Understanding How News Content Utilizes Experiential Media (AR, VR, and 360° Video) in COVID-19 Storytelling

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A growing body of research indicates how experiential media (EM) technologies such as virtual reality (VR), augmented reality (AR), and 360° video are diffusing widely around the world, thereby transforming media practices and the user experience. The current study looks at immersive news content production (EM stories) that seek to inform the public on how the COVID-19 virus spreads, the precautions required to protect from getting infected by the virus, and a general understanding of COVID-19 as a pandemic. Based on a list of six criteria, a total of six EM stories (two AR stories by the New York Times (NYT), two 360° video stories by National Geographic (Nat Geo), and two VR stories by Meta's Oculus App in collaboration with other media organizations) were identified for the study. This exploratory study uses qualitative research methodology and the Experiential Media theoretical framework to understand to 1) what extent such immersive news content production utilizes the six EM qualities in COVID-19 storytelling? 2) what themes do such EM stories and the accompanying static news story reported online cover? 3) what new knowledge, if any, do such EM stories provide compared to the accompanying static news story online? The findings from the study offer a theoretical understanding of the role EM technologies play in highlighting global health crisis such as COVID-19, particularly through immersive 3D visualizations, and provides practical implications for EM content producers.

Keywords: experiential media, augmented reality, virtual reality, 360° video, COVID-19, news

Introduction

The novel Coronavirus (COVID-19) has been a deadly pandemic in history, infecting close to 540.9 million people and claiming the lives of around 6.3 million people worldwide since December 2019 (CNN, 2022). Furthermore, with the onset of the COVID-19 pandemic, the media has played a critical role in keeping people connected and well-informed about the disease and how it spreads. While traditional media and text-based news content online play an important role in creating awareness, an emerging form of media known as experiential media (EM) – which refers to communication platforms or technical interfaces such as augmented reality (AR), virtual reality (VR), and 360° video – through its various multisensory and immersive qualities – enables users to make practical contact or experience with the phenomena virtually. Further, the potential to put the user as part of the story

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or journey in the first-person point of view instead of passively watching, listening, or reading a narrative from a third-person point of view is also being used in COVID-19 storytelling. This study examines such immersive news content production (henceforth called EM stories in this paper) that seeks to inform the public on how the virus spreads, the precautions required to protect from getting infected by the virus, and a general understanding of COVID-19 as a pandemic. The study seeks to understand how and to what extent such immersive stories utilize qualities of EM in COVID-19 storytelling and what themes and new knowledge such content production provides.

Review of Literature

A growing body of research indicates that EM technologies such as AR, VR, and 360° video are transforming media practices, content, and the user experience. Today, through multisensory qualities, EM technologies offer the user the potential to replace real-world experiences, including sight, sound, and haptics, through computer-generated illusions where the user can navigate and interact (Bates-Brkljac, 2011). In explaining how the user is not passive but can be interactive in such a digital sphere, Domínguez (2017) writes:

> "Currently, immersive technologies give a sensory quality to the metaphors of literary immersion: the sensation of feeling oneself transported to the narrative world and being able to perform within it. To be inside the image, move around it, hear the sounds of the scene in three-dimensional quality, and choose what to see at every moment are the most developed expressive characteristics so far, and of these, immersive VR is their maximum component" (p. 9).

Further, studies have explored how such EM technologies are transforming user experience by increasing the sense of presence and empathy. In exploring this phenomenon, Sundar et al. (2017) in the study showed how participants indicated stories experienced in VR significantly outperformed text-based articles in several categories, such as giving them a sense of presence or the feeling of being there and increasing their empathy for the story's characters. Similarly, Archer and Finger (2018), in a study to understand whether 360° video news stories generate empathy in viewers, examined how particular audiences are likely to respond empathetically to certain narratives and analyzed the component parts of immersive experiences – comfort level, interactivity, and perceived amount of user agency – that contribute to producing an empathetic response. Archer and Finger (2018) highlighted what might be the advantage of such a response, including improvement in a viewer's ability to recall the content over time or a resulting behavioral change. Furthermore, studies have also explored how users respond to 360° video news and investigate what 360° video as a means for conveying news stories might add to traditional 2D video. Vettehen et al. (2019) found that 360° video was evaluated higher in terms of presence, enjoyment, and credibility, while there were no negative effects of 360° video on recognition and understanding. The researchers found that the effects on enjoyment and credibility are mediated by the presence and indicated

that the 360° video form of news reporting has the potential to involve audiences as never before. Such studies also offer practical implications on how EM technologies like VR may help journalists pull an audience into their stories.

Meanwhile, scholarly work in health science also indicates the increase in the use of such EM technologies for a better understanding of COVID-19, considering the novelty of such a pandemic. Calvelo et al. (2020) used VR to visualize the three-dimensional biomolecular structures of SARS-CoV-2 to open the possibilities for significant advances in understanding the disease-associated mechanisms and to boost new therapies and treatments. Calvelo et al. (2020) reviewed software implementations currently available for VR visualization of SARS-CoV-2 molecular structures, covering a range of virtual environments, including desktop and web-based software such as VRmol, ProteinVR, Molecular Rift, Nanome, Autodesk Molecular Viewer, iview, etc., that allows users for VR visualization of the virus using virtual reality headsets such as HTC Vive, Vive Pro, Oculus Rift, etc., and cell phone applications such as PROteinVR and Corona VRus Coaster that allows users for VR visualization of the virus using iPhone, and Android smartphones. Similarly, Pears et al. (2020) examined the role of immersive technologies in healthcare education during the COVID-19 pandemic. They identified the innovative uses of immersive media technologies to deliver medical education while maintaining the safety of residents and educators. Furthermore, studies though not related to COVID-19, such as Nowak et al. (2020), showed how using immersive VR improved the beliefs and intentions of influenza vaccine-avoidant 18-to-49-year-olds. Nowak et al. (2020) found that the VR intervention created a stronger perception of presence (i.e., a feeling of "being there" in the story), which, in turn, increased participants' concern about transmitting influenza to others and raised vaccination intention.

While a large body of studies has continued to explore the role of EM technologies in generating empathy, increasing a sense of presence, and driving behavioral changes, a growing body of research has also explored the role of EM technologies in the 3D visualization of abstract topics that are psychologically distant such as raise in sea-level, greenhouse gas emissions or climate change more broadly (Calil et al., 2021; O'Neill and Smith, 2014).

Considering the role of EM technologies in addressing the challenges in science communication and the fact that there is limited scholarly work, particularly exploring EM and COVID-19 storytelling, this study attempts to fill the research gap by examining how and to what extent EM qualities are utilized by immersive news content production; to identify important themes and new knowledge such immersive experiences provide compared to the liner/static text online. This exploratory study will use a qualitative research methodology and is guided by the following research question:

> **RQ1:** *To what extent do immersive news content production (experiential media stories) utilize qualities of experiential media (i.e., interaction, immersion, multi-sensory presentation, algorithm and data, first-person perspective, and the natural user interface) in COVID-19 storytelling?*
> **RQ2:** *What themes do such experiential media stories and the accompanying static news story online cover?*

RQ3: *What new knowledge, if any, do such experiential media stories provide compared to the accompanying static news story online?*

Theoretical Foundations

This study builds on Pavlik's (2018) model of experiential media, which focuses on six primary qualities of the digital environment, namely: (1) interactivity, (2) immersion, (3) multi-sensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) a natural user interface. The EM model provides a framework to understand how EM is transforming the role of the audience to be more of an active user who experiences stories as a participant rather than an audience member who tend to passively watch, listen or read the narrative from a third-person's perspective, i.e., how "experiential media enables the user not just to experience the medium, but also to participate or engage in a story or content itself" (Pavlik, 2018, p. 49).

