DRINVET

DIGITAL REALITY - THE BASIS OF SKILLS TRAINING

www.drinvet-project.eu

Technical Manual

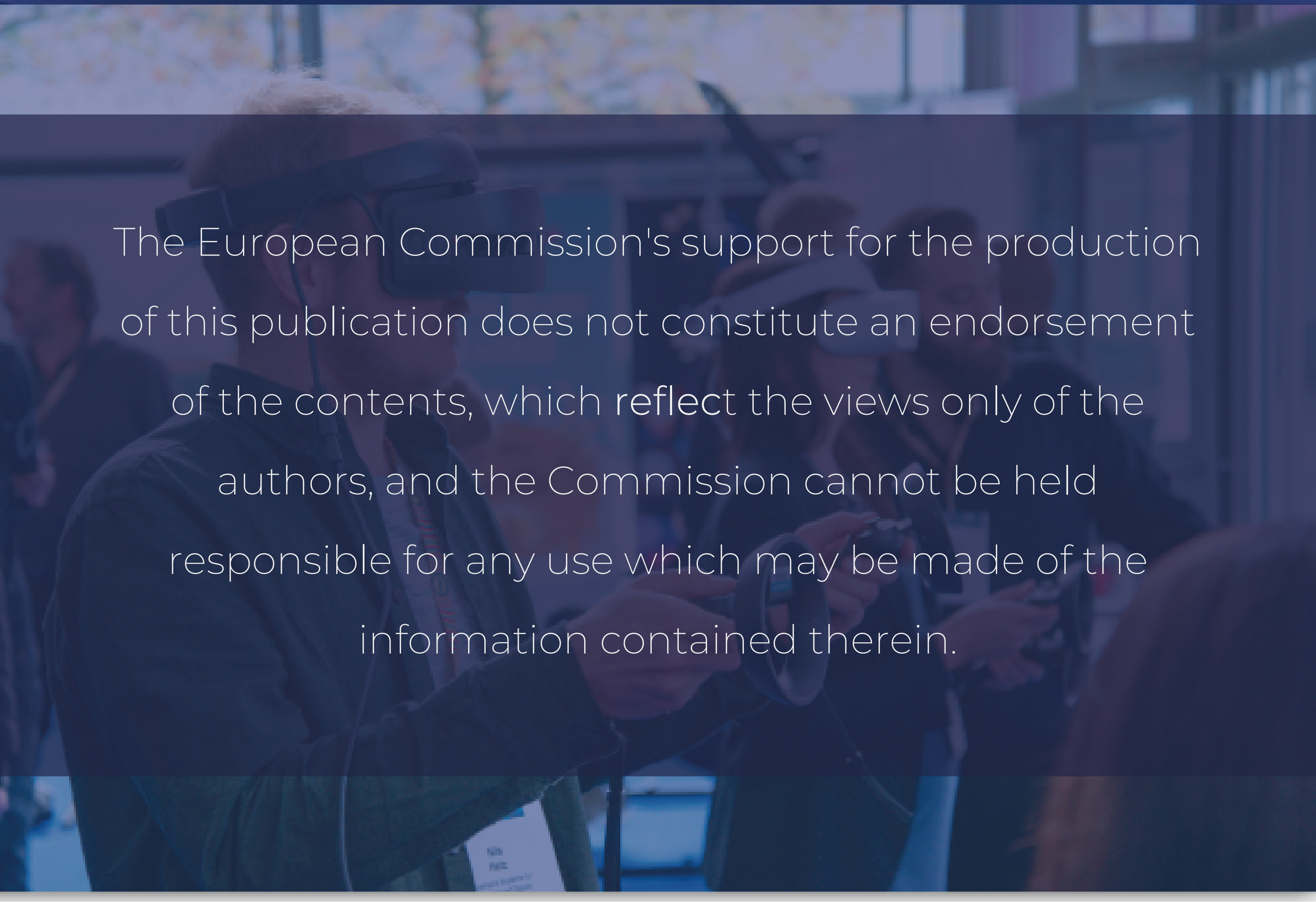
Tools and requierements for the integration of Digital Reality in Education

Prepared by

DRinVET project n° 2020-1-HR01-KA226-VET-094650

DRINVET

DIGITAL REALITY - THE BASIS OF SKILLS TRAINING



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

EWF virsabi

AUGMENTED TRAINING LVE #STRUKA

Executive Summary

The Technical Manual shares the minimum requirements necessary for an education based on digital tools. It provides information on methodologies and pedagogical approaches that make use of digital tools, as well as benefits of using Digital Reality in its many forms, its limitations and general and specific tools for VET teaching.

This handbook is a support for teachers who want to increase their knowledge about digital tools and their applications in teaching. The results of the Intellectual Outputs before and after this one complement the technical manual, being this project, DRinVET, a set of resources for the implementation of Digital Reality in teaching processes.

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

TABLE OF CONTENTS

TABLE OF CONTENTS

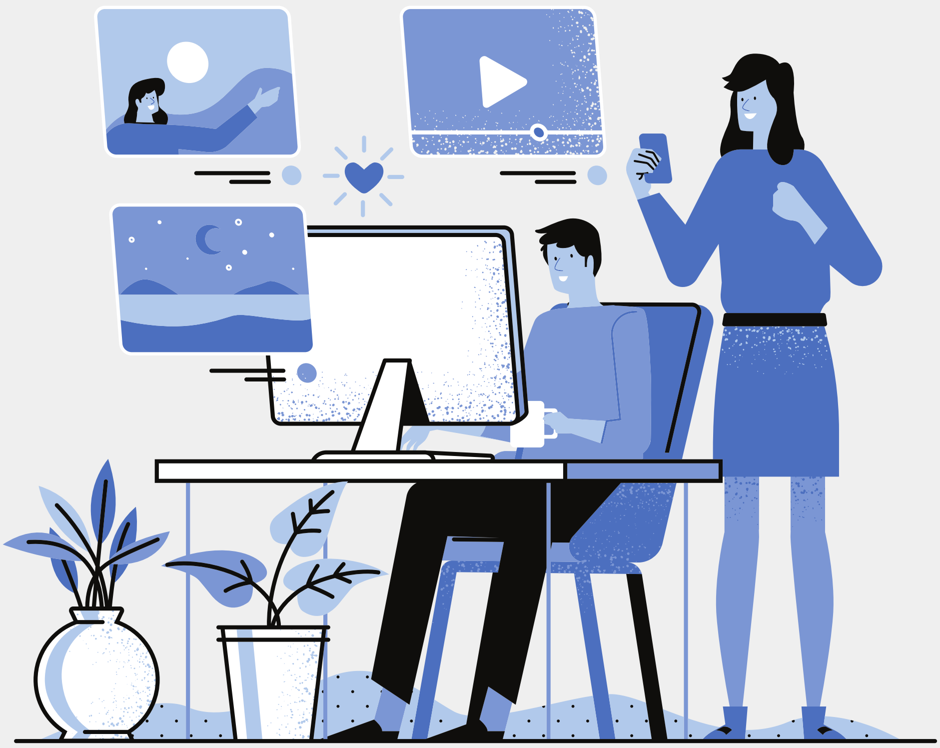
1. GENERAL EDUCATIONAL TECHNOLOGIES & TOOLS

Technology and education are increasingly interconnected, with the former serving the latter in multiple ways. Advances open new horizons and, in addition, give rise to new methodologies, as well as their implementation, and new tools that favour more profitable learning.

In recent years, new educational concepts and approaches have emerged that are linked to this increase in the use of technologies and the development of new tools. Among these new perspectives we find the idea of Personal Learning Environment (PLE), which consists, mainly, of that the learner builds knowledge with ICT, in a learning environment enriched with technologies, the interest has shifted towards the relationship between the "learning environment" and the "personal" to try to describe and interpret what, how and with what the individual who learns with ICT works (Gallego-Arrufat & Chaves-Barboza, 2014, p.2).

In this way, students can organize their own learning pace using technology. In this sense, Martindale and Dowdy (2010) identify three perspectives on what the PLE should consist of:

1. A client software that mediates between the learner and whatever resources the learner wants or needs.
2. A web-based portal.
3. Physical and electronic resources that learners can manipulate and customize to learn effectively.



