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LONG PAPER

Co-creating 360-degree videos with a social and educational approach: the mediaverse experiences

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Abstract
This article aims to present a series of co-creation experiences developed as part of the European project MediaVerse. These experiences show the potential of immersive media co-creation as an educational tool that fosters social inclusion and accessibility. The article is mainly descriptive. It describes how co-creation was developed in MediaVerse and how the needs of the different agents involved were considered, together with evaluation data, which was mainly qualitative. The different co-creation processes have generated interactive 360-degree videos, and participants show high satisfaction levels with the experience. Participants also highlight the potential of immersive media in diverse social and educational fields. The interactive videos produced during the co-creation processes serve different purposes and point at future possibilities in relation to 360-degree video co-creation and accessibility.

Keywords Immersive media · Co-creation · Accessibility · Independent living · Education

1 Introduction

Accessibility to information and communication is a key instrument to achieve human rights [1]. Without access to information and communication, one cannot fully participate in society, enjoy cultural and leisure activities, or have full access to education. Key legislation has recently been passed at a European level to guarantee the accessibility of products and services, such as the European Accessibility Act, and a standardisation request has been issued to revise and harmonise existing accessibility standards and develop new ones. Research is also expanding with investigations gathering user needs, testing new technologies, and finding the best strategies towards accessible communication (see, for instance, the MAP platform at mapaccess.uab.cat).

Accessibility to information and communication—or accessible communication—is the central research topic of many funded projects (see, for instance, the WEL project at webs.uab.cat/wel), but accessibility to information and communication can also permeate projects on other topics as a transversal element. For example, a project on education may also consider accessibility when creating educational resources (see the Young ArcHERs project at youngarchers.eu). A project on sustainability may want to make use of the most effective and accessible communication strategies (see the GreenScent project at www.green-scent.eu).

In this paper I will present how accessibility to information and communication was integrated in the European project MediaVerse (mediaverse-project.eu), a project which developed a blockchain-based decentralised platform that gathers multiple tools to facilitate co-creation and sharing across different contexts. The project developed three use cases: citizen journalism, immersive media co-creation with an educational or social perspective, and artistic experiments. This paper presents different co-creation experiences which were part of the second use case, in which 360-degree videos were created with an educational, social, or accessibility-related perspective. 360-degree videos are a type of virtual reality content that can be enjoyed on a computer, a mobile phone, or a tablet. No specific head-mounted display is needed. Shot with an omnidirectional camera, the user can navigate through a 360-degree environment by clicking and dragging.

This article aims to describe how the different experiences developed and what the main outcome was, which points to the potential of 360-degree videos co-creation. The article begins with a short overview of the MediaVerse project in

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Sect. 2 and of the concept of co-creation in Sect. 3. Section 4 refers to work in which 360-degree videos have been used with a social or educational approach, often with accessibility in mind. Section 5 describes the methodology followed, while Sects. 6 and 7 present the experiences developed in MediaVerse in the first and second iteration, together with some evaluation data. The article finishes with a discussion of the lessons learnt (Sect. 8), as well as some conclusions and suggestions for future work.

2 The MediaVerse project

The MediaVerse project (MediaVerse: a universe of media assets and co-creation opportunities at your fingertips) was a European project funded by the European Commission under the H2020-EU2.1.1. programme. Led by the Centre for Research and Technology-Hellas (CERTH), it was developed in 2021–2023 by a consortium made up of technical (ATC, ATOS, Fincons, Vragments), academic (UAB), broadcasting (Swiss TXT, DW), business development (Links), legal (Timelex), and artistic (ArtShare) partners.

MediaVerse developed a platform which allows anyone to co-create and share media content while keeping control of their intellectual property rights. To this end, the platform includes: (a) co-creation tools, where different users can work on a project; (b) social analytic tools; (c) a decentralised network to share the media; (d) content analysis tools; (e) blockchain-based tools to negotiate intellectual property rights; and (f) automated subtitling tools. More specifically, the tools as described in the following are available on the platform, at https://mediaverse-project.eu/results/tools/.

- Asset management (MAAM): It allows users to manage the automatic and user-provided annotations to the media assets. It also incorporates a content-based recommendation system to facilitate content discovery and retrieval within the network.
- Accessibility toolset: It includes speech-to-text with multilingual translation and a post-editor, RACU, which stands for "reconnaissance automatique avec corrections ultérieures" (automatic recognition with retrospective corrections), a workflow to enhance accessibility. The process starts with automatic speech recognition of the uploaded video assets. The text is then machine translated and automatically segmented into subtitles.
- Content moderation toolset: It contains a set of tools with detection models for misleading or false media content, content associated with hate speech and cyberbullying, disturbing content, and nudity, profanity, and other types of not safe for work content. A near-duplicate detection service is also incorporated in the MediaVerse platform for highly similar or near-duplicate multimedia assets, which contributes to copyright management.
- Immersive storytelling: MediaVerse includes various resources such as Fader, an authoring tool used to produce interactive 360-degree experiences without technical expertise, or VRodos 3D, an authoring space which incorporates tools to create avatars and personal VR spaces. It has also developed a 3D plugin for WordPress.
- Media annotation: MediaVerse asset management includes automatic tools for the extraction of tags, metadata, and semantic representation of new media types, as well as a multilingual annotation tool (TransNER) for text supporting the extraction of various types of entities based on AI methods.
- Social analytics: The MediaVerse engine allows for content ingestion from owned social media accounts for the enriching of MediaVerse content, content publishing on social media platforms, as well as performance tracking of shared content.