Methodology

This part of the study was conducted in four steps, namely: (Step 1) to identify immersive news stories (EM stories and the accompanying static news story online); (Step 2) to identify important themes covered by the static online news story that accompanies the EM story; (Step 3) to understand how such EM stories utilize qualities of EM; and (Step 4) to understand what new knowledge such EM stories provide compared to that of the accompanying static online news story reporting on the same topic by the same organization. The study involved line-by-line coding and memo-writing technique (Charmaz, 2014) for data collection and analysis. A line-by-line coding method was used to look for codes and derive important themes/categories from the static online news stories.

> "Line-by-line coding is a heuristic device to bring researchers into the data, interact with them, and study each fragment. Such a coding approach helps to define implicit meanings and actions, gives researchers directions to explore and spurs in making comparisons between data, and suggests emergent links between processes in the data to pursue and check. The codes also illuminate the situations in which these events occur; readers gain a sense of what is happening in this statement and how it happens" (Charmaz, 2014, p. 222).

Further, pullout or illustrative quotes were identified as important data during line-by-line coding and analysis of the static online news story/text. A pull quote, also known as a lift-out pull quote in journalism/media studies, is a key phrase, quotation, or excerpt that has been pulled from an article to highlight a key topic. Further, the memo-writing process was adopted throughout the experience and observation of EM stories – where memo writing constitutes an important method in this study as it prompts the analysis of the data and codes. This process helped define each code or category by its analytic properties, comparing codes and codes, codes and categories, and categories and categories. The Memo-writing

process also helped sort and order codes and categories as part of data analysis. The data collection and analysis of EM stories were conducted between March and May 2021.

Research Tools

This study involved research tools, including an iPhone 12 Pro Max with light detection and ranging (LiDAR) sensor for AR content experience, and an Oculus Quest 2, VR head-mounted display (HMD) with touch controllers and 3D positional audio for VR and 360° video experience. Further, qualitative data in the form of memos were gathered from observation of the AR, VR, and 360° video immersive news content pertaining to COVID-19.

Step 1 - Identifying EM Stories and the Accompanying Static News Story Online

A list of six criteria to identify EM stories (AR, VR, and 360° video immersive news content) and the accompanying static news story online (i.e., non-interactive and without having to be generated, modified, or processed) was developed considering the scope and significance of the current study which includes the role of EM news stories in informing about COVID-19 virus, health risks and precautionary measures. The six criteria include: (1) the news contents should relate to the COVID-19 pandemic, and reporting should involve experiential media as an accompanying storytelling component to the static online news content; (2) the news contents/stories should seek to inform the public on how the virus spreads; (3) the precautions required to protect from getting infected with the virus; (4) should inform about the lockdown during COVID-19; (5) the point of view of first responders; (6) any general guidelines (by the Centers for Disease Control and Prevention (CDC) and/or World Health Organization) on the COVID-19 pandemic caused by the novel coronavirus (SARS-CoV-2).

Three important media platforms were considered for the study to identify EM stories. The platforms include (1) New York Times (NYT), (2) National Geographic (Nat Geo), and (3) Meta's Oculus. The above three media organizations were chosen for the study as they are active producers of EM content production on various journalism beats, including health. Hence as part of this Step 1 of the methodology, a total of six EM stories (two AR stories by the New York Times (NYT), two 360° video stories by National Geographic (Nat Geo), and two VR stories by Meta's Oculus App in collaboration with other media organizations) were identified for the study based on the above criteria.

AR Stories Identified for the Study

The search for AR stories on *New York Times* official website (nytimes.com) revealed 14 AR stories, of which only three were related to the COVID-19 pandemic. Of the three stories, only two AR stories met the study criteria for

selecting news content/stories for this study, as highlighted in Table 1. The two AR stories selected for this study are: (1) 'Masks Work. Really. We'll Show You How', published/produced by NYT in Oct 2020; and (2) 'Why Opening Windows Is a Key to Reopening Schools', published/produced by *NYT* in Feb 2021.

Table 1. List of Augmented Reality (AR) Stories Identified for the Study

Title	Year	Publisher/Producer
Masks Work. Really. We'll Show You How	October, 2020	New York Times
Why Opening Windows Is a Key to Reopening Schools	February, 2021	New York Times

VR Stories Identified for the Study

The search for VR stories on Meta's Oculus App revealed a total of 25 VR experiences, of which only seven VR experiences met the criteria for selecting stories for this study. Of the seven VR experiences, five stories were related to 'Inside COVID-19', a four-part series produced by Meta's Oculus in collaboration with Wisdom VR Project for Oculus Mobile Application. A full-length version of the 'Inside COVID-19' VR experiences/content was available along with the four-part series. Hence the full-length Inside COVID-19 VR experience/content was considered for the study. Meanwhile, the other two VR experiences were related to the 'COVID-19 Mystery', a two-part series produced by Explore Media for the Oculus app. Only Part One of the series was considered for this study based on the broader criteria set for the selection of stories and considering the limit (set by the researcher) to select only two EM stories per EM technology (i.e., AR, VR, and 360° videos) for this study.

The two VR stories (highlighted in Table 2) selected for this study are: (1) Inside COVID-19, produced by Meta's Oculus in collaboration with Wisdom VR Project in Nov 2020; and (2) The COVID-19 Mystery, produced by Explore Media in Dec 2020.

Table 2. List of Virtual Reality (VR) Stories Identified for the Study

Title	Year	Length	Publisher/Producer
Inside COVID-19	November, 2020	35.37 mins	Meta's Oculus in collaboration with Wisdom VR Project
The COVID-19 Mystery – Part One	December, 2020	8.05 mins	Explore Media

360° Video Stories Identified for the Study

The search for 360° videos on National Geographic's official website (nationalgeographic.com) revealed only two 360° videos (highlighted in Table 3) related to the COVID-19 pandemic. Both stories met the criteria and were considered for this study. The two 360° video stories selected are (1) Visualizing the COVID-19 Tragedy – 360, produced by National Geographic in Nov 2020,

and (2) Lockdown Around the World, produced by National Geographic in May 2020.

Table 3. *List of 360° Videos Identified for the Study*

Title	Year	Length	Publisher/Producer
Visualizing the COVID-19 Tragedy – 360	November, 2020	3:14 mins	National Geographic
Lockdown Around the World	May, 2020	7:40 mins	National Geographic

Meanwhile, all the six EM stories identified for this study were produced in the time frame of December 2019 till March 2021.

Findings

Step 2 - Identifying Important Themes Covered by the Static Online News Content Accompanying the EM Story

As part of this Step 2 to identify the important themes covered by the static online news stories/text that accompanied the EM stories (i.e., news content/ immersive experience), a line-by-line coding method was adopted to look for codes and derive important themes/categories from the static online news stories. Based on findings from line-by-line coding and the list of important pull quotes/ illustrative quotes, and from the memo-writing process, a list of codes and their definitions, pull quotes/illustrative quotes (without any names or designations and used only to highlight the importance of the topic), and categories/themes generated from the overall data was created both to present the findings from Step 2 and to guide the researcher in Step 3 and Step 4 of the analysis process. The Codebook (Appendix 1) with findings from Step 2 and Step 3 is included in the Appendix section of this paper.

