Disaster Scope

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Project name: Disasterscope
Project owner: Itamiya Laboratory
Release date: 2019
Locale: Japan
Languages: Japanese

URL: https://www.youtube.com/channel/UCXAuPhmD_a0q1Q2f_Qtg0uw/videos

XR medium: AR with Smartphone
Hazards: Floods and Fire
Activity: Training and Awareness Raising
Age group: +8 years, adults

Table of Contents

#1 Project Background

Disaster Scope is an augmented reality (AR) application which contains flooding and fire smoke simulations built by [Itamiya laboratory](), an organisation lead by Dr Tomoki Itamiya, a professor at Aichi University of Technology (Japan). Itamiya laboratory specialise in image processing and computer graphics technology, and have been working in the immersive technologies space for the last ten years.

Demo video
https://www.youtube.com/watch?v=jjuzH-geV8Uo

The 2011 Japan earthquake was the country's most powerful earthquake recorded[1] with a magnitude 9.0 and which also caused floods and a major tsunami. During this event over 300 elementary school-aged children died[2] because they did not realise the risk of the tsunami and floods or they could not escape, although warnings were broadcasted to them (for example radio and TV reports). The children and adults were not able to imagine what a tsunami was like and did not understand the necessity for a rapid evacuation. The case of the Okawa elementary school was particularly tragic as students and teachers died because their tsunami evacuation plan was not defined and the teachers committed negligent acts.[3] After these tragic events in Japan, Dr Tomoki Itamiya decided to focus on developing digital tools for DRR education using smartphones, VR and AR.

Disaster Scope can superimpose a virtual disaster situation such as flooding with debris and smoke in the actual scene where the user is located, by using a smartphone and low-cost paper viewer. With the aim of

1 *https://en.wikipedia.org/wiki/2011_T%C5%8Dhoku_earthquake_and_tsunami*
2 *Japan Times, 2011.*
3 *The School Beneath the Wave, The Guardian, 2017. https://www.theguardian.com/world/2017/aug/24/the-school-beneath-the-wave-the-unimaginable-tragedy-of-japans-tsunami*

improving awareness and people's understanding of disaster risk, the Disaster Scope has been used alongside a one hour DRR lecture in evacuation drills organised by public schools and municipalities in Japan. With an estimated time of three minutes per user experience, up to 500 school students can be trained per day by using a total of ten smartphone + AR viewer kits which are available for purchase or rental from the Lab.

"This is the only application of its kind in the world. We utilised this system in evacuation drills organised by elementary schools and municipalities. As a result of the survey and verification, it is very useful for improving crisis awareness of students and citizens."

Dr Itamiya

#2 Aims & Rationale

Natural disasters occur frequently in Japan and there are systems in place for preparedness. Japan is said to be the best prepared country for earthquakes and tsunamis[4], however the great east Japan earthquake in 2011 was very extreme and many people did not have the crisis consciousness enough to evacuate quickly and safely. In response to this tragedy, the Itamiya Lab developed an augmented reality smartphone-application *Disaster Scope* that provides a unique immersive experience to improve crisis awareness of disasters during peacetime.

4 https://www.telegraph.co.uk/news/worldnews/asia/japan/8375591/Japan-earthquake-country-better-prepared-than-anyone-for-quakes-and-tsunamis.html

Evacuation drills are commonly conducted as traditional disaster education to reduce damage from natural disasters. However participants are not always interested in or committed to such drills.[5] Numerous studies of flood simulations have been conducted, but there is a challenge for ordinary people to understand them, especially for young students. Elementary and junior high schools and local governments host disaster preparedness seminars, using hazard maps and photos of past disaster areas to educate about potential risks. To understand the risk, participants select a house or school from the hazard map, read the depth of the flood, and using a numer-

5 *Tsunami Evacuation Drill System Using Smart Glasses*, 2015.

ical value, calculate the disaster scenario. These tasks are difficult to complete, especially for young students.[6]

Disaster Scope was developed as a smartphone application to respond to the need to train young people in recognising the risks of flooding, even in low level waters under 1 meter. In addition, the app also provides a fire evacuation scenario.