The platform was used and tested by different user profiles in various situations. One use case focused on citizen journalism: Users become journalists and can share their content through the MediaVerse platform and assign their copyright and monetisation preferences. Another use case explored the usefulness of the MediaVerse ecosystem for artistic purposes. The use case which is further developed in this paper dealt with the co-creation [2] of 360-degree videos [3] with a social or educational perspective, often dealing with accessibility-related issues.

Virtual reality (VR) ranges from 360-degree videos that can be enjoyed on a computer to interactive content to be enjoyed on a head-mounted display. In the context of MediaVerse, as described, the platform incorporates a web-based tool (Fader) that permits the co-creation of interactive 360-degree videos. With Fader, one can upload 360-degree content (videos and images), create multiple 360-degree scenes, adding layers of information (i.e. text, 2D videos and audios, sound, interactive hotspots), and publish the result as a web-based experience. The outcome is a 360-degree video where interactive hotspots give access to additional content.

3 Co-creation in MediaVerse

"Co-creation" is a term that has been defined in business as the participation in the creation of products and services [2]. In their seminal paper, Prahalad and Ramaswamy [4] demonstrate how customers evolve from a passive audience to active players. Similarly, in the artistic environment, Brown et al. [5] suggest a spectrum of audience

involvement in which the term "co-creation" is also used. The spectrum moves from receptive audiences to participatory audiences, which can "contribute towards an artistic experience curated by a professional artist" [5, p. 15]. Walmsley [6, p. 116] concludes that a single definition of co-creation remains "elusive", but common traits emerge: "collaboration, agency, interaction, invention, experience, value and exchange". More recently, Matarasso [7] defines artistic co-creation as the interaction of "professionals and non-professionals", and suggests a spectrum of co-creation, with less professional control at one end and more professional control at the other end.

Co-creation is also a term used in higher education. Bovill et al. [8] define it as "occupying the space in between student engagement and partnership, to suggest a meaningful collaboration between students and staff, with students becoming more active participants in the learning process, constructing understanding and resources with academic staff" (197). This co-creation can take place at two different levels: co-creation of the curriculum and co-creation in the curriculum, with students adopting many roles: representative, consultant, co-researcher, and pedagogical co-designer [9].

Rill and Hämäläinen [2, p. 23] suggest the following definition: "Co-creation is a creative process that taps into the collective potential of groups to generate insights and innovation. Specifically, it is a process, in which teams of diverse stakeholders are actively engaged in a mutually empowering act of collective creativity with experiential and practical outcomes". They do not define who these stakeholders are because they believe that co-creation is not limited to any specific combination of participants.

In the context of MediaVerse, a broad definition of co-creation was adopted in which different participant profiles work together towards the creation of a 360-degree video, although the motivation behind each of the co-creation processes and the outcome may differ.

4 360-degree videos in educational and social settings

A virtual environment is "an environment created by an interaction of a human participant with a world displayed by the computer" [10, p. 221]. Within this broad umbrella definition, one can find virtual reality (VR), augmented reality (AR) and mixed reality (MR) [11]. VR is a "a medium composed of interactive computer simulations that sense the participants' position and actions and replace or augment the feedback to one or more senses" [12, p. 13]. 360-degree videos, the focus of our research, are viewed as a form of VR [13] in which the content is primarily video-based and provide a 360-degree horizontal and 180-degree vertical vision in relation to the viewer's location. To navigate the virtual world, users move their head if using a head-mounted display, use the mouse if using a desktop PC, and can use a finger on a mobile device. Virtual reality provides immersion – or the feeling of "being there" –, sensory feedback, and interactivity.

A concept tightly linked to 360-degree videos is that of cinematic virtual reality (CVR), defined by Mateer [14, p. 15] as a "type of immersive VR experience where individual users can look around synthetic worlds in 360°, often with stereoscopic views, and hear spatialised audio specifically designed to reinforce the veracity of the virtual environment […] CVR uses pre-rendered picture and sound elements exclusively. This means that the quality of these assets can approach that found in high-end television or feature film". CVR is captured with specially designed cameras and the result tends to be short content [15].

Multiple applications of 360-degree videos have been researched, exploring a new grammar of storytelling in virtual reality [15]. Non-fiction stories are one of such examples [14], next to social interventions [16], cultural experiences [17], and educational uses (see below), among others.

Ranieri et al. carry out a review of empirical research on educational uses of 360-degree videos, with the aim of "developing a more systematic and evidence informed approach to the understanding of the educational uses of 360-degree in different educational contexts" [18, p. 1]. They highlight how the interest towards educational approaches to immersive media is growing and analyse 29 studies at different educational levels, from primary school to higher education. They focus on 360-degree videos, like in MediaVerse, because the creation of content is less technically demanding that other types of virtual reality content. Results show that most studies focus on science in higher education, and three main instructional approaches are found: 360-degree videos for lecturing (i.e. to transmit knowledge in a typical lecture situation), for modelling (i.e. to show procedures and activities with higher realism), and for exploring (i.e. to discover a new place or environment). In terms of benefits, the review indicates that participants in the studies under analysis generally report high levels of engagement, attentiveness, information retention, and knowledge transfer from one context to another one, as well as high levels of enjoyment. The study focuses on the use of 360-degree videos and reports the lack of available educational 360-degree videos as a major setback. Similarly, Evens et al. [19] carry out a literature review on 360-degree videos as an educational tool and provide some design guidelines. In this regard, their review finds three studies which stress the importance of involving students when creating 360-degree videos, increasing the students'

engagement and granting them more ownership of their learning process.