Findings from Step 2 i.e., thematic analysis of all six static online news stories/text

(1) Masks Work. Really. We'll Show You How

The static online news story/text titled "Masks Work. Really. We'll Show You How," revealed important themes and categories/codes including: Public Debate on masks - to protect oneself and others; Effectiveness of Masks – fighting the pandemic and reduce the transmission; Masks (styles and materials); Materials (woven) such as cotton and other fabrics; Materials (non-woven) - materials N95 masks made of synthetic materials; N95 effectiveness - to reduce respiratory droplets; Aerosols - Coronavirus airborne particles; Filtration efficiency – Woven and non-woven materials used in masks; N95 - electrostatic charge to attract and capture particles; Laws of Physics - influence how particles interact with the fiber; COVID-19 (small particle) - not easy to trap/filter, air molecules, zigzag pattern; COVID-19 (large particles) - easy to trap/filter; COVID-19 (medium size particles) - hardest to trap/filter; N95 filters - at least 95 percent of elusive medium particles

and even large and small particles; Masks (shapes and sizes) defines efficiency; Bad Masks - loose-fitting masks allow aerosols to leak; Good Masks with small breathing zone - tight fit with edges and shape that leaves space around nostrils and mouth; Masks (everyone wearing a mask) increases the combined filtration efficiency; Good Ventilation - reduce transmission of COVID-19; and finally Social Distancing (six feet distance) - reduces transmission of COVID-19.

Illustrative quotes identified from 'Masks Work. Really. We'll Show You How'

Effectiveness of Masks:

"It's become clear that cloth masks, even though they're not as effective as the N95s, are still effective at reducing transmission. Even if you're not achieving that 95 percent reduction, something is better than nothing."

Protecting the Community, and Moral:

"When you wear a mask, you protect yourself, you protect others, you prevent yourself from touching your face, and you signal that wearing a mask is the right thing to do."

(2) Why Opening Windows Is a Key to Reopening Schools

The static online news story/text titled "*Why Opening Windows Is a Key to Reopening Schools*" revealed important themes and categories/codes including:

Concerns and Questions: by Parents and Teacher on School reopening; Quality of Ventilation – in the Public School Classrooms to protect students against the coronavirus; Importance of Building Engineering - specializing in building systems; Pre-COVID Classroom– classroom occupants i.e., 30 students in a classroom; Classroom During COVID-19 – limited classroom seats i.e., nine students; Importance of Wearing Masks - all students should wear typical cloth face masks, facing forward and sitting six feet apart; Lack of Ventilation - With all of the windows closed, the room would lack sufficient ventilation; Protocols - strict protocols in place for reopening schools, and to reduce in-school transmission and classrooms must have windows that open; Social Distancing (six feet distance) - Students must practice social distancing and wear masks; COVID-19 is Airborne - problems with an airborne virus; Masks Not Sufficient - While students wear masks, their breath still circulates and mixes around the room; Virus Transmission In-doors - about 3 percent of the air each person in the room breathes will be exhaled by other people; Asymptomatic - Even students who look healthy may be asymptomatic carriers who can transmit the virus; Infected Students (windows closed) - the student's warm breath as it rises, begins to disperse contaminated respiratory aerosols throughout the room; Infected Students (windows open): The fresh air dilutes the contaminants as they move around the room; Good ventilation - Good ventilation is the most effective and practical way to rid a space of contaminants. Reopening Schools Recommendations - The Healthy Buildings program recommends four to six air exchanges per hour in classrooms through any

combination of ventilation and filtration; Fan and Air Cleaner - increased fresh air blowing into the room and the filtered air coming from the air cleaner help to further dilute the contaminants as they spread in the space.

Illustrative quotes identified from 'Why Opening Windows Is a Key to Reopening Schools'

Transmission of Virus:

> "While we still do not know exactly what level of contamination presents, the greatest risk of infection exposure is a function of concentration and time."

Good Ventilation and Use of Fans and Air Cleaners:

> "Simple and inexpensive measures can make schools much safer."

(3) Inside COVID-19

The static online news story/text titled *"Inside COVID-19"* revealed important themes and categories/codes, including Frontline Workers - working to prepare the emergency departments at hospitals to weather the impending storm/pandemic; Struggles - of Medical, political and societal responses to COVID-19; 3D visualization - 3D animations that reveal the microscopic layer of the virus's spread through the body and our population; Importance of 3D COVID-19 Visualization - A virus is invisible to the eye, but 3D animation is perfect for illustrating exactly COVID-19; Breaking the Fourth Wall - The ability to break the fourth wall (traditional media) and share stories directly with the users using VR; Global Urgency - the global tragedy of the pandemic.

Illustrative quotes identified from Inside COVID-19

Immersive:

> "When a viewer is experiencing a dramatic story in a headset, completely surrounded by hyper-real stereoscopic 360° imagery, this feeling is heightened even further. We make sure that every shot being experienced belongs in the story and is filmed in a way that is heightened by being in a headset. This technique gives us a way to cut through the confusion we all have about the pandemic."

Empathy and Awareness:

> "Many people might not know someone who's been so deeply affected by COVID-19, but after watching our piece you'll come away from it feeling that you do. Our goal is to orient viewers more deeply into the human scale of the pandemic and help them to stay safe."

(4) The COVID-19 Mystery

The static online news story/text titled *"The COVID-19 Mystery"* revealed important themes and categories/codes including COVID-19 - the global pandemic that ranges on unrelenting; Mystery - how some countries rank higher in controlling the pandemic compared to other countries; COVID-19 statistics - The number of COVID-19 cases; Controlling the Pandemic - Factors surrounding the remarkable medical achievements; Solutions - Attempt to bring reduce the COVID-19 crisis.

Illustrative quotes identified from The COVID-19 Mystery
Mystery of COVID-19:

> "How did Thailand rank second only to New Zealand in controlling the spread of Covid-19? We will look at the factors surrounding this remarkable medical achievement and attempt to solve the Covid-19 Mystery of How Did Thailand Do It?"

(5) Visualizing the COVID-19 Tragedy – 360

The static online news story/text titled "Visualizing the COVID-19 Tragedy" revealed important themes and categories/codes, including Art and COVID-19 - How art helps us make sense of COVID-19 incomprehensible toll; Creative and Symbolic Ways - to come to terms with the tragic milestone (COVID-19 Deaths); Art Installations - a field of more than 248,000 white flags rippling in the breeze in Washington, D.C.,— one for each person who has died from COVID-19 in America; Humanizing the Statistics - as the death toll becomes increasingly difficult to comprehend, people across the country, including artists are doing what they can to humanize the statistics and create spaces for mourning; Planting Flags - artists and volunteers have planted roughly a thousand small surveyor flags daily to keep up with the rising number of deaths.

Illustrative quotes identified from Visualizing the COVID-19 Tragedy

Humanizing the Statistics:

> "Look at a single flag. Now conjure up a story. Think of it as a schoolteacher who just lost her life. Try to hold all that grief—and then look up and multiply."

