VETToolbox

Co-funded by the European Union

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Stocktaking Report

The current status quo of XR use in VET development projects

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

1 Introduction
2 Overview of basic terminology
3 XR and VET projects in DC
4 Summary/learnings
5 References

Contents

1. Introduction

This Stocktaking Report presents the current status quo regarding Extended Reality (XR) use in the nexus of Vocational Education and Training (VET) in development cooperation.

The report was produced within the framework of the VET Toolbox Project[1], which is a project of the Employment and Skills for Development in Africa (E4D) programme of GIZ and financed by the European Union (EU) and the Federal Ministry for Economic Cooperation and Development of Germany (BMZ).

This report gives an overview of XR terminology and the differentiation between its subgroups. On this basis, a desk study was conducted as a first step in assessing the current level of XR application in VET. In addition, 11 interviews were conducted with professionals who are working with XR technology in the context of VET or have considered to do so. Two other professionals gave written input. The key findings are summarised in this report. To complement this perspective, three projects in which XR in VET has been or is successfully being piloted in development cooperation are presented as case studies.

1 https://www.vettoolbox.eu/

2. Overview of basic terminology

2.1 What is Extended Reality (XR)?

XR is the abbreviation for the term «extended reality», which is an umbrella term for virtual reality (VR), augmented reality (AR), mixed reality (MR) and 360° technology. These different technologies are described in more detail in the following sections. The terminology is not entirely clear yet and definitions vary as the respective technologies are still in the process of being developed or further developed, so it can be described as a continuum from "real reality" to "virtual reality". The term VR is also used for applications which are not necessarily virtual reality, but rather 360°-videos or animations (e.g., 360° soft skill trainings are usually represented under the term VR). Hence, the following definitions seek to further clarify differences and commonalities between the different technologies. All technologies that are part of XR have in common that they extend the real world by at least one virtual aspect, in the case of VR even creating completely virtual environments.[2]

2 Laan, José/ Verweij, Sandra: XR Technologies for industrial SMEs. The VAMR*s University-Business Cooperation Handbook (Project: VAM Realities), Fachhochschule des Mittelstands (FHM) GmbH University of Applied Sciences, Germany, 2022. p.6

2.2 What is Virtual Reality (VR)?

Example:
DHL Cargo Loading VR Simulation

VR is a technology in which virtual environments are composed of image and sound and in which the users can immerse themselves with the help of VR glasses. The virtual reality can consist of animated images or even 360° photos of the real world. The user's level of interaction with the virtual environment varies depending on the product and equipment. Specific to VR is that the user is completely immersed in the virtual world, which is why VR usually requires technical equipment, such as VR glasses with handheld controllers but some applications can even be used with cardboard glasses that a smartphone can be inserted into.[3] Immersion describes "becoming completely involved in something"[4] which means that the user is not just an outside observer but a part of and participating in the (learning) experience. Immersion in XR technology is achieved by including the users' senses such as touch, sight, and sound. This offers the opportunity to acquire experience-based rather than theory-based knowledge. The strictest definition of VR requires the technology to offer "6 degrees of freedom" to the user. Degrees of freedom refer to the freedom of movement on the directional axes a user is given within a virtual environment. There are 2 categories to the 6 degrees of freedom: "rotational movement" and "translational movement". Translational movement describes the movement in the 3-dimensional space (forward, sideways, up/ down), "rotational movement" measures pitch, yaw, and roll.[5] However, only few practical examples outside of the gaming industry apply 6 degrees of freedom so far.[6]

3 https://www.oxfordlearnersdictionaries.com/definition/english/virtual-reality?q=Virtual+reality (15.08.2022) / Laan, José/Verweij, Sandra: XR Technologies for industriel SMEs. The VAMR*s University-Business Cooperation Handbook (Project: VAM Realities), Fachhochschule des Mittelstands (FHM) GmbH University of Applied Sciences, Germany, 2022. p.6

4 https://dictionary.cambridge.org/dictionary/english/immersion (03.11.2022)

5 Degrees of freedom – Virtual Reality and Augmented Reality Wiki – VR AR & XR Wiki (xinreality.com) (03.11.2022)

6 https://www.iotforall.com/difference-between-vr-ar-mr-360 (20.09.2022)

2.3 What is 360° technology?

Example:
Telekom GOP Varieté-Theater 360°-tour

360° photos or movies also allow users to immerse themselves in a virtual environment. However, 360° photos or movies can basically be viewed on the computer, via VR glasses or with cardboard glasses. 360° technology is usually also referred to as VR when the user is completely immersed in the virtual world via VR glasses. In 360° environments, the user can turn in all directions and look around (3 degrees of freedom) yet cannot move within the surrounding. Depending on the product the user can also interact with the environment, but it is not possible to move around as freely as in VR. The user can only stay in the place where the photo/movie was taken, interactivity with objects is limited to clicking on objects to access further information.[7]

7 Federal Institute for Vocational Education and Training (BIBB): *Planning the Use of Augmented and Virtual Reality for Vocational Education and Training, A Practical Guide*, Bonn, 2021. p.5

2.4 What is Augmented Reality (AR)?

Example:
Supplement Material of the research article “Augmented Reality Application in Vocational Education: A Case of Welding Training” (ISS’20). Scroll down to video

AR is a technology where virtual content is inserted into a real environment. This can be done, for example, via smartphones, tablets, or other devices suitable for this purpose. For example, the “inside” of a device or machine can be inserted into the user's field of vision using a corresponding program.[8] Augmented items are layered over the real-world environment. A well-known example of the use of AR is the game Pokémon Go, where users catch virtual fantasy creatures in the “real world” via an app, or the IKEA app with which the user can place virtual furniture into their actual home using their smartphone camera in order to check whether it fits in.

8 https://www.oxfordlearnersdictionaries.com/definition/english/augmented-reality?q=Augmented+reality (15.08.2022)/Laan, José/ Verweij, Sandra: XR Technologies for industriel SMEs. The VAMR*s University-Business Cooperation Handbook (Project: VAM Realities), Fachhochschule des Mittelstands (FHM) GmbH University of Applied Sciences, Germany, 2022. p.6

2.5 What is Mixed Reality (MR)?

Example:
Microsoft HoloLens

MR is a technology in which elements of the real world are augmented with virtual elements just like AR. MR can be seen as a continuation and further development of AR as there are even more possibilities for interaction between objects of the real world and the virtual world.[9] For example, a virtual object, such as a bookshelf, may be inserted into the real-world environment, such as your office, by MR. It is then also possible to interact with the virtual bookshelf in your office by, for instance, taking virtual books out of the virtual bookshelf. MR is the newest and least developed category of the XR technologies.

9 Federal Institute for Vocational Education and Training (BIBB): *Planning the Use of Augmented and Virtual Reality for Vocational Education and Training, A Practical Guide*, Bonn, 2021. p.5

2.6 What is the Metaverse?

The metaverse is a virtual environment which mirrors the real world. Users can access it with an avatar, a virtual person functioning as their representative in this virtual environment. It ideally offers users all the freedoms reality does. The metaverse can function as a collaborative environment, a meeting space, it can offer marketplaces, gaming experiences or for learning and training purposes.