On the other hand, we also find the update of Bloom's Taxonomy: "Bloom's Digital Taxonomy". This proposal by Bloom in 1956 consists of a set of three hierarchical models used to classify learning objectives into levels of complexity. "The purpose of Bloom's Digital Taxonomy is to inform instructors of how to use technology and digital tools to facilitate student learning experiences and outcomes" (Sneed, 2006 may).

As we can see in Figure 1, Bloom's Taxonomy goes from the most basic, remembering the information, to the most complex, creating from the information based on what has been previously learned, analysed, and evaluated. In this figure we see some examples of how to use technology in each of the phases of Bloom's taxonomy.

More and more studies share ways to make use of digital tools that are part of our daily lives, such as Facebook, Instagram, or even the use of Word to improve written expression skills.

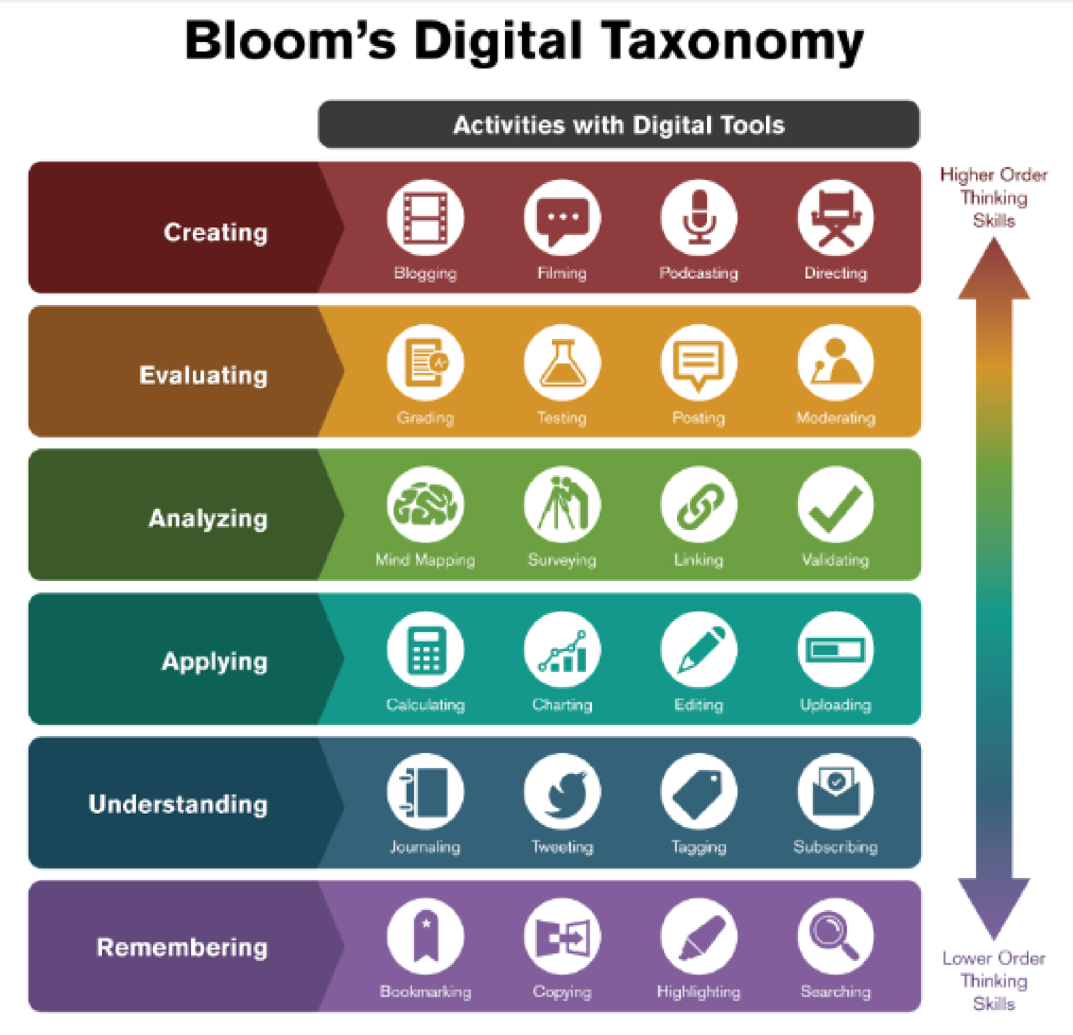


Image: How to Use Bloom's Digital Taxonomy - The Edvocate (theedadvocate.org)

Otherwise, we find The SAMR Model (Substitution, Augmentation, Modification, Redefinition), whose objective is to gradually integrate new technological tools so that students become familiar with them.
In this case, as described by Best (October 2020), there are four phases of technology integration in teaching and learning:

- Substitution: technology is a direct substitute that does not bring improvements to teaching.
- Augmentation: technology is a direct substitute that brings improvements to teaching.
- Modification: technology allows for a major redesign of tasks.
- Redefinition: technology allows the creation of new, previously inconceivable tasks.

Globally, the union of a new educational vision and the implementation of multiple technological resources, both familiar to students and specific to the development of specific skills, has advantages that favour the improvement of the teaching-learning process.

Among the most widespread tools for the digitization and accessibility of training are Learning Management Systems[1]. These software allow to manage, document, monitor and evaluate learning processes. There are different proposals based on this concept: Moodle, Chamilo, Canvas, Edmodo, Edubrtie, Proprofs or OpenEdX.

Some of the most current innovations that offer the greatest possibilities include Digital Reality (DR), which encompasses Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Extended Reality (XR). Below we will see the advantages of some of these technologies and concrete examples of their application in Vocational Education and Training (VET) teaching. We will also look at how to apply robotic technology in education, with a view to a future that will be increasingly robotic.

1 - For more information see IO6 Guideline for Online Assessment, chapter 4. DIGITAL LEARNING MANAGEMENT SYSTEM.

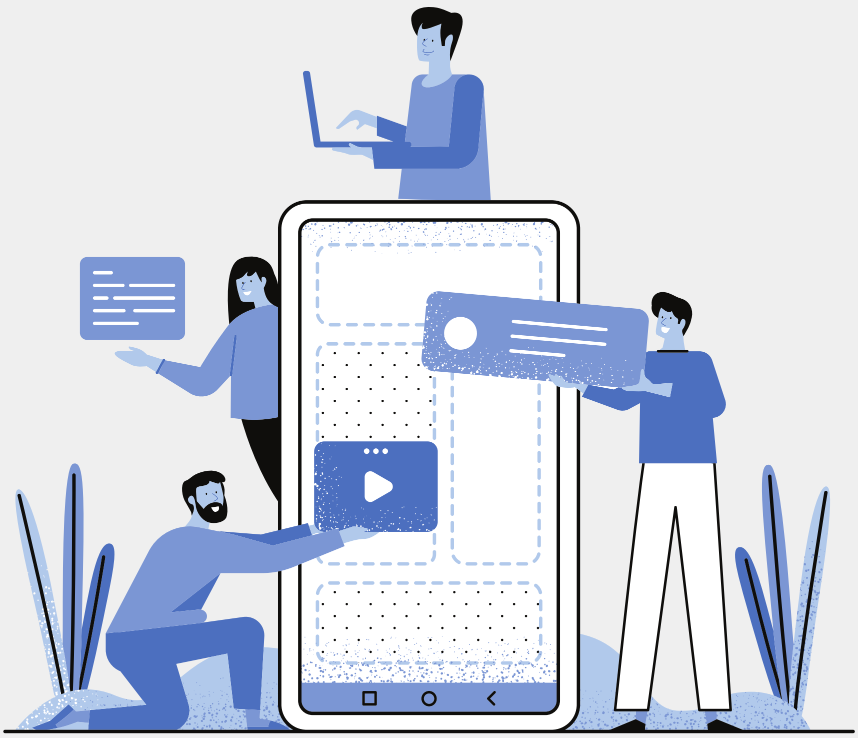
2. AUGMENTED REALITY IN THE EDUCATIONAL PROCESS

Augmented Reality (AR) emerged around 1992 by Tom Caudell when he developed a device that helped electricians in an aeronautical factory to perform their work with information added through glasses (Kreleven, 2007). Augmented Reality is understood as a technology that allows the user to visualize part of the real world through a technological device with added graphical information.