Embodying Grief:

> "People needed a place to come. Even if they couldn't come here physically, they needed an emotional place to understand that their loved one was acknowledged."

Planting Flags:

> "This is my way of saying, We miss you. We are still going to live on, but you're not forgotten. That's why I plant flags every day."

(6) Lockdown Around the World

The static online news story/text titled "Lockdown Around the World" revealed important themes and categories/codes, including Lockdown - amidst the pandemic, many cities and countries around the world went into lockdown, attempting to combat the COVID-19 pandemic; Restricting movements – as an impact of lockdown; Social Distancing – following six feet distance; Worldwide Solutions – lockdown as an attempt to bring down COVID-19 pandemic.

Illustrative quotes identified from Lockdown Around the World

Lockdown:

> "In March 2020, many cities and countries around the world went into lockdown, restricting movement and encouraging social distancing in an attempt to combat the COVID-19 pandemic."

## Step 3 - Understanding How Each EM Story Utilize Qualities of EM (EM Model)

To understand to what extent the six EM stories identified for the study utilize qualities of experiential media (the six qualities identified in the EM model are namely: (1) interaction; (2) immersion; (3) multi-sensory presentation; (4) algorithm and data; (5) first-person perspective; (6) and the natural user interface), each story was experienced using EM tools such as iPhone 12 Pro Max with LiDAR sensor for AR news content production; Oculus Quest 2, a VR Head Mounted Display (HMD) used for VR and 360° video news content experience; and observations were recorded in the form of memos. The EM stories were experienced in a closed environment free of any distraction and examined each story for the six EM qualities (identified in the experiential media model and stated above). A list of important codes; definitions; pull quotes/illustrative quotes; etic/theoretical codes (codes identified in the data that connect to the theoretical foundations of this study, i.e., experiential media model); and important categories/themes from each EM story were noted as part of this Step 3 methodology, and the same has been included in the Codebook in the Appendix section of this paper.

Findings from the Analysis of Augmented Reality (AR) Stories:

Masks Work. Really. We'll Show You How

This AR story published/produced by the New York Times in October 2020 highlights the importance of wearing a mask during the COVID-19 pandemic. This AR story, that can be experienced on a smartphone through Meta's Instagram app, allows the user to take a deeper look at the inner workings of the N95 respirator/masks – where the AR experience provides a magnified view of the synthetic fibers of N95 and how such fibers filters aerosols. The AR experience is

not timed, and the user can switch back and forth between different stages or chapters during the immersive experience. At first, the user is given a quick look at how an N95 respirator looks, along with a description of its high efficiency in filtering microscopic airborne droplets, which can carry the coronavirus. Upon a touch/tap on the screen, the user is given a perspective on the size of an aerosol compared to that of a human, where the text on the screen reads, "if you were a human-size aerosol, you would have to travel through about 1.7 miles of fibers to reach the other side of the N95 respirator." In terms of the EM qualities this immersive experience utilizes, the observations showed that the storyline was from the first-person perspective, as if the user was inside the N95 respirator, exploring the inner workings of the fibers and how it filters microscopic droplets that cause COVID-19. In terms of *immersion*, the researcher observed the 6 Degrees of Freedom (DOF), where the user had an opportunity to walk around (forward and step back) to take a closer look at the fibers and particles inside the respirator and also look up, down, left and right. In terms of the use of *multisensory engagement*, the researcher did not notice any haptic feedback, despite the actual experience requiring a touch/tap on the screen to proceed to the next stage of the immersive journey/experience. The researcher also observed that overall, there was zero latency (i.e., no delay) in terms of consumption of the content; this was possibly due to the advanced LiDAR sensor used in the iPhone 12 Pro Max that has the potential to trigger AR content faster and provide a seamless AR experience. The observation also showed no use of gaze or voice commands as use of a natural user interface. The researcher also did not notice any sound effects or background music, which helped heighten the sense of presence as the researcher was experiencing the AR content in his living space, i.e., where the AR overlays were triggered. Figure 1 highlights screenshots from 'Masks Work. Really. We'll Show You How' AR experience.

Figure 1. Screenshots of 'Masks Work. Really. We'll Show You How' AR Experience
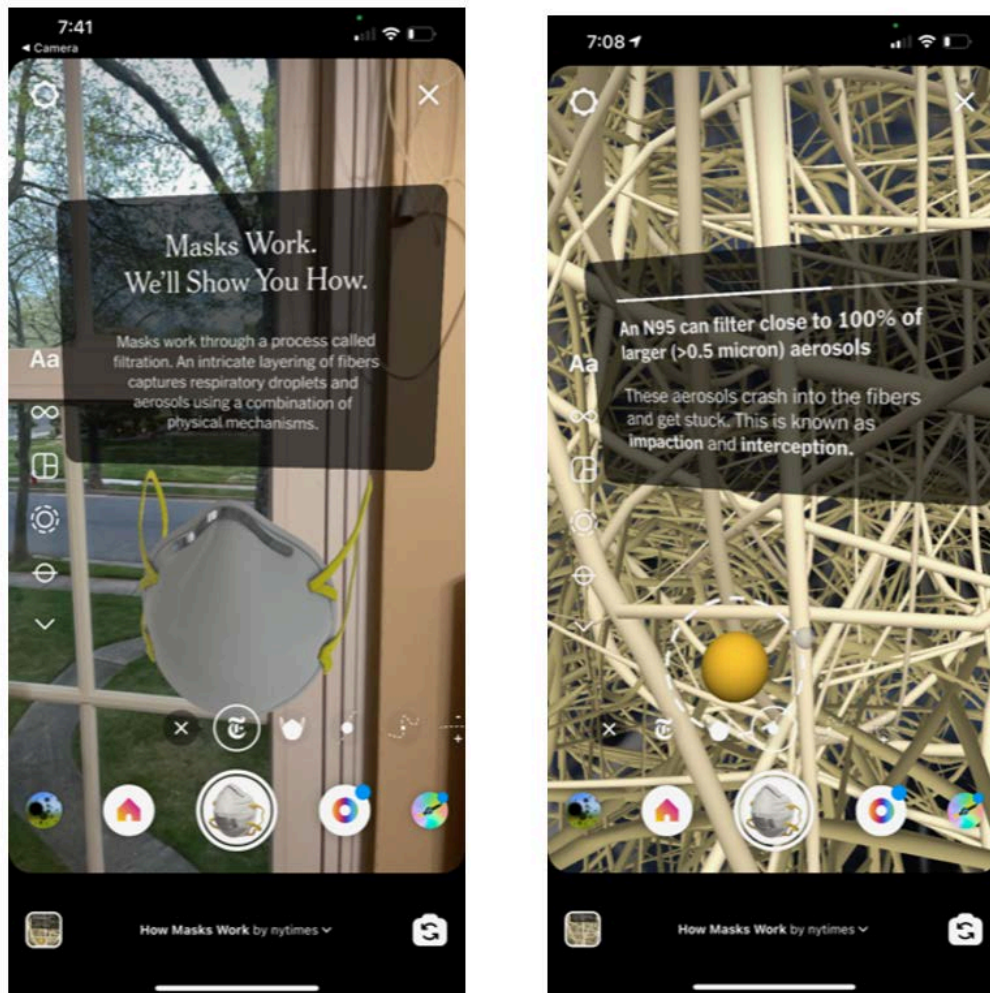

