Combating crisis situations by innovative STEM tools and entrepreneurship skills

Guide on AR, VR & 3D printing

Learning the basics and where to begin

18th January 2023

David Kvaternik \\ Tovarna.Tech \\ david@tovarna.tech

Co-funded by the Erasmus+ Programme of the European Union

1. EXECUTIVE SUMMARY

It is one thing to enjoy a funny video on your phone and another to marvel at a complex and impressively detailed 3D model of a nuclear reactor. Technology is easy to use yet hard to use wisely. When understanding more about the actual functioning and usage of 3D printing, VR and AR we can bridge the gap between senseless usage of technology and wise creativity. VR and AR are established in a range of industries, including architecture, healthcare, and education field is quickly gaining the level at which the usage of this digital technologies offers a significant advantage in conveying knowledge, offering yet unprecedented level of not only immersion, but participation. Mixed reality technologies have promising applications that are beginning to see adoption, although hardware costs remain high, while the cost of VR devices is falling at a rapid pace, which now makes it feasible to equip entire classrooms with it. AR is at this point available to almost everyone, since most students and teachers already posses the smartphones capable of running augmented reality experiences and thus bringing the digital content in the real world.

VR experiences have yet to revolutionize education, but the lack of content and hardware price are not the obstacles anymore. Students might previously have had to travel long distances to see a real-world site, now anyone with a headset and a "key" to the virtual visit — that is, access to an app or the experience — can experience the site virtually. AR allows students to make virtual changes to their classrooms: You can see what an active volcano would look like on a desk, and with moving the phone closer or tapping, it could „open up" and students would get a chance to explore what is happening underneath the surface, what processes are pushing the magma upwards.

Broad potential applications are being developed right now, however, what is available right now is far beyond the point of it being the mere novelty; more and more experience creators strive to utilize these technologies to offer content that would simply be inaccessible without it.

All three technologies enable immersive educational experiences, making classroom learning more engaging and creating expansive training opportunities in a variety of settings.

Virtual reality is engaging, yes — its novelty can be an excellent hook for learning — but it can also be so much more than that. Students are no longer mere spectators, reading about an event or watching it unfold, but participants in it. Virtual reality can create a visceral experience, evoke memories, and foster empathy and emotional connection in a way that is rare in other mediums.

Digital Reality represents the next digital transformation. It changes how we engage with technology, through augmented-, virtual-, and mixed-reality, 360 video, and immersive experiences that are at once intuitive and data-rich, and which put the human user at the center of design.

2. DIGITAL REALITY TECHNOLOGIES

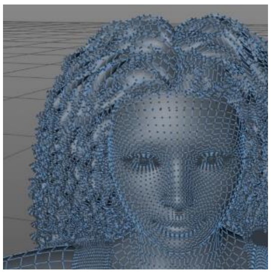
2.1. 3D MODEL AS A BASE BUILDING BLOCK

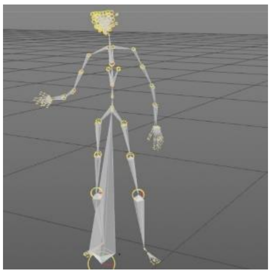
Whether you want to make an augmented reality creation or a virtual reality creation you first have to be able to model something in 3D, or use one of other ways of 3D model generation. After you imagine what you want to create, 3D modeling and scanning are the key to an end product that functions, appears and can be used optimally.

A 3D model is a representation of an object or scene in a 3-dimensional space

3D models consist of points and surfaces between them. They can be laden with materials, starting with a texture and further enhanced with different shaders – they determine effects as reflectance, depth or perception of depth, subsurface scattering, etc.

They can be rigged and animated. Connecting the inanimate 3D model to a strawman results in a rigged 3D model, on which animation can be applied. In human characters, this animation is obtained through mocap, or motion capture, which means capturing the actual movement of a human, to be later transferred to an animated character.

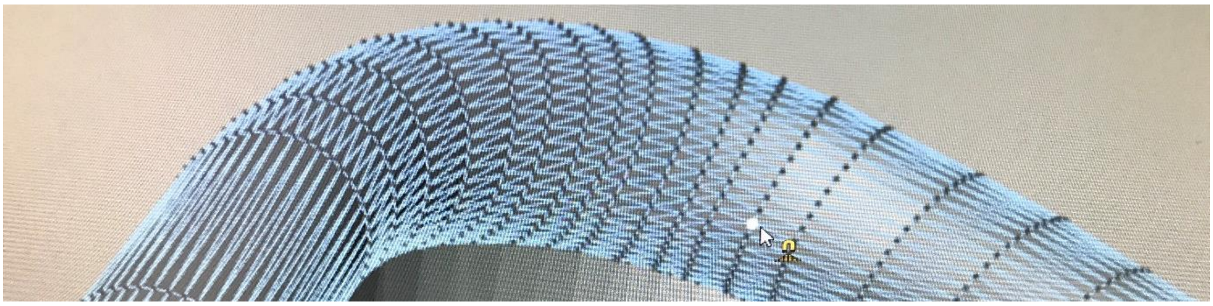





2.2. 3D MODELLING

3D modeling is the practice of creating a virtual, three-dimensional object using specialized software

There are many different software tools available. From industrial grade to open source. We often recommend beginners to start with Tinkercad. It is free and works in your browser, you don't have to install it on your computer. Tinkercad offers beginner lessons and has a built-in feature to export your model as a printable file e.g .STL or .OBJ. Another very intuitive and easy to learn tool is SketchUp, in some cases, it is free to use for educational purposes, some older versions that are



free can also be found. When the user achieves proficiency with these tools, the next logical step would be Blender, a massively feature-rich, free and open-source software, which also enables animating, rigging, and other advanced features, used as well by professionals.

