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Overview of Virtual Reality Technology and Equipment

Tutorial

VR4VET Consortium | 2024

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Overview of Virtual Reality technology and equipment

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Summary

This tutorial provides an overview of various aspects of Virtual Reality technology from the hardware point of view.

The tutorial is designed for adult learners who do not necessarily have technical or engineering background.

After completing this tutorial, the learners will be able to navigate among the brands and models of modern Virtual Reality equipment and be aware of the setup, configuration, and maintenance processes.

Learning objectives

- Be familiar with the modern Virtual Reality equipment
- Be familiar with the setup and maintenance processes
- Be familiar with the

1. Virtual Reality glasses

All of the following headsets require some sort of account to be used.

Meta Quest 2

Good cheap alternative for consumers, not optimal tracking and graphics, but still good.

Producer: Meta
Release year: oct. 2020
Resolution: 1832 x 1920
Frame rate: 70-120
Connection method: wireless or wired
Other notes: standalone OS, built-in app marketplace
Price: €249.99

Meta Quest 3

Newest model as of 20204, a standalone quest headset, more expensive than Quest 2, but has a much better resolution, field of view and framerate. Quest 3 is also more compact and compact compared to Quest 2.

Producer: Meta
Release year: oct 2023
Resolution: 2064 × 2208p
Frame rate: 90-120
Connection method: wireless or wired
Other notes: standalone OS, built-in app marketplace, 110° FOV

Price: €549.99

Meta Quest Pro

Very expensive “luxury” headset by Meta, good specs and very comfortable, but not necessarily better than Quest 3 although it is quite comfortable. Rechargeable controllers are a plus.

Producer: Meta
Release year: oct 2022
Resolution: 1800 x 1920
Frame rate: 72-90
Connection method: wireless or wired
Other notes: standalone OS, built-in app marketplace

