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# Information technology for learning, education, and training — Immersive content and technology



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# Contents

Page

# Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 36, *Information technology for learning, education, and training*.

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# Introduction

In recent years, many people have widely spoken about virtual reality (VR) and augmented reality (AR). As the terms have not yet been standardized, media and IT companies use various words such as VR, AR, and mixed or merged reality (MR). This document refers to VR and AR as immersive technologies.

Immersive technologies are now becoming popular. At an early age, it grew in the entertainment industry, such as games, but now it is expanding its scope into education and training. Various standardization organizations have also begun to study the standards required for 360° video, virtual environments, and rendering technologies and the problems associated with using these technologies.

Due to the sense of immersion and practicality, immersive technology in the learning, education, and training (LET) domain is expected to improve learning efficiency. At the same time, however, there are some concerns, such as the age of the device's available use and VR sickness or fatigue. It is essential to consider several issues carefully, as some problems can have a more severe effect when applied to the education sector.

Immersive technologies are emerging technology addressing a diverse group of stakeholders and covering a wide range of applications. The following issues were identified and captured as general requirements for Immersive content and technology in the LET domain.

— Human factors guideline for the utilization of VR and MR content

— A catalogue information model for the utilization of VR and MR content

Therefore, this document gives a trend and outlook description of the immersive technology related to LET. This document specifies the understanding of immersive technology implications of using immersive technologies; and provides suggestions for items that could be standardized.

# Information technology for learning, education, and training — Immersive content and technology

## 1 Scope

This document specifies potential directions for using immersive technologies in learning, education, and training (LET) and provides suggestions on what can be standardized for this purpose. For the purposes of this document, immersive technologies include augmented reality (AR), virtual reality (VR), mixed reality or merged reality (MR).

This document does not apply to technologies such as metaverse, digital twin and extended reality (XR).

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

**3.1**
**virtual reality**
artificial environment presented using computer technologies

Note 1 to entry: Virtual reality has a high level of immersiveness, fidelity of information representation, and degree of active learner participation compared to other forms of mixed reality.

[SOURCE: ISO/IEC TR 18121:2015, 3.6]

**3.2**
**mixed reality**
display continuum in which both real and virtual images are combined in some way and in some proportion

Note 1 to entry: Augmented reality (AR) and virtual reality (VR) are considered to be on the mixed reality continuum

**3.3**
**immersive technology**
tools that enable the integration of virtual content and the physical environment in a manner that supports user engagement with the resulting blended reality

Note 1 to entry: Some types of immersive activities and experiences include virtual reality, augmented reality, pervasive games, digital twins, telepresence, and holography.

Note 2 to entry: Supportive technologies that are used to support these activities and experiences may include a combination of different items such as speech recognition, haptics, cameras, 3D displays, headsets, audio, gesture recognition, omnidirectional treadmills, etc.

**3.4**
**augmented reality**
virtual objects superimposed upon or composited with the real world

Note 1 to entry: Virtual and real-world objects co-exist in augmented reality systems.

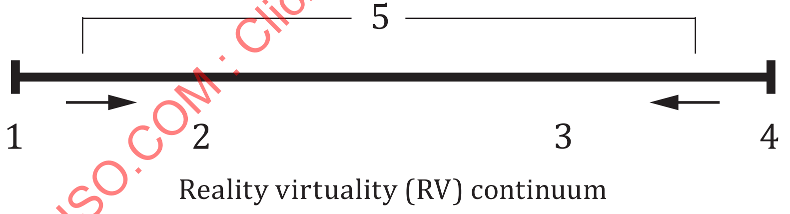
# 4 Abbreviated terms

| | |
|---|---|
| AR | augmented reality |
| AV | augmented virtuality |
| HMD | head mounted display |
| LET | learning, education, and training |
| MR | mixed reality or merged reality |
| VR | virtual reality |

# 5 Understanding immersive technology

## 5.1 Immersive technology

The Virtuality continuum represents all the technological possibilities between the real and virtual worlds, as shown in Figure 1.[10] The space in between these two extremes could characterize as MR. At the two ends of the sub-continuum making up this mixed reality are the AR (closer to the real environment) and AV (closer to the virtual environment). Adding elements of virtuality to the real world is the nature of AR, while adding elements of the real world to virtuality is that of AV. Immersive technologies integrate virtual content into the real environment by leveraging these technologies (AR, VR, MR) to allow users to participate in mixed reality naturally.