2.3. 3D SCANNING

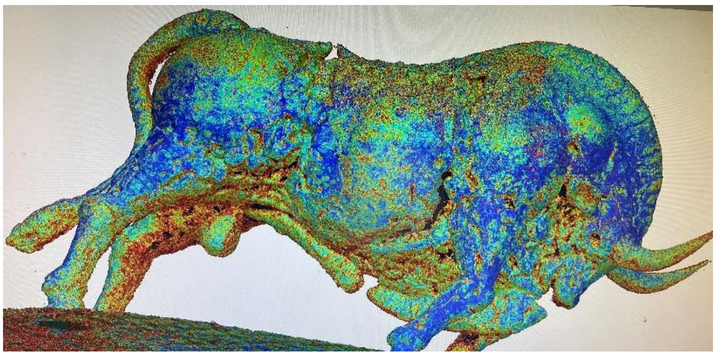
The process of capturing the shape and appearance of real-world objects or environments and converting them into digital 3D models using specialized technology such as laser scanners or structured light scanners.

When modeling something in 3D you sometimes want to incorporate shapes or proportions from the real-world environment. When that is needed, you will need to scan those surfaces to be able to use them in the 3D model you are making. In order to do that you will need the proper tool to bridge that gap between reality and digital form. There are many different hardware and software tools available, the beginning needs not be expensive.

2.4. PHOTOGRAMMETRY

When creating with digital reality technologies you can model using an array of different data collection techniques. One of them is also photogrammetry, which consists of assembling data in the form of pictures of an object. The information from a picture is extracted and then converted into digital data that is later processed by a computer into a 3D model with textures. Photogrammetry allows 3D coordinates, in this case defining a surface, to be derived from points within two 2D pictures that have been taken from slightly different positions. In this case, the points within each of the 2D pictures (i.e., the points known to be the same in the two pictures) were determined by the intersection of horizontal and vertical laser lines that were scanned across the surface. Instead of individual points or a grid, lines were used as a compromise between speed

Photogrammetry is the process of using photographs and computer processing power to measure and create 3D representations of objects and environments.



of acquisition and ease of accuracy of automated identification of the points. We recommend this technique when other tools are not available or affordable enough. Every phone with a camera can be used to take pictures of an object, of which a 3D model we desire. We only need to know how to properly take pictures in order for the computer to be able to extrapolate point distances. In short, there has to be a large (usually at least 80%) overlap between pictures, and all angles have te be covered. So a user starts with a single picture, and in then making concentric circles around the objects, taking pictures. There is an abundance of free software available, we would recommend Agisoft Photoscan.

2.5. WHAT IS VIRTUAL REALITY

When perceiving the environment around us we use our senses. We see, smell, hear, taste and touch. All of the stimuli we get from the tools that are senses are then interpreted into a sense of our surroundings. Virtual reality is about getting a sense of surroundings that are virtual and not real. That is achieved through application of digital data through digital technology tools. Even though virtual reality is completely artificial, it is made to be experienced as real.

Virtual reality today is achieved by the means of a VR headset, a device that displays a different image to each eye, through a lens, made to display image as if it were happening afar, not from a few centimeters away. Together with sensors, from motion sensors like gyroscope, to spatial sensors determining the position in the real world, and changes of it. Users interact with digital world with their hand gestures and with the use of dedicated controllers.

VR is the use of computer technology to create a simulated virtual environment that can be experienced through a headset

2.6. WHAT IS MIXED REALITY

VR and AR converge in mixed reality. Researchers coined the term in 1994 to describe the continuum between totally real and totally virtual environments. These days, mixed reality describes environments in which real and virtual subjects and objects interact in real time — and in which you can interact with both real and virtual components. This requires a headset that has either a transparent lens or a camera, so that you can still see the real world. Note that the Windows Mixed Reality headset is a VR headset with a camera.

Examples of a MR headset are Microsoft Hololens and Magic Leap. They are quite expensive still.

They work much like AR, the main difference is that user does not look at real world through camera and mobile device's screen, but through a see-through glass, on which digital content is projected. Together with sensors, similar, in a way more advanced even, to a VR headset, MR headset is able to place 3D content in the real world in a very realistic way; location of a digital object in real world is exact, the object stays in place, lighting is correct, etc. Depending on the headset, interaction is through audio controls, and hand gestures.

Mixed reality is the blending of the real and virtual worlds, where physical and digital objects coexist and interact in real-time.

2.7. WHAT IS AUGMENTED REALITY

When you want to integrate digital information into the environment, you get augmented reality. It can be used as a tool for education, promotion, entertainment.