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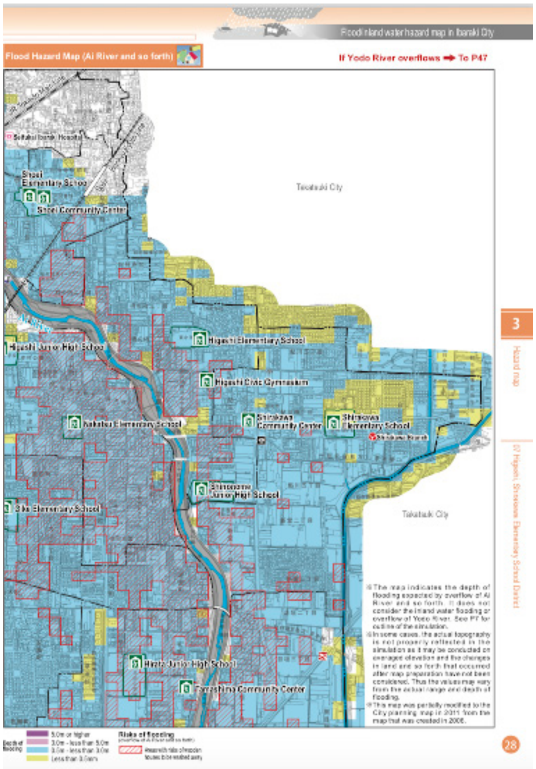
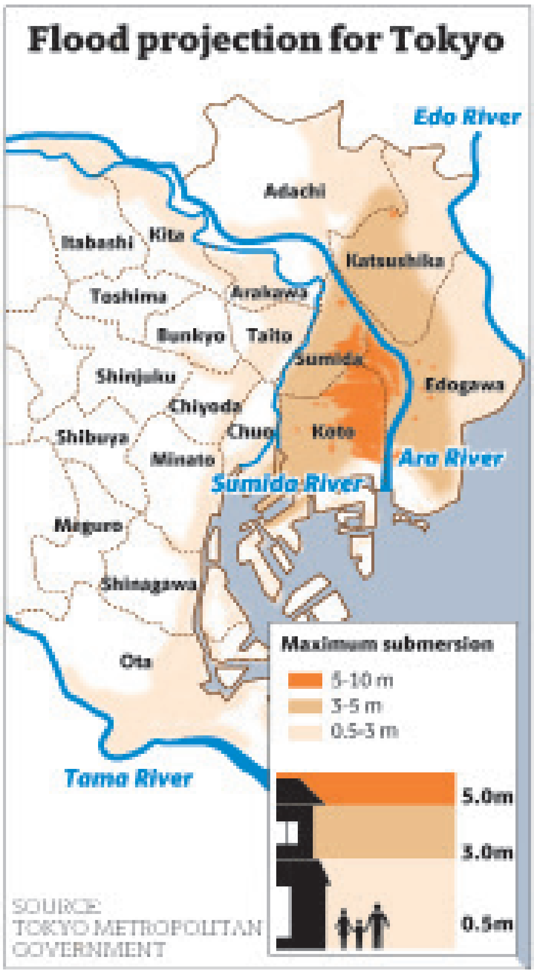
6 *Disaster Scope paper, Dr Tomoki Itamiya*

Examples flood hazard map indicating food depth levels:



Overflow of the Ai river, Ibaraki City Japan.



Large scale flood projection map, source Tokyo Metropolitan Government

#3
Audience

Disaster Scope is primarily aimed at school children over eight, and can also be used by adults. The app has been tested with younger students under seven, however the response observed by the Lab was that the students under 7 could not properly differentiate between fun and risk. Therefore the Lab recommend to offer *Disaster Scope* to +8 year olds.

#4
Experience

Disaster Scope puts the user inside a disaster scenario by using augmented reality to overlay computer generated simulations into the real world. The application can superimpose two virtual disaster situations including a flood situation with debris, and a fire with smoke. To experience the application a smartphone with special 3D scanning technology must be used alongside an augmented reality headset viewer.

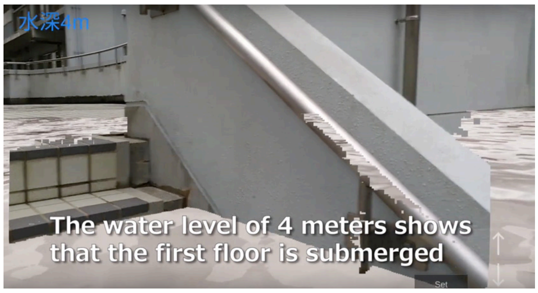
Below is a description of the two main experiences. The average user experience engagement is approximately three minutes.

1 Virtual Tsunami and Flash Floods.

On entering the experience, water in the form of rain and flood is superimposed on the actual place the user is located and water levels start rising. The field of view is about ten meters, and users can also view other people integrated in the scene.

