where it is important to engage students in high levels of empathy and understanding of different perspectives
4. Understand how to use 360 video as part of a narrative or storytelling activity to engage students
5. The use of 360 video as a pedagogical resource requires careful planning and design to be effective. Learn the design rules for creating high quality 360 video resources
6. When designing engaging 360 video it is important to focus on a character or protagonist to focus the viewer's attention
7. Navigational aids in a 360 video are important but beware of creating unnecessary clutter and distraction for viewers

Part 3: The use of 360 video reported in Social media

3.1 Introduction

The concept of crowd wisdom suggests that the aggregation of information of public groups yields more efficient results while leveraging the collective knowledge and decisions of a group of individuals instead of relying on a handful of experts' opinions (Surowiecki, 2004). This type of data retrieval and analysis can be regarded as a form of crowdsourcing. Crowdsourcing is the act of outsourcing a task or a job conventionally carried out by a definite agent to an undefined public (Howe, 2006) and is based on the fact that a higher value is created when people work collectively in virtual and physical networks and not independently. Nowadays, both concepts of crowd wisdom and crowdsourcing are ubiquitous due to the technological advancements and the development of user-centered applications. Moreover, the rise of social media and their continuously increasing number of users have led to the creation of an immense volume of data, known as Big Data, which is exponentially increasing daily (Wu et al., 2013). Social media (e.g. Twitter, Facebook, YouTube, Instagram etc.) enable users to publicly share their opinions and viewpoints in real time. Additionally, these platforms provide useful tools such as Application Programming Interfaces (API) to make the available open data easily accessible by everyone. It goes without saying that social media along with the tools they offer can be used to extract invaluable knowledge regarding the public's opinion on certain matters. In our research, we selected to use Twitter's API to access and collect open raw data of text (tweets) that users choose to share publicly. This specific platform was chosen as it is regarded as the platform people visit to share their opinion on matters as soon as they occur or on breaking news and it urges them to be concise and precise in their posts due to the limited amount of characters per tweet (Java, 2007; Phuvipadawat and Murata, 2010; Bruns et al., 2012).
In this section, the results of the social media data analysis regarding the public's viewpoints about 360º videos are presented as well as its use in educational settings. More specifically, the methodology used and the results based on two different datasets consisting of Twitter data collected from January 2015 to March 2020 are described. The analyses included: word, hashtag, mention, user, tweets and country frequency analysis as well as sentiment analysis.

3.2 Research questions

This section is focused is addressing on three main research questions:

a) What are the public's viewpoints regarding 360º videos based on public data on Twitter;
b) What are the public's viewpoints regarding the use of 360º videos in educational settings based on public data on Twitter;
c) What are the sentiments associated with the use of 360º videos in educational settings based on public data on Twitter;

To address these research questions, the analysis involved the identification and collection of relative social media data, its processing, analysis and visualization in order to extract useful results and reliable information in simple, readable and comprehensible graphs, diagrams and charts.

3.3 Method

In order to meet the requirements and fulfil the aims of this specific task successfully, the below described methodology was followed:

- **Data requirements**: As data quality affects the analysis drastically and consequently the conclusions drawn, the high quality of data is significant. In order to ensure data validity, accuracy, completeness, consistency and uniformity, specific aims were set regarding the data retrieval, collection, analysis and visualization processes such as the selection of time periods, variables, sources etc.
- **Data collection**: In order to get the public's opinion regarding 360º videos as well as its use in educational settings, the Twitter social networking service was used. After testing various keywords both separately and in combination, we resulted in using the keywords "360 video", "360 degree video", "360-degree video", "360° video" to acquire public's opinion on 360º videos and the same keywords were used in combination with the keywords "education", "university", "higher education", "professional development", "school" to obtain their viewpoint on the specific use of 360º videos in education. For our use case, we collected data from Twitter over the period of January 2015 to March 2020. In total, 509,235 tweets were collected out of which 4,148 tweets corresponded to the public's opinion on the use of 360º videos in educational settings. Moreover, for each tweet the following information was stored: id, permalink, date, author_id, username, location, text, hashtags, mentions, urls, favorites, retweets and replies.
- **Data processing, cleaning and storage**: In order to create "clean" datasets, the collected data were processed. More specifically, the text was converted into lowercase and the punctuations, single characters, URLs and stop-words were omitted, where necessary and the abbreviated words were expanded. Both datasets including the retrieved tweets were stored in Comma-separated Values (CSV) files as well as in JSON format files to enhance the overall usability, flexibility and extensibility.
- **Data analysis and visualization**: After creating the two datasets, data analysis was conducted i) on an annual basis and ii) throughout the period of January 2015 - March 2020 as a whole. For the data visualization process, the results of the data analysis were showcased through graphs which were specifically generated for each of the following cases: total number of tweets, most frequently used words, most frequently used hashtags, most frequently used mentions, most active users, tweets per given interval and tweets per country.
- **Sentiment analysis**: Sentiment analysis is widely applied in order to analyze and better identify and comprehend crowd sentiment regarding specific matters. It can be regarded as the interpretation and classification of emotions within text data. Two different sentiment analysis methods, namely polarity and emotional detection, were used for the purposes of this case study. More specifically, in order to identify the crowd's basic viewpoints (e.g. positive, negative or neutral) the open-source library TextBlob was used as a basis for the lexicon-based sentiment analysis (Loria, 2020). Moreover, with a view to detecting the sentiment of the crowd, the emotion analysis based on Plutchik's wheel of emotions was used (Plutchik, 1980; Plutchik, 1984). The emotions along with their pairings are: joy and sadness, acceptance and disgust, fear and anger as well as surprise and anticipation. Furthermore, the latest National Research Council Canada (NRC) Word-Emotion Association Lexicon (EmoLex) (Mohammad and Turney, 2010; Mohammad and Turney, 2013; Mohammad, 2020) was used as a basis for the lexicon-based sentiment analysis for emotion detection.

3.3.1 Tools

The whole code and all scripts developed for the purposes of fulfilling this task were based on the Python programming language (version 3.8) which is an interpreted, object-oriented, high-level programming language with dynamic semantics (Van Rossum and Drake, 2009). PyCharm was selected as the open source integrated development environment (IDE) (JetBrains, Inc., 2020). Furthermore, in order to retrieve the related data, in our case tweets, the Twitter API was used. To surpass the limitations of the official Twitter API, the open source Python libraries GetOldTweet3 (Mottl, 2020) and Tweepy (2020) were utilized to access and retrieve the related tweets. For the purposes of data visualization, the open-source python library Matplotlib was used (Hunter, 2007) while for generating word cloud graphs, the open-source python library Wordcloud was utilized (Mueller, 2020). Additionally, for specific cases, Microsoft Excel was also used (Microsoft Corporation, 2018). Finally, both TextBlob and EmoLex, which were presented earlier, were used for the sentiment analysis.

3.4 Results

With a view to answering our main research questions and understanding the crowd's wisdom on these specific matters two separate datasets containing Twitter data which was retrieved from January 2015 to March 2020 were created. The first dataset contained a total of 509.235 data entries (tweets) regarding the public's opinion on 360º videos while the second one consisted of 4.148 data entries concerning the public's viewpoints on the use of 360º videos in education. The analysis results include tables, figures, graphs, word clouds, plots and diagrams. The data of both datasets was examined i) as a whole and ii) annually. Particularly, the most frequently used words (with and without keywords), hashtags and mentions as well as the most active users in the relevant tweets were analyzed. Additionally, the number of tweets made per each year and month as well as the countries that tweeted the most about the relevant topics were analyzed. Finally, we carried out polarity and emotion detection sentiment analysis. Based on the results, we noticed an increasing interest in 360º videos in September 2015 and afterwards and more specifically on 23/9/2015 when Facebook introduced 360º videos on their platform. The highest number of tweets was observed during December 2016 and particularly on 28/12/2016 when 360º videos was also introduced on Twitter. Moreover, we noticed that 360º videos is highly associated with social media, immersive experiences and contemporary technologies such as virtual reality and 4k video. YouTube was by far the most mentioned account within the tweets. According to the polarity detection, the majority of the tweets was positive (47.92%) followed by neutral (41.84%) while only 10.24% of the tweets was negative. Additionally, based on the emotion detection, the tweets expressed joy, anticipation and trust but neutral tweets made up the majority. Finally, the top-5 countries that tweeted the most were the United States, India, Japan, Canada and Australia.