As can be seen, from its origin AR has been conceived as an element that adds information to improve professional performance. Therefore, it is a technology that had a practical application in the performance of manual work, which could also be transferred to teaching and learning – in addition to being used for medical, industrial or entertainment purposes.

Its application is significant for education because "it is an interactive technology, its ease of use, and that through its use we enrich or alter the information of reality by adding additional information" (Cabero, 2017, p.4).

Therefore, AR technology is increasingly being used in the classroom as a support or launching pad for new teaching methodologies. Moreover, this technology can be found at different educational levels; here we are going to focus on VET.



2.1. Learning benefits and limitations of Augmented Reality

In recent years the use of Augmented Reality in training has increased. That is why it should be considered what benefits the use of this technology brings to education. Based on the study by Radu (2014) we find "the positive impact that augmented reality experiences have been shown to have on learners, as compared to non-AR initiatives" (p.1534) and lists the following advantages: 1) Increasing content understanding: Learning spatial structure and function and learning language associations; 2) Long-term memory retention; 3) Improved physical task performance; 4) Improved collaboration; and 5) Increased student motivation. In addition,

> *The AR app allows saving the teacher's time for repeating the explanations; repetitions can be performed by the learner himself using the mobile app. Students tend to show sympathy and affection for this technology, so that they can be motivated in using it. AR is an economically effective technology, it provides students with more attractive and demonstrative content than paper didactic material (Bazarov, Kholodilin, Nesterov & Sokhina, 2017, p.6).*

We also find other advantages that go beyond the students and teachers, such as, in the specific case of welding, the reduction of CO_2 and environmentally harmful materials (between 40 and 60% depending on the welding process) (Margeta, Fernández, Benius, Schmelzer, Konig and Habek, July 2022). In addition, in welding as in other TEVs, although the price of these tools can be expensive, material costs are reduced, as well as the risks associated with some practices, so that investment in AR tools can bring savings in the future.

On the other hand, the AR implementation carries with it some detriments, such as attention tunnelling, usability difficulties, ineffective classroom integration and learner differences (Radu, 2014). However, as we will see in the concrete examples below, it does not only depend on the tool, but also on integrating this tool with a methodology that helps to enhance the positive aspects and reduce the negative ones, as we will find in the case of the Augmented Training Methodology, we will see it below in the Soldamatic section.

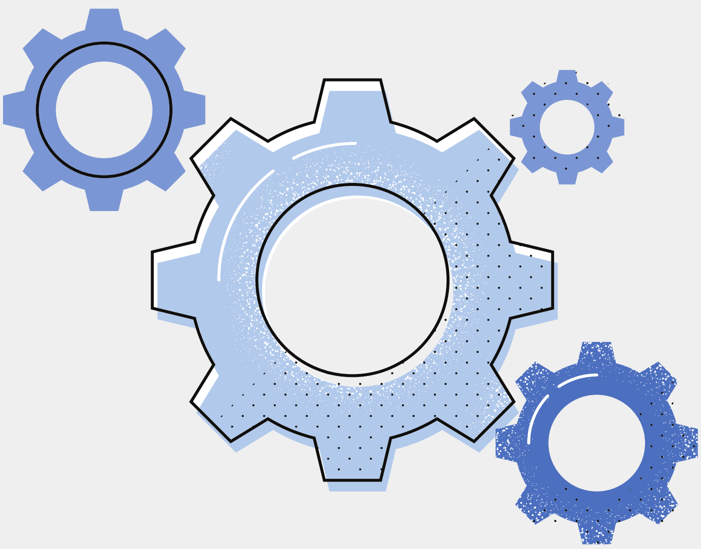
2.2. Augmented Reality educational tools general inventory

There are multiple educational tools based on Augmented Reality. In this case, we will mention some examples in a general sense, and we will delve into a specific tool developed for the specific teaching of a profession. AR has been used in different fields from tourism to medicine, from interior design to product design. These tools not only allow students to interact with technology, but also enable them to create their own content. Furthermore, “the combination of AR technologies with learning subjects creates a new type of automated application for increasing the effectiveness and attractiveness of students' learning and their knowledge in a real life” (Bazarov, et al., 2017, p.2).

Augmented Reality can be presented in different devices, if we want to use an AR app it will be enough with a standard camera and a mobile device graphics chip. But also, it is possible to use specialized hardware and software.

We find tools for the creation of AR content by the teacher himself. In this case, the following stand out: Assemblr Studio, EyeJack Creator and MyWebAR. All of them offer a web environment in which to experiment with AR in a simple way.

There are some more general tools that can be useful for teaching, usually for the creation of AR:



- Metaio
- Vuforia
- Tango
- Wikitude
- ARKit
- ARCore
- Vision Lib
- Metaverse
- QuiverVision

2.2.1. AR tools for VET

In the case of specific tools for teaching various VET[2], we see that there are devices and educational solutions for different sectors such as painting, agriculture or welding. The simulator "allow students to get acquainted with the industrial equipment, which they will meet in the industry later" (Bazarov et al., 2017, p.3).

Educational Area	Solution
Welding[3]	• *Soldamatic* • *Realweld* • *Miller AugmentedArc* • *Miller LiveArc* • *guideWELD® LIVE real welding guidance system* • *123 Certification Inc.*
Ship navigation	• Ocean Industries Concept Lab
Criminalistic	• Forensics - Augmented Reality Crime Scene App
Military	• Hägglunds
Healthcare	• CAE VimedixAR
Maintenance & Repair	• Spray Gun Service Maintenance • WorxAR

2 - In this link (https://drinvet-project.eu/vet-platform-dr.html) you will find a VET library of DR with a lot of information about Digital Reality tools and resources. This corresponds to the IO2 of the DRinVET project.

3 - More information on AR, VR and XR welding simulators can be found in Annexes.

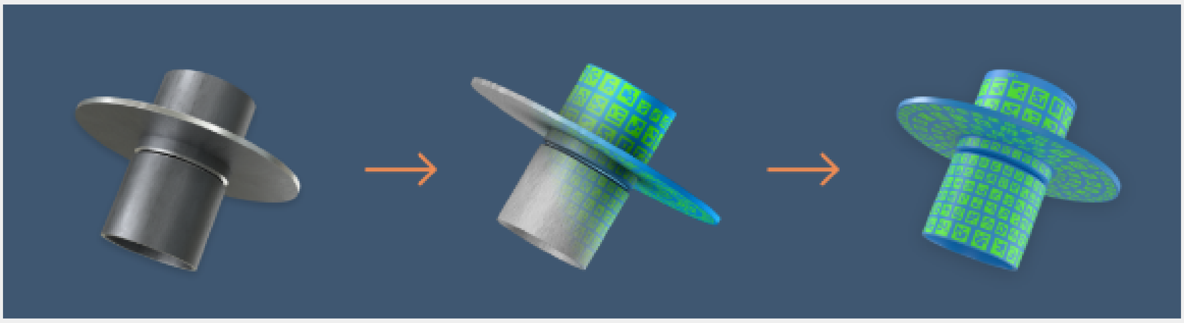
2.2.2. Specific AR tool for welding training: SOLDAMATIC

Soldamatic, developed by Augmented Training Services (educational division of the Seabery group), in addition to being an AR simulator, offers a methodology that integrally shapes the training of future welders, the Augmented Training (AT) methodology.

The AT methodology is composed of three parts (shown in Figure 2): an e-Learning application, the simulator, and the practices in the real workshop. The educational solution provided by AT offers a variety of options, it is a complete tool that allows the creation of courses, modules, units, exercises, and quizzes adapted to each student and their educational needs.

Images: ATS

Soldamatic can reproduce various welding processes (GMAW, FCAW, SMAW and GTAW), as well as different positions and materials (carbon steel, stainless steel and aluminium). Therefore, it is a tool with multiple simulation possibilities. In addition, it allows to configure customized practices, apart from those that come predefined with the simulator. In this configuration you can select the characteristics of different parameters such as wire diameter, gas (in the processes that require it), bead length, number of passes or pattern, among others.