There is a scale to show height in meters which allows to measure the impact of the flood and the flood's height can be customised to increase or decrease water levels through the menu. The user can both experience impact above and underwater. When the user is above water, the water speed can also be controlled through a menu to simulate flash floods, and there are objects and debris impacting with real physical objects, such as tables or walls. This allows for a very realistic view of the disaster.

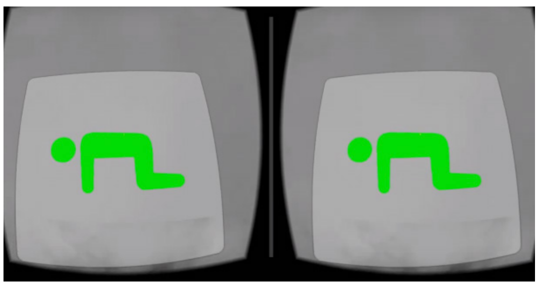
If the water level height is situated higher than the smartphone, an underwater scene appears. This view is coloured in dark red and objects floating around. The water surface can be seen along with the scale by looking up. If the user walks up, for example using a staircase, they can instantly view the point above the water surface and return to the above water scene. This allows for instant understanding of the risk of flooding in the current location.



2 Fire Smoke Scenario

In this scenario, a fire appears and smoke starts filling the room (indoors). The computer generated smoke is superimposed on the image of the real location. Depending on the height where the phone is placed, the density of the smoke changes. If standing up for example, the smoke is dark, very dense and the visibility very poor.

The app prompts the user to go on hands and knees and crawl to escape. When crouching or crawling on the floor the smoke becomes clearer, thinner and the surrounding area can be viewed. Therefore the user understands that the safest way to evacuate is by crawling on the floor.

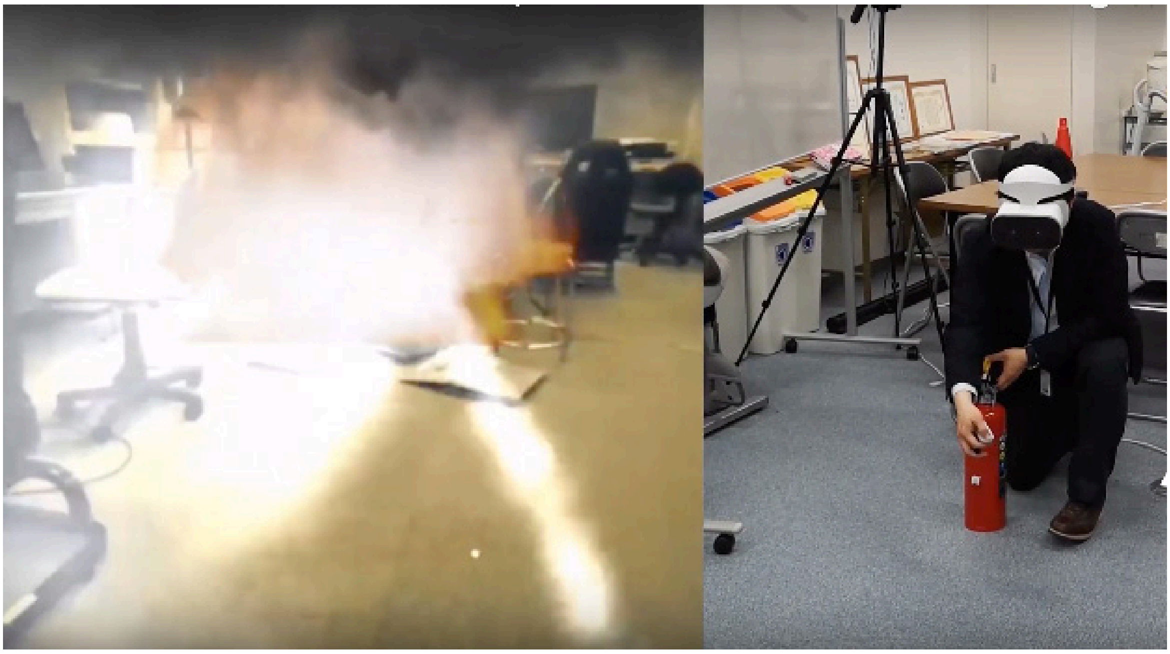


The representation of smoke was created with technical input from firefighters and is based on a video taken by the author of the appearance of smoke indoors at a real firefighter's training room in Kyoto Multifunctional Fire Fighting Centre. The low height of the smoke is 0.7 meters.