From a social point of view, 360-degree videos have been used to spread social messages and increase engagement in international humanitarian aid non-profit organisations [20]. This type of content has also been used in social care environments, as a tool for social intervention [21]. Hansdotter [22] discusses how virtual reality can stimulate prosocial behaviour. According to the researcher, VR can immerse users in a virtual environment and help them feel that they are there. VR can allow user to access experiences that are impossible in real life and support embodied cognition. All these factors can contribute to our understanding and compassion towards others and to a process of self-transformation that ends in a prosocial change, i.e. a voluntary action intended to help someone else, often due to feelings of empathy and concern.

Finally, when we look at the use of 360-degree videos for accessibility, seminal work was done in the context of the Immersive Accessibility (ImAc) project, which researched: (a) editors to create accessible content; (b) players, to play accessible content; and (c) access services such as audio description, spoken subtitles, sign language interpreting, and subtitling. In this regard, tests with users on the best strategies to integrate access services in 360-degree videos were carried out [23]. In their review of efforts to improve accessibility in virtual reality, augmented reality, and the metaverse, Dudley et al. [24] present an overview of how research has been performed in other settings beyond broadcast immersive media such as health care - where immersive technologies have often been used for rehabilitation - or work training and disability simulation. The possibilities of immersive media and the applications of 360-degree videos are varied, but MediaVerse wanted to test different approaches to co-creation processes in which 360-degree videos would be created with a strong social or educational perspective, and with accessibility as a focal element.

5 Methodology

The development of the MediaVerse platform followed an iterative process: requirements were gathered in an initial stage from users, which helped design a first prototype and identify how the platform could be used for different purposes. This prototype was assessed by diverse user groups in terms of usability, usefulness and satisfaction, and new user requirements were gathered. These new requirements were then implemented, and the improved version of the prototype was tested in a second iteration of pilots which evaluated the usefulness of the MediaVerse ecosystem for different purposes.

As mentioned in the introduction, MediaVerse focused on three use cases: citizen journalism, immersive media co-creation with an educational or social perspective, and artistic experiments. In the second use case, which is described in this article, there was a strong interest in exploring the potential of 360-degree video co-creation in different settings, always with a social or educational perspective in mind. In a first phase, the co-creation processes took place with five different user profiles:

- young children in vulnerable socio-economic situations taking part in the CROMA programme at the Fundació Autònoma Solidària (FAS) at Universitat Autònoma de Barcelona (UAB);
- teenagers taking part in the ITACA summer camp, also organised by FAS-UAB;
- workers from an association of persons with intellectual disabilities (Som Fundació);
- workers from an association of migrants (CEPAIM), and.
- university students in Occupational Therapy and Nursing (EUIT).

In this stage, apart from testing the platform, users were asked about their enjoyment and satisfaction through three statements that were assessed on a Likert scale: (a) I have enjoyed co-creating 360-degree content; (b) I would like to do it again; and (c) I would recommend it to a friend. Additionally, two open questions asked “How do you think co-creating 360-degree content impacts social inclusion?” and “In what other projects or in what other ways do you think 360-degree video cocreation can be used?”

Drawing from this first-year experience, a second iteration of co-creation processes took place with:

- workers from associations of persons with disabilities, such as Som Fundació (persons with intellectual disabilities) and ACAPPS (persons with hearing loss);
- teenagers from secondary schools (Manuel Carrasco High School);
- young students from vocational schools teaching media studies (EMAV);
- an independent dancer interested in audio description;
- university students in Occupational Therapy and Nursing (EUIT), and.
- teenagers taking part in the ITACA summer camp at the UAB.

Apart from quantitative feedback on the MediaVerse platform, qualitative feedback on the whole co-creation experience was gathered through three key questions: (a) How did co-creating 360-degree content impact social inclusion? (b)

What was the impact from an educational perspective? (c) In which other projects/ways do you think the co-creation of 360-degree content could be applied? The following sections report on the different experiences and the qualitative evaluation results.

6 Co-creation processes in the first iteration

6.1 Co-creating with children and teenagers at FAS

This action with primary school children was possible thanks to the CROMA 2.0 programme developed by FAS, a foundation at the Universitat Autònoma de Barcelona. The CROMA 2.0 programme offers extracurricular activities to children aged 10 to 12 in a vulnerable socio-economic situation. The aim of the programme, which involves 20 primary schools close to the university, is to raise interest in learning and research. University students act as volunteers and implement the proposals designed by UAB research groups. In this context, a proposal linked to the MediaVerse project was sent to the CROMA programme and, after an internal evaluation process, it was accepted with minor adjustments. The aims of the proposal "Seeing with your ears, hearing with your eyes" were to:

(a) raise awareness about the needs of persons with disabilities;
(b) learn about solutions to make audiovisual content accessible;
(c) co-create a 360-degree interactive video and make it accessible.