On the other hand, by means of the e-Learning application, student and instructor profiles can be created. With this, the practice and performance of each student can be monitored to see their progress, as well as their strengths and weaknesses. In this way, the contents and practices can be adapted to strengthen the necessary aspects for each student.

Another of the options offered by this tool is the possibility of connecting different simulators to create a simulation classroom, so that the instructor can see at the same time the practice being carried out by each of the students in real time. This is called Augmented Lab and is usually connected to a physical server or in the cloud.

Images: ATS

2.2.3. Robotic tools based in AR technology for education

The implementation and use of robots to perform various jobs is becoming more and more frequent, and, therefore, they have been incorporated into the educational field. From primary education to specialized teachings.

Some of the jobs that are being automated through the use of Robots have to do with those industrial and vocational jobs, which is why in turn should be involved the educational system of VET teaching in the insertion of subjects that focus on teaching the use of robots for the performance of work activity.

Some proposals have been found in which the teaching of the handling of these robots has been carried out using AR technologies. ROBOTICS, a tool also developed by Augmented Training Services, has been found, which uses the same technology and methodology as in SOLDAMATIC. This tool can be used with different robots in the welding sector for the training of future welders who will use them.

Image: ATS

3. VIRTUAL REALITY IN THE EDUCATIONAL PROCESS

In contrast to Augmented Reality, Virtual Reality (VR) in education offers endless possibilities because instead of taking reality as a reference, it is a completely virtual space. This allows the creation of environments and scenarios of all kinds to promote learning. This technology has been popularized by its use in the world of video games, however, it has applications in VET education.

Virtual Reality as we know it today dates to the nineteenth century and since then there have been multiple proposals, improvements, and innovations over the years to reach the concept of "Virtual Reality" and the format that has become popular.

In academia, implementing VR "with self-managed learning processes can provide an immersive, interactive experience that complements traditional classroom lectures and creates innovative online learning in curricula and professional training" (Norman-Acevedo, 2019, p.5). In this sense, many studies emphasize the contribution of the immersion that Virtual Reality allows, linked to the autonomy of the students, due to the fact that these tools are generally intuitive and dynamic (Mariscal, Jiménez, Vivas-Urias, Redondo-Duarte & Moreno-Pérez, 2020; Man, Guo & Ma, 2020; Sousa, Campanari & Rodrígues, 2021). It is important to note that

> *there has been a boost to this technology with the emergence of new virtual reality devices on the market that are increasingly accessible to the public. With the appearance of Google Cardboard (Google, 2019), immersive virtual reality is available to any user with a smartphone and the minimum investment to acquire or manufacture cardboard glasses that are compatible with Google's (Mariscal et al., 2020, p.2).*

In this sense, we can highlight that Virtual Reality can be accessible, it will be enough with a mobile phone and a structure like the Google Cardboard. In addition, several companies have developed virtual reality glasses with controllers (one for each hand), which also democratizes the use of VR in society.

3.1. Learning benefits and limitations of Virtual Reality

As with the application of AR tools in education, Virtual Reality offers advantages associated with its characteristics. The main virtue of this technology is the immersion that occurs, so that a person can experience experiences through different senses, interacting with the space and moving freely in 360°.

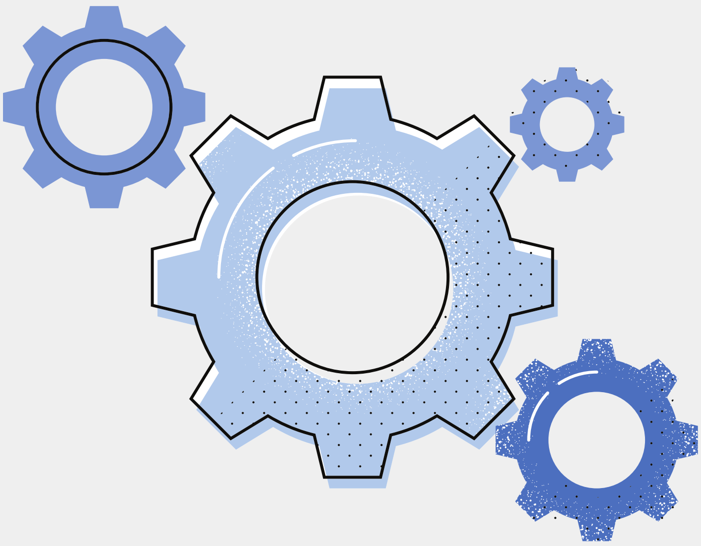
However, it should be noted that

> *despite the potential benefits of using virtual reality in the educational process, this experience alone does not guarantee an improvement in motivation and learning. The extended use of sensory immersion may not bring a good experience for the student. For example, spending a long period of time in an immersive environment may make the learner uncomfortable, and the learner's attention may be at odds with the richness provided by the virtual environment, thus reducing his or her attention and potentially diverting him or her from the learning objective. Likewise, the visual resolution may hinder reading (Sousa, Campanari & Rodrígues, 2021, p.234).*

This reminds us that any tool should be used in a conscious and useful way for its purpose. If we use VR for VET training, we must propose a methodology that fits it and that enhances its benefits and reduces its disadvantages.

3.2. Virtual Reality educational tools general inventory

Similarly, to Augmented Reality, there are a few tools, some of which require more knowledge and experience to create VR, and some devices:



- Unity
- Unreal Engine
- CoSpaces Edu
- ThingLink
- VR Chat
- Google Cardboard
- Oculus
- Gear VR
- HTC Vive
- Open VR
- DayDream

3.2.1. VR tools for VET

On the other hand, we find several solutions in VR focused on the teaching of various professions:

Educational Area	Solution
Industrial Painting	• *SimsSpray*
Heavy machinery operators/car-bus-truck drivers	• Tenstar Simulation (construction, transportation, agriculture, forestry) • CMlabs (construction, transportation, forestry) • Acreos (construction, transportation, agriculture, forestry, miming)

Educational Area	Solution
Welding	• Apolo • VRTEX 360 • VRTEX Mobile • VRTEX Engage • VRTEX 360 Compact • E-Tech Simulation • Fronius Virtual Welding • guideWELD®VR Welding Simulator • Wave NG • Simbott
Wood working	• WOOD-ED TABLE • WOOD-ED FACTORY
Electrical accreditation & electrical maintenance	• Virtual INDUS (electrical accreditation, electrical maintenance)
Production line operators	• Virtual INDUS: product line operator
Refrigerant accreditation (HVAC)	• Virtual INDUS: Refrigerant accreditation
Chemistry	• MIMBUS Chemistry
Healthcare	• VRNA

In addition to specific VR simulators for different areas, there are two solutions that focus on broader aspects such as the choice of the VET career that best suits the student (MIMBUS Discover, Virtual Reality career guidance tool). There is also the Vulcan tool, which allows connecting various AR and VR devices and tools. It can be used to evaluate, manage classes, observe practices in simulators or customize training paths, among other options.

3.2.2. Robotic tools based in VR technology for education

Just as there have been tools in AR focused on the use and programming of robots for welding practice, we find similar solutions using Virtual Reality technology. Tools such as Valk Welding, K-Virtual Arc, Panasonic's Virtual Robot Programming System VRPS or Fronius Virtual Welding open the possibilities for training in the field of robotic welding.

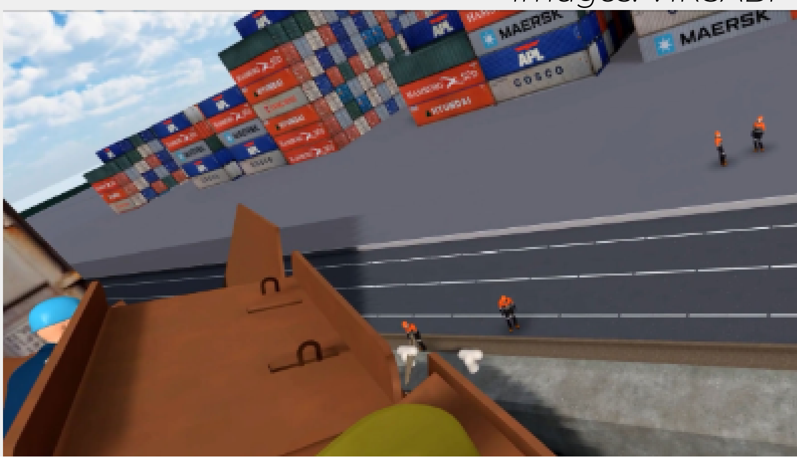
As López and Andrade (2013) point out robotics is increasingly present in people's daily lives and, moreover, in multiple professions that are facilitated or improved by the inclusion of robotic tools. Therefore, they will be more present in the educational field either for their use, their creation or as a means for learning other subjects.