Why Opening Windows Is a Key to Reopening Schools

This AR story, published/produced by the New York Times in February 2021, highlights the importance of ventilation in a classroom during the COVID-19 pandemic. This AR story that can be experienced in the living space of the user on a smartphone through Meta's Instagram app allows the user to step inside a classroom to understand how the coronavirus/contaminants spread indoors. Similar to the 'Masks Work. Really. We'll Show You How' AR experience, 'Why Opening Windows Is a Key to Reopening Schools' is also not timed, and the user can switch back and forth between different stages or scenarios during the immersive experience journey. In this AR experience, the user is shown a simulation of airflow in a real New York City classroom, showing how simple ventilation efforts can reduce the probability of coronavirus exposure. At first, the user, from a bird's eye view, is shown a scenario where the classroom windows are closed. At this stage of the AR experience, the user can see how the contaminants travel with an

infected student's breath. The graphical illustration of the airflow pattern shows how the airflow pattern varies depending on where the infected student sits. In another scenario, the windows of the classroom are kept open, and here due to the fresh flow of air, there is a drastic drop in overall contamination.

In terms of the EM qualities this immersive experience utilizes, the researcher observed the storyline to be from the first-person perspective as if the user was inside the New York City classroom, understanding how the coronavirus/ contaminants spread with windows closed, thereby infecting more students in the classroom, and how with proper ventilation this spread of the COVID-19 can be prevented. In terms of *immersion*, the researcher *observed* 6 DOF, where the user had an opportunity to walk around (forward and step-back) to take a closer look at the classroom, and also look up, down, left, and right. In terms of the use of *multisensory engagement*, the researcher did not notice any haptic feedback, despite the experience requiring a touch/tap on the screen to proceed to the next stage of the immersive journey/experience. The researcher also observed that overall, there was zero latency (i.e., no delay) in terms of consumption of the content. The observation also showed no use of gaze or voice commands as use of a natural user interface. The researcher also did not notice any sound effects or background music, which helped heighten the sense of presence as the researcher was experiencing the AR content in his living space, i.e., where the AR overlays were triggered. Figure 2 highlights screenshots from 'Why Opening Windows Is a Key to Reopening Schools' AR experience.

Figure 2. Screenshots of 'Why Opening Windows Is a Key to Reopening Schools' AR Experience
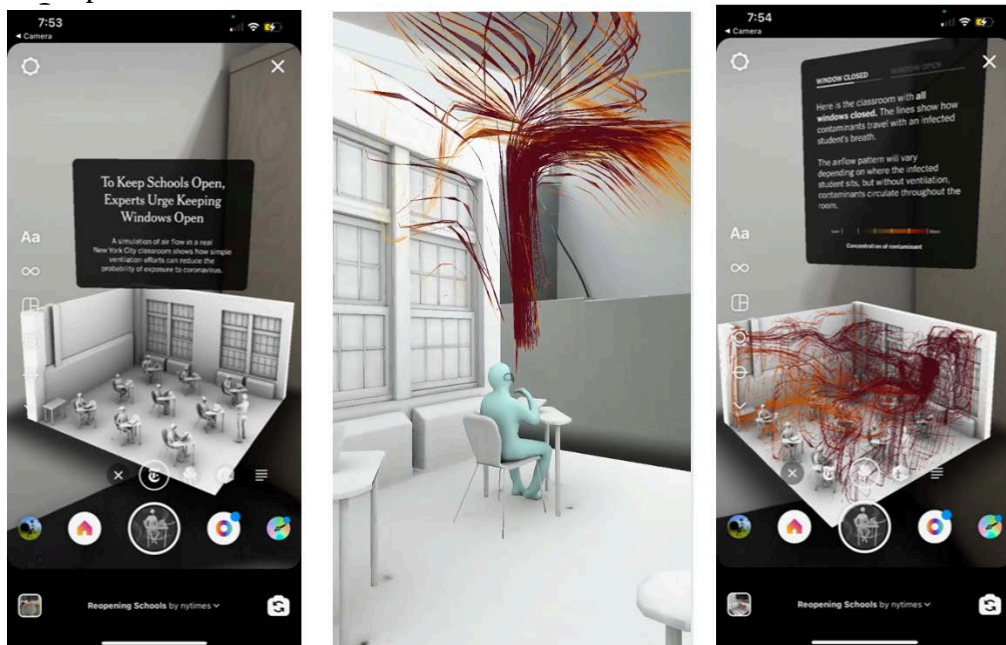
Findings from the Analysis of Virtual Reality (VR) Stories

Inside COVID-19

The VR experience opens with the sound of a person inhaling and exhaling deep breaths and the 3D animation of particles that follow the rhythm of the breath. This scene is followed by a family sitting in their living room watching the news of the COVID-19 pandemic outbreak. The scene transitions to Dr. Josiah Child, a physician and a frontline healthcare personnel whom the VR experience/ content follows as he goes through the challenges of the pandemic and even getting infected. The VR experience uses real-world 360° footage and artistic impression of a novel coronavirus and other graphical illustrations throughout the VR experience. In terms of the EM qualities this immersive experience utilizes, the researcher observed the storyline to be from both the first-person and third-person perspectives narrative. Dr. Child is sometimes seen explaining the gravity of the problem directly to the 360° camera, sometimes making it feel both as if the doctor is talking directly to the user and sometimes from a 3rd-person point of view when the doctor is in conversation with the patients in the care unit and other staff in the hospital.

In terms of *immersion*, the researcher observed that though the actual content is a 360° video with 3 DOF, the sudden movement of the visuals from the birds-eye-view of the earth or the 3D visualization of the coronavirus itself made the researcher feel 6 DOF, although the movement was restricted. In terms of the use of *multisensory engagement*, since the researcher experienced the content on Oculus Quest 2 HMD, the process of viewing the 360° VR content involved the use of haptic-enabled controllers to pause, play, forward, rewind, etc., where the controllers made vibrations (i.e., send haptic feedback every time the controller buttons were triggered). The fact that Quest 2 has inbuilt speakers with 3D sound enhanced the overall immersive experience with a sense of multisensory engagement. Meta's Oculus App with Oculus Quest HMD is the only platform where this VR content can be experienced. The researcher observed that overall, there was zero latency (i.e., no delay) in terms of content consumption. But the observation showed that there was no use of touch, gaze, or voice commands as use of a natural user interface. In terms of the duration of the content, this immersive experience was about 35.37 mins long. The researcher felt the sense of presence heightened through the VR experience and the ambiance sound of the hospital, living room, forests, etc., added to the sense of presence. Figure 3 highlights screenshots from 'Inside COVID-19' VR experience.

Figure 3. Screenshots of Inside COVID-19 VR Experience

The COVID-19 Mystery – Part One

The COVID-19 Mystery VR experience opens with a view of the user as a patient on the bed inside the hospital with friends, and family members gathered around to help the user relieve pain and suffering. The scene transitions to the user on the same bed, but this time with no family members or friends around to talk to; this shows the novelty of the pandemic and the grave threat it poses. The scene gets even more complicated with the hospital room filled with COVID-19 particles and the patient alone in the isolation ward. This transitions to the heart rate and monitors sound danger warnings, and then the patient, i.e., the user, takes the last breath before death. The VR experience shows this as the unimaginable way more than 1.4 million people who lost their lives since the onset of the COVID-19 pandemic. In terms of the EM qualities this immersive experience utilizes, the researcher found the opening few scenarios to be from the first-person narrative while most of the experience/content was in the third-person perspective.