A recent test[7] documented by Tomoki Itamiya Laboratory on their Youtube channel shows a new variation of this scene with another headset, the Lenovo Mirage Solo Head Mount Display with Google VR see-through mode enabled. This iteration allows for a more realistic simulation of the smoke on walls and also coming out of specific points as well as including a fire extinguisher simulation using the headset's controller.

7 23 July 2019 *https://www.youtube.com/watch?v=L9LyzZZsLwQ*

Demo video: https://www.youtube.com/watch?v=L9LyzZZsLwQ



#5
Technology

Disaster Scope is an application developed with Unity's game engine which can superimpose a virtual disaster simulation using computer graphics (CG) on the view from a smartphone to reveal floods, debris and fire smoke in the actual scene.

The Itamiya Laboratory selected a specific smartphone the Asus Zenfone AR, which is equipped with 3D depth sensors and is powered with Google Tango (currently replaced by newer code Google ARCore) and Daydream technologies. Using the Tango SDK, this device is able to sense the height from the ground and recognise surrounding objects. One of the goals was to obtain real-time occlusion[8], and it was achieved using the smartphone technology. This means that for example, in the tsunami and floods simulation, users cannot perceive what is beyond the water surface until they reach the right height to be above it.

Other key features that make the simulation more realistic include:

- flooding streams with accompanying drifting objects
- detection of real world objects and collisions with CG debris
- flow speed variations
- rain falling
- smoke and fire propagation

As a result, it is possible to more realistically understand the danger of floods and fire.

Both simulations are recommended with a headset viewer, to allow better immersion in the scene. The Lab's recommended headset is a version of Google Cardboard for AR called Docooler 3D AR, which can be purchased for about 12.99 USD. In the case of the pilots performed in schools, this cardboard headset was chosen as it is easy to use and very affordable.

Dr Tomoki also recommends using the Lenovo standalone headset as the simulation looks more realistic with this device. When wearing a paper viewer and launching this application, the CG smoke is displayed superimposed on the image of the real-time scene. Since the height position of the smartphone from the floor can be precisely sensed from a 3D depth sensor, when standing up, the smoke is very dense and the surrounding visibility very poor. But when taking a crouching low posture, the smoke becomes thinner and the real scene becomes easier to see and users can fully understand how to avoid smoke during a fire.

8 AR Occlusion: *hiding virtual objects behind real things.*

#6
Production & Distribution

Production

Production is managed by Itamiya Labs. This includes mainly work by Dr Tomoki Itamiya, other members of the lab as well as external parties including schools. The laboratory has ten students who are part of the undergraduate programme and contribute to the research and development of the applications.
The Lab provide equipment kits which include Asus smartphones and an augmented reality paper viewer for rental to schools and municipal governments. In some cases school staff can manage the smartphone applications themselves, along with the DRR training lecture, and in other cases Lab members go to the schools to implement the training. The copyright of the app is owned by the Lab.

The Lab has estimated that they can train about 500 students in one day by renting ten kits. This includes DRR training and evacuation drill including both simulations. Schools participating in the experiences have recommended to repeat this training once per year.

Distribution

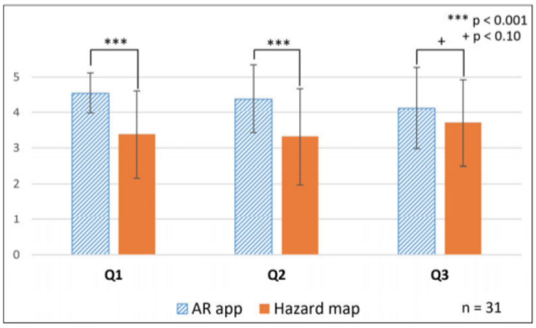
The experiences have been demoed at events such as the Global Platform for Disaster Risk Reduction organised by the UN Office for DRR.

The Lab are partnering with NTTDocomo to release and license the application for schools and local governments. The cost for a single license is about 1500 USD plus the cost of the devices - approximately 500 USD. Another option is the rental service in collaboration with NTTDocomo which offers a single kit daily rental for 200 USD, or a set of ten units for a cost of 1500 USD per day.