The project involved different stages, which are described next. In the first phase, researchers trained 10 volunteers from the UAB (7 female, 2 male and 1 non-binary participant). They were introduced to immersive content, 360-degree video creation and virtual reality, and the MediaVerse project and platform. They were also trained in managing the virtual reality cameras and in using Fader, a web-based application integrated in the MediaVerse platform that facilitates interactive 360-degree video creation. These training sessions were assessed independently by the CROMA programme, which looked at the information available prior to the training sessions, the timing of the training, how the training was carried out, how the doubts were solved, the methodology, and the communication skills of the trainers. The mean global satisfaction was 4.75 on a 5-point Likert scale. Qualitative comments highlighted the high level of technical expertise required for such a project and the need for a good preparation. In this regard, the researchers provided continuous support to the volunteers during the entire project.

The central stage was the co-creation process with primary school students. In this case, 66 children from 6 schools took part in the experience, which developed along different 2-hour sessions.

In the three initial sessions, primary school students were told what virtual reality is and they started planning the recording of a 360-degree video in their school. The aim of the project - raising awareness about accessibility - was not announced at this stage. First, they decided which school spaces would be recorded, who would be interviewed, and what they would ask during the interview. Then, they recorded all content, both with a 360-degree camera (spaces in the school) and with mobile phones (interviews).

In the fourth session, titled "You are my eyes", students became aware of sensory and physical barriers encountered by persons with sight loss. Thanks to the cooperation of an association of users with disabilities, children were shown a short video in which a young blind man explains that he is aware that they are recording a video but, unfortunately, he will not be able to enjoy it because he is blind. In a friendly tone, he challenges them to find a solution so that he can also enjoy the video. This video by the blind man was followed by two activities: In the first one, students tried to walk through the classroom blindfolded and with the assistance of a colleague. In the second activity, students tried to understand a movie by only listening to the audio. Once the challenges of persons with sight loss had been raised, students learnt about audio description, a translation of images into words [25], and started co-creating a short audio description of one of the spaces. This audio description was integrated as an audio file in the interactive video.

The two sessions that followed ("You are my ears") focused on the challenges of persons with hearing loss. A video of a person with hearing loss compelled the primary school students to find solutions and they were then trained in intralingual subtitling, from Catalan into Catalan, and subtitled some of the interviews they had recorded.

In the seventh session, a video of a Deaf person was shown, but in this case explaining she was a Catalan Sign Language speaker. She taught them how to sign a few words. Students learnt a few expressions in Catalan Sign Language and they recorded them.

The last session ("A video for all") was used to conclude the co-creation process and finish the interactive video with the tool. It was also the moment to discuss and share their views on the needs of diverse people in relation to audiovisual content and on the different access services available, which proved their learnings in relation to accessibility.

The main output of this co-creation process, which lasted two months, was an interactive 360-degree video per

school, with a total of six videos. A video summary can be found online (https://www.youtube.com/watch?v=T3OMlD505zg). Although each school decided the specific design of the interactive video, most of them included a landing page in which students welcome visitors to the school in Catalan Sign Language. Different buttons then give access to school spaces. For example, in one of the videos, one could click on an interactive button and access audio described images of the school main corridor where paintings were hanging on the walls. Another example illustrating how students acquired new accessibility-related skills is a video of a teacher being interviewed in a subtitled video.

The CROMA programme also included a visit to the university premises by the students in which they presented the results of their co-creation process and were invited to take part in three fun activities prepared by the researchers:

(a) a "guess-who game" in which half of the group could see a famous character on a screen and the other half could not. The ones seeing the character had to audio describe it to the other half, applying their knowledge about audio description;
(b) a "tactile discovery activity" in which they had to guess what certain objects were just by touching them, which allowed us to highlight the importance of touch tours in cultural venues;
(c) a "what did s/he say game" in which participants had to guess the origin of certain sounds (for instance, a train, an ambulance, ice cubes in a glass, etc.) and the languages spoken. A list of languages taught at the Faculty of Translation and Interpreting, where the activity was taking place, was presented on screen to facilitate the last activity.

At the end of the co-creation process, satisfaction measures were gathered from both facilitators and students. They are reported in Sect. 6.6.

FAS also has a social and educational program for secondary students which takes place in the summer, the ITACA project. Researchers organise pedagogical game-oriented activities to raise interest in staying in formal education and learning about research. A project proposal was submitted to FAS with the title "360-degree accessible TikToks". The proposal was accepted and it took place with two different groups, in July 2022. A total of 10 students per group plus one university student acting as a facilitator were involved in this 6-hour activity which developed during an entire day.

The structure was as follows: First, they learnt about and discussed virtual reality and the MediaVerse project and platform. Then, they were introduced to the topic of accessibility (specifically, audio description and audio introduction) through gamified activities and they were shown how to create an interactive video. With all this information, they were invited to co-create a video with support from a researcher and the facilitator. They recorded themselves with a 360-degree camera and added an accessibility layer to the video. The topics they chose dealt with social aspects of interest to teenagers: "No to bullying", "Healthy Habits", and "Secondary School versus University" were the titles of the videos they created. Evaluation results are presented in Sect. 6.4., and a sample video can be consulted online at https://www.youtube.com/watch?v=3hTRh9DzJSw.