3.2.3. Specific VR tool for Safety: Maersk Building Capacity

Maersk Building Capacity: behavioural training in virtual reality, is an educational solution developed ad hoc by Virsabi for Maersk focused mainly on safety training for the company's ship's officers. This VR tool trains ship's officers in predicting, monitoring, and acting on danger signals during mooring, which is a complex and varied task aboard a ship.This solution brings numerous benefits, mainly risk reduction; it also offers more uniform training as well as cost and time savings.

Using a fully immersive tool, scenarios are proposed in which students learn how to deal with safety-critical situations. Therefore, this educational solution proposes an experiential learning methodology where the student follows the captain's instructions. Through VR, scenarios can be proposed that in real life would be more difficult to reproduce or would involve great risks.

Images: VIRSABI



4. MIXED REALITY IN THE EDUCATIONAL PROCESS

Mixed reality is that which combines virtual reality, augmented reality and reality, and "offers the possibility of physically interacting with virtual objects in the real world" (Ortega-Rodríguez, 2022, p.195). Similar to AR and VR technologies, there have been several studies of their application in education. From the use of MR, the concept of Mixed Reality Learning Environment (MRLE) has emerged. In this sense, there are laboratories that combine the virtual and the real to provide a mixed space that contributes in an integral way to the improvement and proliferation of education based on digital technologies.

As it is a technology that integrates various digital and physical tools, it is less common to find solutions based on RM. We find Microsoft devices (HoloLens) or Magic Leap (one and two), which make this technology accessible in classrooms, but they are not the only ones, as we will see below.

4.1. Learning benefits and limitations of Mixed Reality

The advantages and disadvantages of RM are very similar to those shared above about AR and VR. In general, it reduces costs and allows immersive experiences that would not be possible without the virtual recreation of environments and objects, using the most interesting possibilities of both technologies: AR and VR, added to the real physical world.

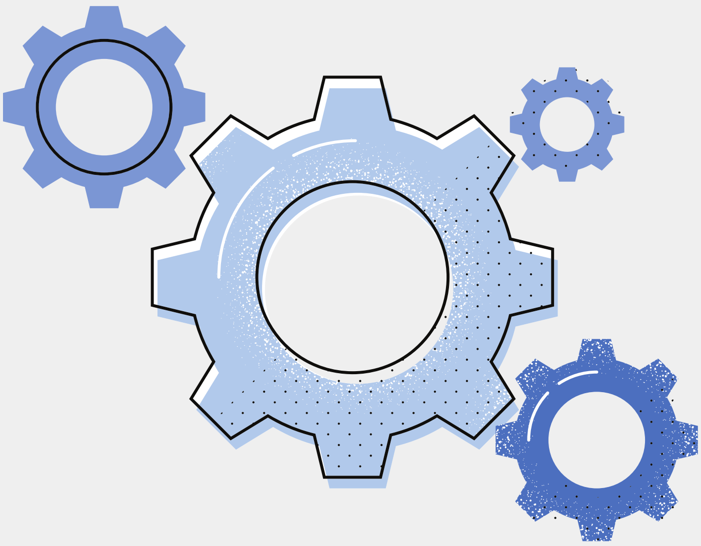
> *The advantages of MR are related to its multiple applications from a methodological point of view, as it combines the possibilities of VR and AR in the same approach, leading to the design and development of learning experiences that give relevance, interest and significance to student learning (Ortega-Rodríguez, 2022, pp. 196-197).*

In addition, the author adds that it is common to use RM in relation to serious games, which are games that promote learning. Among the characteristics of this technology, we find that they are: attractive, universal and multipurpose, and, also, they offer the possibility of accessing distant worlds (spatiotemporally), thus overcoming geographical limitations (Acer for education, 2017).

On the other hand, the main disadvantage found in the application of this technology in educational processes has to do, mainly, with the lack of collaboration between technological and pedagogical researchers. However, advances in the study of these technologies have led teachers and pedagogues to become interested in deepening their studies to better understand the possibilities and limitations of these tools and try to find methodologies and fruitful applications for education (Ortega-Rodríguez, 2022).

4.2. Mixed Reality educational tools general inventory

In the following, we will list some tools for the creation and devices for the implementation of RM.



- AfterNow
- HoloLens
- MagicLeap
- AjnaLens
- Holoboard Enterprise Edition
- ZapBox
- Lightfield
- Bridge – Occipital

4.2.1. MR tools for VET

Regarding specific tools for VET, we find that they are more scarce than VR andAR tools.

Educational Area	Solution
Welding	• *VRT Steinhauser UG*
Armed Forces	• FC-TRAINER • AIRC2 TRAINER • SOLSTICE • RAINBOW EXCON • UAV-X
Maintenance operation	• VIRTUAL MAINTENANCE TRAINER

5. EXTENDED REALITY IN THE EDUCATIONAL PROCESS

If mixed reality makes use of AR, VR and also some physical elements of the real world, the XR goes further,

extends across VR, AR and MR, as well as all future immersive technologies that enable an extension of reality while blending virtual graphics with real-world elements. Such technologies include, for example, Artificial Intelligence (AI), Internet of Things (IoT), 5G network, and others. XR covers the full spectrum of real and virtual environments (Breia, April 2022).

As Negrete (2022) indicates, the incorporation of XR in education is being progressive, we find studies on its application in nutrition, architecture, medicine and language teaching (Kharvari and Kaiser, 2022; Singh, Kainth, Manjila, Jain, Vaysberg, Spektor, Prasanna and Manjila, 2021; Tegoan, Wibowo and Grandhi, 2021; McGuirt, Cooke, Burgermaster, Enahora, Huebner, Meng, Tripicchio, Dyson, Stage and Wong, 2020; Andrews, Southworth, Silva and Silva, 2019). All these studies, as we can see, are quite recent since it is the most current technology and it is still being developed, studied and applied in the educational field.