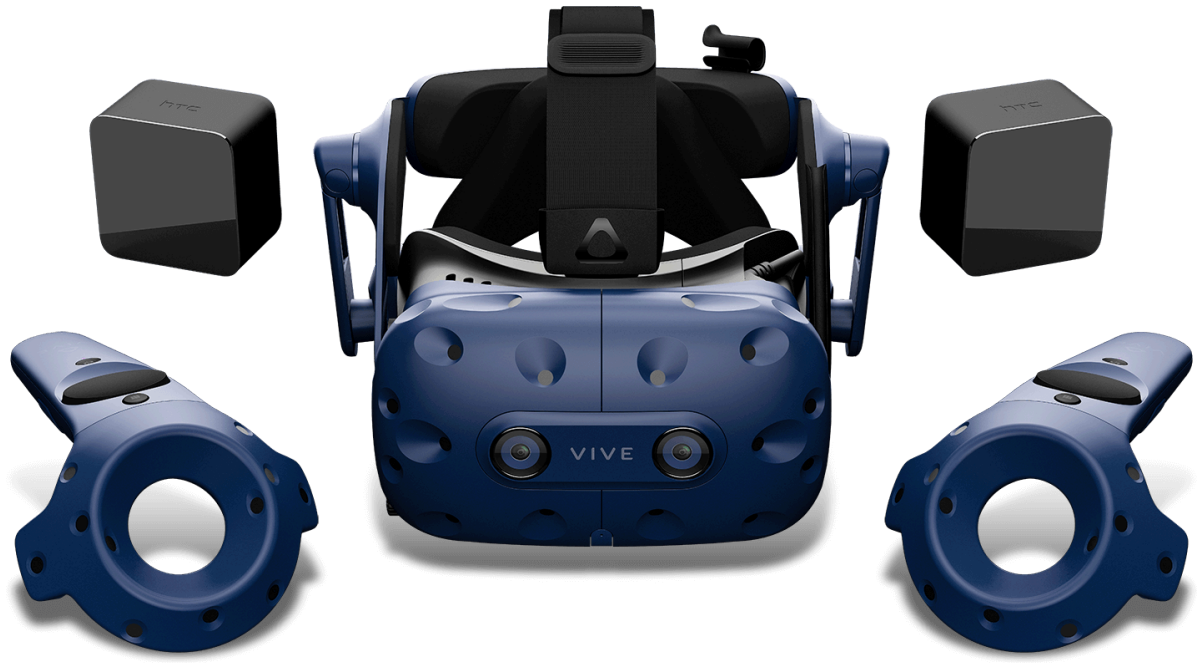
Price: €1,199.99

HTC Vive Pro

Older headset model produced by HTC, still holds up well compared to Quest, but it is not a standalone device and requires a rather powerful computer to be connected.

Producer: HTC
Release year: jan 2018
Resolution: 1440×1600
Frame rate: 90
Connection method: wired
Other notes:

Price: €999



HTC Vive XR Elite

The headset has good AR capabilities, but otherwise subpar specs. It has better terms of service and privacy policy than the Meta devices.

Producer: HTC
Release year: jan 2023
Resolution: 1920 × 1920
Frame rate: 90
Connection method: wireless or wired
Other notes: standalone OS, built-in app marketplace, 110° FOV

Price: €1,099

Valve Index

Valve Index has excellent specs all-around, quite expensive, also not standalone. However, the headset is quite comfortable to wear for longer periods.

Producer: Valve
Release year: jun 2019
Resolution: 1440x1600
Frame rate: 120-144
Connection method: wired
Other notes: 130° FOV

Price: $999

2. Setup

New Virtual Reality glasses. When switching any new Virtual Reality glasses for the first time, they will offer an onboarding/setup experience. This experience usually includes some basic information about the device, creating a user account or logging in with an existing account, and basic configuration. This process is similar to the onboarding/setup experience of a new PC or a phone.

A basic room setup to define the bounds of the room must be done as well.

User account. All VR setups headsets, standalone or wired, require some sort of user account to be used.

Factory reset. This feature allows users to erase all user data on the Virtual Reality glasses and start using it as it was new including the onboarding/setup experience.

3. Cables

There are several factors that need to be taken into account for each tethered Virtual Reality setup.

USB-C cable (image below[1]) also known as USB Type-C, is a 24-pin reversible connector (not a protocol) that supersedes previous USB connectors and can carry audio, video, and other data, to connect to monitors, external drives, hubs/docking stations, mobile phones, and many more peripheral devices[2].

Length. It is important to keep in mind the intended use of a cable. If the cable is to be used for connecting a Virtual Reality headset to a PC in a tethered setup or for streaming, a 3-meters length or more makes it comfortable.

Durability. When used intensively, for example, in fairs, at public events, or in a Virtual Reality lab, cables tend to wear out. So, when purchasing the more durable alternatives should be prioritized.

Charging-only vs data cables. Most headsets come with only the necessary cables, for example: the Quest 3 headset does not come with a data cable that can be used for streaming, so a separate data cable must be purchased (the Meta Quest Link cable is very expensive compared to any other USB-C cable designed for data).

The cables are required (for tethered setup) and optional (for wireless).

[1] https://en.wikipedia.org/wiki/File:USB-C_plug,_focus_stacked.jpg
[2] https://en.wikipedia.org/wiki/USB-C

4. Battery life

All standalone headsets have varying battery life usually somewhere around five hours, some devices have additional battery extensions purchased separately.

It is important to plan the play time. If the VR glasses are to be used a full day (e.g., eight hours), the battery will most likely not last so long. The device can be charged between the playing sessions of different users. Otherwise, additional devices or battery extensions can be used.

Battery extensions such as the one by Meta Quest can prolong the use of the VR glasses significantly (image below[3]). The use of battery extensions can also negatively or positively affect the ergonomics. The glasses might become heavier, but their weight might be better distributed between front and back.

[3] https://www.meta.com/no/en/quest/accessories/quest-2-elite-strap-battery/

5. Virtual Reality glasses

Comfort and ergonomics:

For many VR glasses, you can put the front part ON first and then adjust side and top straps.