6.2 Co-creating with user associations

Two user associations were involved in the first stage of the project: on the one hand, Som Fundació, an association supporting persons with intellectual disabilities and, on the other, CEPAIM, an association giving support to migrants. Both associations work towards a more inclusive society and help users in vulnerable situations. In both cases, the procedure was the same: a focus group with workers from the association was the starting point. The project, the platform and its possibilities were presented to them, and participants engaged in a discussion on how their users could benefit from a co-created video.

Som Fundació workers started testing the platform by creating a virtual tour of their premises, as they considered this would allow users with intellectual disabilities to become familiar with the premises and people before a visit. They then identified that many users experience difficulties performing daily life activities, such as going to the supermarket or to the bank. Therefore, they decided to create a video to show how to go to the supermarket and how to prepare a shopping list (see a sample online at https://www.youtube.com/watch?v=jyGtLmxZH3k). On the other hand, CEPAIM workers identified a need, which is to present the apartments they have in Barcelona for refugees. This is why they created a virtual tour addressed to European Commission representatives (see a sample at https://www.youtube.com/watch?v=TP-xlGwsCk4). In both cases, the co-creation processes developed freely without a pre-established structure, always with the support of the researchers. Evaluation results are presented in Sect. 6.4.

6.3 Co-creating with university students from the occupational therapy and nursing degrees

This co-creation activity involved university students from Escola Universitària d'Infermeria i Teràpia Ocupacional (EUIT), a university college of Nursing and Occupational Therapy. The MediaVerse project and tools were presented to university lecturers, who showed interest in the project. On the one hand, a presentation was given to students from

Table 1 Satisfaction and enjoyment measures

Responses	Statement	1	2	3	4	5	Mean	St. dev.	Median
CROMA children	1	3%	2%	11%	20%	64%	4.4	1	5
	2	7%	7%	16%	18%	52%	4	1.3	5
	3	3%	8%	10%	21%	58%	4.2	1.1	5
CROMA facilitators	1	0%	0%	25%	50%	25%	4	0.8	4
	2	0%	0%	0%	75%	25%	4.5	0.5	4
	3	0%	0%	50%	25%	25%	3.75	0.9	3.5
ITACA	1	0%	0%	10%	20%	70%	4.54	0.66	5
	2	5%	0%	10%	25%	60%	4.33	0.96	5
	3	0%	5%	10%	10%	75%	4.5	0.83	5
Som Fundació	1	0%	0%	0%	83%	17%	4.17	0.41	4
	2	0%	0%	0%	67%	33%	4.33	0.52	4
	3	0%	0%	0%	83%	17%	4.17	0.41	4
CEPAIM	1	0%	0%	33%	33%	33%	4	1	4
	2	0%	0%	0%	33%	67%	4.67	0.58	5
	3	0%	0%	0%	67%	33%	4.33	0.58	4
EUIT	1	0%	5%	21%	32%	42%	4.11	0.94	4
	2	10%	0%	16%	21%	53%	4.05	1.31	5
	3	0%	10%	16%	21%	53%	4.16	1.07	5

the BA in Nursing, offering them the possibility to work with the MediaVerse tools for some of their projects; three students became interested. They worked freely in the co-creation with support from the researchers, where needed.

On the other hand, a lecturer decided to include the co-creation process as part of the course "Health Education", and 26 university students took part in the co-creation experience. Students were instructed to co-create a 360-degree video with social impact. Students were sent to a collaboration institution, where they interacted with diverse users and professionals. These included professionals from a children's therapy centre, from a medical centre, from a care home for the elderly, from a city council, and from a foundation. During this open process, a researcher provided support on technical aspects and the lecturer provided support on conceptual aspects linked to occupational therapy.

The final co-created videos, 8 in total, covered a myriad of user needs such as: recommendations for parents with neurodiverse children, videos including landmarks in a village that helped elderly people with limited mobility to visit spaces from their youth again, an immersive experience to reduce anxiety and improve mental health, and a hospital tour for oncological patients. Results from the evaluation are presented in the following subsection, and a sample of a video can be consulted online at https://www.youtube.com/watch?v=_-2fPKk5osA.

6.4 Evaluation

The co-creation processes involved the following number of co-creators: 66 children and 11 student facilitators from CROMA, 20 teenagers and 2 student facilitators from ITACA, 9 participants from Som Fundació, 11 participants from CEPAIM, and 28 students from EUIT. Quantitative data were collected from: 61 children and 4 facilitators from the CROMA co-creation activity, 20 participants and 2 facilitators from the ITACA experience, 6 from Som Fundació, 3 from CEPAIM, and 26 from EUIT. A total of 119 responses were gathered. Unfortunately, data from users collaborating with the university students could not be gathered.

Results are presented in Table 1. The statements were the following:

- Statement 1: "I enjoyed co-creating 360 content";
- Statement 2: "I would do it again";
- Statement 3: "I would recommend it to a friend".

Statement 1 evaluates enjoyment, whereas statements 2 and 3 typically measure satisfaction.