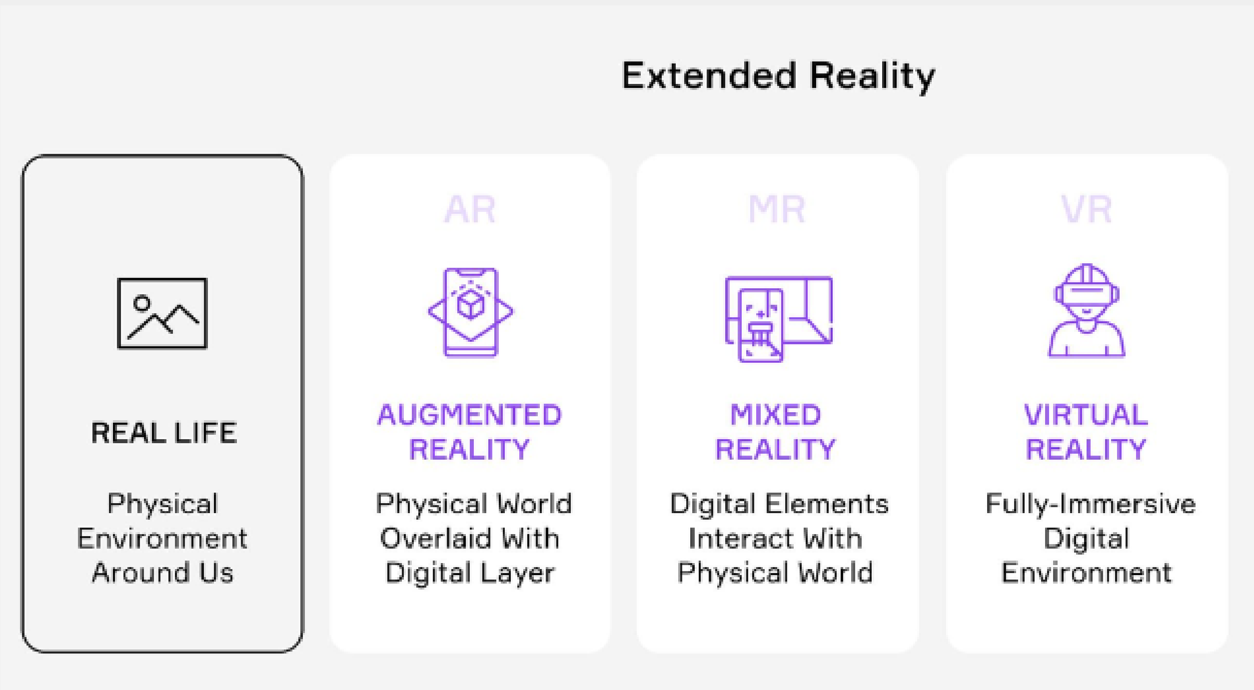


Image: Breia, 2022

5.1. Learning benefits and limitations of Extended Reality

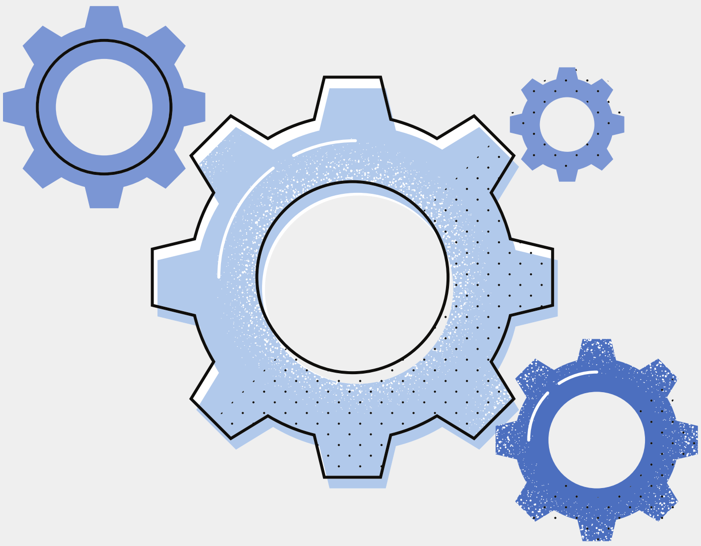
Extended reality presents some differences in its benefits and limitations with respect to its application in teaching. On the one hand, in a positive way, it offers even greater immersion, however, its cost is higher as it involves the use of various technologies and tools, as well as the adaptation of a real space.

Ortega-Rodríguez (2022) points out four challenges facing XR in the education sector:

- *The high investment required for schools to implement VR and AR to create new learning experiences in laboratories AR, which make it possible to create new learning experiences in digital laboratories.*
- *The personalization of training, which considers the students' starting point, so that the pace of learning and the teaching approach are the learning pace and teaching approach are organized according to the needs of each student.*
- *The integration of active methodologies and emerging technologies, which involves the development of methodologies, such as the inverted or flipped classroom, in which flipped classroom, in which students prepare the syllabus before a class and spend time in the classroom to put the content into practice.*
- *The search for meaningful learning, which does not conceive of emerging technologies only as an end, but also as tools at the service of teachers and students to improve the teaching-learning process (p.201).*

5.2. Extended Reality educational tools general inventory

Among the general tools, we find, mainly:



- XR MergeCube
- Education XR
- XR Guru
- Votanic XR
- Impala XR

5.2.1. XR tools for VET

On the other hand, there are also specific tools for VET based on XR technology.

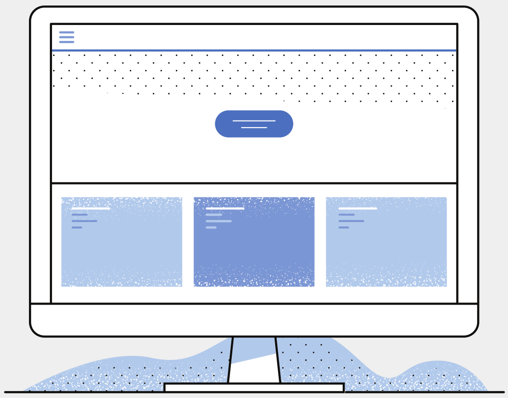
Educational Area	Solution
Welding	• *Skillveri Aura X*
Painting	• Skillveri Chroma® Spray Painting Simulators
Healthcare	• Kyalio

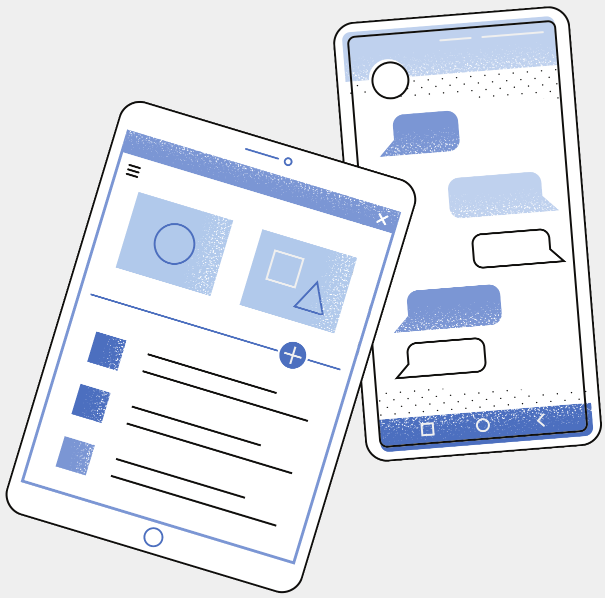
6. MINIMUM REQUIEREMENTS FOR THE INTEGRATION OF DIGITAL REALITY IN THE EDUCATIONAL PROCESS

Finally, let's highlight what is needed from trainers and training centers to ensure an effective integration of the different forms of Digital Reality in the educational process.

The main requirement for the incorporation of AR, VR, MR and XR in education is to ensure the "specific training of teachers in order to create contents that improve the teaching-learning process" (Ortega-Rodríguez, 2022, p.194), as well as to certify their knowledge of the tools with which they are going to teach in the classroom. Therefore, it is essential, first of all, to have well-trained and qualified trainers, both in their subjects and in the application of the tools.

On the other hand, it is necessary to have access to tools for the creation of content with DR, as well as to the devices with which to implement it[4]. In the case of using specific solutions, it will be necessary for them to receive training from the distribution company and be given access to the solution prior to its implementation in the classroom in order to be able to practice what they have learned before teaching.





4 - For more information access to IO3 HOW TO... Best practice examples from VET digital classrooms across Europe.

6. MINIMUM REQUIEREMENTS FOR THE INTEGRATION OF DIGITAL REALITY IN THE EDUCATIONAL PROCESS

In addition, teachers who are going to use RD tools in their classrooms must have certain characteristics such as being proficient in the use of these tools in general and, in turn, have an open mind to learning and improving their management and their integration through methodological innovation to make a comprehensive and effective use of RD.

Finally, the importance of assessments should be noted. With a new methodology and new tools, teachers need to adapt their assessments. To this end, in IO4 of this project, a pedagogical guide has been developed to share relevant aspects to ensure quality when performing online assessment, with rules, examples and templates.

REFERENCES

Acer for Fducation (June's 16, 2017). "Mixed Reality in Education: boosting students' learning experience". Acer. https://acerforeducation.acer.com/education-trends/steam/mixed-reality-in-education-boosting-students-learning-experience/

Andrews, C., Southworth, M.K., Silva, J.N.A. & Silva, J. R. (2019). "Extended Reality in Medical Practice". Current Treatment Options Cardiovascular Medicine, 21(18). https://doi.org/10.1007/s11936-019-0722-7

Bazarov, S.E., Kholodilin, I. Y., Nesterov, A. S. & Sokhina, A. S. (2017). "Applying Augmented Reality in practical classes for engineering students". IOP Conf. Series: Earth and Environmental Science, 87 032004. doi:10.1088/1755-1315/87/3/032004.