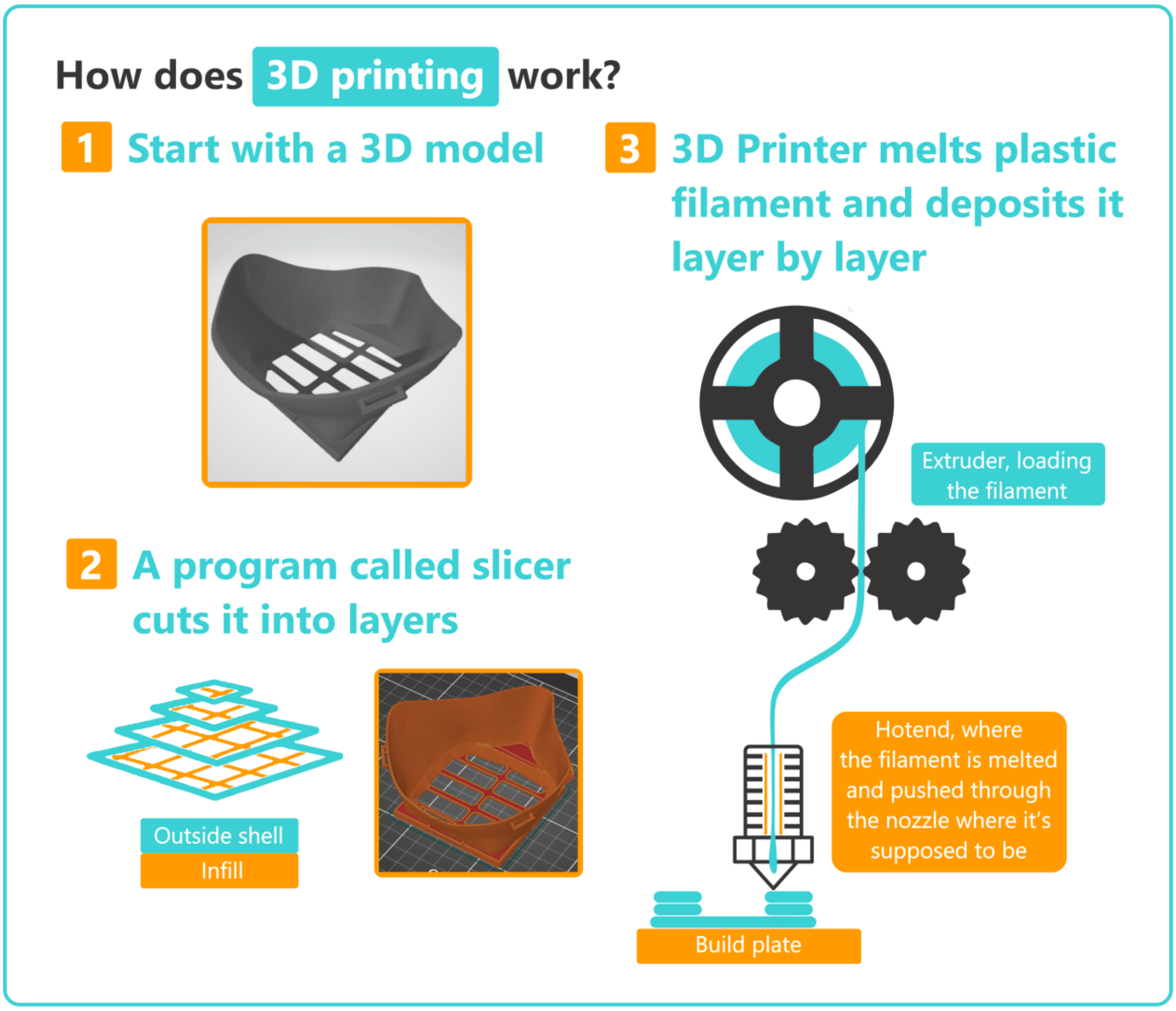
Amid the rise of data collection_and analysis, one of augmented reality's primary goals is to highlight specific features of the physical world, increase understanding of those features, and derive smart and accessible insight that can be applied to real-world applications. Such big data can help inform companies' decision-making and gain insight into consumer spending habits, among others.

Augmented reality is the overlay of digital information onto the user's view of the real world, typically through a smartphone

AR has broad applications in the entertainment industry as well, including both cinema_and. Pokémon Go is perhaps the best-known example of an AR app that went viral, when millions of people around the globe became engaged in a world populated with cartoon characters where reality, and the user environment, was a little more magical.

AR refers to enhancing human perception with additional, artificially generated sensory input to create a new experience including, but not restricted to, enhancing human vision by combining natural and digital content. AR gives us the ability to treat reality like a medium.

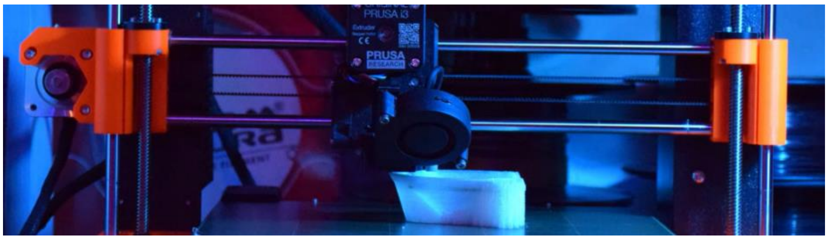
3. WHAT IS 3D PRINTING



3.1. ADDITIVE MANUFACTURING

To create an object using additive manufacturing, someone must first create a design. This is typically done using computer aided design, or CAD, software, or by taking a scan of the object someone wants to print. Software then translates the design into a layer-by-layer framework for the additive manufacturing machine to follow. This is sent to the 3D printer, which begins creating the object immediately. You go directly from digital to physical, which is quite a change. Additive manufacturing uses any number of materials, from polymers, metals, and ceramics to foams, gels, and even biomaterials. You can use pretty much anything, as long as you find a way to locally join two parts, you can 3D print it.

Additive manufacturing is the process of creating physical objects by building them up layer by layer using materials such as plastics, metals, or ceramics



3.2. PREPARING THE 3D MODEL

There is often a very small difference between what is real and what is imaginary. With 3D modeling this is often the case as well, since scenes can now come alive and be reproduced in highly realistic ways. If it is to develop an animation, create a model for a website or video games, the basics of 3D creation remain the same.

Repairing any errors in the model, checking for “water tightness”, and ensuring that the model is of the correct format and scale

In order to 3D print a model, we must first “slice” it, this means transforming the spatial object data into raw machine code a 3D printer can understand, using a slicer; a program that converts digital 3D models into printing instructions for a given 3D printer to build an object. In addition to the model itself, the instructions contain user-entered 3D printing parameters, such as layer height, speed, and support structure settings.

Every 3D printing technology creates 3D objects by adding material layer-by-layer. Slicer software is therefore appropriately named because it virtually “cuts” 3D models into many horizontal 2D layers that will later be printed, one at a time.

Co-funded by the Erasmus+ Programme of the European Union

3.3. TYPES OF 3D PRINTERS

The term 3D printing encompasses several manufacturing technologies that build parts layer-by-layer. Each vary in the way they form plastic and metal parts and can differ in material selection, surface finish, durability, and manufacturing speed and cost.

There are several types of 3D printing, which include:

- **Stereolithography (SLA)**
- Selective Laser Sintering (SLS)
- **Fused Deposition Modeling (FDM)**
- Digital Light Process (DLP)
- Multi Jet Fusion (MJF)
- PolyJet
- Direct Metal Laser Sintering (DMLS)
- Electron Beam Melting (EBM)

Selecting the right 3D printing process for your application requires an understanding of each process' strengths and weaknesses and mapping those attributes to your product development needs.