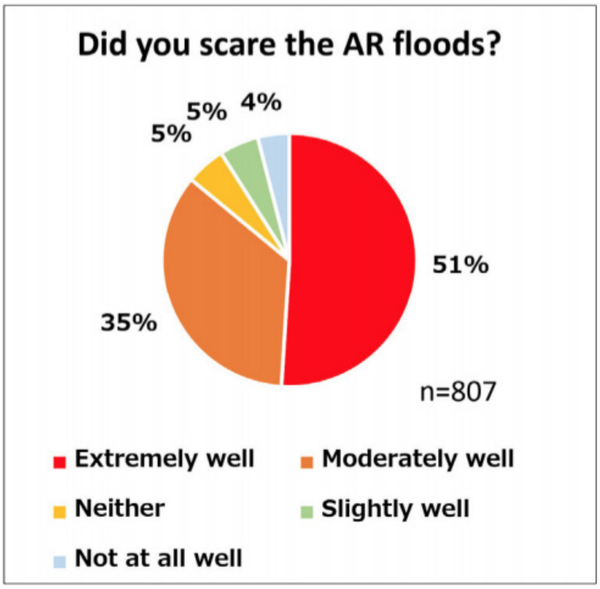
#7
Outcomes and Future Planning

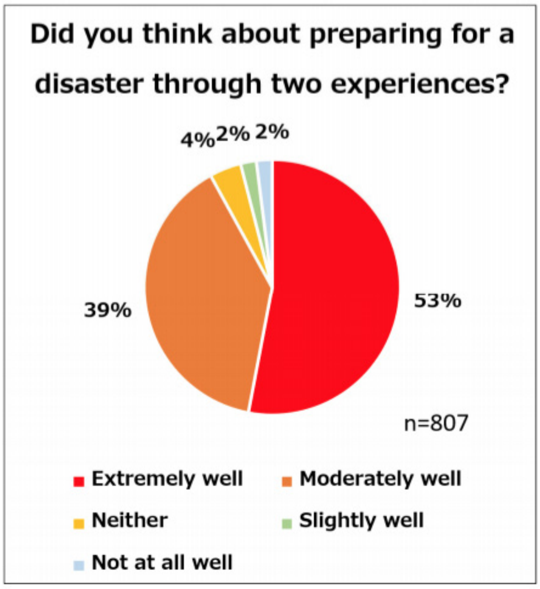
Evaluation

The Itamiya Laboratory have conducted a series of pilots in several schools and municipal governments in Japan, as well as one pilot was tested in Samoa. A survey was made to assess the impact of the drill evacuation training on 807 people aged seven to 70 in elementary and secondary schools, as well as during disaster prevention events sponsored by the municipal governments. Results include:



Contents of question	
Q1	Did you accurately understand the floods depth?
Q2	Did you feel a sense of crisis due to floods depth?
Q3	In the event of an earthquake or heavy rain, will you think about evacuating yourself by thinking of tsunamis and flooding?





- The experiences produced a high level of impact however 51 per cent of users were frightened. Further investigation should be done regarding the response amongst age groups.
- The experiences meet the goal of raising awareness of preparedness with 94 per cent of respondents saying they would think of preparing for a disaster after completing the experience.
- The experiences perform better than a hazard map, as shown on the right hand graph. In particular, users respond better to understanding floods depth and provoking a sense of crisis due to the flood depth.

Future plans

The Lab would like to spread this education programme worldwide. In Geneva they demoed the experience and got interest from organisations globally. Currently the interface is only in Japanese, however it was also piloted in Samoa at an elementary school. Since the application is not text heavy it would not need much language customisation. However the educational curriculum would have to be localised.

The Lab are also developing a VR experience for earthquakes. Some early stages of this experience are published on the Lab's Youtube channel. The VR experience shows an earthquake simulation, which can be experienced using the Youtube 360 / Stereoscopic simulation with Oculus Go. For earthquake simulations they have decided to use VR rather than AR, as it is very difficult to replicate the motion of an earthquake in AR. However Dr. Tomoki thinks in the near future (one to two years), if pictures of a location are taken with the phone and then animated, AR would be possible for earthquakes. For this to happen AR libraries would have to develop new features.

Through the Lab resources, all their applications are being developed and researched using the latest technologies and following academic practices.

#8
Internal Evaluation and Learnings

Process

There are benefits in working within an academic environment: to generate partnerships with schools, governments and commercial brands; to use internal resources to generate research; and to develop applications in a cost effective way.

Involving schools and local governments was a strength in developing the application, getting feedback from this range of stakeholders as well as distributing it to them.

Responding to an actual need highlighted by a disaster killing school students means that the experience will be tailored to actual needs and gaps identified. This ensures the technology is working towards an identified gap in traditional methods of DRR education. In the case of the floods simulation, awareness of the depth of a flood was one of the achieved results.