Many VR glasses allow for depth adjustment - distance between lenses and eyes.

Many VR glasses also allow adjusting the distance between lenses to match the distance between eyes.

Cleaning. Virtual Reality glasses have different parts that require different clearing. The lenses should be carefully cleaned with a special lens wipe, which is often included in the package when you purchase a device. Plastic parts of the glasses can be cleaned with disinfectant wipes. Some models of Virtual Reality glasses have detachable parts, which helps with cleaning.

Additional disinfection can be done with a UVC machine, for example Cleanbox https://cleanboxtech.com/.

6. Virtual Reality controllers

There are many different controllers with different layouts, but most of them have a basic design including: 1 trigger, 1 grip button, 1 touchpad/joystick, 2+ thumb buttons. But the most important buttons to get familiar with are the grip, trigger and joystick buttons. Most controllers are rechargeable except the Meta quest devices which use AA batteries.

Meta Quest 2 controllers (image credit Meta)

Meta Quest 3 controllers (image credit Meta)

Most VR controllers have safety straps. They should be used to prevent the users from dropping them. Many users get very immersed in VR, and may forget both that they have VR controllers in their hands and that there are physical objects around them. Users might also get so immersed in VR, that they attempt to tough VR objects with their hands, releasing and dropping the controllers.

Meta Quest 2 controller with a safety strap

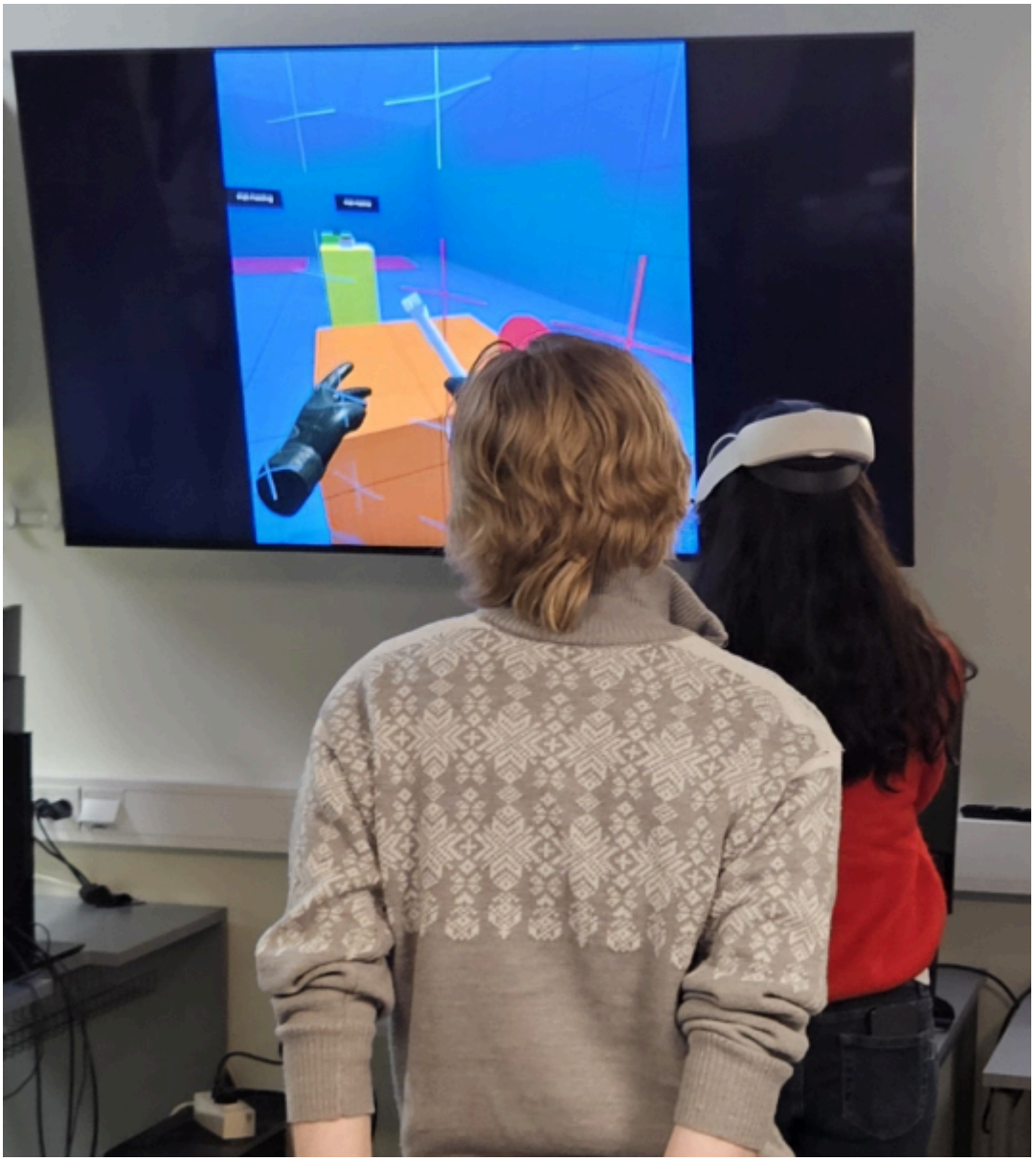
7. Casting

Casting allows the VR experience to be shared on an external screen, such as a PC screen, TV, or tablet. This allows others to watch what the VR user sees in real-time. Casting is very often required to guide a novice user in VR, as it allows a more experienced person to see exactly what is happening in VR and understand possible challenges. Casting is typically used to monitor the VR experience of users or students as part of their learning activities or research. For example, the authors of a study used casting to let instructors observe students' interactions in real time through a web-based casting method by Meta. Each student's VR view is displayed on individual screens, which helps with supervision and evaluation during practical learning sessions[4].