The results regarding the public's opinion on 360º videos from January 2015 to March 2020 are presented below:

- **Word frequency analysis with keywords:** The top-5 most commonly used words (excluding verbs) including keywords were: video (494.734), 360º (481.049), degree (144.400), virtual reality (vr) (120.821) and 360º video (85.155).
- **Word frequency analysis without keywords:** The top-5 most commonly used words excluding verbs and keywords were: virtual reality (vr) (120.821), youtube (74.570), facebook (44.473), new (43.522) and via (42.725).
- **Hashtag frequency analysis:** The top-5 most commonly used hashtags were: #360º video

(63.478), #VR (41.496), #360º Video (19.592), #VirtualReality (15.609), #vr (7.566).

- **Mention frequency analysis**: The top-5 most commonly used mentions were: @YouTube (44.782), @mashable (1.427), @SMExaminer (1.317), @TechCrunch (1.262), @VuzeCamera (1.073). While the top-4 most commonly used magazine and manufacturer mentions were @TechCrunch (1.312), @nytimes (791), @WIRED (473), @USATODAY (371) and @VuzeCamera (1.073), @GoPro (692), @insta360o (582) and @oculus (249) respectively. Finally, the top-5 most commonly used social media platform mentions were @YouTube (44.782), @Facebook (1.029), @Vimeo (296), @Twitter (291), @instagram (47) with YouTube being the most mentioned social media platform for each year.
- **User frequency analysis:** The top-5 users that tweeted the most were: @sweetgregrmndel (9.449), @Camera_Pro_Shop (6.022), @360º vr_videos (5.589), @laura2abadd (2.222) and @titanfallonebay (2.163).
- **Annual tweets over the years 2015-2020:** The annual tweets for each year were: 2015 (83.565), 2016 (211.713), 2017 (124.295), 2018 (54.939), 2019(29.282) and 2020 (5.541).
- **Country frequency analysis:** The top-5 countries that tweeted the most were: the United States (23.597), India (10.638), Japan (8.203), Canada (7.897) and Australia (4.803).
- **Sentiment Analysis – Polarity Detection**: Based on the results, the majority of tweets (47.92%) were positive, 41.84% of tweets were neutral while 10.24% were negative. Table 10 displays the polarity frequency for each year.
- **Sentiment Analysis – Emotion Detection**: According to the analysis, the emotion frequency based on the most intense emotion of each tweet was: Joy (115.225), Trust (52.047), Fear (35.809), Surprise (7.642), Sadness (11.103), Disgust (5.871), Anger (30.273), Anticipation (86.792) and Neutral (164.573). While the emotion frequency based on the summary of words within the tweets was: Joy (265.401), Trust (172.210), Fear (134.765), Surprise (66.017), Sadness (65.664), Disgust (26.140), Anger (63.856), Anticipation (177.392) and Neutral (164.573). Moreover, Table 11 depicts the emotion frequency based on the most intense emotion of each tweet for each year.

Table 10: The polarity frequency of the tweets over the years 2015-2020

	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Positive	38.198	94.437	62.497	28.693	17.008	3.224
Negative	6.930	27.927	9.858	4.383	2.571	486
Neutral	38.437	89.349	51.940	21.863	9.703	1.831

Table 11: Emotion frequency based on the most intense emotion of each tweet for each year over the years 2015-2020

Year	**Joy**	**Trust**	**Fear**	**Surprise**	**Sadness**	**Disgust**	**Anger**	**Anticipation**	**Neutral**
2015	11.182	8.778	7.640	846	1.577	942	4.160	14.237	34.203
2016	47.612	19.216	16.249	3.009	5.183	2.647	12.568	35.881	69.348
2017	29.621	12.650	6.901	2.403	2.409	1.309	8.189	22.022	38.791
2018	13.353	7.060	3.161	981	1.226	516	3.504	9.556	15.582
2019	10.962	3.683	1.598	346	621	406	1.600	4.319	5.747
2020	2.495	660	260	57	87	51	252	777	902

The results regarding the public's opinion on 360º video in education from January 2015 to March 2020 are:

- **Word frequency analysis with keywords:** The top-5 most commonly used words (excluding verbs) including keywords were: 360º (3553), video (3551), school (2400), degree (1634) and rock (1499).
- **Word frequency analysis without keywords:** The top-5 most commonly used words excluding verbs and keywords were: rock (1499), virtualreality (vr) (1116), history (1041), broadways (1027) and reality (522).
- **Hashtag frequency analysis:** The top-5 most commonly used hashtags were: #360º video (787), #education (567), #technology (384), #VR (376) and #immersive (371).
- **Mention frequency analysis**: The top-5 most commonly used mentions were: @YouTube (269), @BBC (31), @ClassTechTips (24), @ElmoRLugo (20), @Kodak (19).
- **User frequency analysis:** The top-5 users that tweeted the most were: @morningcalmblog (305), @ClassTechTips (86), @360o Commercials (55), @scene2ltd (40) and @360o vr_videos (36).
- **Annual tweets over the years 2015-2020:** The annual tweets for each year were: 2015 (1508), 2016 (702), 2017 (726), 2018 (542), 2019 (459), 2020 (211).
- **Country frequency analysis:** The top-5 countries that tweeted the most were: Spain (318), the United States (130), Canada (41), Australia (41) and India (22).
- **Sentiment Analysis – Polarity Detection**: Based on the results, the majority of tweets (66.56%) were neutral, 29.53% of tweets were positive while only 3.91% were negative. Table 12 displays the polarity frequency for each year.
- **Sentiment Analysis – Emotion Detection**: According to the analysis, the emotion frequency based on the most intense emotion of each tweet was: Joy (633), Trust (1276), Fear (80), Surprise (56), Sadness (21), Disgust (14), Anger (56), Anticipation (1650) and Neutral (362). While the emotion frequency based on the summary of words within the tweets was: Joy (2268), Trust (4584), Fear (1631), Surprise (1170), Sadness (682), Disgust (94), Anger (648), Anticipation (3503) and Neutral (362). Moreover, Table 13 depicts the emotion frequency based on the most intense emotion of each tweet for each year.

Table 12: The polarity frequency of the tweets over the years 2015-2020

	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Positive	155	231	297	321	189	32
Negative	35	62	21	26	11	7
Neutral	1318	409	408	195	259	172

Table 13: Emotion frequency based on the most intense emotion of each tweet for each year over the years 2015-2020

Year	**Joy**	**Trust**	**Fear**	**Surprise**	**Sadness**	**Disgust**	**Anger**	**Anticipation**	**Neutral**
2015	31	31	31	31	31	1	1	1051	8
2016	57	270	30	2	5	8	15	229	86
2017	55	289	16	43	7	1	14	167	134
2018	106	178	15	10	3	3	14	134	79
2019	217	104	11	1	3	1	11	60	51
2020	167	22	6	0	2	0	1	9	4

3.5 Discussion - Conclusions

The crowdsourcing analysis involved the collection of data obtained from social media and its analysis in order to comprehend the public's viewpoints regarding 360º video as well as its use in educational settings. The final dataset included 509.235 tweets about the public's opinion on 360º video. A small proportion of these tweets, i.e., 4.148, was related to the use of 360º video in education. This signifies that in education the use of 360º videos is not common. Taking into consideration the usefulness of 360º video, in the future a more widespread dissemination of the benefits from using 360º video in education is needed. The analysis indicated an expansion of tweets around 360º video relevant events. However, people from only a few countries were active in social media about 360º videos, which suggests that their use is not widespread.

Additionally, lexicon-based sentiment analysis was conducted in order to detect the tweet polarity as well as users' emotional state. The public's opinion regarding 360º videos as well as its use in education was rather positive throughout the period we analyzed and was associated with expressed joy, anticipation and trust when talking about them. Importantly, the number of tweets with positive emotions, such as joy and trust, increased and those with negative emotions was decreased from 2015 to 2020. Interestingly, the number of tweets demonstrating anticipation decreased over the course of years. This may imply that people may have been using 360º videos, so they were better informed about the possibilities. Another explanation may be that users were not satisfied with 360º videos use and thus, reported less anticipation in learning more and being involved with 360º. In this case, future efforts to promote 360º should focus on persuading people about the ease of use and usefulness of 360º videos; and of course the development of user-friendly softwares. Nevertheless, a large number of tweets about 360º video on education with neutral emotions was recorded. This may suggest that a large number educators is not familiar with or may not be willing to integrate 360º video into their daily teaching activities. Hence, more efforts are needed in order to promote 360º in the academic community.

Overall, the crowdsourcing analysis indicated that there is a growing interest about 360º videos. However, educators are not adequately informed about the benefits of using 360º videos. Future efforts should focus on promoting the ease of use, usefulness, and the benefits of using 360º in the teaching practice.

3.6 Recommendations

1. Develop a culture for using 360º videos in education;
2. Promote 360º videos with events open to the academic community and across several countries;
3. Explain the ease of use, usefulness and benefits from using 360º videos in education;
4. Develop user-friendly softwares that would encourage educators integrate 360º videos in their educational practice.

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