In primary and secondary schools, FDM is the most used 3D printing technology, due to its cost effectiveness, simplicity, lack of hazardous materials and it being most widespread

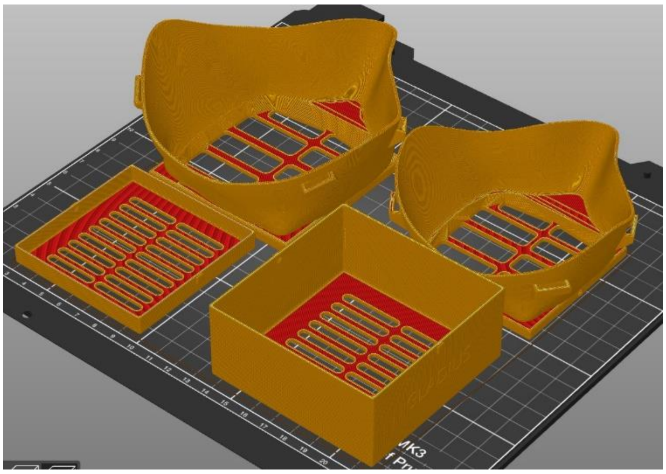
SLA, or often commonly referred to as resin printing, also offers these benefits with the exception of it being potentially health-hazardous when the resin is not handled properly.

Other technologies are most often prohibitively expensive for school environments, and consequently offer diminishing returns, compared to FDM and SLA.

3.4. SLICING THE 3D MODEL

The purpose of slicing software is to convert the object model file into instructions for the 3D printer. To perform this task, the software separates the object into many layers - slices. After the layers have been created, the slicing software applies various values to each of them. The values denote how the layers should be built. In other words, they tell the 3D printer how and where to move, as well as how much material to use, to build each layer of the object model.

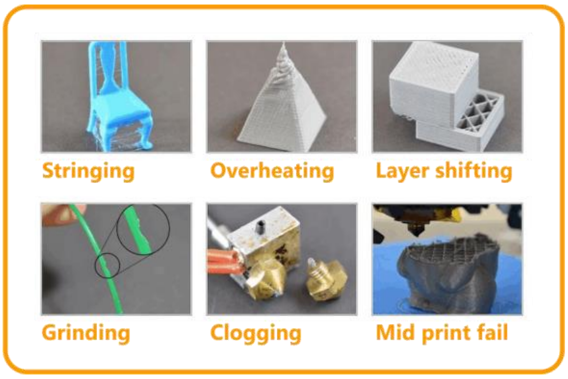
Slicing is the process of dividing a 3D model into layers for 3D printing, which involves taking the digital 3D model and breaking it down into hundreds or thousands of horizontal layers, and then generating the instructions that the 3D printer uses to physically create the object.



While slicing software is designed primarily to convert object models into instructions for a 3D printer, they often have other noteworthy features. Most slicing software, for instance, allows you to control the infill. Other types of slicing software allow you to add supporting structures, which are oftentimes essential for large and complex objects. Furthermore, rafts, skirts and brims can all be controlled in slicing software.

3.5. PRINTING TIPS AND TECHNIQUES

Few rules should be adhered to when starting out with 3D printing. Filament spools should be as fresh as possible, and kept in moisture-free enclosures. If that fails, they can be renewed in an oven on a temperature of 60 degrees Celsius. A lot of articles can be found online explaining the most common 3D printing errors. What it important is that the troubleshooting is done by teams, if possible, in order to avoid printer tuning to seem overwhelming, which might result in the loss of interest with the student.



Printer should be well maintained. On a day-to-day basis, we should keep It dust free, grease the axis rods, clean the nozzle, perform cold-pulls of the filament (at nozzle temperature of 90-110 degrees depending on the filament type) and keep the print bed clean.

Having spare parts on hand is a good practice, as waiting for shipping can greatly increase your classroom printer downtime.

3.6. CLASSROOM APPLICATION

3D printers are helping to inspire a new generation of STEM learners by combining problem-solving skills with creativity and innovation. But this technology also has the potential to support the learning processes across all disciplines.

Co-funded by the Erasmus+ Programme of the European Union

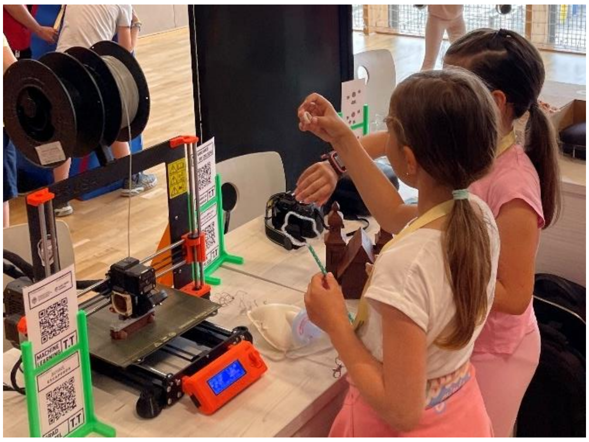
3.6.1. MAKE LEARNING ACTIVE

Students learn best through interaction and application. By doing rather than by reading a book or listening to a lecture. As such, 3D printers are an excellent way to deploy experiential learning and give pupils more hands-on experiences. With 3D printers, teachers can create activities that take academic concepts from the theoretical to the practical. For example, in biology lessons, students could create an anatomical heart. Such active learning also ensures that pupils retain information with greater ease.

3.6.2. ENCOURAGE REAL-WORLD UNDERSTANDING

3D printers help to put learning into context, so students see the value of lessons in the form of real-world problem-solving. For example, a student can develop a 3D printed bee home prototype which he hopes will allow the bee population to increase.

3.6.3. AUGMENT THE EDUCATIONAL PROCESS



Students can easily spot where they have made mistakes, discuss these errors with the class, learn from these mistakes, and rectify them.