3. XR and current VET projects in Development Cooperation

Overview of projects which directly contributed to this study

	Programme/project	Organisation	Country of implementation	Main contact person	Focus sector(s) for XR implementation	Form of input
1	VR Skills Lab	Blink 42-21/Centre for Social Innovations	North Macedonia	Zorica Velkovska	Electrical installation, tower crane installation	Interview
2	DeveloPPP Strategic Alliance on Occupational Training in Egypt (StAGS)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Egypt	Mariam Walid	Welding	Interview
3	Employment Promotion Project (EPP)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Egypt	Josef Schulte	Manufacturing	Interview
4	Sustainability and Value Added in Agricultural Supply Chains	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Global	Saskia Widenhorn	Agriculture	Interview
5	Indo-German Programme for Vocational and Educational Training (IGVET/ IGVET 2)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	India	Sarah Stadler	Window and door making technology	Interview
6	DeveloPPP ASCENT – Alliance for Skill and Capacity Enhancement	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	India	Priyanka Kohli	Healthcare, logistics, digital technologies	Interview
7	Technical and Vocational Education and Training (TVET) System Reform (TSR)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Indonesia	Philipp Johannsen and team	Hospitality, soft skills	Interview

8	Programa Desarrollo del Modelo Mexicano de Formación Dual (MMFD)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Mexico	Torsten Klinke	Hospitality, mechatronics, soft skills	Interview
9	Employment Promotion Darfur for Refugees, IDPs and Host Communities	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Sudan	Marek Stahl	N/A	Interview
10	Renewables and Migration (REMI) Project	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Turkey	Melanie Vieker	Solar installation	Interview
11	Programme for Employment Policy and Analysis	International Labour Organization	Italy/Global	Stefano Merrante	N/A	Interview

	Programme/project	Organisation	Country of implementation	Main contact person	Focus sector(s) for XR implementation	Form of input
1	Digital Partnerships and Innovation	British Council	N/A	John McMurtrie	N/A	Written input
2	BTEL – Support the implementation of the TVSDC Action Plan with focus on blended training, eLearning and teaching services	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Jordan	Luca Azzoni	eLearning and blended learning in TVET	Written input

3.1 Status Quo – Challenges and opportunities

3.1.1 Overview: the current situation

As XR in general is a relatively new technology, there is limited wealth of experience and public knowledge on the subject – especially with regards to the use of XR technologies in VET and its promotion in the context of development cooperation. Therefore, more research is needed to find out which settings and contexts are well-suited for the application of XR technologies in VET.[10] Interviewed practitioners applying XR emphasised that research on the outcomes of XR use in VET is crucial. They stressed that there was a need for creating use cases and impact evaluation data for how learning can become more effective by integrating XR solutions into teaching and learning settings. This would in turn enable informed cost-benefit-assessments for the application of the technology.[11]

So far, a limited number of development cooperation projects exist that promote XR use in VET contexts. Many of the practitioners interviewed were either implementing an XR project for the first time or were early in the implementation phase of the project with limited learnings.[12] Furthermore, some of the projects were still only at the planning stage of the project (pre-implementation). This is an indication that XR technology is still at the infancy level regarding its application in the VET sector. One exception is the International Training Center of the International Labour Organization (ITC-ILO) which started mainstreaming XR as a cross-cutting topic throughout two technical programmes in 2019. This includes the promotion of a Center of Excellence on XR with an eco-system approach which actively involved not only development partners, but also the private sector, such as tech companies and start-ups, and other stakeholders such as government partners,employers' and workers' organisations, in events and pilot projects on XR.

10 The World Bank Group: *Unleashing the power of educational technology in TVET systems*, Washington DC, 2021. p.Xiii

11 Merante, ITC-ILO; Walid, GIZ

12 Johannsen, GIZ, Kohli, GIZ, Stadler, GIZ; Vieker, GIZ; Walid, GIZ, Widenhorn, GIZ

3.1 Status Quo – Challenges and opportunities

3.1.2 Scope of application of the technologies

Research thus far explored the use of XR in VET and higher education, as well as for teacher training and general education and learning.[13] The conclusions provide first insights regarding the potential, requirements, but also the limitations of XR use in the specific field and point at the fact that further research is necessary to assess the context-specific possibilities for the technology.[14] Both, general research as well as feedback by some interview partners on why the technology was introduced in their projects suggest that the Covid-19 pandemic has been an accelerator for the use of XR and has set a precedent for remote, ideally immersive, learning and training.[15] [16]

Some interview partners have had first experiences and/ or interest in the use of XR for soft skills training. Research showed that the majority of XR technology in VET is sector-specific, which means that its application is targeting and limited to one sector only (e.g., metal works).[17] Specifically, XR use has been increasing in training in some sectors, such as manufacturing, engineering, and health care.[18] Even though some research points out that XR has seen a higher application in an industrial setting rather than in education so far[19], this is not an indicator that it does not have potential in the VET sector.

At this stage, VR and mainly 360°-applications are the most commonly implemented XR technologies in the VET sector. Few interventions make use of AR[20] or explore options like using a metaverse in the form of a collaborative virtual space. The majority of XR projects which this research investigated apply the technology with a sector-approach focusing the

13 Hurkmans, Rajagopal (2021); Ziker, Truman, Dodds (2021)
14 e.g. Kosko, Ferdig, Roche (2021); Ziker, Truman, Dodds (2021)
15 Estrada, Prasolova-Førland (2022)
16 Johannsen, GIZ, Kohli, GIZ
17 E.g. Dede et al (2020); Doolani (2021)
18 e.g. Doolani et al (2020); Pennefather, Krebs (2019), Dede et al (2020)
19 Dede et al (2020)
20 Agrawal, Pillai (2020); Kohli, GIZ

3.1 Status Quo – Challenges and opportunities

XR intervention on imparting trade specific skills, experience, and practice.[21] Two projects within the interview group implemented VR based soft skills training modules complementing the respective trade-specific VR training modules.[22]

3.1.3 Fields of application

The projects which informed this report in the form of interviews showed that XR technology was implemented in the following sectors: tourism and hospitality[23], healthcare[24], logistics[25], digital technologies[26], manufacturing, such as welding[27] and carpentry[28], agriculture[29], the industrial sector[30], including solar panel installation, maintenance, and repair[31], electrical installations, and crane installation and operation[32]. Apart from these projects, there are several practical examples of XR use in VET.

Here is a list of **sector-specific examples** for the use of XR technology in VET:

21 Velkovska, Blink 42 – 21; Johannsen, GIZ; Kohli, GIZ; Stadler, GIZ; Vieker, GIZ; Walid, GIZ; Widenhorn, GIZ
22 Johanssen, GIZ; Klinke, GIZ
23 Johannsen, GIZ
24 Kohli, GIZ
25 Kohli, GIZ
26 Kohli, GIZ
27 Walid, GIZ
28 Stadler, GIZ
29 Widenhorn, GIZ
30 Klinke, GIZ
31 Vieker, GIZ
32 Velkovska, Blink 42 – 21

3.1 Status Quo – Challenges and opportunities

Manufacturing and technology

There are many examples in manufacturing and technology occupations. In particular, the handling of complex machines and systems can be trained, both at the theoretical and at the practical level.

→ Various VR applications make it possible to train motor skills by introducing special equipment like handheld controllers in the shape of welding machines to train welding. Such a VR training for welding has been introduced in a training centre of the Safadi Foundation in Lebanon.[33]

→ VR is also applied to support the development of motor skills in the paint shop sector, as shown by Simspray, a virtual spray-painting learning system developed by MIMBUS and implemented in Morocco.[34]

Safety training and dealing with dangerous situations

Various examples can also be found in safety training and dealing with dangerous situations.[35] To avoid endangering learners during practical training, while they still acquire the competence to react appropriately in dangerous situations, XR technologies' potential is particularly great.

33 https://www.safadi-foundation.org/about/ (08.11.2022)
34 https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_MIMBUS_SIMSPRAY_final.pdf (08.11.2022)
35 United Nations Educational, Scientific and Cultural Organization and UNESCO Bangkok Office: *Beyond Access: ICT-enhanced Innovative Pedagogy in TVET in the Asia-Pacific*, Paris, 2017. p. 11 / p. 36

3.1 Status Quo – Challenges and opportunities

→ One example for this is the Marine and Offshore Technology course at the ITE (Institute of Technical Education (Singapore)) under Singapore's Ministry of Education and funded by multiple private donors, which utilises VR technology to train participants on a simulated oil rig platform which enables learners to practice for adverse weather conditions risk-free.[36]

Agriculture

The training of the correct handling of tools and machinery with the help of XR technology can also be seen in the agricultural sector.