In terms of *immersion*, the researcher observed only 3 DOF. Further, similar to the Inside COVID-19 VR experience, in terms of the use of *multisensory engagement*, since the researcher experienced the content on Oculus Quest 2 HMD, the process of viewing the 360° VR content involved the use of haptic-enabled controllers to pause, play, forward, rewind, etc., where the controllers made vibrations (i.e., send haptic feedback every time the controller buttons were triggered). The fact that Quest 2 has inbuilt speakers with 3D sound enhanced the overall immersive experience with a sense of multisensory engagement. The researcher observed that overall, there was zero latency (i.e., no delay) in terms of content consumption. However, the observation showed that there was no use of touch, gaze, or voice commands as use of a natural user interface.

In terms of the duration of the content, this immersive experience was about 8.05 mins long. The researcher felt the sense of presence heightened through the VR experience and the ambiance sound of the hospital, which added to the sense of presence. Figure 4 highlights screenshots from 'The COVID-19 Mystery – Part One' VR experience.

Figure 4. Screenshots of the COVID-19 Mystery – Part One VR Experience

Findings from the Analysis of 360° Video EM Stories

Visualizing the COVID-19 Tragedy – 360

Visualizing the COVID-19 Tragedy is a 360° immersive video produced by National Geographic in Nov 2020. This 360° video highlights the use of art as a creative and symbolic way to come to terms with the tragic milestone, i.e., 250,000 deaths in the United States due to the COVID-19 pandemic. In terms of the EM qualities this immersive experience utilizes, the researcher observed the storyline to be from the first-person perspective as if the user was present at the art installation and saw the artist and the volunteers updating the installation, i.e., plating of flags to reflect the rising death count, by changing the numbers and adding more flags in Washington, D.C. In terms of immersion, the researcher observed only 3 DOF, i.e., (up/down, left/right, and forward/back), but with different camera angles such as the birds-eye view, ground-level view, and human-eye level view of the art installation.

In terms of the use of multisensory engagement, since the researcher experienced the content on Oculus Quest 2 HMD, the process of viewing the 360° video content involved the use of haptic-enabled controllers to pause, play, forward, rewind, etc., where the controllers made vibrations (i.e., send haptic feedback every time the controller buttons were triggered). The fact that Quest 2 has inbuilt speakers with 3D sound enhanced the overall immersive experience with a sense of multisensory

engagement. This might not be an immersive experience for those who view this 360° content on a smartphone or a laptop. The researchers observed that overall, there was zero latency (i.e., no delay) in terms of content consumption. However, the observation showed that there was no use of touch, gaze, or voice commands as use of a natural user interface. In terms of the duration of the content, this immersive experience is timed and is 3:14 mins long. Using a first-person narrative storyline and the wide array of visual/camera angles made it a memorable virtual experience. This immersive 360° video experience did heighten the sense of presence, considering the use of the first-person point of view. The researcher also noticed the use of the artists' voices in the background (with ambiance sound) explaining their art installation, which makes the user again feel a heightened sense of presence. Figure 5 highlights screenshots from 'Visualizing the COVID-19 Tragedy', 360° experience.

Figure 5. Screenshot of Visualizing the COVID-19 Tragedy, 360° Experience


Lockdown Around the World

Lockdown Around the World is a 360° immersive video produced by National Geographic in May 2020. This 360° video highlighted the impact of COVID-19 in early 2020 when many cities and countries worldwide went into lockdown, restricting movement and encouraging social distancing to bring down the spread of the COVID-19 pandemic. In terms of the EM qualities this immersive experience utilizes, the researcher observed the storyline to be from the first-person perspective as if the user was present with those actual locations witnessing the impact of lockdown. In the opening scene of the 360° video, the user can feel standing on the empty streets and footpath of Times Square, which is arguably the busiest street in the world pre-pandemic. In the later part of the 360° video, the researcher felt experienced lockdown in the first-person perspective in other countries such as Australia, India, South Africa, and Germany. The voiceover of the filmmakers from respective countries explaining the impact of COVID-19 added more to the experience, including additional knowledge.

In terms of immersion, the researcher observed only 3 DOF, but with different camera angles such as the birds-eye view, ground-level view, and human-eye level view of the art installation. Further, similar to the "Visualizing the COVID-19 Tragedy" 360° video experience, in terms of the use of multisensory engagement, since the researcher experienced the content on Oculus Quest 2 HMD, the process of viewing the 360° video content involved the use of haptic-enabled controllers to pause, play, forward, rewind, etc., where the controllers made vibrations (i.e., send

haptic feedback every time the controller buttons were triggered). The fact that Quest 2 has inbuilt speakers with 3D sound enhanced the overall immersive experience with a sense of multisensory engagement. This might not be an immersive experience for those who view this 360° content on a smartphone or a laptop. The researcher observed that overall, there was zero latency (i.e., no delay) in terms of content consumption. But the observation showed that there was no use of touch, gaze, or voice commands as use of a natural user interface. In terms of the duration of the content, this immersive experience is timed and is 7:40 mins long. The use of a first-person narrative storyline and the wide array of visual/camera angles made it a memorable virtual experience. Figure 6 highlights screenshots from 'Lockdown Around the World' 360° experience.

Figure 6. Screenshot of Lockdown Around the World, 360° Experience
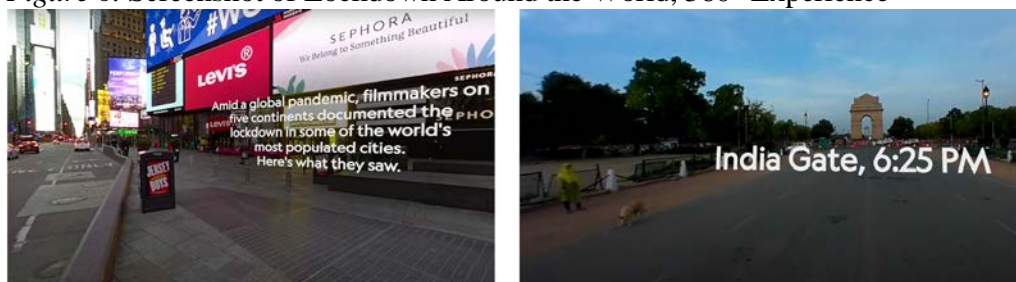
Step 4 - Understanding What New Knowledge Such EM Stories Provide Compared to That of the Accompanying Static Online News Story Reporting on the Same Topic by the Same Organization

To understand what new knowledge such EM stories provide compared to that of the accompanying static online news story reporting on the same topic by the same organization, the researcher experienced all six EM stories again, this time to look for important themes/categories and to identify whether the EM stories provide any new knowledge on the topic reported in the accompanying static online news story. The Codebook from Step 2 was used as a guide for this part of the analysis – where the themes derived from the line-by-line coding scheme, memo-writing, and pull quotes/illustrative quotes gathered from the static online news stories were compared with the findings from Step 3 and to see if such 'themes' were captured in those EM stories as well. This part of the process also helped understand whether EM stories provide any new knowledge compared to the topic reported in the accompanying static online news story. Table 4 illustrates the list of themes/new knowledge EM stories add compared to its accompanying static online news story/text.