3.6.4. FIRE IMAGINATIONS

3D printers and design software inspire creativity and ignite young imaginations. In fact, the possibilities of what students can create through 3D printing are infinite; and its remarkable how creative children can be when empowered with the ability to turn their 3D designs into real physical objects.

3.6.5. INSTILL SPATIAL INTELLIGENCE

Spatial intelligence involves analyzing and interpreting the size, shape, movement and relationships between objects; it's the ability to draw correct conclusions from observing three-dimensional environments. The use of 3D printers in lessons enhances a student's spatial intelligence, with such intelligence an important predictor of achievement in STEM subjects.

3.6.6. BOOST DIGITAL ENGAGEMENT

3D printing is a hands-on, fun activity. By incorporating this technology into lessons, teachers can uncover fresh ways to keep students engaged; adding extra value and relevance to lessons in a way that is both mentally stimulating and enjoyable. Furthermore, 3D printers in our digital world are becoming increasingly important, so encouraging students to explore tools that help them to

Co-funded by the Erasmus+ Programme of the European Union

think differently will prepare them for life after education. That said, it's not about technology for technology's sake. Schools should use 3D printers as a way to expose students to this soon to be widely used-tech, and get them future ready. The use of 3D printing is applicable across education levels; making it a natural starting point for early years digital engagement.

3.6.7. BOOST COMPUTATIONAL THINKING

Computational thinking and skills such as decomposition, pattern recognition, logical thinking, reasoning, and problem-solving are becoming increasingly important. 3D printers are helping to make computational thinking a key part of the modern curriculum.

3.6.8. CREATE NEW LEARNING MATERIALS

If your school doesn't have access to specific learning materials, a 3D printer could help you to make them instantly.

3.6.9. HOW TEACHERS ARE ALREADY USING 3D PRINTERS IN THE CLASSROOM

Integrating a 3D printer into the classroom is affordable, despite increasingly squeezed academic budgets. In fact, 3D printers often come in cheaper than laptops and computers. Nevertheless, most teachers are still reluctant to use one in their lessons.

Here are just some examples of how you can use 3D printers in your classroom:

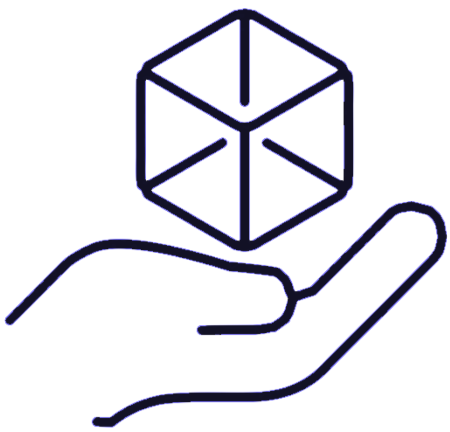
- **Create interactive maps -** 3D printers can be used to design and build interactive maps. These can be of real-life modern cities, maps setting out what pupils think the city of the future will look like, historical locations (an Ancient Roman settlement, for example), or even fictional places from books
- **Create decorations -** younger children can use 3D printing to create their own seasonal decorations
- **Recreate real-life structures -** Create models of world-famous buildings such as the Brandenburg Gate or the Tower of London. You can also recreate historical ruins such as the Colosseum in all its former glory
- **Get musical -** Ask a class to design and create a new musical instrument
- **Consider the tools for a job -** For example, you could ask pupils to print out what they think an astronaut needs in space
- **Bring back the dinosaurs -** Use a 3D printer to create a sculpture of a T-Rex or other dinosaur
- **Create a human skeleton and/or internal organs -** Create anatomical models to teach pupils about the human body
- **Build math experiments -** Design larger experiences to facilitate mathematical thinking

4. AUGMENTED REALITY

The nature of augmented reality is highly interactive, which means that AR technology is based on the communication between:

- User and objects in the real world
- User and the remote assistance

In the first case, we are talking about the extreme scope of action that AR makes it possible for its users. People, in fact, may interact with the objects in front of them through the virtual information that AR is displaying, creating a new kind of experience. In the second case, instead, we are referring to the specific aspect of AR devices in industrial application. Usually, this kind of tools have a functionality that allows on-site workers to be in constant connection with a remote assistance. Companies understood that remote connection is the key element through which they can improve efficiency and productivity, and augmented reality may provide it.



Education should follow the successful examples from the economy to enhance remote learning, diminish the effects of pandemics, and scale best-made lessons, along with enabling better learning to students with disabilities.

4.1. WEB AR

Online AR or augmented reality for web is nothing more than the consumption of this type of technology and AR experiences from a mobile web browser, such as Google Chrome or Safari on iOS.

What is so significant about it is that there is no need for the user to install a dedicated app, and hence no problems deriving from this need.

A specific experience can be loaded quickly, without any additional barriers and considerations.

Several e-learning platforms are starting to opt for this approach.

4.2. APP AR

App-based AR provides an immersive augmented reality experience that is accessible through downloadable apps. This kind of AR is developed using tools that have a powerful object, depth, surface, and lighting recognition. This allows for extensive placement and tracking of objects in detailed rendered environments.

4.3. ANCHORING (ADVANCED)

Anchors are one of the most significant differences between augmented reality and virtual reality (VR). In VR, the user does not see the real world so the developer can "place" the learner in any virtual location to begin the experience. With AR, the learner can see the real world in or through the device display. The device and the software platform have to recognize something in the real world and then build the experience around that. Specifically, in AR the experience needs to know where to place the content (hence the name: anchor). The anchor also triggers the experience. Main types of anchor, depending on the platform and the targeted device:

> Anchoring is the process of attaching a virtual object to a specific location in the real world, so that it appears in the same place every time the user views the scene

IMAGE ANCHOR

The image anchor is one of the most commonly used types. This anchor allows you to associate an image that will be in the real world. The image could be a magazine ad, a printed sign in your office, or a billboard out in the real world. Your image must provide enough detail to be recognizable: distinct patterns, images, logos, text, or anything else that will help your image stand out.