**Key**

1 real environment
2 augmented reality (AR)
3 augmented virtuality (AV)
4 virtual environment
5 mixed reality (MR)

**Figure 1 — Simplified representation of a RV Continuum[10]**

## 5.2 Industrial trends and outlook

### 5.2.1 Market trends and outlook

According to Gartner's Hype Cycle report,[5] which analyzes the development and maturity of various emerging technologies, AR and MR technologies have entered a "difficulty of disillusionment" as of

2018. These technologies are poised to become part of mainstream technology within the next 5 to 10 years. Gartner predicts that MR will outperform AR and VR in terms of technology, and MR will be an essential interface technology connecting humans and machines. Their report, published in 2022,[4] predicted that metaverse, based on immersive technologies such as AR and MR, would become the mainstream technology, which entered the innovation trigger stage.

Related industries are also still growing, and many new players have appeared in this field. According to an estimate by Goldman Sachs, AR and VR are expected to grow into a $95 billion market by 2025.[13] Today's most sustainable demand for technology is in the gaming, live events, video entertainment, and retail industries, but over time, applications utilizing immersive technology will emerge in various areas, such as healthcare, education, the military, and real estate.

### 5.2.2 Standardization trends of ISO and IEC

The VR and MR related standards are usually in the purview of ISO/IEC JTC 1/SC 24 (Computer Graphics, Image Processing, and Environmental Data Representation) and ISO/IEC JTC 1/SC 29 (Coding of Audio Picture, Multimedia, and Hypermedia Information). VR and MR applications relating to LET come under ISO/IEC JTC 1/SC 36 (Information Technology for LET). Recently, through the cooperation of ISO/IEC JTC 1/SC 24 and ISO/IEC JTC 1/SC 36, ways to utilize immersive technology in the field of education have been discussed.

### 5.2.3 *De-facto* standard organizations

The IEEE and Khronos group are the two leading organizations associated with de-facto standards on VR and MR technologies.

The IEEE P2048[6] is developing 12 standards for VR and AR. They are working on standardization with a focus on the technical side. IEEE P3079[7] is setting technical guidance to resolve VR sickness caused by the visual mechanism of the head-mounted display (HMD).

The Khronos Group also released a VR Initiative called OpenXR™1) (open standard for virtual and augmented reality).[8] First, the Application Interface, which application developers and middleware providers write to, and which serves to define and combine common, cross-platform functionality. OpenXR™ enables application developers to write code that will run everywhere, focus on innovating in their applications, and not have to support multiple interfaces for various devices. Next, the device layer allows VR/AR runtimes to interface with various devices. If a hardware manufacturer wants to add support for a new device, they implement code that conforms to the device layer specification, and their hardware will be immediately compatible with the applications written for the application layer.

# 6 Implications of immersive technology in LET domain

## 6.1 Prospect of immersive technology in LET domain

As the Fourth Industrial Revolution (Industry 4.0) progresses around the world, attempts to introduce new technologies such as robots, VR, and artificial intelligence (AI) into learning, education, and training are growing. The educational content market is only a fraction of the VR and MR markets. But someday, when devices are available at a large scale, investment in learning, education, and training applications using immersive technology will increase, driving the entire industry's growth.

The role of VR in the LET domain enables activities that are difficult to experience in the real-world (airplane piloting, surgery, archaeological experience, etc.,) which can be classified as personal experiences.[2] In contrast, multi-user accessible VR environments help design active learner-centered teaching and learning strategies such as problem, project, and game-based learning[11]. VR technology is positioned as an educational tool to create immersive environments, driving learner-centered, experiential, and collaborative learning. Additionally, immersive technologies such as VR can provide

1) OpenXR™ is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.



another opportunity for students with disabilities. It has proven to be an effective complement to traditional learning methods and provides an essential bridge between theory and practice[3].