→ In South Africa the United Nations Industrial Development Organization (UNIDO) have piloted several VR programmes in forest industries. This endeavour is financed by the Government of Finland. The VR programmes help train the correct usage of chain saws without putting learners at risk. These programmes will be replicated in Malawi, Zambia, and Zimbabwe.[37]

Health sector

XR is also frequently used to increase exposure and practical vocational experience in the health sector. The cost of medical materials and machinery is very high. Also, the possibilities to practice in real-life situations are limited and, in many cases, risky. Especially training situations that require possibly expensive material or equipment make XR applications valuable and cost-efficient alternatives for hands-on practical training.[38]

36 United Nations Educational, Scientific and Cultural Organization and UNESCO Bangkok Office: *Beyond Access: ICT-enhanced Innovative Pedagogy in TVET in the Asia-Pacific*, Paris, 2017.

37 https://www.unido.org/stories/virtual-reality-training-southern-africa (08.11.2022)

38 United Nations Educational, Scientific and Cultural Organization and UNESCO Bangkok Office: *Beyond Access: ICT-enhanced Innovative Pedagogy in TVET in the Asia-Pacific*, Paris, 2017. p. 11/p. 36

3.1 Status Quo – Challenges and opportunities

→ The project DeveloPPP ASCENT – Alliance for Skill and Capacity Enhancement in India, funded by the GIZ, uses VR technology to provide a large number of learners with the opportunity to gain experience in a medical lab during their training. As machinery, tools, and resources are scarce, VR offers a viable alternative for all learners to gain hands-on experience in a recreated virtual environment.[39]

Soft skills trainings

Moreover, various VR applications for soft skills training can also be found. The use in this area enables users to simulate challenging situations of conflict, communication, and relationship management with clients, as well as train for dealing with stress in a safe virtual environment.

→ In Indonesia, the project Technical and Vocational Education and Training (TVET) System Reform (TSR) funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the GIZ established a VR soft skills training for complaint management and customer care and -relations as well as food safety and hygiene.

→ The Mexican project, „Konsolidierung und Ausweitung des mexikanischen Systems der dualen Berufsausbildung"/"Programa Desarrollo del Modelo Mexicano de Formación Dual (MMFD)", funded by the GIZ and the Ministry of Public Education (SEP), incorporated two VR components, one of which focused on training negotiation skills. The VR training offers the learners an individualised learning path through a VR scenario in which they can choose from multiple answering options and receive feedback right away. They also have the opportunity to try again to achieve a better outcome in their negotiation.

39 Kohli, GIZ

3.1 Status Quo – Challenges and opportunities

Sector-unspecific examples for the use of XR technology in VET:
VR is also used to fill the gap in areas with limited access to practical training opportunities (internships, on-the-job training).

→ The Ugandan government implements a 10-year plan and strategy to improve Business, Technical, Vocational Education and Training (BTVET) in Uganda that meets the needs of the labour market. The project "Skilling Uganda" is supported by Enabel, the Belgian development agency, through its project "Support to Skilling Uganda" and uses VR training in remote areas of Uganda. VR offers job training in real-life work environments. This program is not specific to just one sector[40].

→ A VR training programme in South Africa implemented by FOSH in cooperation with Bridging Innovation and Learning in TVET (BILT), the UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training with support of the Federal German Ministry of Education and Research and BIBB (German Federal Institute for Vocational Education and Training). This programme enables learners to practice authentic work situations in school-based lessons at VET institutions. The project has shown positive effects on learners' skills, outweighing initial costs for development. However, the implementation also showed that trainers need enough time and comprehensive orientation to be introduced to and made familiar with such new technologies, as they show more resistance to technological changes than learners do.[41]

40 https://www.enabel.be/story/title-3 (08.11.2022)
41 https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_FOSH_final.pdf (08.11.2022)

3.1 Status Quo – Challenges and opportunities

3.1.4 Opportunities and challenges of XR in VET

Advantages and opportunities of XR in VET in development cooperation

1 **Safety and reduction of risks for users and equipment**
One major aspect of XR training is that potentially risky or hazardous tasks and aspects of training can be experienced in a safe space[42] which is especially beneficial at early stages of vocational training when height, dangerous materials or processes have never been experienced before.[43] Thereby, dealing with risks can be trained and the learner can get used to potentially frightening situations. Moreover, the operation, maintenance, and repair of expensive machines and/ or tools can be trained by inexperienced users without the danger of damage or loss of valuable materials or equipment. Especially in sectors such as manufacturing or agriculture, XR use in training can, therefore, also be an environmentally-friendly and sustainable alternative by using less consumables and saving resources and energy.[44]VR specifically adds value in areas of safety, health and in technical training, and especially for which the appropriate training venues or materials do not exist on site or which involve too high a safety risk if implemented in the real world.[45]

2 **Immersion and enhancement of reality – pedagogical magic keys**
Ideally XR application should be integrated into the curriculum. Depending on the setting, XR can be an opportunity for independent learning in one's own space, time, and pace.[46] This requires that the users are well-equipped (e.g., VR-glasses, cardboard and smartphone for VR, or AR-glasses) and can rely on a good infrastructure,

42 Schulte, GIZ
43 Stadler, GIZ; Velkovska, Blink 42-21; Vieker, GIZ; Walid, GIZ
44 Stadler, GIZ; Walid, GIZ
45 Angel-Urdinola, Diego F. (The World Bank): *Meta-Analysis Assessing the Effects of Virtual Reality Training on Student Learning and Skills Development*, Washington DC, 2021. p.27/28
46 Kohli, GIZ

3.1 Status Quo – Challenges and opportunities

such as stable electricity supply and internet connection. More common is that training centres, VET schools and/ or companies are equipped with XR tools, and that the application is part of the training and learning process. Both scenarios share several pedagogical advantages and opportunities:

XR, especially VR, enhances learning outcomes through immersion.[47] It helps opening black boxes for learners, e.g., by providing the possibility to enter engines with the help of AR[48]. XR also enhances teaching possibilities. For example, with the support of AR, it is possible to demonstrate the cuts of meats in cooking live, rather than only to explain such by the means of showing static images or a video.[49] XR allows to train at a more complex level since visualisation and practical context is immediately given.[50] Repetitions are possible as often as necessary – for everyone.[51] This is especially relevant in contexts where many people share a limited space, e.g., highly populated areas, and where, for instance, the use of tools and machines or the practice in a lab is restricted by the sheer number of learners who are meant to use and practice on them. In such a setting, it can have a positive effect on the individual learning outcomes, when individuals can practice many times on a tool – even though it is in a virtual context – than to practice on it in real life very few times.[52]

In times when remote learning is required, as during the COVID-pandemic, XR offers an immersive option for practical experiences and to train tasks and competencies. The practical exposure and training outcome is assumed to be higher than by solely theoretical remote learning.[53] The flexibility that remote learning with XR provides is

47 Merante, ITC-ILO
48 Merante, ITC-ILO
49 Merante, ITC-ILO
50 Kohli, GIZ
51 Vieker, GIZ
52 Kohli, GIZ
53 Vieker, GIZ

3.1 Status Quo – Challenges and opportunities

an additional motivator.[54] Furthermore, XR use adds diversity of teaching and training methods.[55] It motivates learners as it is an exciting and innovative technology that many learners have never experienced before.[56]

3 Positive experiences of VET-practitioners and learners with XR

Feedback by learners and teachers/trainers on the use of XR was often very positive: learning and training motivation seems to have increased in many cases.[57] Surprising is that despite the common perception, older, less digitally literate teachers and technical trainers are not always reluctant to learn about and apply XR technologies. Even language barriers are found to be less of an obstacle when the teachers/ trainers operate in an empowering framework where learning about and applying XR tools is part of their compensated work.[58] Learners who are otherwise rather introverted seem to be able to show their competences and knowledge better with XR tools. This could be due to being able to practice in a safe personal space.