Table 4. List of Themes/New Knowledge EM Stories Added Compared to its Accompanying Static Online News Story/Text

	Themes/New Knowledge
Masks Work. Really. We'll Show You How	Effectiveness of Masks; Filtration efficiency; Synthetic fibers; Impaction and Interception; COVID-19 (small particle); COVID-19 (large particles); COVID-19 (medium size particles); ZigZag motion of the particles; Diffusion; Masks (shapes and sizes); Social Distancing.
	Themes/New Knowledge
Why Opening Windows Is a Key to Reopening Schools	Quality of Ventilation; Importance of Building Engineering; Classroom During COVID-19; Importance of Wearing Masks; Lack of Ventilation; Protocols; Social Distancing (six feet distance); COVID-19 is Airborne; Concentration of the Contaminant; Masks Not Sufficient; Virus Transmission In-doors; Asymptomatic; Infected Students (windows closed); Infected Students (windows open); Good ventilation.
	Themes/New Knowledge
Inside COVID-19	Frontline Workers; Struggles; Doctor-Patient Interaction; Emergency Care; National Emergency; For-Profit Health Care Systems; Global Urgency; Protocols; Isolation; Social Distancing and Surviving COVID-19; Lockdown; Ventilators; COVID-19 Testing.
	Themes/New Knowledge
The COVID-19 Mystery	COVID-19; Mystery; COVID-19 statistics; Controlling the Pandemic; Hospitals and Care Units, Doctors, Patients, Isolation, COVID-19 Particles, 3D Visualization; Solutions; Social Distancing.
	Themes/New Knowledge
Visualizing the COVID-19 Tragedy – 360	Art and COVID-19; Creative and Symbolic Ways; Art Installations; Humanizing the Statistics; Planting Flags; Making Numbers Comprehensible; Public Participation; Personalize Flags with Messages, Names; Embodying Grief, Bill-Board with Numbers.
	Themes/New Knowledge
Lockdown Around the World	Lockdown; Feeling of Apocalypse; Economic impact; Not real; Restricting movements; No Public Transports; Hard to find Food and Shelter; Essential Workers; Small Businesses; Daily Labours; Stress; Hope; Social Distancing; Worldwide Solutions.

Discussion and Conclusion

Although the six EM stories captured the main themes reported in their accompanying static news story (text-based news), experiencing the EM stories (with most using the first-person narrative, varied camera angles, and the use of narration to present facts in the background in the immersive content), the researcher observed new knowledge presented at various stages of the immersive experiences and the new knowledge ranged on various topic and added more meaning to the overall stories reported/produced. For instance, the use of the filmmakers' voice as narration, along with the immersive visuals in the 360° video of the lockdown around the world, gave new knowledge in terms of how the lockdown felt like an Apocalypse; the Economic impact; Not feeling real; Restricting movements; No Public Transports; Hard to find Food and Shelter for many including Essential Workers; hardship for Small Businesses; Daily Labours; Stress; Hope; Social Distancing as the only solution. These new insights added more meaning to the overall immersive experience. The illustrative quotes identified during the study also highlighted key themes such as the Effectiveness of Masks; Protecting the Community; and Moral Responsibility; Transmission of the Virus; Good Ventilation and Use of Fans and Air Cleaners; Empathy and Awareness; Mystery of COVID-19; Humanizing the Statistics; Embodying Grief; and Lockdown.

In terms of the use of EM qualities, the majority of the EM stories only used certain qualities of EM and did not include all six qualities, i.e., 1) interactivity, (2) immersion, (3) multi-sensory presentation, (4) algorithm and data, (5) first-person perspective, and (6) natural user interface. These six EM qualities were also noted as etic/theoretical codes during the coding process of EM stories.

In terms of the implications of the current study, considering how EM technologies are transforming media practices, content, and the user experience (as highlighted in the review of literature section) and the fact that EM offers users the potential to visualize and experience challenging topics such as the COVID-19 through the multi-sensory presentation, there is a need for immersive news content producers to more fully utilize the qualities of EM, including the 6DOF with haptics, touch, gaze, and voice commands to enhance the overall immersive experience and inform the users about such health crisis and beyond. Further, in terms of the contribution to the growing scholarship on AR, VR, and 360° video in health communication (Cheng et al., 2022; Singh et al., 2020; Matamala-Gomez et al., 2021), the current study extends the theoretical understanding on the role EM technologies play in health crisis communication, particularly in 3D visualization of complex topics such as COVID-19 to help understand how the virus spreads, the health risks involved, and precautions required to mitigate the spread of the virus.

To conclude, this study provides a better understanding of how and to what extent immersive news content production utilizes the qualities of experiential media in COVID-19 storytelling. The findings also highlight important themes EM stories and the accompanying static news story online offer; and new knowledge such EM stories provide compared to the accompanying text story online.

Future Research Directions

Considering the increasing number of AR, VR, and 360° video immersive news production and to address and potentially overcome communication challenges in future pandemics or any health crisis, there is a need to further explore the role of EM in health communication, including challenging topics such as the COVID-19 communication through participant observation and surveys.

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Appendix

Codebook with the List of Important Codes, Definitions, Pull Quotes/Data, and Important Categories/Themes Identified from Step 2 i.e., Analysis of the Static Online News Stories, and Step 3 i.e., Analysis of the EM Stories

Coding Scheme for Augmented Reality (AR) stories		
Code#	Code or Category/Theme	Description
1	Public Debate	Relating to masks - to protecting oneself and others
2	Effectiveness of Masks	Fighting the pandemic and reduce the transmission
3	Materials (woven materials)	Such as Cotton and other fabrics;
4	Materials (non-woven)	Materials N95 masks made of synthetic materials
5	N95 effectiveness	To reduce respiratory droplets; Aerosols - Coronavirus airborne particles
6	Filtration efficiency	Woven and non-woven materials used in masks; N95 - electrostatic charge to attract and capture particles
7	Laws of Physics	Influence how particles interact with the fiber
8	COVID-19 (small particle)	Not easy to trap/filter, air molecules, zig-zag pattern
9	COVID-19 (large particles)	Easy to trap/filter
10	COVID-19 (medium size particles)	Hardest to trap/filter
11	N95 filters and Masks (shapes and sizes)	At least 95 percent of elusive medium particles and even large and small particles, shapes and sizes defines efficiency.
12	Bad Masks	Loose-fitting masks allow aerosols to leak
13	Good Masks	With small breathing zone - tight fit with edges and shape that leaves space around nostrils and mouth
14	Masks (everyone wearing a mask)	Increases the combined filtration efficiency
15	Good Ventilation or Quality of Ventilation	Reduce transmission of COVID-19
16	Social Distancing	Maintaining six feet distance
17	Concerns and Questions	Relating to concerns and questions by parents and teachers on school reopening
18	Importance of Building Engineering	All students should wear typical cloth face masks, facing forward and sitting six feet apart
19	Classroom During COVID-19	Limited classroom seats i.e., nine students per class (NYC Classroom)
20	Importance of Wearing Masks	All students should wear typical cloth face masks, facing forward and sitting six feet apart
21	Lack of Ventilation	With all of the windows closed, the room would lack sufficient ventilation
22	Protocols	Strict protocols in place for reopening schools, and to reduce in-school transmission and classrooms must have windows that open
23	Asymptomatic	Even students who look healthy may be asymptomatic carriers who can transmit the virus