Design

The design of *Disaster Scope* is simple and its strength lies in the power of the disaster simulation. Even a simple design can provide a high level of efficiency given that the simulation is overlaid in the users' actual location. It tackles some of the most important shortcomings of traditional flood drills including showing a simulation of the flood in the exact location with a scale to assess how the surrounding woul be affected. The design of the application does not respond to the question of what to do, but it effectively illustrates what is happening. The interpretation how to act during the crisis situation is provided by the DRR lecture, which can be targeted to different audiences, including students, teachers and other adults.

Product and features

The application does not offer additional learning features above and beyond experiencing the flood or smoke in a realistic way, therefore the content of the accompanying lecture is key to reinforce the learning element, and provides children with more resources to be equipped for responding to disasters.

Both experiences provide a very efficient and realistic view of the disasters:

- The flood experience shows the scale at all times, providing an instant and efficient reference to users of the impact of the flood.
- In the case of the fire, the use of realistic smoke with layers from top being thicker to bottom being lighter allows the user to get a sense of the reality of a fire and how to escape.

Survey results indicate that the augmented reality version of the app provides a more realistic picture of the flood depth than the traditional hazard map. This is a great achievement given that during the 2011 disaster this was one of the key reasons why people were not able to save their lives. It is expected that this training would allow people to be safe during crisis, however there is no evidence of this recorded yet given how new the experience is.

Content

The realism of the simulations, combined with the use of the real location make the experience highly effective in achieving its goal of raising awareness of the disaster. This means that the app can be used in any location and it will always be customised to that location. The use of simple visual messages, such as the scale and the crawling alert, make it very simple for users of all ages to understand. However the lack of guidance in the experience and the lack of targeted learning features makes the project difficult to understand without the accompanying lecture.

In the case of the fire evacuation experience, the main learning presented was simple and effective, to train children that below the fire there is a safe route to escape by crawling. However there is no evidence that this goal has been achieved.

Scalability

The rental system is an innovative approach to provide an affordable system which is suited to schools and government to allow them to focus on training rather than maintaining the technology. With the estimated 500 students per day of training and the cost of 1500 USD for rental, the cost per student works out as 0.33 cents. This is expected to be considerably cheaper than physical disaster simulations in Japan.

In order to scale up the distribution of this simulation to other countries, translation into other languages would be required. However the computer animations would not have to be localised as they can overlay on any scenario. This would save cost in relation to other XR media like 360 video which is more resource intensive to localise, as the content is filmed in a specific location.

Effectiveness

The results from the customer surveys showed that using the application was useful in the context of improving awareness amongst students and citizens. However further evaluation would have to be performed to identify the potential opportunities and challenges of the experience.

Key Learnings of Relevance for SBDRR

- The potential of augmented reality for SBDDR is immense and is yet to be discovered.
- AR can come with limitations to knowledge acquisition. The immersive experience will not achieve all the desired learning goals. Any immersive experience is recommended to be used alongside a curriculum module in which students can learn and retain DRR knowledge.
- Given that augmented reality technology overlays virtual content on the location where is played, it can make the experience highly scalable, and can fit any specific location, by simply using a smartphone and an affordable paper headset.
- Language customisation is necessary for full scalability.
- AR is effective and impactful but should be used with caution as the high level of realism can be frightening, particularly for younger audiences. Further investigation is recommended to assess the impact of this experience in relation to a control group.
- The age groups have to be considered carefully when showing disaster content, as it can trigger traumatic experiences. More research is needed to assess the impact of disaster simulations on all age groups, as well as on sensitive groups who have already experienced trauma.
- Simplifying the experience's features to the minimum can be very effective in achieving targeted goals. For example in the fire evacuation training, children learn to evacuate the premises by crawling.
- Teachers have to be targeted as much as students, particularly given that they are responsible for managing the students during crises. Further research is required on how to best target teachers.
- Offering flexible distribution options to schools such as the rental service could be very beneficial model for schools and local governments. This method takes away the difficulties of updating and maintaining the technology, whilst saving costs per trained user.
- Working with academic research groups could be beneficial to pilot test experiences that could further developed and be scaled following extensive user testing.
- A commercial partnership with a technology provider might be beneficial to scale the project as well as to maintain the technological standards and maintenance.
- In approximately one to two years, the augmented reality technology tested in this experience is expected to become more powerful, affordable and available at a wider scale. This will be an immense opportunity to further investigate and develop new lines of work.

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