4 XR – a tool for inclusion and social integration

XR applications can offer possibilities for learners with special needs to practice tasks in a safe setting and/ or in a field which would otherwise not be accessible to them.[59] Based on implementation experience of a pilot project, learners with learning disabilities seemed to have great gains from learning with XR and were enjoying it the most, as the immersion made learning much easier for them.[60] Using XR for teaching and training can also offer the possibility for those to participate in training who would otherwise not have access to travel to training institutions on a daily or weekly basis

54 Stadler, GIZ
55 Schulte, GIZ
56 GIZ, Indonesia: Technical and Vocational Education and Training Reform (TSR 2.0)
57 Johannsen, GIZ; Merante ITC-ILO; Vieker, GIZ
58 Walid, GIZ
59 Merante, ITC-ILO; Velkovska, Blink 42 – 21
60 Merante, ITC-ILO

3.1 Status Quo – Challenges and opportunities

due to regional disparities, far distances or infrastructural issues. If infrastructural requirements allow it, XR can increase mobility of learning and training. Users can, for instance, avoid long journeys to practical assignments.[61] Since XR applications can be translated into other languages relatively easily, they can also be used for teaching learners from different regions and with different native languages.[62] XR soft skills trainings have the benefit that those VET learners who have never stayed at a hotel, ate at a restaurant or had to demonstrate advanced interpersonal problem-solving skills can gain an insight, get used to their new world of work, practice basic skills and gain confidence in a protected space.[63]

5 XR as a tool to change the perception of VET
The VET sector struggles with an image problem in many countries, especially in direct comparison with higher education. While the improvement of the quality in VET should be promoted continuously everywhere, applying state-of-the-art technology has improved the perception, as well as the self-identification and confidence of learners, teachers, administrative staff, and management personnel in the sector.[64] Equipping VET institutions with state-of-the-art technology and complementing vocational training curricula by XR trainings can lift the quality of education and its public image to new levels.

6 Possibilities for cost effectiveness
Depending on the context of its use, the costs to produce XR content and to acquire VR goggles can be perceived as manageable considering the output, impact and upscaling opportunities as VR goggles can be used for different content and subjects. Because of the possibility to translate XR content relatively easily to other

61 Vieker, GIZ
62 https://www.unido.org/stories/virtual-reality-training-southern-africa (17.08.2022)
63 Johannsen, GIZ; Stadler, GIZ
64 Johannsen, GIZ

3.1 Status Quo – Challenges and opportunities

languages, once developed XR content can be (re-)used and transferred. This might be an option to outweigh costs for acquisition and maintenance.[65] Moreover, costs for training facilities and equipment, consumables, energy, materials, as well as the potential breakage of such, and waste can be reduced through XR training. An analysis by Angel-Urdinola (2018) found that VR in VET has much potential when it comes to learning opportunities that would be too expensive to implement in the real world.[66]

Disadvantages and challenges of XR in VET in development cooperation

1 **Costs – more than the price for the initial procurement**
Decision-makers usually focus on the initial costs for content production, hard- and software procurement and training. The costs for maintenance, technical assistance and backstopping, repair and ongoing training of new personnel are often overlooked.[67] This is especially critical when financial and human resources are scarce. If equipment cannot be updated and/ or fixed because there are no personnel with the required expertise and the competence to do so, the equipment can become obsolete or outdated relatively quickly.

Research suggests that the benefits of XR use are attractive in remote learning contexts, such as required by the Covid-19 pandemic. Yet, it also points out that the challenge of logistics management, as in acquisition, storage, distribution, collection,

65 Vieker, GIZ

66 Angel-Urdinola, Diego F. (The World Bank): *Meta-Analysis Assessing the Effects of Virtual Reality Training on Student Learning and Skills Development*, Washington DC, 2021. p. 27/28

67 Stahl, GIZ

3.1 Status Quo – Challenges and opportunities

and maintenance of the technology, is real.[68] This would be another aspect for which human and financial resources have to be dedicated, if interventions using XR technology are meant to be effective and sustainable.

Due to lack of XR experience and expertise of technical staff in the development cooperation sector, it can be challenging to make budget-relevant decisions on large numbers of devices and XR equipment procurements.[69] Limited IT know-how and expertise in the VET sector is a major barrier in the use of XR technology for teaching and training. Acquisition costs of equipment may not be amortised if it is not used correctly or not at all.

Ideally, XR applications should be context- and/ or sector-specific and fit into the national occupational standards and curricula. Ready-to-use XR content for VET is still very limited and can be expensive. Even more costly is the development of individualised and specifically tailored XR content. To provide high-quality XR training, complex XR software may be needed which can be extensive and cost-intensive.[70] The cost-benefit ratio does not always convince practitioners and decision-makers, especially when the sustainability of the technology cannot be guaranteed without continued investments.

The XR equipment itself is relatively cost-intensive and the technology is fast evolving. Due to the complexity of the XR applications developed for the VET sector and the respective long durations of content development, there is the risk that the technology might be already outdated by the time the training is ready to be implemented.[71]

68 Estrada, Prasolova-Førland (2022)

69 Johannsen, GIZ

70 Schulte, GIZ; Klinke, GIZ

71 Kohli, GIZ

3.1 Status Quo – Challenges and opportunities

2 Duration and complexity of project execution and implementation

Several interview partners reported that the realisation of their XR interventions took much longer than anticipated.[72] XR expertise and networks with private sector providers, such as developers, were sometimes missing in the respective projects to devise realistic project planning for the implementation of XR endeavours. This can result in longer project implementation durations, differences between planned and executed content of the XR applications, unexpected need of soft- and/or hardware procurements and, as a result, extra costs due to prolonged implementation or missing information on requirements, specifications, and equipment for the initial budget planning.[73] The complexity of developing and implementing XR content is often underestimated by practitioners in the field of development cooperation and/or oversimplified by XR service providers which, in turn, often do not fully understand the budget limitations and context-specific requirements initially.

3 XR cannot not fully replace in-person VET training

In most cases, XR is not able to fully replace live (inter-)personal training and the practical handling of tools and machines.[74] Most experts agree that it cannot be the sole way of imparting technical and vocational competence and offer respective training.[75]

The use of XR in interpersonal and soft skills training is highly debated.[76] While some practitioners and experts are fully convinced of such, others question the effectiveness of XR use in this case. As for most aspects of XR use in education and training,

72 Kohli, GIZ; Stadler, GIZ; Velkovska, Blink 42-21, Vieker, GIZ
73 Stadler, GIZ
74 Vieker, GIZ
75 Vieker, GIZ
76 E.g. Schulte, GIZ; Johannsen, GIZ; Walid, GIZ

3.1 Status Quo – Challenges and opportunities

there is not yet sufficient research and evaluation data available to assess the actual learning and training benefit of XR facilitated soft skills and critical incident trainings on a larger scale.

Another significant challenge is that XR modules are not always integrated into a pedagogical framework and/ or the nationally accredited occupational standards and curriculum. This integration is crucial in order to be relevant and used by practitioners.[77]

4 Infrastructure requirements for XR use not always met in reality
Reliable electricity supply and internet connectivity cannot be guaranteed on an institutional level in many countries, let alone with regards to the private provision.[78] In these contexts, XR is not only unsuitable, but can also lead to an exclusion trend.[79] Moreover, safe storage, the availability of repair and replacement parts, as well as communication infrastructure in order to clarify issues or remotely troubleshoot are often not planned and/ or not provided for. An open question is still, how the technology can be distributed and used in rural and remote areas.[80]

5 Sparking enthusiasm for XR use in VET
The biggest challenge in VET is enabling and motivating the users, such as teaching personnel and learners, to understand how to use the technology effectively.[81] Instilling interest past the novelty and first experience level is generally an aspect which is seen quite critically. Moreover, there might be resistance to change and to applying new technology not only by the users themselves, but also by implementors, mul-

77 Merante, ITC-ILO; Schulte, GIZ
78 Walid, GIZ
79 Merante, ITC-ILO
80 Kohli, GIZ
81 Velkovska, Blink 42–21; Merante, ITC-ILO

3.1 Status Quo – Challenges and opportunities

tipliers, administrative staff or management in VET institutions. If the technology is not embraced and supported by all levels, the user-level will face severe challenges in sustainably adopting the technology in the learning and training context. All users require comprehensive technical support which cannot always be provided by the technical staff of the development cooperation projects or within VET institutions.[82] This has raised the concern that technical issues cannot always be solved, and a service provider infrastructure is not always available.[83]

5.1 Teachers and trainers

If XR technology use is not part of the curriculum, it is extremely challenging to convince VET teachers and trainers to learn using the technology in the classroom. Whenever XR learning offers are an extra-curricular activity on the long and often not well-compensated list of VET practitioners, it is usually not mainstreamed into their teaching and training activities successfully.[84] Other obstacles of the successful application of the technology on the teachers'/trainers' level are:

→ An overall low degree of digitalisation in many contexts also leads to low digital literacy of respective staff.[85]
→ If the technology is not intuitive for teaching staff, they experience trouble to internalise it and to pass its use on to learners[86].
→ Often, there is no support and technical backstopping infrastructure[87]. If teaching staff feel left alone with potential technical issues or questions regarding the use, they are not likely to continue implementing XR into their teaching.