Most satisfaction and enjoyment values are on the higher range, with a very low percentage of participants selecting 1 or 2 on a 5-point Likert scale. As for the qualitative replies to the two open questions, responses can be summarised as follows. It should be noted that in CROMA these questions were only posed to facilitators, not to the children.

6.4.1 How do you think co-creating 360-degree content impacts social inclusion?

CROMA facilitators thought the co-creation process encourages teamwork, dialogue, and empathy, and facilitates the acquisition of new technological skills. They believed there is an increased awareness about diversity, and considered that children enhanced their creative skills

through a motivating activity. This opinion was also shared by the ITACA students, who also viewed it as a positive tool for teamwork because it facilitated engagement. Students thought that the technological novelty may have an impact on audiences and believed that "more people should be able to see" the video they created, generating a wider impact. They were also convinced that their co-created video can have an impact on persons with disabilities. ITACA facilitators highlighted diversity as a key aspect and added that "being cooperative helps disadvantaged groups and those at social risk of exclusion to participate in both creative and visualisation projects". University students from EUIT also considered that the impact on social inclusion could be positive or very positive, illustrating various situations in which the co-creation process could be used. Participants from Som Fundació expressed that the impact was positive, as it allowed users to express their needs through co-created videos. Another positive aspect mentioned by the social workers at the foundation was that the videos can have a positive impact on the user's quality of life. Again, the concept of engagement with this attractive format was mentioned. CEPAIM, working with migrants, exposed that a positive aspect of the co-creation process was that it is not discriminating and allows people in a situation of exclusion to get closer to technology and work towards greater autonomy.

6.4.2 In what other projects or in what other ways do you think 360-degree video co-creation can be used?

Multiple suggestions were made in this open question, including educational contexts, tourism, entertainment, culture, health, capacity-building for the job market, anthropology, and occupational therapy. Projects with the elderly and persons with disabilities were mentioned by various participants. University students provided examples such as leisure spaces, community work in occupational therapy, or bringing a place closer to the participants who cannot reach it in real life due to disabilities. The scope was broad and, as put by one of the respondents, "with 360-degree content it is all more understandable and close".

7 Co-creation processes in the second iteration

The co-creation processes in the second iteration were carried out in different types of settings, as described in the following sub-sections, but were less guided and more open. A succinct overview of each of them is provided next to illustrate the multiple scenarios in which the MediaVerse concept was implemented.

7.1 Co-creating in an association of persons with disabilities

In the second year, Som Fundació did not develop any more videos but contributed to the discussions on how they were assessing the impact of the experience. Nevertheless, another association of persons with disabilities - ACAPPS, supporting persons with hearing loss and their families - learnt about the Som Fundació experience and wanted to participate in a similar co-creation experience. ACAPPS decided to co-create a virtual tour of their premises using the MediaVerse tools, similarly to what Som Fundació had done in the first iteration. The association also integrated subtitled videos in their co-created content, in which the professionals from the association explain who they are and what they do in the association. This is yet another example of a bottom-up proposal to co-create a video which responds to the needs of an association of persons with disabilities.

7.2 Co-creating at a secondary school and at a vocational media school

High school teachers working at a public school in Barcelona (Manuel Carrasco High School) became involved in the project and co-created different stories in their courses with secondary school students. Again, the process was open and the researchers did not intervene, only providing technical support when questions related to the tools arose. The outcomes were 3 interactive projects.

The first was developed as part of the History class: *The 13 Pillars of Holocaust Education: A Virtual Exhibition on the Holocaust* featured a virtual exhibition on the Holocaust with videos created by students aged 15 and 16 years old. The second video was a virtual tour of the high school showcasing activities through videos and photos. The third was a 360-degree story about a Christmas concert at the school. The music teacher and many students recorded their musical performances during the Christmas festival at the school auditorium, reaching an audience of 120 parents through the online video.

On the other hand, EMAV, a vocational film school, included the Fader co-creation process in one of its final modules, in which 57 students from various courses (production, direction, animation, lighting, etc.) collaborated towards the creation of a unique work. The students used the MediaVerse tools to create a multimedia exhibition as their final project, focusing on the Spanish Civil War. They co-created a wide array of assets (videos, photographs, pictures, animations, and even 3D models) and, in collaboration with a group of actors, they produced *Escarcha y Plomo*, a speculative fiction story set in the 1960–70s in Spain, after Franco's dictatorship, which also included subtitles.

7.3 An independent dancer interested in audio description

This action took place at the Francesc Candel Library in Barcelona, and in El Graner, a Centre for Creation of Dance and Performing Arts, also in Barcelona. Four participants were involved: a primary school teacher, an audio description student, an audiovisual producer, and a professional dancer coordinating the research and creative project. The aim was not to describe a dance performance but to create a space where blind and sighted people could dance together and co-describe the movements. Overall, 15 dancers (6 blind and 9 sighted) took part in a series of sessions led by the coordinator in which a 360-degree video was co-created. Due to the interest in this activity, the teacher from the secondary school also involved some of his students in co-creating additional content. MediaVerse researchers provided support when needed, though overall, the pilot ran freely in an open format.

7.4 A repeated experience: ITACA and the occupational therapy and nursing school

Due to the success of the first year and the availability of the participants, the ITACA and EUIT experiences were repeated in the second year.