Different casting approaches (offered by Meta and HTC) are described and compared by the authors a research article[5]. The authors emphasize that VR casting is essential for real-time oversight in multiuser training environments, where instructors must monitor each participant's unique perspective to ensure safety and consistency.

Technically, to allow casting the VR headset and the second device that shows the cast video should be connected. They can be connected either with a cable or wirelessly via WiFi. The VR headset and the receiving device must be connected first. Casting is typically initiated either from the headset's menu, a companion app on a PC or a mobile device, or through a web browser, depending on the VR system.

[4] Enhancing automotive engineering education in vocational schools through virtual reality (2025) https://doi.org/10.1117/12.3066245
[5] Real-Time Multi-Headset VR Environment Casting Solution (2025) https://doi.org/10.1109/ICEST66328.2025.11098252



Casting from the VR headset of the user (in red) on a large screen

Most standalone headsets have their own streaming tools, such as software programs for PC, companion apps for phones and tables, and dedicated web pages.

Important considerations

A strong, stable Wi-Fi connection is crucial for a smooth experience and to avoid latency when casting over the network. It is advised to have a USB cable at hand to use it if the wireless casting is too slow or fails.

Some casting methods, like casting through a phone to a TV, may introduce a delay of a few seconds.

Casting can typically include audio from the headset, but you may need to enable certain settings depending on the device and app you are using.

Alternative tools

SideQuest[6] is an alternative software tool that provides casting functionality by allowing you to install third-party VR apps, and connect to a VR headset, cast to a PC. SideQuest is a good alternative in case the official casting tools provided by hardware manufacturers fail. SideQuest also offers additional tools, related to casting and recording VR experience.

8. Stand alone, tethered and link to PC

VR glasses and a PC can be connected via a cable not only for casting.

In VR, 'tethering' - i.e. connecting the VR glasses to a PC via a cable - provides higher power and visual fidelity by using a PC's Graphical Processing Unit (GPU). In this configuration setup, the VR app is started and is running on the PC, while the VR glasses perform two functions (a) gather the movement and orientation data using sensors, sending them to the PC to process and (b) displaying the rendered VR experience for the user to view.