82 Kohli, GIZ
83 Johannsen, GIZ
84 Klinke, GIZ; Velkovska, Bink 42 – 21
85 Stahl, GIZ
86 Schulte, GIZ
87 Johannsen, GIZ; Kohli, GIZ

3.1 Status Quo – Challenges and opportunities

→ Among those teachers who have little digital literacy and/or are non-IT-staff, reluctance in learning about and using XR for their teaching.[88]

5.2 Learners/beneficiaries
When XR tools move into the private sphere, it can be challenging to focus learners' attention on the learning and skills acquisition value of XR rather than entertainment, similar as with smartphones and tablets.[89] Other learners seem to have to get used to such a paradigm shift in training and feel frightened by the immersion.[90] In some contexts, there may be hindering cultural values and/or economic realities which have a negative impact on XR learning. If family members and society in general expect learners and apprentices to follow a more traditional educational path that includes hands on practical training, it can be hard to justify the use of an XR tool at home.[91]

5.3 Political and funding level
When decisions for the implementation of XR technology are mainly based on its novelty character or the wish to introduce a new, digital progress promising tool, rather than careful contextual assessments and cost-benefit assessments, this may result in a lack of ownership. This makes it hard to sustainably anchor the technology in the national VET system.[92]

Some practitioners emphasise that the focus of interventions using XR or any interventions introducing new technology should be needs-based in order for it to be sustainable.[93] Furthermore, XR application should address specific needs and learning

88 Johannsen, GIZ
89 Kohli, GIZ
90 Johannsen, GIZ
91 Kohli, GIZ
92 Klinke, GIZ
93 Stahl, GIZ

objectives.[94] This means that it cannot always be distributed widely which can be another challenge when trying to develop a cost-effective, sustainable tool.

3.1.5 Preconditions to implementing XR applications sustainably

Setting the framework for teachers/trainers to become XR enthusiasts

An important aspect is to convince teachers and trainers that XR can be beneficial for their work. This is even more crucial, if XR technology is applied on an extra-curricular basis. Overall, it is advisable to design XR in accordance with the curriculum. Challenges arise for teachers and trainers who take on the integration of XR into their curriculum as an additional task to their already demanding and often poorly compensated jobs. Only when they recognise a workload reduction in the medium- to long-term future through the use of XR in combination with the added value for learners, pedagogical staff may be fully convinced of the use of the technology in the VET-sector.[95]

Moreover, the following aspects are relevant with regards to motivating pedagogical and training staff:

1. Pedagogical staff must feel safe and competent, therefore a low-threshold introduction and practical training on XR with on-site support for questions and technical issues is vital. Generally, XR content needs to be accessible and intuitive.[96] This is especially important if digital literacy is low. Users should not be deterred by assuming knowledge. In contexts where digital literacy is generally very low, a

94 Schulte, GIZ
95 Schulte, GIZ; Walid, GIZ
96 Schulte, GIZ

3.1 Status Quo – Challenges and opportunities

step-by-step model should be applied where teachers and trainers are introduced to digital applications and their use generally, before moving on to XR.[97]

2. Pedagogical staff need to be continuously motivated by educational work in XR, motivating examples and research on the added learning and training outcomes due to XR use. The awareness of the technology's potentials should not be taken for granted – it needs to be created.[98]
3. The language of the training courses and the VR content seems to play a role on whether trainers and teachers use the technology. While there are positive examples of individuals who successfully and continuously applied XR despite language barriers, it is generally advisable for VR applications and VR equipment to be set to local languages (in addition to English).[99] For training materials on XR, one can avoid using extensive written language and rather use more inclusive forms of materials, such as images or videos. The latter should, of course, be provided in local languages and potentially with sub-titles in the local and/ or another language(s). Otherwise, manuals should be concise and user-friendly.[100]
4. Support systems for teachers and trainers on XR, e.g., assistance with technical issues, are critical in the initial introduction phase, but also on an ongoing basis. This can be provided by technical staff within the development cooperation framework, by private service providers and/ or external consultants, initially ideally on site, whilst remote support can be provided in the medium- and longer term depending on the support needs of the pedagogical staff.

97 Walid, GIZ; Velkovska, Bink 42–21

98 Merante, ITC-ILO

99 Stahl, GIZ; Vieker, GIZ

100 Kohli, GIZ; Velkovska, Bink 42–21

3.1 Status Quo – Challenges and opportunities

Guaranteeing the sustainable application of XR by users

Whether extensive support for the initial and continuous implementation and sustainable application of XR in the VET-system is required seems to depend strongly on the respective users. Many interview partners suggested that the initial training for XR users in VET (e.g., training for trainers, teachers, and learners) needs to be intensive. Thereafter, extensive training and backstopping options for technical troubleshooting need to be provided on an ongoing basis for XR adoption to be successful in the long run.[101]

For users/trainers who have many years of experience and very little or no digital literacy, and for those in management and decision-making positions in the VET-sector, there is need for further exposure to the advantages of XR and the potential impact of its use through access to exchange programs to contexts where XR is used in order to motivate uptake of the technology and to reap the full potential of XR in VET.[102]

Realistic Budgeting for XR

The costs of XR application development and XR technology acquisition must be in balance with the benefits of their application in the respective context and sector. Therefore, thorough cost-benefit assessments before, but also throughout the planning and implementation process are highly advisable.[103] In general, the interview partners reported that it is not easy to acquire funding for XR projects and to convince decision-makers of the benefits of XR technology. It seems to be of value in this context to demonstrate which needs and demands can be addressed more effectively with XR. Overall, viable research on the comparative benefits and improved learning outcomes with the use of XR in comparison to traditional teaching and training is

101 Walid, GIZ; Johannsen, GIZ; Kohli, GIZ

102 Stadler, GIZ; Merante, ITC-ILO

103 Vieker, GIZ; Walid, GIZ

3.1 Status Quo – Challenges and opportunities

scarce. This resulted in the lack of a convincing tool which appeals to funding organisations and/ or decision makers and addresses their concerns.[104]

To reduce costs and to sustainably anchor XR projects locally, it is advisable to promote capacity-building for developing XR content on the national or local level and within the VET system. In the longer term, this saves costs on expensive international software and product licenses. The EU-financed GIZ *International Services* project in Jordan developed such local capacities within its partner structures i.e., the Ministry of Education, and proved effective, sustainable, and affordable.

Allocation of implementation time for XR projects

Furthermore, several interviewed experts pointed out that the development and/ or implementation of XR projects took longer and was more expensive than initially planned. Making realistic calculations was perceived as particularly challenging as the technology was usually new for the practitioners themselves and subject-specific expertise was scarce in their professional environment.[105] Continuous training and learning of the personnel in development cooperation working on XR would be beneficial to avoid miscalculations and project prolongations. Developing a network of service providers accompanying the project design and implementation, as well as the continuous technical backstopping and maintenance once implemented, who can further fill in their expertise when needed, might also be decisive for the project success.[106] These are, however, additional, and ongoing costs which need to be taken into account for project planning.