These new technologies comprise real and virtual combined environments and human-machine interactions generated by computer technology and wearables.

## 6.2 Types of immersive content

### 6.2.1 VR-based content

Content using virtual reality could divide into content created by 360° images and content made by 3D simulations. Most VR-based content types are played through a see-closed HMD.

— **Content created by 360° images**: Panoramic pictures or moving images that capture objects in all 360° is used. This type is primarily used for virtual tours of places that are not easily accessed due to locations and time limitations. These could most fruitfully apply to social studies or science. 360° images containing actual landscapes could make students feel as if they had been transported into those places. Creators also show only the intended images and thereby maximize the presence of the experiences by fixing the target user's vision to the camera. This type has the merit of cost relatively. Also, it is possible to play on common mobile devices.

— **Content by 3D simulations**: With authoring or graphics tools in the computer, it could place 3D objects in virtual simulated spaces. It could represent spaces like ancient cities and future worlds that don't exist. Creators enable greater freedom in users' eyes and body movements. As this is more costly than 360° image content, it primarily utilizes in-game and entertainment fields that could generate profits. A user needs a computer-based device with high specifications to try this content.

### 6.2.2 AR-based content

AR-based content includes marker or image recognition, location-based service (LBS), and projection type. Because this content overlays the real world with virtual objects, they require the use of a mobile device or the see-through device.

— **LBS content**: global positioning system (GPS) and/or gyroscope sensors, images showing gathering and identifying user locations. This type is mostly found in an advertisement, marketing, and entertainment. A leading example is Pokémon GO[2] which requires active movements of users. Teachers or schools can use this technology for field trip activities.

— **Marker or image-recognition content**: The cameras mounted on the display devices recognized given markers or images to display additional information by overlapping those. Most of these are in the form of AR cards or AR books. This technology is used to project onto images not only to show data in textbooks or relics at museums but also to help little children learn the alphabet and vocabulary.

— **Projection-type content**: Small projectors mounted on display devices project images directly onto users' retinas or eyeglasses to display the intended images. Since it needs high costs to implement the devices required for use, few contents have developed so far. Recently, various companies have been investing in the development of these types. It could use for sharing the same content in the classroom or auditorium for many students.

### 6.2.3 Education beyond the constraints of time and space

Even in school, students could experience various sites and places they could not normally visit due to time and money constraints. In science, abstract concepts such as observing the impact of a hurricane or getting an up-close view of how blood moves through veins are now possible. Concerning geography

2) Pokémon GO is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC of this product.



and culture, students could seamlessly move from one virtual city to another, taking in the sights and sounds of a historic site or natural wonder.

Immersive technology could bridge the gap between students. The sick children in the hospital who cannot attend school classes could participate in classes as if they were together in the classroom. It is possible to experience various occupations, even in the countryside, where there are not diverse career groups.

In the K-20 education and training field, there are many use cases for complex tasks such as a turbine or car assembly. In the past, it took much time to learn assembly, but now complex assemblies can efficiently work out with an AR guideline spread out in front of them.

### 6.2.4 Higher emotional engagement

VR could deliver higher emotional engagement to learners. The exhilaration of walking on the moon or traversing the deadly trenches of World War I could elicit an emotional response far more in-depth than any movie ever could. According to the studies measuring biometric eye-tracking, electrodermal response, and heart rate changes, Nielsen found that VR users had a 27 % higher emotional engagement than the content provided with the two dimensions of traditional video.[15]

### 6.2.5 Self-directed learning

To learn through VR/AR experience could be seen as a reasonably active information activity, i.e. a learning activity, in that the user directly selects what they see rather than viewing a single image. The learner could choose many things from VR and AR-based learning, which means the key to learning pass on to the student rather than the teacher. The advantage of self-directed learning is that, regardless of their level, they would feel a sense of challenge and accomplishment and improve their skills as they could.