Tethered - a VR device that is physically connected to a host device (e.g., a powerful PC), usually via a cable like USB.

- Pros: Access to the host's more powerful resources, like a desktop-grade GPU for high-fidelity graphics.
- Cons: Limited by the physical length of the tether cable.

The so-called 'standalone' configuration setup assumes that the headsets use their own mobile processing power. This allows for much greater portability but has more performance limitations.

Standalone - a VR device that functions without being connected to another computer. The headset works on its own.

- Pros: Portability and freedom from a host device.
- Cons: Performance is limited by the device's internal hardware, such as a mobile processor.

Some VR devices work only in a tethered configuration, such as HTC Vive.

Other devices work only in the standalone configuration, such as Oculus Go, which was designed as a more affordable, standalone device that did not require a host PC or a smartphone. It was completely self-contained and could not be tethered to a computer for higher-end processing.

Some VR headsets (more popular in 2015-2020) offered a configuration that was specifically designed to be used with a compatible smartphone, such as Samsung Gear VR. While it was

[6] https://sidequestvr.com/

"wireless" in the sense of not being tethered to a PC, the processing still depended on the smartphone plugged into the headset, and it could not be used independently.

Finally, there are devices that can work in both tethered and standalone configurations, such as Meta Quest, Meta Quest 3 and HTC Vive Focus.

9. Physical space

Creating a safe and comfortable environment is essential for an enjoyable VR experience.

Space setup

Before you start, make sure your physical space is suitable for VR use. Size matters! Ideally, you need a clear area of at least 2m x 2m for room-scale VR. For stationary setups, remove obstacles like chairs, cables, and fragile items. These measures are just as much for the user's safety as much as everyone else's safety. A well-prepared space improves tracking and safety.

- Ensure good lighting (avoid direct sunlight or reflective surfaces).
- Keep cables organized to prevent tripping.
- Position external sensors high and angled toward the play area if required.

Stationary vs. Room-Scale

Decide how much movement your VR experience will involve.

- Stationary: Best for seated experiences or limited space.
- Room-Scale: Allows walking within a defined zone. Requires more space and careful boundary (play zone) setup.

Sitting vs. Standing

Consider whether you will be seated or standing during sessions. Some VR applications provide dedicated "seated" and "standing" modes.

- Seated: Great for long sessions or apps designed for minimal movement. This option is also the only one possible for users in a wheelchair.
- Standing: Offers more immersion but requires extra attention to safety and balance.

Guardian Boundary / Play Zone

Your headset's guardian system helps keep you safe while moving. Usually, when moving outside of the guardian zone of the physical space, the VR headset will display the guardian to remind the user about the danger of hitting physical objects.

- Use it to define a safe play area that prevents you from hitting walls or furniture.
- Test the boundary by moving around before starting your session.

Floor Calibration

Accurate floor calibration ensures comfort and proper tracking. Most modern VR headsets automatically detect the floor level. However, it is often required to calibrate it manually.

- Make sure the VR system knows where the floor is to avoid awkward interactions.
- Follow headset prompts carefully when setting floor height.
- If tracking seems inaccurate or the floor feels wrong, recalibrate. The settings of the VR headset have a way to start the floor calibration process on demand. This is especially important when changing rooms or lighting conditions.

Passthrough

Passthrough mode helps you stay aware of your surroundings without removing the headset. Many modern VR headsets have cameras located on the front of the headset, film the physical environment in front of the user, and can stream this video data to the screen of the headset. This is called 'passthrough'. Enable it for quick checks or adjustments during your session.