PLANE ANCHORS

There are really three types of plane anchors: horizontal plane, vertical plane and mid-air plane.

These anchors scan for a plane (ground or wall). Once that plane is found, the camera will build the AR experience on it. This could create a birds-eye view of a world that the user can explore (Figure 4), or it could allow the user to place objects in the real world

FACE ANCHORS

Another common anchor in AR is the face anchor or face tracker. Usually the person's face is used as the tracker, to build the experience around the face.

You see this commonly used with social media filters and Apple's MeMoji features.

3D OBJECT ANCHORS

This anchor allows the platform to detect a 3D object in the real world and build the experience around that 3D object. It is the most advanced way to anchor an AR experience; around an actual object.

Co-funded by the Erasmus+ Programme of the European Union

4.4. CLASSROOM APPLICATION

AR is a tool that can be used to support students in becoming 21st century thinkers and problem solvers. It is important to take advantage of these new tools and the affordances they provide.

Four main general benefits of how AR can extend and enhance teaching and learning are the ability to support; authentic learning, student-centered learning, contextualized learning, and visualize subject content.

AUTHENTIC LEARNING is having students connecting to real-world tasks. Students can use a mobile device to become surgeons, pilots and many other important roles as learners get to act out this role in the safety of a digital environment.

STUDENT-CENTERED LEARNING is arguably integrated into learning with AR itself, as it „natively" allows the students to see and experience what the subject content is on their own terms.

CONTEXTUALIZED LEARNING is learning that is directly connected to the real-world context in which is occurs. AR is a tool that directly engages the student in looking at the world around them while providing additional supports such as prompts and tools to take the learner to a further depth of understanding than they would independently.

INFORMATION VISUALIZATION is to represent abstract information in a dynamic way that facilitates human interaction for exploring and understanding. Graphical illustrations, interactive demonstrations, tutorials, and audio and video presentations can be used for students to fully grasp and understand the meaning of a certain topic. Experience shows that AR can make a positive difference to how students learn, and there is promise and potential for an even brighter future of AR.

Co-funded by the Erasmus+ Programme of the European Union

5. VIRTUAL REALITY

5.1. WHY VIRTUAL REALITY

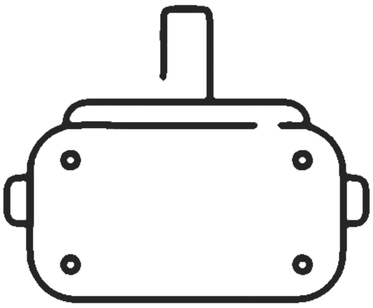
One of the most significant strengths of the classroom use of Virtual Reality is that it changes the role of the teacher from the deliverer of knowledge into a facilitator who helps the students explore and learn. It has been proven that the students feel empowered and engaged because they have control over the learning process. Students can learn experientially and proceed at their own pace, since they are exploring a virtual environment. Preventing situations, where students are left behind during the lecture and spend the rest of the class trying to catch up, is solved by a well-designed VR learning object. Furthermore, virtual reality can help students learn abstract concepts because they can experience and visualize these concepts in the virtual environment.

In contrast with the traditional learning process, which is usually language-based, conceptual, and abstract, a virtual reality learning environment fosters active learning and helps students more easily grasp abstract knowledge. Low-spatial ability learners particularly benefit from virtual reality because the visualizations help lower the cognitive load of the learning objectives. Virtual reality allows the user to comprehend systems or objects that are of widely different scales. For example, the charcoal mini-blast furnace virtual reality application allows students to look at the big picture of how the entire system works and to explore the individual components of the system, all in a single, fluid experience. Studying human anatomy with virtual reality gives students a better grasp of the relative size of the different organs and parts.

The additional context, gained by the use of VR, of visualizing where the organs are in the body and the surrounding parts makes it easier for students to commit the information to memory, compared to raw memorization of names and terms. Dangerous and rare situations can be simulated in virtual reality, enabling students to learn in safety. Some examples include practicing surgery techniques or learning how to use machine tools safely. Furthermore, in a simulated environment, students can learn about the potentially dangerous consequences of failure from failing to follow procedures or exceeding design specifications without physical damage to equipment or loss of life. The ability to easily change the virtual world opens new possibilities in the realm of testing and design. For instance, digital prototypes can be copied, modified, and tested without the expense and time required to build and test physical prototypes. This allows the students to refine and test their design quickly and inexpensively before creating a physical version.

Virtual reality also makes it easier to test different scenarios and hypotheses because the environment can be designed to prevent extraneous variables from disrupting the test results and the experimental variables can be precisely controlled. Finally, the immersive nature of virtual reality can help block out other distractions so the students can focus on the learning objectives. Several virtual reality studies have revealed that students are more focused and show better concentration when using immersive virtual reality. The interactive nature of virtual reality transforms students from passive learners into active learners, improving student motivation and their sense of control over their own learning.

5.2. TYPES OF VR HARDWARE AND 6DOF (ADVANCED)



To discover the various experiences of virtual reality, different types of VR headsets are available. Some of them need connectivity to the PC, while some can work in a standalone scenario. Every type comes with its unique properties and advantages. It is important to point out that tethered VR headsets are older, first viable commercial VR headsets like this came out in 2016, and only in 2020, Meta launched Oculus Quest 2, a first fully viable untethered VR headset. For educational purposes, we recommend untethered headsets, mainly for the sake of cost efficiency and simplicity of use.

5.2.1. TETHERED VIRTUAL REALITY HEADSETS:

Tethered virtual reality headsets are presently considerably more vivid than different sorts of VR because of the great quality of experience they can convey. These superior VR headsets require a specific measure of arrangement space, just like a cable connection with a gaming PC. A tethered virtual reality headset should be connected to a computer through a cable, although lately there are wireless options available; heavy lifting is still done by the PC, hence the naming: PCVR.