Best, J. (October's 9, 2020). "The SAMR Model Explained (With 15 Practical Examples)". 3P Learning. https://www.3plearning.com/blog/connectingsamrmodel/

Breia, R. (April's 29, 2022). "What Is Extended Reality - XR Explained". Sensorium. https://sensoriumxr.com/articles/what-is-extended-reality

Cabero, J. (2017). "Presentación: Aplicaciones de la Realidad Aumentada en educación". EDMETIC (Revista de Educación Mediática y TIC), 6 (1), pp. 4-8.

Gallego-Arrufat, M. J. & Chaves-Barboza, E. (2014) "Tendencias en estudios sobre Entornos Personales De Aprendizaje (Personal Learning Environments-PLE-)". EDUTEC. Revista Electrónica de Tecnología Educativa, 49. https://www.edutec.es/revista/index.php/edutec-e/article/view/89/13

Gagandeep, S., Tejasvi, K., Nihal, M., Shubham, J., Anatoliy, V., Vadim, S., Prateek, P., & Sunil, M. (2021). "Editorial. Long-term solutions in neurosurgery using extended reality technologies". Neurosurgical Focus, 51(2), E2. https://thejns.org/focus/view/journals/neurosurg-focus/51/2/article-pE2.xml

Kharvari, F. & Kaiser, L. E. (2022). "Impact of extended reality on architectural education and the design process". Automation in Construction, 141, 104393. https://doi.org/10.1016/j.autcon.2022.104393

Kreleven, (2007). "Augmented Reality: Technologies, Applications, and Limitations". doi:10.13140/RG.2.1.1874.7929

López Ramírez, P. A. & Andrade Sosa, H. (2013). “Aprendizaje de y con robótica, algunas experiencias”. Revista Educación, 37(1), pp.43-63. https://revistas.ucr.ac.cr/index.php/educacion/article/view/10628/10298

Andrews, C., Southworth, M.K., Silva, J.N.A. & Silva, J. R. (2019). “Extended Reality in Medical Practice”. Current Treatment Options Cardiovascular Medicine, 21(18). https://doi.org/10.1007/s11936-019-0722-7

Man, J., Guo, F. & Ma, C. (2020). “Innovative Analysis of Higher Vocational Education Model Based on Virtual Reality Technology”. Journal of Physics: Conference Series. 1533. doi:10.1088/1742-6596/1533/2/022097

Margeta, E., Fernández, A., Benius, F., Schmelzer, A. & Habek, Z. (July’s 18, 2022). “Welding simulators - green training for top welders”. The 75th IIW Annual Assembly and International Conference, Tokyo, Japan.

Mariscal, G., Jiménez, E., Vivas-Urias, M. D., Redondo-Duarte, S. & Moreno-Pérez, S. (2020). “Virtual Reality Simulation-Based Learning”. Education in the Knowledge Society 2, art. 11. https://doi.org/10.14201/eks.20809

Martindale, T. & Dowdy, M. (2010). “Personal Learning Environments”.

Mcguirt, J. T., Cooke, N. K., Burgermaster, M., Enahora, B., Huebner, G., Meng, Y., Tripicchio, G., Dyson, O., Stage, V. C. & Wong, S. S. (2020). Extended Reality Technologies in Nutrition Education and Behavior: Comprehensive Scoping Review and Future Directions. Nutrients, 12(9):2899. https://doi.org/10.3390/nu12092899

Negrete Calderón, M. J. (2022). “Realidad extendida y sus posibilidades de mediación en ambientes de aprendizaje” [Degree Thesis]. Universidad de Córdoba.

Norman-Acevedo, E. (2019). “Nuevos lenguajes para aprendizaje virtual herramientas para los escenarios de aprendizaje”. PANORAMA, 13(24), pp.5-7. https://doi.org/10.15765/pnrm.v13i24.1214

Ortega Rodríguez, P. J. (2022). “De la Realidad Extendida al Metaverso: una reflexión crítica sobre las aportaciones a la educación”. Teoría De La Educación. Revista Interuniversitaria, 34(2), 189–208. https://doi.org/10.14201/teri.27864

Radu, I. (2014). “Augmented reality in education: a meta-review and cross-media analysis”. Pers Ubiquit Comput, 18, pp. 1533–1543.

Sneed, O. (May’s 9, 2016). “Integrating Technology with Bloom’s Taxonomy”. Teach Online, Arizona State University. https://teachonline.asu.edu/2016/05/integrating-technology-blooms-taxonomy/

Sousa Ferreira, R., Campanari Xabier, R.A. & Rodrígues Ancioto, A. R. (2021). “La realidad virtual como herramienta para la educación básica y profesional”. Revista Científica General José María Córdova: Revista colombiana de estudios militares y estratégicos, 19(33), pp. 223-241. https://doi.org/10.21830/19006586.728

Tegoan, N.; Wibowo, S. & Grandhi, S. (2021). “Application of the Extended Reality Technology for Teaching New Languages: A Systematic Review”. Applied Science, 11, 11360. https://doi.org/10.3390/app112311360

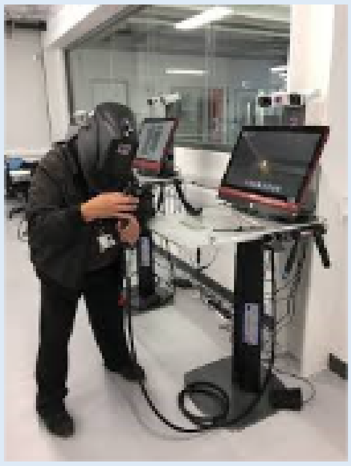
DRINVET

DIGITAL REALITY - THE BASIS OF SKILLS TRAINING

ANNEXES

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

EWF virsabi AT AUGMENTED TRAINING LVE Learn Virtual Europe #STRUKA

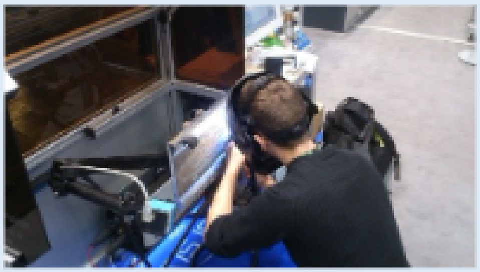
	123 Certification Inc., Kanada	http://www.123arc.com/
Technology: AR Augmented Reality **Welding procedures:** REL, MAG, FCAW, MCAW, TIG **Material:** low alloy steel, stainless steel, aluminum **Work piece / welded joint:** corner joint, butt joint, lap joint **Welding positions:** PA, PB, PD, PE, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Specification of welding procedures (WPS)- Training playback (playback		

	E-Tech Simulation, SAD	http://www.etechsimulation.com/
Technology: VR – Virtual Reality **Welding processes:** REL, MAG, FCAW, TIG **Material:** low alloy steel **Workpiece / welded joint:** the possibility of importing a workpiece and welding on it **Welding positions:** PA, PB, PC, PF, PD, PH, PE, HL-045 **Welding technique:** pulling, pushing **Other functions:** - Training análisis - Ability to work with right and left hand		

	Apolo Studios, Spain	http://apolostudios.com/
Technology: VR Virtual Reality **Welding procedures:** REL, MAG, FCAW, MCAW, TIG **Material:** low alloy steel, stainless steel, aluminum, copper **Work piece / welded joint:** corner joint, butt joint, lap joint, plate and pipe **Welding positions:** PA, PB, PD, PE, PF, PG, PH, HL-045 **Welding technique:** pulling, pushing **Other functions:** - Welding training system - Training analysis - Training playback (playback)		

	FRONIUS Virtual Welding 2.0, Austrija	www.fronius.com
Technology: VR virtual reality **Welding procedures:** REL, MAG, TIG, robotic welding (MAG) **Material:** low alloy steel **Work piece / welded joint:** plate, filett joint, butt joint, pipe to pipe, pipe to plate **Welding positions:** PA, PB, PD, PE, PF, PG, PH, PJ, **Welding technique:** pulling, pushing **Other possibilities:** - Welding training system - Training analysis - Training playback (playback)		

DVS SLV HALLE	GSI SLV-Schweißtrainer, Njemačka	https://www.slv-halle.de/en/

Technology: Optical tracking comined with real arc **Welding procedures:** MAG, TIG without filler material **Material:** low alloy steel **Work piece / welded joint:** plate **Welding positions:** PA, PB, PE, PF, PG **Welding technique:** push **Other functions:** - Voltage and current regulator - Training analysis - Curriculum	