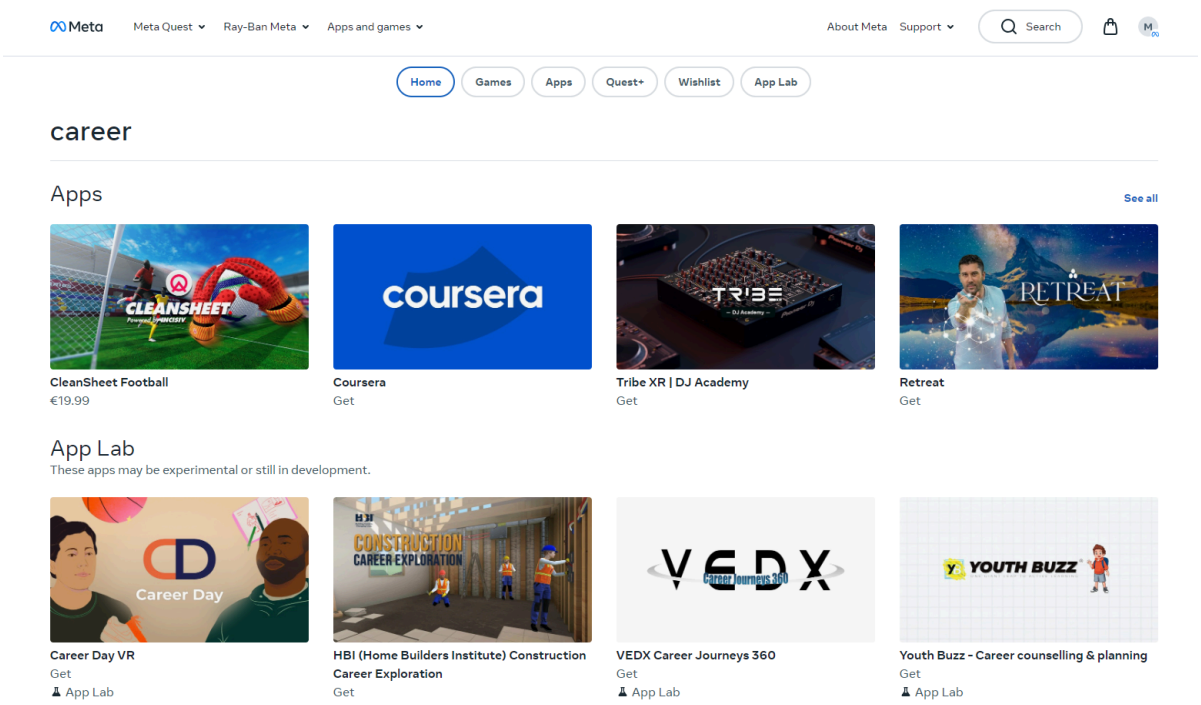
Safety First

Safety is the foundation of a good VR experience. It is very easy to get carried away by the VR experience and forget about the obstacles in the physical environment. This is especially important if the VR headset is installed in a public space.

- Clear the area of pets, people, and obstacles.
- Take breaks to avoid fatigue and motion sickness.
- Stay aware of your physical limits. VR can be surprisingly intense.

10. VR Apps

There are multiple sources of software applications for VR headsets. Depending on the headset manufacturer, a different store can be more convenient.



Meta Horizon Store

The official store for the Meta Quest headsets, where users can download and install VR games and apps. This store is accessible directly from the headset or through the companion Meta Horizon app on a smartphone[7].

Viveport

The official store for HTC's VR headsets, it offers apps, games, and experiences beyond just gaming, including social, educational, and cinematic content. It even has a separate version called the VIVE Business AppStore for professional and enterprise use[8].

SteamVR

SteamVR is the VR platform developed by Valve that allows users to run VR games and applications, providing a software layer between the user's PC and various VR headsets. It

[7] https://www.meta.com/en-gb/experiences/
[8] https://www.viveport.com/ and https://www.vive.com/us/setup/viveport/

supports a wide range of hardware, including headsets from HTC, Valve, Oculus, and Windows Mixed Reality, making it a versatile and cross-compatible platform for PC VR[9].

[9] https://store.steampowered.com/steamvr/