The idea of designing a headset that will require the least computing power is in infancy. However, doing so shrinks the image and graphic quality of the VR headset. The tethered device is best for people who already own a computer system with a powerful graphics card, capable of running VR experiences.

5.2.2. STANDALONE VR HEADSETS:

Unlike the tethered headset, a standalone virtual reality headset does not have a connection to the PC. This class of headsets requires the least dependency on computing power. They are independent headsets that work on a plug-in and play basis. The user only needs to charge the batteries and create an account to access various VR platforms. Apart from these, nothing else is required. Since these headsets come with built-in sensors, batteries, and processors, they don't need a connection with a PC.

The graphics quality of the standalone VR headsets is not as powerful as you would expect. However, tech giants are putting efforts into making this category a better one. The device is good

Co-funded by the
Erasmus+ Programme
of the European Union

for those who do not have access to a powerful gaming PC and lack the time or resources to set up a complex gaming system.

5.2.3. 6 DEGREES OF FREEDOM

The amount of freedom in Virtual Reality decides the immersiveness and the possible ways we can move within the VR space. DOF or degrees of freedom play a critical role in making VR come to life. It refers to the movement of a rigid body in 3-dimensional space. 6DOF considers the user's head position, head movement, and overall orientation.

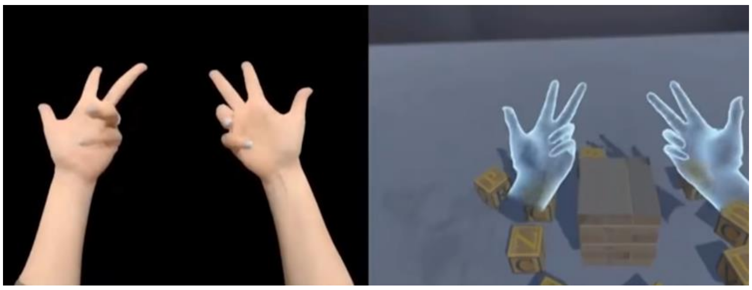
> 6 degrees of freedom refers to the six directions of that are possible in VR, allowing the user to move freely and fully interact with the virtual environment

The combination of translation and rotation allows the user to walk around freely, view an object from all 360-degree angles, even look at it from a top-down angle or crouch below for a bottom-up view. This freedom to inspect an item enables delivering an immersive VR experience.

5.3. INTERACTION

Beyond the body and head movement being translated into VR space, gestures and hands play an essential role in achieving the full immersiveness.

At the beginning, the only option to bring hands into VR space has been the use of controllers, which evolved through the years into a quite seamless control interface of today. Although, more and more headsets are experimenting with controller-less hand control, and not only through preprogrammed gestures, like we mainly have in contemporary MR headsets, but full hand and finger tracking, literally bringing your real hands into VR, without the use of an additional tool.



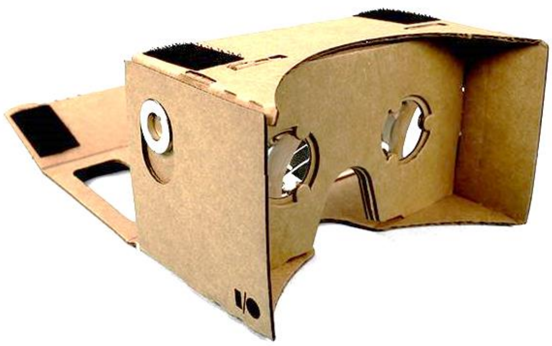
Especially in education, having to deal with less hardware would be a very welcome improvement. Experiences that we are at present able to control in such a way, are increasing day by day.

5.4. 360

360-degree VR (360-degree virtual reality) is an audiovisual simulation of an altered, augmented or substituted environment that surrounds the user, allowing them to look around them in all directions, just as they can in real life, although without 6DoF.

Cardbord VR is a type of virtual reality headset that is made of cardboard and uses a smartphone as the screen. It is an affordable way to experience virtual reality, as it is significantly less expensive than proper VR headset. It is easy to use and set up and can provide a taste of what VR has to offer before investing in more expensive equipment

By creating a 360-degree environment that encircles the viewer, virtual reality creates the experience of being present within distant worlds, making it uniquely suited to projects that speak to our senses of empathy and community.



Students can be transported from their classrooms to far-flung places — from Antarctica to Ethiopia, the depths of the ocean to Pluto, back to the beginning of the universe and through Olympic history.

It can also make abstract concepts concrete — taking students inside a giant microscope that smashes together subatomic particles, transporting them to iconic moments in history, or introducing them to people affected by the global refugee crisis.

Production costs of such experiences are usually much lower, and such experiences can be viewed without the proper VR hardware; they can be viewed through the use of Cardboard – the umbrella term for simple headsets that utilize smartphone screen to display a seperate image for each eye, also utilizing it's gyroscope to control the view angle. Such headsets can be bought very cheaply, and existing smartphones utilized to power them.

Co-funded by the Erasmus+ Programme of the European Union

5.5. CLASSROOM APPLICATION

Budget is realistically most often the main determining factor in choosing which VR experience to include in your classroom. We would recommend you include at least 360 videos, of which cost is negligible. When you have the possibility to of at least a single headset, we recommend that you arrange so that what the person using the headset sees, so does the rest of the classroom. In this way, the rest of the class is included as well, the cohesion is maintained, interest is not lost, as others meaningfully participate as well. We would recommend rotation of students with the headset on, so everybody gets a chance to try at least part of the experience. Also, Q&A can be had while the rest of the class gets their time in VR. It is often meaningful to present students with a few questions beforehand, so that their experience is perhaps a bit more structured and. Focus, as they know, what will be asked of them at the end of the session.

> VR provides immersive and interactive learning experiences, allowing students to explore and interact with **virtual environments** and **simulations**. This can enhance learning and engagement by making the subject matter **more relatable** and **engaging**

Given the limited amount of VR experiences, additional preparation, such as instructing the students in advance on the basics of the topic covered, is recommended. In this way, even if the VR experience is not totally related to the curriculum or is meant for a different age group, participation is more fruitful.