24	Infected Students (windows closed)	The student's warm breath as it rises, begins to disperse contaminated respiratory aerosols throughout the room
25	Infected Students (windows open)	The flow of fresh air dilutes the contaminants as they move around the room
26	Reopening Schools Recommendations	The Healthy Buildings program recommends four to six air exchanges per hour in classrooms, through any combination of ventilation and filtration
27	Illustrative Quote (Effectiveness of Masks)	"It's become clear that cloth masks, even though they're not as effective as the N95s, are still effective at reducing transmission. Even if you're not achieving that 95 percent reduction, something is better than nothing."
28	Illustrative Quote (Protecting the community, and moral)	"When you wear a mask you protect yourself, you protect others, you prevent yourself from touching your face, and you signal that wearing a mask is the right thing to do."
29	Illustrative Quote (Transmission of Virus)	"While we still do not know exactly what level of contamination presents, the greatest risk of infection exposure is a function of concentration and time."
30	Illustrative Quote (Good Ventilation and Use of Fans and Air Cleaners)	"Simple and inexpensive measures can make schools much safer."
31	Synthetic fibers	Relates to the material/fiber used in N95 masks
32	Impaction and Interception	Aerosols crash into the fibers (materials used in the masks) and get stuck. This is known as Impaction and Interception.
33	ZigZag motion of the particles, and Diffusion	Aerosols zigzag along airstreams because of a principle called Brownian motion. This is known as Diffusion.
Coding scheme for Virtual Reality (VR) stories		
Code#	**Code or Category/Theme**	**Description**
1	Frontline Workers	Working to prepare the emergency departments at hospitals to weather the impending storm/pandemic
2	Struggles	Relates to struggles of medical, political and societal responses to COVID-19
3	Hospitals and Care Units	Relates to hospitals and special care units to treat COVID-19 patients
4	3D Visualization of COVID-19	3D animations that reveal the microscopic layer of the virus's spread through the body and our population
5	Breaking the Fourth Wall	The ability to break the fourth wall (traditional media) and share stories directly with our viewers in headsets guides much of our process in the medium of VR
6	Global Urgency	The global tragedy of the pandemic that filled with urgency that this is a transformative moment.
7	Mystery of COVID-19	How some countries rank higher in controlling the pandemic compared to other countries.
8	COVID-19 statistics	The number of COVID-19 cases

9	Controlling the Pandemic or Solutions	Attempt to bring solutions to the COVID-19 crisis
10	Illustrative Quote (immersive)	"When a viewer is experiencing a dramatic story in a headset, completely surrounded by hyper-real stereoscopic 360° imagery, this feeling is heightened even further. We make sure that every shot being experienced belongs in the story and is filmed in a way that is heightened by being in a headset. This technique gives us a way to cut through the confusion we all have about the pandemic."
11	Illustrative Quote (empathy and awareness)	"Many people might not know someone who's been so deeply affected by COVID-19, but after watching our piece you'll come away from it feeling that you do. Our goal is to orient viewers more deeply into the human scale of the pandemic and help them to stay safe."
12	Illustrative Quote (Mystery of COVID-19)	How did Thailand rank second only to New Zealand in controlling the spread of Covid-19? We will look at the factors surrounding this remarkable medical achievement and attempt to solve the Covid-19 Mystery of How Did Thailand Do It?
13	Doctor Patient Interaction	Communication between doctor and patient
14	Emergency Care	Both inpatient and outpatient hospital services necessary to prevent the death or serious impairment of the health of the recipient
15	National Emergency	Relates to COVID-19 as a Public Health Emergency Declaration
16	For-Profit Health Care Systems	For-profit Health Care Systems or hospitals are investor-owned
Coding scheme for 360° video stories		
Code#	**Code or Category/Theme**	**Description**
1	Art and COVID-19	How art helps us make sense of COVID-19's incomprehensible toll
2	Creative and Symbolic Ways	To come to terms with the tragic milestone (COVID-19 Deaths)
3	Art Installations	A field of more than 248,000 white flags rippling in the breeze in Washington, D.C – one for each person who has died from COVID-19 in America
4	Humanizing the Statistics	As the death toll becomes increasingly difficult to comprehend, people across the country, including artists are doing what they can to humanize the statistics and create spaces for mourning
5	Planting Flags	Artists and volunteers have planted roughly a thousand small surveyor flags daily to keep up with the rising number of deaths
6	Making Numbers Comprehensible	Relates to helping public understand the growing number of COVID-19 cases and deaths.

7	Personalize Flags with Messages	Relates to personalized messages (including name of the deceased and date of death) written on the flags planted as part of the art installation.
8	Bill-Board with Numbers	Relates to the number of COVID-19 deaths displayed on a billboard
9	Illustrative Quote (Humanizing the Statistics)	"Look at a single flag, Now conjure up a story. Think of it as a school teacher who just lost her life. Try to hold all that grief—and then look up and multiply."
10	Illustrative Quote (Embodying Grief)	People needed a place to come. Even if they couldn't come here physically, they needed an emotional place to understand that their loved one was acknowledged."
11	Illustrative Quote (Planting Flags)	"This is my way of saying, we miss you. We are still going to live on, but you're not forgotten. That's why I plant flags every day."
12	Illustrative quote (Lockdown)	In March 2020, many cities and countries around the world went into lockdown, restricting movement and encouraging social distancing in an attempt to combat the COVID-19 pandemic. Five filmmakers documented their cities under lockdown in 360. This is what they saw.
13	Feeling of Apocalypse	Relates to COVID-19 as an event involving destruction or damage on a catastrophic scale
14	Economic impact	Relates to economic impact both national and worldwide due to COVID-19 pandemic
15	No Public Transports	Relates to lack of public transport during COVID-19
Etic or Theoretical Codes (Experiential Media Model)		
1	Interactivity	Interactivity is defined here as a form of exchange or communication dialog between users and the content experience or with others simultaneously (or asynchronously) engaged in the experience, whether remotely or in physical proximity.
2	Immersion	Immersion refers to the envelopment of the user, whether visually, aurally or via other senses (e.g., haptic).
3	Multi-Sensory Presentation	Multi-sensory communication typically takes the form of visual and aural. But with newer VR platforms haptic, or tactile, user engagement is also available. Taste and smell are also possible in a virtual environment although most current VR platforms do not include technology to enable user taste or smell experiences.
4	Algorithmic and Data-Driven	Data-driven AI takes the form of advanced algorithms (programmed instructions or coding) and sensors that track user actions (e.g., gestures, eye movement) and support the generation of an experience with near-zero latency. This means the delay between a user action and a response from the system or virtual experience is imperceptible to the user.

| 5 | First-Person Perspective | First-person perspective means the user enters the virtual experience as if present as a participant or virtual witness to events or experiences. |
| 6 | Natural User Interface | The natural user interface (NUI) means that the user engages the system and interacts using intuitive means of communication, including voice, gesture, touch or gaze (Marcus, 2015). This enhances the user's sense of presence within the virtual environment and enables participation without the need for training, literacy or other more technical means of interaction and experience navigation. |