104 Merante, ITC-ILO
105 Stadler, GIZ
106 Johannsen, GIZ

3.1 Status Quo – Challenges and opportunities

Integration of XR in VET systems

It is of utmost importance to frame the XR use with a meaningful and trade-/ context-specific pedagogical concept for XR in vocational training[107]. Including XR into the respective VET curricula assures that its use is tailored towards the actual training objectives and competence acquisition outcomes. Here, it can be most effectively checked whether XR is an actual benefit on a pedagogical and training level. Experienced trainers and instructors, such as master-trainers, could help to develop curricula including XR use. To do so, they must learn about and ideally witness the potential and benefits of XR use in their specific field, which can be achieved through pilot project implementation in individual sectors.

Context-specific and needs-oriented decision making on application of XR

The conversations with practitioners on the ground have shown that thorough contextual, needs and demands analysis is vital in the decision-making process on whether to implement XR technology or not.[108] There is a consensus that there is a need to be context- and sector-specific in design, implementation and dissemination of XR applications. XR applications and the respective technology must fit the needs on the ground. Especially the technical requirements should be realistic to the level of equipment and existing infrastructure.[109]

Applying an ecosystem approach

Feedback by the interviewed experts suggests that assessing whether there are strong partners and key stakeholders for the XR design and implementation process is integral when considering the use of XR. Throughout any XR project, building partnerships and a network of XR stakeholders – or an 'XR ecosystem' as ITC-ILO calls it – are crucial for its success.[110]

107 https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_SBG-Paint-VR_final.pdf (08.09.2022)

108 Stahl, GIZ

109 Klinke, GIZ; Schulte, GIZ; Stahl, GIZ

110 Merante, ITC-ILO

This extends to several levels:

- → The decision-making process should be accompanied by in-depth planning of the development and implementation phase of the XR application(s). How to sustainably anchor and to disseminate those are questions that should be considered right in the beginning, too.[111]
- → It is fundamental for the success of any XR based intervention that decision-makers and responsible stakeholders on the political level, the development partner and the VET institutions, as well as potential private sector partner(s) are convinced of the benefits of the technology, the applications and the intervention in general.
- → Management, administration, and staff in the VET sector all need to be engaged in the process of launching the new technology.[112]
- → Once the XR applications are developed and implemented, it is important to ensure continuing support for users to solve technical issues, maintain, update, and potentially repair the equipment and to support and/ or advise trainers and teachers on the continuing pedagogical implementation of the tools. This requires a network of XR service providers who can troubleshoot, solve technical problems, make application development adjustments, and manage logistical issues, such as distribution, safe storage, etc.[113]

Fulfilment of minimum infrastructure requirements

- → Need for reliable power and internet.[114]
- → Support and technical backstopping infrastructure for XR-implementors, such as teaching personnel.

111 Klinke, GIZ

112 Merante, ITC-ILO; Johannsen, GIZ

113 Velkovska, Bink 42 – 21

114 Walid, GIZ

- → Logistical and maintenance aspects: delivery, storage and maintenance of the equipment must be financed, planned, and organised up-front.[115]
- → Ability to purchase software licenses: sometimes licensing prohibits transfer of software to partners or might increase original price calculations for dissemination to many beneficiaries.

3.1.6 Outlook

The results on the way ahead for XR in VET and development cooperation are mixed. While the ITC-ILO has just applied for further funding jointly with its partners to scale up the XR activities in technical training, career guidance and in competence certification, and to promote further research on the use of XR in this nexus, other practitioners remain more hesitant.

There is a consensus that XR technology should not be introduced for the sake of novelty and visibility only, even though some interview partners admit that this was how their interventions originated. Context-specific needs should be considered, the required preconditions should be met, and a thorough cost-benefit analysis should be undertaken before designing and implementing XR technologies in the VET sector.

Linking XR development and its application to VET curricula and occupational frameworks increases the likelihood of making XR use sustainable, relevant, and cost-effective. More research comparing the learning outcomes with XR use to those without is needed.

Positive findings would not only underline the strengths and benefits of XR in VET and for learning in general scientifically, but also be a convincing tool in creating awareness of XR benefits among decision-makers and VET practitioners.

115 Stahl, GIZ

3.2 Case studies

3.3.1 In-depth teachers training and One-on-One support on VR use

Case study 1:

Technical and Vocational Education and Training (TVET) System Reform (TSR 2.0)

GIZ, Indonesia, 2021 – 2024

OVERVIEW

Comissioned by	German Federal Ministry for Economic Cooperation and Development (BMZ)
Leading executing agency	Coordinating Ministry for Economic Affairs

How is XR used in the project?

Production of four VR Soft-Skill-Trainings for the hospitality industry (reception, restaurant), 3 VR training modules for Hygiene and food safety in Hotels and Restaurants, and eight VR training modules for TVET as well as one VR learning scenario focussing on technical skillsets within a hotel kitchen.

Two lines of intervention:

- Content creation including several feedback loops on technical and pedagogical aspects to generate acceptance by decision-makers, teachers, learners, and the private sector, thus making it a sustainable set-up.
- Piloting of VR-equipment with interactive training for the hospitality sector in 16 VET schools.

What are the success factors of XR use in the project?

A **three-fold approach** was applied:

- **Creating a common understanding of VR** among all relevant stakeholders in the VET system on the national level

  ✓ **GOAL:** decrease hesitation and resistance, and close knowledge gaps by showing the use in other countries and by demonstrating that it is not meant to replace teachers, but to complement their work

3.2 Case studies

Case study 1: Technical and Vocational Education and Training (TVET) System Reform (TSR 2.0)

What are the success factors of XR use in the project?

- **Conduct visits to & trainings** in the VET schools which received the VR-equipment:
  - → How to use VR-glasses (technical introduction)
  - → Problem-solving when there are issues/ glitches
  - → Pedagogical training, how to use training materials in the classroom

  ✓ **GOAL:** enable teachers to use technology and provide answers to content questions, e.g., how to integrate VR into curriculum
- **Backstopping framework** with service providers (companies)

  ✓ **GOAL**: provide direct support with technical glitches and insecurities to empower teachers using VR

How does XR benefit achieving the project objectives?

1. VR is a game-changer regarding improving the relevance and quality of VET and trade-specific work readiness in the Indonesian context.
2. VR provides practical insights into the world of work and concrete tasks and situations in the respective occupations which VET learners would otherwise not get at all or not at this stage of training.
3. VR is bridging gaps:
   - → Regional disparities mean that internships are not always possible or available. The VR-scenarios provide first-time user experiences with regards to the technology, but also first hands-on experience in their future workplace.
   - → Socio-economic realities determine that many learners have never set foot into their future work environment, such as (international) restaurants or hotels, before starting to work there. VR-based critical incidents training can provide crucial skills and boost self-confidence by experiencing the work environment and typical aspects of the job in a safe space.

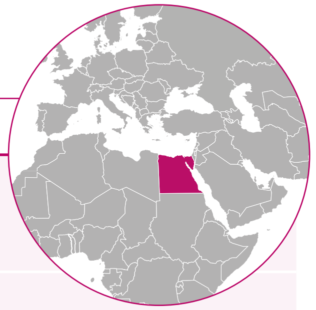
3.2 Case studies

3.3.2 Demand-driven XR application

Case study 2:

DeveloPPP Strategic Alliance on Occupational Training

GIZ, Egypt, 2017 – 2024



OVERVIEW

Comissioned by	German Federal Ministry for Economic Cooperation and Development (BMZ)
Leading executing agency	SIEMENS Energy

How is XR used in the project?

SIEMENS Energy owns and operates the SIEMENS Training Academy, a private training centre, which trained 2.500 people in three streams from 2017 until 07/2024:

- → Basic formative training and basic skills for technicians and engineers
- → Trainings engineers and technicians on power plants
- → Automation trainings for technicians and engineers

The use of XR constitutes a rather small part of the project (< 5% of the overall project costs): the Academy offers a welding training on a VR welding kit as well as a computer-based simulator for power plants which have been very popular. Due to its success, there is an interest in further expanding the use of XR in the Academy.