Realityworks Live it. Learn it.	guideWELD®VR Welding Simulator, SAD	https://www.realityworks.com/

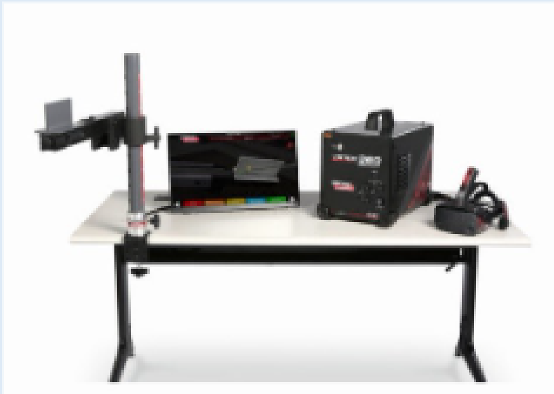
Technology: VR Virtual reality **Welding procedures:** REL, MAG **Material:** low alloy steel, stainless steel **Work piece / welded joint:** filett joint, butt joint, lap joint **Welding positions:** PA, PB **Welding technique:** by pushing **Other functions:** - Training analysis - Curriculum - WPS welding procedure specification - Training playback (playback)	

Realityworks	**guideWELD® LIVE real welding guidance system, SAD**	https://www.realityworks.com/
Technology: AR Augmented Reality **Welding procedures:** REL, MAG **Material:** low alloy steel **Work piece / welded joint:** filett joint, butt joint, lap joint **Welding positions:** PA, PB **Welding technique:** by pushing **Other functions:** - Voltage and current regulator - Curriculum - WPS welding procedure specification		

LINCOLN ELECTRIC	**VRTEX 360, SAD**	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: VR virtual reality **Welding procedures:** REL, MAG, FCAW, MCAW, TIG **Material:** low alloy steel, stainless steel, aluminum **Work piece / welded joint:** plate, corner joint, butt joint, lap joint, pipe to pipe, pipe to plate. **Welding positions:** PA, PB, PD, PE, PF, PG, PH, PJ, HL045, JL045 **Welding technique:** pulling, pushing **Other functions:** - Voltage and current regulator - Training analysis - Curriculum - Specification of welding procedures (WPS) - Training playback (playback)		

LINCOLN ELECTRIC	VRTEX Mobile, SAD	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: VR virtual reality **Welding procedures:** REL, MAG, FCAW, MCAW **Material:** low alloy steel **Work piece / welded joint:** plate, filett joint, butt joint **Welding positions:** PA, PB, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Training analysis - Curriculum - Specification of welding procedures (WPS) - Training playback (playback)		

LINCOLN ELECTRIC	VRTEX Engage, SAD	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: VR virtual reality **Welding procedures:** REL, MAG, FCAW, MCAW **Material:** low alloy steel **Work piece / welded joint:** plate, filett joint, butt joint **Welding positions:** PA, PB, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Training analysis - Curriculum - Specification of welding procedures (WPS)		

LINCOLN ELECTRIC	VRTEX 360 Compatct, SAD	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: VR virtual reality **Welding procedures:** REL, MAG, FCAW **Material:** low alloy steel **Work piece / welded joint:** plate, filett joint, butt joint, lap joint **Welding positions:** PA, PB, PD, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Voltage and current regulator - Training analysis - Curriculum - Specification of welding procedures (WPS)		

LINCOLN ELECTRIC	Realweld, USA	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: AR Augmented reality **Welding procedures:** REL, MAG, FCAW **Material:** low alloy steel **Work piece / welded joint:** plate, filett joint, butt joint, lap joint **Welding positions:** PA, PB, PD, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Voltage and current regulator - Training analysis - Curriculum - Specification of welding procedures (WPS)		

Miller	Miller AugmentedArc, SAD	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: AR Augmented reality **Welding procedures:** REL, MAG, FCAW, TIG **Material:** low alloy Steel, stainless Steel, aluminium **Work piece / welded joint:** plate, corner joint, butt joint, lap joint, pipe to pipe, pipe to plate **Welding positions:** PA, PB, PD, PE, PF, PG, PH, PJ, HL045, JL045 **Welding technique:** pulling, pushing **Other functions:** - Voltage and current regulator - Training analysis - Training playback (playback)		

Miller	Miller LiveArc, SAD	https://www.lincolnelectric.com/en-us/Pages/default.aspx
Technology: AR Augmented reality **Welding procedures:** REL, MAG, FCAW **Material:** low alloy steel **Work piece / welded joint:** **Welding positions:** PA, PB, PD, PE, PF, PG **Welding technique:** pushing **Other functions:** - Voltage and current regulator - Training analysis - Curriculum - Specification of welding procedures (WPS)		

<table>
<tr><td>Mimbus</td><td>WAVE NG zSpace Pro AIO, Francuska</td><td>https://www.mimbus.com/</td></tr>
<tr><td colspan="2">Technology: VR Virtual reality
Welding procedures: REL, MAG, FCAW
Material: low alloy steel
Work piece / welded joint: filett joint, butt joint, pipe to pipe, pipe to plate
Welding positions: PA, PB, PF, PG
Welding technique: pulling, pushing
Other functions:
- Training analysis
- Training playback (playback)</td><td></td></tr>
</table>

<table>
<tr><td>Mimbus</td><td>WAVE NG Lite, Francuska</td><td>https://www.mimbus.com/</td></tr>
<tr><td colspan="2">Technology: VR Virtual reality
Welding procedures: REL, MAG, FCAW
Material: low alloy steel
Work piece / welded joint: filett joint, butt joint, pipe to pipe, pipe to plate
Welding positions: PA, PB, PD, PE, PF, PG
Welding technique: pulling, pushing
Other functions:
- Training analysis
- Training playback (playback)</td><td></td></tr>
</table>

Mimbus	WAVE NG Workbench, Francuska	https://www.mimbus.com/
Technology: VR Virtual reality **Welding procedures:** REL, MAG, TIG **Material:** low alloy steel **Work piece / welded joint:** filett joint, butt joint, pipe to pipe, pipe to plate **Welding positions:** PA, PB, PD, PE, PF, PG **Welding technique:** pulling, pushing **Other functions:** - Training analysis - Training playback (playback)		

Skillveri	Skillveri Aura X, Indija	https://skillveri.in
Technology: XR Crossed reality **Welding procedures:** REL, MAG, TIG **Material:** low alloy steel **Work piece / welded joint:** filett joint, butt joint, pipe to pipe, pipe to plate **Welding positions:** PA, PB, PD, PE, PF, PG, PH, PJ, HL045, JL045 **Welding technique:** pulling, pushing **Other functions:** - Training analysis		

<table>
<tr><td>Seabery</td><td>Soldamatic, Spain</td><td>https://www.soldamatic.com/</td></tr>
<tr><td colspan="2">Technology: AR Augmented reality
Welding procedures: REL, MAG, FCAW, TIG
Material: low alloy steel, stainless steel, aluminium
Work piece / welded joint: filett joint, butt joint, lap joint, pipe to pipe, pipe to plate
Welding positions: PA, PB, PD, PE, PF, PG, PH, PJ, HL045, JL045
Welding technique: pulling, pushing
Other functions:
- Voltage and current regulator
- Training analysis
- Training playback (playback)
- Curriculum
- Specification of welding procedures (WPS)</td><td></td></tr>
</table>

<table>
<tr><td>Seabery</td><td>Robotics, Spain</td><td>https://www.soldamatic.com/</td></tr>
<tr><td colspan="2">Technology: AR Augmented reality
Welding procedures: MAG
Material: low alloy steel, stainless steel, aluminium
Work piece / welded joint: filett joint, butt joint, lap joint, pipe to pipe, pipe to plate
Welding positions: PA, PB, PD, PE, PF, PG, PH, PJ, HL045, JL045
Welding technique: pulling, pushing
Other functions:
- Training analysis
- Introduction to robotic welding
- Specification of welding procedures (WPS)
- Training playback (playback)</td><td></td></tr>
</table>

Project Partners

Project Associated Partners

Co-funded by

the Erasmus+ Programme of the European Union