In ITACA, 28 high school students and three university students acting as facilitators took part. In EUIT, 36 participants were involved in the co-creation of 360-degree videos in different settings:

- a hospital where videos were created for neurorehabilitation of neurological disorders such as unilateral spatial neglect: Students created a virtual reality experience where users need to find objects or look at things on their affected side;
- a centre for children on the autism spectrum, where students co-created a 360-degree experience for parents to raise awareness about autism and better understand how children perceive the world;
- a former history teacher interested in heritage could not move due to a stroke, and students co-created an experience for him so he could visit some significant places again (see a sample at https://www.youtube.com/watch?v=AOPdsGBpVIo);
- some students co-created 360-degree videos for women with dementia who cannot leave their homes in order to improve their cognitive, physical, and emotional capabilities. These videos included challenges such as finding objects in a supermarket, but also pleasant activities such as walking a dog in a park.

7.5 Evaluation

At the end of the co-creation process, an evaluation of the platform and the whole co-creation experience took place. The co-creation processes involved the following number of co-creators: 24 participants in ACAPPS, 131 in Manual Carrasco High School, 57 in EMAV, 48 in the dance action, 36 at EUIT, and 31 in the ITACA programme. Of these 327 participants, a total of 89 interacted directly with the MediaVerse tools and 73 replied to the questions posed in the evaluation. This paper only reports on the qualitative aspects related to the whole experience, as quantitative data referred to the usefulness and satisfaction with the MediaVerse platform, which is beyond the scope of this article. A summary of the responses to the following open questions is provided: (a) How did co-creating 360-degree content impact social inclusion? (b) What was the impact from an educational perspective? and (c) In which other projects/ways do you think the co-creation of 360-degree content could be applied?

7.5.1 How did co-creating 360-degree content impact social inclusion?

In the association of persons with hearing loss ACAPPS, respondents thought that the project "gave the participants the opportunity to explain their experience to the users" as "they were included all along the process". Still, one participant believed the real impact could only be measured once the video was published on the website. Respondents from the association of persons with intellectual disabilities Som Fundació believed "users suffer a digital divide" and it is crucial to "help them with digital skills". In this regard, 360-degree videos are more visual outputs, hence more understandable. Another respondent identified impact at two different levels: on the one hand, impact on raising awareness about the work performed by the associations and, on the other hand, impact on users with disabilities.

As for the high school respondents, one participant mentioned the interaction and collaboration among students as a clear benefit, whereas another one thought the project had given higher visibility to the Holocaust project. EMAV students saw the potential of 360-degree content co-creation in reaching inaccessible places and in bringing tourism closer to people who cannot travel, fostering their inclusion. They also mentioned that raising awareness about disabilities could be beneficial towards social inclusion.

In the case of the dance action, persons with and without disabilities co-created together, which helped "give visibility to the world of audio description", as put by one respondent. The university students from Occupational Therapy were a bit more cautious and explained that "it's not easy to see

social inclusion because our goals were very specific". Still, one respondent thought that, even if they worked with specific cases, they were "applicable to many people with the same condition". Another participant hoped that, by watching their video, parents of children with autism will better understand their children, and these children's lives will be better. Generally speaking, respondents also acknowledged the impact of technology in accessing inaccessible places for some of the participants, and they praised the engagement and impact of this innovative format on participants, as mentioned by ITACA respondents.

7.5.2 What was the impact from an educational perspective?

ACAPPS participants praised the co-creation process and valued the fact that they had learnt to use new digital tools. Still, they acknowledge some technical challenges, an aspect also highlighted by participants from the high school. Connectivity at school and equipment availability were two additional challenges in this educational context. EMAV students thought that the process of co-creating with MediaVerse tools taught them about licensing digital content, but also about new ways of communicating. A strong educational potential when working with children was mentioned by one participant. The dance experience also showed the cultural potential of this activity, and one participant acknowledged the excellent dissemination potential of the co-created images. University students mentioned that they had learnt about virtual reality, about new tools, and about interacting with end users while co-creating. Similarly, participants from an association of persons with intellectual disabilities considered the video they had co-created reinforced the users' autonomy, as it was a very visual format and enhanced comprehension. Participants defined the experience as "enjoyable" and made different suggestions, which are reproduced in the following paragraphs.

7.5.3 In which other projects/ways do you think the co-creation of 360-degree content could be applied?

Participants saw a lot of potential in many areas, but also put forward the time invested in planning, organising, and editing the content. ACAPPS participants thought they "could apply it to almost every activity that we do in the organisation, it would be very useful", and provided as an example "interactive stories for kids". Similarly, workers from Som Fundació thought that it could be applied to "reduce the digital divide in users, especially the elderly". Some also saw the potential of co-creating 360-degree videos to promote their association and to involve new volunteers. A respondent from the association already suggested a new video on how to move around the public transport network.