What are the success factors of XR use in the project?

Demand-based approach:

1. Training at the Academy, including VR-supported welding and power plant training, is paid for by the users, e.g., private companies
2. As part of the public–private partnership (PPP), GIZ receives a 75% discount when sending learners to the Academy for training
3. XR does not have a self-serving character: if there is no demand for VR-supported training, it will not be continued

3.2 Case studies

Case study 2: | DeveloPPP Strategic Alliance on Occupational Training

What are the success factors of XR use in the project?

Linking XR to the training curriculum to ensure its effectiveness and sustainability:

4. As part of a general 6-month master trainers' curriculum and the pedagogical training to maintain quality of training, two welding trainers were trained on the use of VR-equipment in accordance with their curriculum
5. It is also used in a 3-month welding training where the learners start with the virtual welding as an introduction to welding, as a training for employment stream.

How does XR benefit achieving the project objectives?

VR supports the goal of creating a network of competent occupationally trained engineers and technicians and helps bridging the gap between theoretical education and preparing for what the industry needs. Moreover, VR supports the objectives by providing:

→ Security of training
Right in the beginning of training, it is of utmost importance to reduce security risks and occupational hazards to a minimum. VR is a great solution for providing safe, yet realistic and pedagogically effective training and learning environment

→ Cost-effectiveness
As all training equipment, including tools, machines and consumables are virtual, less consumables are used and the risk for damage of tools and machines is reduced to the VR-technology itself

→ Positive environmental impact
The less welding is practiced in reality, the better for the environment.

3.2 Case studies

3.3.2 VR-training in electrical installation and crane operation in North-Macedonia

Case study 3:

VR-Skills Lab

Blink 42 – 21, North-Macedonia, 2020 – 2023

OVERVIEW

Funded by	VR Skills Lab: International Labour Association (ILO) Crane Operation Training: Swiss Agency for Development and Cooperation (SDC)
Leading executing agency	Blink 42 – 21

How is XR used in the project?

- Development of a VR-training tool in electrical installation which was piloted at 5 high schools
  - → Assessment of technical context and current status quo, as well as thorough content development for VR-tool were large parts of the project.
- Development of a VR-training tool in tower crane operation which will be piloted at Certified Training Centers for Vocational Training.
  - → This project could be built on general learnings and experiences from the first project. Hence the focus could be much more on the VR-application and the technology itself.

What are the success factors of XR use in the project?

Training of users with a focus on teaching and training staff:

- **Peer-learning approach:**

  The goal is to empower the teachers/ trainers who have a high interest in learning to use VR and/ or have already relatively high digital literacy; often these are the younger generations, but not exclusively. Those who are more easily and faster acquainted with the technology and convinced by its benefits then work with their peers who need more time and/ or support it or are less intrigued by its use.

3.2 Case studies

Case study 2: | DeveloPPP Strategic Alliance on Occupational Training

What are the success factors of XR use in the project?

Practical guide:

Development of a manual for teachers and trainers with pedagogical information and didactical suggestions

→ Insight: Teachers cannot be forced to adopt VR-technology if it is meant to be implemented sustainably. They can only be inspired. The best inspiration is to show how XR can make their job easier, rather than creating additional work for them.

How does XR benefit achieving the project objectives?

VR is the ideal tool to make learning and training safe in these two training courses:

→ Occupational hazards and risks are excluded at the early stage of learning and training with VR. The VR-applications provide the safe environment needed to get familiar with the occupational environment, machines, tools and typical processes and tasks, before applying them and being trained on them in real life.

→ Personal safe spaces created by VR enable learners to feel more confident in their learning environment. First ex periences suggest that especially introvert and otherwise seemingly underperforming learners benefit greatly from a protected initial learning environment.

Costs can be saved in the medium- to long-term, as remote, and difficult to access training sites do not have to be frequented so much and costs related to occupational health and safety can be reduced.

4. Summary/learnings

✓ XR provides great opportunities to enhance and complement learning and training in VET.

- → Major benefits of XR are safety and reduction of risks for users and equipment, as well as inducing high levels of motivation and likely better learning outcomes for users.
- → If XR is planned and implemented effectively, ongoing costs within VET can be reduced.
- → Experiences show that VET-practitioners and learners have responded positively to training with XR.

✓ It is pivotal to not only spark enthusiasm with IT staff, but all.

- → Teachers and trainers are key for making XR use effective and sustainable. They need to be taken aboard when XR projects are developed.
- → Information, training, and ongoing technical support for VET personnel are crucial for the sustainable and effective implementation of XR technology in the sector.
- → Best overall results may be achieved when XR is integrated into the VET system by incorporating it into curricula and tailoring it towards occupational standards.
- → Linking XR training to curricula for teachers and trainers to be able to learn its use and work with it in their regular working time and environment can be of great importance when mainstreaming XR in the VET sector and motivating staff to apply the technology.
- → An eco-system-approach brings the political level, the private sector, VET managements and administration, VET trainers, development partners and potentially employers' and workers' organisations together to make XR relevant and successful in the specific context.
- → Training staff on use of XR is the most cost-effective way to implement XR use.
- → Decision makers and VET management and administration need to understand and support XR endeavours to provide an enabling environment for its implementation.

√ **Immersion and enhancement of reality are important tools in providing state-of-the-art teaching and training in VET.**

- → XR has the potential to positively change the perception VET – state-of-the-art technology use in VET can help bring about the image shift needed in many contexts.
- → Context-specific needs should be considered for the design and implementation of XR projects. Hence, decision making on whether applying XR or not should be context-specific and needs-oriented.
- → While XR cannot and is not meant to fully replace in-person training and learning, XR use in VET thus far has shown that trainers/ teachers and learners have had positive teaching and learning experiences through XR.
- → Moreover, XR is a great tool for inclusion and social integration by enabling learners to participate and achieve good learning outcomes who might otherwise not have been able to be trained at all or not to the same standard.

√ **Realistic budgeting for XR projects is important for their cost effectiveness especially considering that the production can be quite expensive.**

- → Cost-benefit analysis should be undertaken before designing and implementing XR technologies. Sometimes the introduction of XR is too expensive compared to its benefits.
- → XR content usually needs to be developed context and sector specifically which is costly and time intensive.
- → Ready-to-use content for VET is still scarce or expensive and does not fully fit the individual context and occupation.
- → Building up an XR unit in the local context, e.g., as part of the Ministry of Education, can be sustainable and cost-effective in the medium to long term, as content can be continuously developed, added, and re-used based on national curricula and occupational standards.
- → As XR content is relatively easy to translate, it is possible to reuse content for similar contexts in different languages.

- → When duration and complexity of XR project execution and implementation are taken into account, more realistic project planning can be undertaken. Enough time for implementation and training should be allocated.
- → Logistics management, maintenance, repairment and continuous technical support should not be forgotten when planning XR projects, as they are ongoing tasks for which personnel and budget need to be allocated.

✓ Fulfilling some infrastructure requirements is key for XR use.

Whether XR use makes sense in a specific context is determined on the simplest level by the question whether electricity supply and ideally stable internet connection are available. Without these preconditions, XR use might not be suitable.

✓ In certain contexts, it can also be helpful to consider introducing a demand-based approach once the technology has been implemented in order to avoid using technology for technology's sake.

✓ Generally, much more research is required to fully assess the additional learning and training outcomes of XR use in VET, especially in the context of developing and emerging countries. Further research would also be beneficial on demands- and needs-based approaches, as well as the degree of the inclusion of different stakeholders and their roles in XR endeavours.

5. References

Angel-Urdinola, Diego F. (The World Bank): *Meta-Analysis Assessing the Effects of Virtual Reality Training on Student Learning and Skills Development*, Washington DC, 2021.

AIZ (Academy for International Cooperation): Report PEP, *Social Cohesion Roundtables: Contextualizing Social Cohesion for Different Sectors and Actors in the Refugee Response in Turkey*, Ankara, 2022.