## 6.3 Issues about immersive technology

On the other hand, new technologies leave room for questions such as whether they are suitable for children or whether there is an educational benefit. It is essential to analyze the causes and solutions of the issues carefully before adopting them in education, considering the unknown side effect of new technology.

### 6.3.1 Age of use

There are many devices available now, but few devices for children. In particular, the tools used for the quality of content, such as also specify the use under adult supervision. They do not state why. Some articles cited that children are still in their mental and physical growing stage, and they could be affected more than adults. Someone mentioned that the distance between each eye is the factor.

Apart from the device, we also consider the age ratings for content. Most of the material has been created for gaming and entertainment purposes, and ratings have not yet matched for educational purposes. Recently, the education category was added content and has begun to specify age. Some companies are making content based on the curriculum. These situations expect to see more content suitable for education in the future.

### 6.3.2 The effect on the body or/and mental/emotional

There are concerns about photo seizures, fatigue in the eye, dizziness, and musculoskeletal disorders. Several institutions conducted experiments.[1][14] They tested the user's vision, stereoacuity, sense of balance, and so on compared to the past after spending 20 minutes looking at the content. There was nothing unusual about vision, but we were able to see that partial things of participant's stereoacuity and sense of balance had a gap.[14] According to the study,[1] extended use of high-end HMDs has beneficial effects on preteen's vision and, in some cases, improves kids' myopia or hyperopia. According to some studies,[9,12] it is mentioned that the utilization of HMD-based VR content can cause significant visual fatigue, and further research is needed to confirm the visual impact of using VR devices from a long-term perspective.

Reset syndrome is a delusion that could start over again in real life, such as when the computer malfunctions and presses the reset button. This state is due to a lack of distinction between virtual and real. Because the virtual world is not real, that could prevent wrong behaviour such as violence or profanity while using content. Also, acts in the virtual world (for example, jumping from a high place) could happen in the real world because of not distinguishing between virtual and reality. This phenomenon could be a fatal problem for young children with immature cognitive abilities.

### 6.3.3 Ambiguity regarding how to use AR/VR/MR in LET

People who want to use AR and VR in education are not usually technical experts, so they do not have enough understanding of the equipment. The following were considered to be confusing:

— Which content is available in the actual class?

— Smartphone-based, console-based, PC based on the type of products, features, and budget, and would like guidance.

— Guidance needed on safety education for virtual reality through consideration of students' grades, age, and prevention education methods for addiction.

— Consider the relationship between educational goals and content. AR and VR technologies cannot be considered suitable for all subjects.

— What considerations are taken when creating educational content? For example, when shooting a student with a 360° camera, how should the camera location or editing point be handled?



## 7 The items for standardization to suggest

Immersive technology devices and content are so diverse that standardization is required for application to education. Given the speed of development of immersive devices, the hardware area is expected to become increasingly standardized, and this document proposes a standardization element in terms of immersive content.

— Human factor guidelines for AR and VR content in LET;

— Interaction model in AR and VR content for educational usage;

— Cataloguing models that bring together the curriculum and AR/VR learning resources;

— Packaging standards for adding AR and VR content to existing learning platforms;

— Learning analytic systems that reflect the use of AR and VR content, etc.

However, given the past activities and the trends of other standardization organizations, the following focused on two themes. The following categories are the things to be needed standardization before applying AR and VR for in the field of education:

### 7.1 Human factor guidelines for VR content in the LET domain

Practical and granular guidelines are needed to apply AR and VR technology to education. The guidelines will help you make the most of your AR and VR skills in education. Guidelines may include:

— Things to consider before proceeding with VR, AR-based lessons (how to effectively check the learner's health condition, Considering hygiene, etc.);

— Appropriate length or recommended time by content type;

— How to educate or prevent addiction or ethical issues based on learner's ages or grade;