6. TIPS FOR GETTING STARTED

6.1. TECHNOLOGY AS A TOOL

The dangers and downsides of technology are something that is ever present nowadays. It can be abused in the form of addiction or just distraction. Even though it has this unhealthy stigma and dangerous predisposition for usage, it is the building block of future. When used in healthy amounts and with creativity, it opens up the user to wonder.

In order for it to contribute in an educational environment, it has to be presented in a correct manner.

Integration of technology in education simply refers to the use of technology to enhance the student learning experience. Utilizing different types of technology in the classroom, including a virtual classroom, creates learners who are actively engaged with learning objectives. The implementation of technology also creates pathways for differentiated instruction to meet the unique needs of students as individual learners within a broader classroom climate.

6.2. SAFETY

We always recommend sitting when participating in VR experiences. Partners create an additional safety measure because the partner who is observing can ensure that his or her partner is safely experiencing the VR content, we recommend this concept to improve safety of the students while in VR. Virtual reality can sometimes be an intensely emotional experience.

Remind students that if they are feeling overwhelmed, they can stop and take off the headset at any time.

Still, there are some VR experience which are poorly optimized for motion sickness, which can also hamper the experience for some students. They should take breaks more often and avoid experiences where movement in VR does not correlate with real world movement.

6.3. CONSIDERATIONS WHEN PLANNING A LESSON

Bridging the gap between reality and virtual is often hard to achieve. To have a maximal and optimal effect of learning, trajectory is crucial. There are many considerations on how to go about it.

Internet search

VR experiences can be downloaded or streamed. We recommend downloading the experience to the device so that streaming issues are avoided, as VR content is often quite large, despite fast connection.

Mobile Device

Smartphones are essential to powering these 360 experiences, inserted into a cardboard, this is the easiest entry into a world of VR. Choose a headset that makes the most sense for the mobile devices that you are using. There are mobile device-agnostic headsets called Cardboard that could work with a variety of phones. Prices start under 10€ for a simple cardboard viewer and go up from there. Most headsets also come with compatibility specs, so that you can be better informed on how to pair accurately.

Headset

Choose a headset that fits your budget, we recommend Standalone VR headset for educational environment. Considering all aspects, these devices offer the best balance between deciding factors.

Without Headset

Co-funded by the Erasmus+ Programme of the European Union

360 videos can also be viewed without a headset, but the experience isn't as immersive. When viewing 360 videos in this format, you can drag the screen while the video is playing to view the surrounding environment in 360 degrees.

Headphones

Headphones allow the user to be more immersed and reduce the disruption to the experience that could arise from using speakers.

6.4. FINDING EXPERIENCES

You can browse for 360 VR experiences via your mobile device on the YouTubeVR. You can also find several experiences on subscription-based V.R. and video delivery services for educational content.

Choosing what to create is as important as choosing how to do it. And since there are so many options to using technology, picking the right idea that will stimulate the young mind is of great importance.

At present, there is no quality accessible open content-rich web platform which we could recommend. Creating XR educational experiences is expensive and requires significant investments, therefore even textbook publishers are slow to invest in XR content development, although, this is beginning to change. Great progress is expected in years to come.

The best way to find relevant VR experiences for your classroom is to do a web search with relevant keywords. Start with the topic, and add keywords like VR, Virtual Reality, AR, Augmented Reality, XR, extended reality, digital reality. Also keeping in mind your targeted platform.

The VR platform you are using could also influence the way you search for experiences; most VR headset manufacturers have their own proprietary stores, although the most well-populated ones are Oculus Store and Steam Store.

7. References

[1] Takushi Narumi (2021) Recommendations on future VR technologies. Available on: https://univ-journal.net/120721/

[2] E-student.org (2020) VR in Education. Available on: https://e-student.org/virtual-reality-in-education/

[3] All3DP (2022) Common 3D Printing Problems. Available on: https://all3dp.com/1/common-3d-printing-problems-troubleshooting-3d-printer-issues/

[4] VRS (2020) History Of Virtual Reality. Available on: https://www.vrs.org.uk/virtual-reality/history.html

[5] VRS (2020) Virtual Reality and Education. Available on: https://www.vrs.org.uk/virtual-reality-education/

[6] IGN (2022) Best VR Headset 2022. Available on: https://www.ign.com/articles/best-vr-headset

[7] Frontiersin.org (2018) The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature. Available on: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.02086/full

[8] Wikipedia (2022) Virtual Reality. Available on: https://en.wikipedia.org/wiki/Virtual_reality

[9] Wikipedia (2022) Augmented Reality. Available on: https://en.wikipedia.org/wiki/Augmented_reality

[10] HP (2018) What is the Difference Between AR and VR?. Available on: https://www.hp.com/us-en/shop/tech-takes/what-is-the-difference-between-ar-and-vr

[11] Allcoat D, von Mühlenen A (2018) Learning in virtual reality: effects on performance, emotion and engagement. Available on: https://doi.org/10.25304/rlt.v26.2140

[12] Banerjee P, Bochenek GM, Ragusa JM (2002) Analyzing the relationship of presence and immersive tendencies on the conceptual design review process. Available on: https://doi.org/10.1115/1.1486218

[13] S Ceylan. (2020). Using virtual reality to improve visual recognition skills of first year architecture students: a comparative study. Available on: https://doi.org/10.5220/0009346800540063

[14] Hamilton D, McKechnie J, Edgerton E, Wilson C (2021) Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. Available on: https://doi.org/10.1007/s40692-020-00169-2

Co-funded by the Erasmus+ Programme of the European Union

[15] Fabbaloo (2018) Six Good 3D Printing Troubleshooting Guides. Available on: https://www.fabbaloo.com/2018/08/six-good-3d-printing-troubleshooting-guides

[15] Road to VR (2018) Oculus Hand-tracking Research. Available on: https://www.youtube.com/watch?v=y1DmFKiQCvk

Co-funded by the Erasmus+ Programme of the European Union