AIZ (Academy for International Cooperation): *Conference "Digitalization and TVET", International Conference on Digitalization in Vocational Education and Training,* Magdeburg, 2021.

AIZ (Academy for International Cooperation): *Technical and Vocational Education and Training System Reform (TSR 2.0), Supporting the implementation of key elements of the Indonesian government's National TVET Strategy,* Bonn, 2021.

AIZ (Academy for International Cooperation): *TVET and Digitalization, 21st century technologies for Teaching and Learning*, Bonn, 2021.

AIZ (Academy for International Cooperation): Conceptual approaches in piloting and dissemination of e-learning in TVET colleges in Vietnam, Bonn, 2022.

Center for Social Innovations Blink 42 – 21/supported by ILO: *First VR Application for Skills Development in North Macedonia, VR simulation of control and maintenance of electric installations,* Skopje, 2020

Dede, D., Abdullah, A. G., Mulyanti, B., Rohendi, D.: *Review TVET learning innovation: Aumented reality technology for virtual 3D laboratory,* Journal of Physics: Conference Series, Vol. 1402/7

Doolani, Sanika: Vistas: Vocational Immersive Storytelling Training and Support Framework for Augmenting Work Performance, The University of Texas at Arlington ProQuest Dissertations Publishing, 2021

Doolani, Sanika; Wessels, Callen; Kanal, Varun; et al: *A Review of Extended Reality (XR) Technologies for Manufacturing Training,* Technologies 2020, 8(4), 77, 2020

Estrada, Jose Garcia; Prasolova-Førland, Ekaterina: *Running an XR lab in the context of COVID-19 pandemic: Lessons learned from a Norwegian university,* Education and Information Technologies 27, p. 773 – 789, 2022

Federal Institute for Vocational Education and Training (BIBB): *Planning the Use of Augmented and Virtual Reality for Vocational Education and Training, A Practical Guide,* Bonn, 2021.

FOSH Learning (Harald Fleischmann (CEO)): Integration of BIM, VR & Mixed Reality software in project based training, https://www.giz.de/akademie/en/downloads/WS2-3-Harald-Fleischmann-Fosh-Learning.pdf

Hurkmans, Berten; Rajagopal, Kamakshi: *The use of extended reality technologies for learning in industry,* EdMedia + Innovate Learning, 2020 (https://www.learntechlib.org/p/217460/)

Kim, K. G., Oertel, C., Dobricki, M., Olsen, J. K., Coppi, A. E., Cattaneo, A., & Dillenbourg, P.: *Using immersive virtual reality to support designing skills in vocational education.* British Journal of Educational Technology, 51(6), 2020

Kosko, Karl W., Ferdig, Richard E., Roche, Lionel: *Conceptualizing a Shared Definition and Future Directions for Extended Reality (XR) in Teacher Education, Journal of Technology and Teacher Education,* Volume 29, No 3, 2021

Laan, José/Verweij, Sandra: XR Technologies for industriel SMEs. The VAMR*s University-Business Cooparation Handbook (Project: VAM Realities), Fachhochschule des Mittelstands (FHM) GmbH University of Applied Sciences, Germany, 2022.

MIMBUS: *Virtual Workshops for manual skills learning,* Saint Jean (France)/Chicago (USA), 2022.

Pennefather, Patrick; Krebs, Claudia: *Exploring the Role of XR in Visualisations for Use in Medical Education,* Biomedical Visulation, pp. 15–23, 2019

Rojas Ramos, Alessandro (European Training Foundation (ETF): WEBINAR-Material: *Emerging Tech for Learning and Training, Enhancing Skills Development and TVET through the use of XR technologies,* 2022.

United Nations Educational, Scientific and Cultural Organization and UNESCO Bangkok Office: *Beyond Access: ICT-enhanced Innovative Pedagogy in TVET in the Asia-Pacific,* Paris, 2017.

The World Bank Group: *Unleaching the power of educational technology in TVET systems,* Washington DC, 2021.

Ziker, Cindy; Truman, Barbara; Dodd, Heather: *Cross Reality (XR): Challenges and Opportunities Across the Spectrum,* in: Ryoo, J.; Winkelmann, K.: Innovative Learning Environments in STEM, Higher Education, Springer Briefs in Statistics, 2021

Internet-Links:

https://www.vettoolbox.eu/ (25.08.2022)

https://tvet-academy.de (10.08.2022)

www.mimbus.com (10.08.2022)

https://vrskillslab.eu (10.08.2022)

https://www.ilo.org/skills/projects/skill-up/WCMS_766255/lang--en/index.htm (25.08.2022)

https://www.ilo.org/skills/projects/innovation-facility/challenge-call/lang--en/index.htm (25.08.2022)

https://www.christiani.de/akademie/ (10.08.2022)

https://www.bibb.de/en/28313.php (10.08.2022)
https://www.unido.org/stories/virtual-reality-training-southern-africa (10.08.2022)
https://www.giz.de/en/worldwide/70532.html (10.08.2022)
https://www.3dbear.io/ (10.08.2022)
https://eonreality.com (10.08.2022)
http://unvr.sdgactioncampaign.org/get-involved/vr-for-education/#.Yuo7vxxBw2x (10.08.2022)
https://www.uninnovation.network/virtual-reality (10.08.2022)
https://www.giz.de/en/worldwide/39671.html (10.08.2022)
https://www.giz.de/en/worldwide/107424.html (10.08.2022)
https://www.giz.de/akademie/de/downloads/TD_5.1_21centurytechnologies_VRARXR.pdf (10.08.2022)
https://www.giz.de/akademie/en/downloads/20211018_Agenda%20Workshops_Final.pdf (10.08.2022)
https://fosh-learning.co.za/ (10.08.2022)
https://ak-vrarl.gi.de/projekte (10.08.2022)
https://vam-realities.eu (15.08.2022)
https://www.oxfordlearnersdictionaries.com/definition/english/virtual-reality?q=Virtual+reality (15.08.2022)
https://www.oxfordlearnersdictionaries.com/definition/english/augmented-reality?q=Augmented+reality (15.08.2022)
https://www.enabel.be/ (15.08.2022)
https://renewables-migration.com/ (15.08.2022)
https://renewables-migration.com/solar-installation-with-virtual-reality/ (15.08.2022)
https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_VTC-Event-Space-Design_final.pdf (08.09.2022)
https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_VTC-Fashion-Design_final.pdf (08.09.2022)
https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_VTC-Lift-maintenance-final.pdf (08.09.2022)
https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_SBG_AR-Remote-Training_final.pdf (08.09.2022)
https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_SBG-Paint-VR_final.pdf (08.09.2022)

https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_MIMBUS_SIMSPRAY_final.pdf (08.09.2022)

https://www.bibb.de/dokumente/media/XR-Use-Cases-in-TVET_GIZ-Vietnam_final.pdf (08.09.2022)

https://www.iotforall.com/difference-between-vr-ar-mr-360 (20.09.2022)

https://link.springer.com/article/10.1007/s11266-020-00280-z (10.08.2022)

https://impalaxr.io/ (10.08.2022)

http://step.go.kr/ (10.08.2022)

https://technobraingroup.com/digital/virtual-reality/ (10.08.2022)

https://www.immersivelearning.institute/ (10.08.2022)

Imprint

This document has been developed as part of the VET Toolbox project.
VET Toolbox is co-funded by the European Commission and the German Government.
The VET Toolbox partnership is composed of the British Council, Enabel, Expertise France, GIZ, and LuxDev.

Publisher

VET Toolbox Coordination Hub
c/o Belgian Development Agency
Enabel
Rue Haute, 147
1000 Brussels – Belgium
Tel: +32 2 505 37 00
Email: info@vettoolbox.eu
www.vettoolbox.eu

Authors

GIZ
Nathan Lenzin
Chenai Tsorayi

Studio2B GmbH
Hannah Hoffmann
Susanne Messer
Jasmin Siebold-Fournier

Design/Layout

now [nau]
communicative & visual design
Frankfurt – Germany