High school teachers saw great potential for "artistic creation" and for "having fun", whereas one teacher explicitly referred to "immersive exhibitions" as a possible future project. EMAV students saw the potential of co-creation for "student presentations in class" and to develop a type of "gallery of memories and experiences". Journalism and cultural venues were two areas identified as key and with a lot of potential by different respondents. The educational field was another area mentioned by the dance experience participants. University students thought co-creation could be used for therapeutic reasons, but also saw its potential with younger generations. ITACA students, in this regard, suggested a myriad of contexts to co-create videos: to help migrants and persons with disabilities, to raise awareness about discrimination against women, to develop architectural projects, to learn languages, to provide psychological support, to assist scientists in explorations, to create more engaging advertisements, for sports, for online classes, among many other ideas.

8 Lessons learnt

The MediaVerse 360-degree video co-creation project has provided some invaluable lessons for immersive co-creation processes with an educational and social perspective, including accessibility awareness-raising activities.

First, the potential of immersive storytelling is immense as most users are fascinated by the novelty of VR. Young participants are enthusiastic when recording themselves with 360-degree cameras and producing digital content, whereas older participants are moved when feeling present in places they can no longer physically access.

However, even if the MediaVerse platform has been developed considering accessibility and usability requirements, technical challenges still exist, from setting up the 360-degree camera and recording content to editing this content in the dedicated software or managing a head-mounted display or mobile phone in some cases. Even if an effort has been made to increase the usability of the tools, there is still a digital divide with some users who struggle with the technology.

Second, there is not a one-size-fits-all approach to co-creation. MediaVerse has developed both top-down and bottom-up co-creation processes, with diverging degrees of structuring, and they have all been successful. Adapting to the context is of the essence. For CROMA and ITACA, which are structured programmes organised by a university, a detailed proposal was submitted, assessed, and modified. Even though the children in CROMA and teenagers

in ITACA could develop their own ideas, there was a clear planning and a framework for the co-creation process. On the other hand, when working with associations of persons with disabilities or migrants, co-creation processes were initiated by the users and facilitators from the associations, after the researchers presented them with the potential of the technology. A specific case was that of higher education students, where a lecturer realised the potential of the MediaVerse tools and integrated the co-creation process in her own university course. Regardless of the approach, though, all MediaVerse co-creation processes were user-centric and MediaVerse partners acted as mere facilitators, providing technical support when necessary.

Third, virtual reality has shown its potential to raise awareness about accessibility. Integrating accessibility and universal design in higher education programmes has been advocated by the ATHENA project (https://athenaproject.eu/) as a way to foster accessibility in our society and ensure accessibility permeates all fields of knowledge. Similarly, one could argue that some fundamental knowledge about accessibility should be integrated in primary and secondary education curricula. This could take the form of awareness-raising activities that show the diversity of user needs and how they can be catered for. Since this integration in the formal curriculum is not a reality, alternative non-formal training activities such as the ones developed in CROMA can contribute to fill this gap in an engaging and dynamic way.

Engagement is clearly one of the benefits of using VR content. The combination of co-creation processes - which have been reported to increase engagement and sense of ownership - and virtual reality environments, boost engagement among participants, hence showing high degrees of satisfaction (see section on evaluation data). However, as already acknowledged, three critical aspects need to be considered for the successful completion of the activities: excellent planning, even if the co-creation is bottom-up, as very often activities take longer than expected and changes may occur; technological support and facilitation, to ease any digital barriers that may arise during the process, and flexibility to adapt to a live process which may suffer changes as it develops. One could add sustainability to the equation, as a critical aspect in any project is to explore how these activities can continue to have an impact beyond the life of the project and how the outputs that have been produced can still be available. In the case of MediaVerse, access to the tools was limited after the project, so researchers created alternative open access formats (such as YouTube videos) to showcase the results of the project.

Finally, the project has generated valuable evaluation data, but the length of questionnaires and number of evaluation activities has been strictly controlled. Finding a balance between the interests of researchers, who may want to gather as much data as possible, and the needs of users is of the essence for an ethical approach to co-creation and research. This has been another one of the lessons learnt in the MediaVerse project, in which users can be put at the centre not only in the co-creation activities but also when designing the evaluation activities from a research perspective.

9 Conclusions

This article has put forward the power of co-creation with new technologies such as immersive media. It has also shown how social and educational perspectives can be adopted, with accessibility in a central place, in very diverse projects.

Through multiple actions developed in two iterations, the article has illustrated the multiple facets of co-creation, from a top-down co-creation process with children in the CROMA project with a well-defined programme, to open co-creation processes in user associations where the content to be created is defined collaboratively and the project only provides the tools, some support, and training. The multiple videos created showcase the potential of 360-degree videos, a potential highlighted also in the qualitative evaluations where participants were asked about the experience. One of the limitations of the article is the limited quantitative evaluation data available, but this is a direct consequence of the decision to intervene as little as possible in the co-creation processes and put the focus on the global results, which illustrate the potential of co-creation of immersive media.

The MediaVerse co-creation experiences have also shown how accessibility can be integrated at different levels in social and educational proposals, ranging from proposals where raising awareness about accessibility is central (CROMA) to proposals which support persons with disabilities (ACAPPS and Som Fundació) and projects where access services are integrated (EMAV).

The applications of immersive media in relation to accessibility are manyfold, but there is also a need to further research how these forms of immersive media will be made accessible to all. As we move towards a society in which the metaverses, or virtual worlds, will become commonplace, an effort to make them accessible from the very beginning should be made. Existing research [23, 24], can be the basis on which born-accessible virtual environments [26] are developed.

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