

KNOWLEDGE PACK

Virtual and XR Laboratories for Workforce Development





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VIRTUAL and XR LABORATORIES FOR WORKFORCE DEVELOPMENT

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FAQ

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Introduction

What is a KP?

Knowledge Packages (KPs) are short, pragmatic guides on individual topics within EdTech, meant to provide sufficient knowledge and understanding so that non-technical stakeholders can make key planning, design, and procurement decisions when integrating EdTech in education.

They can be used as a starting point for the planning of technology deployment to improve education processes, within education and labor ministries and education institutions.

About this KP

This KP informs **decision-makers of the potential of virtual and XR labs** to enhance the learning experience of students participating in workforce development programs. These labs can offer students training experiences that are personalized, interactive, hands-on, cost-effective, and up-to-date with industry standards.

The KP compiles information to support the delivery of training programs with a duration of between one-week up to one semester, offered by formal and non-formal TVET institutions, including secondary vocational training centers.

The KP also:

- Provides evidence and case studies **showcasing the advantages and results** of virtual and XR labs for training.
- Offers guidance on **implementation and steps necessary to deploy virtual and XR labs.**
- Compiles a **catalog of available virtual and XR labs** in the market in high-demand sectors, such as auto-mechanics, nursing, and welding.

Operational definition of TVET (Technical and Vocational Education and Training)

Formal TVET (conducive to an academic degree) and **non-formal TVET** (workforce development and vocational training).

After reading the main content of this KP, some questions might pop* :

FAQ

- Are there any concerns regarding the effectiveness and usability of virtual and XR labs?
- Are virtual and XR labs an adequate mechanism for instruction in all education fields?
- What methods can be employed to assess and monitor the effectiveness of virtual and XR labs?
- Are virtual and XR labs affordable and cost-effective?

WHO are the main stakeholders ?

KPs are designed with a human-centered vision.



RESPONSIBILITY

Project Managers



- Assist practitioners who lead investment projects and consider using virtual and XR labs to deliver workforce development programs or equipping laboratories and workshops.

Policymakers in the Ministries of Education and Labor / Donors / NGOs / social partners



- Raise awareness about the pros and cons of using virtual and XR labs for workforce development and inform decisions related to their planning, design, implementation, and procurement.

Training Providers and Education Institutions



- Provide education institutions (i.e., technical universities, secondary vocational education, vocational training centers) with an overview of the process to implement virtual and XR labs for workforce development, and of lessons learned by education systems that have adopted this technology.

WHY is this KP designed ?

Problem statement and value proposition

PROBLEM STATEMENT AND VALUE PROPOSITION



COMPARED TO TRADITIONAL LABORATORIES, VIRTUAL AND XR LABS COULD BE A COST-EFFECTIVE ALTERNATIVE

	'TRADITIONAL' LABORATORIES	VIRTUAL AND XR LABORATORIES
INVESTMENTS	Require large investments for set-up and functioning , including equipment, maintenance, inputs and consumables . Infrastructure depreciates rapidly, requiring periodic updates. Challenging to maintain state-of-the-art technology .	Require less investment in inputs and consumables but more in technical support, licenses, and software updates. Allow for easier adjustments to changes in the industry, facilitating access to up-to-date training and equipment .
RISKS AND SAFETY	Some training situations and learning experiences may be dangerous or difficult to access (e.g., healthcare, welding training, emergency preparedness, mass disasters, etc.).	Reduce potentially expensive and life-endangering risks and allows for practice in a safer environment without pressure or danger .
PROFICIENCY DEVELOPMENT	Limited opportunities to practice, repeat or rehearse due to cost, time, supervision, and space limitations.	Allow for unlimited practice opportunities and can personalize the pace (and scenarios) of the learning experiences in a simulated environment.
PROFICIENCY MONITORING	Not always capable of monitoring and producing data on student use, performance, and completion of laboratory practices. Teachers are the primary monitoring system .	Facilitate data collection and data analysis , as they automatically register and save data of students' performance. Also, they generally allow for direct feedback.
PEDAGOGY	Teachers are the main source of learning .	Teachers are facilitators , allowing personalized learning based on student performance, preferences, and goals.



IMPACT

When compared to traditional laboratories, students exposed to **training in Virtual and XR Laboratories (on average)**:

- ✓ Are **up to 30% more efficient** using inputs, time, and/or avoiding performance errors, per additional hour of instruction.
- ✓ Score **3% higher in technical (cognitive) learning**, for each additional hour (¼ hour) of VR training.
- ✓ Report on average **30% higher scores in socio-emotional skills assessments** after completing their training.



are the potential solutions?

[Type of virtual and XR labs](#)

[Country experiences](#)

[Private sector experiences](#)

TYPE OF LABORATORIES

WHAT IS A VIRTUAL / XR LAB? SPECTRUM OF OPTIONS

A virtual or XR laboratory is an interactive computer simulation of a laboratory. Its purpose is to give students training opportunities conducive to practical learning for skills development.

TAXONOMY

	Main features	Effects on learning
3D-VISUALIZATION IN A 2D SCREEN	3D objects or environments presented in a two-dimensional display, such as a computer screen or a mobile device. Requires input devices such as a keyboard and a mouse for navigating and interacting with software tools. Useful for remote education or when physical access to a laboratory is limited.	Supports acquisition of knowledge. Allows for better understanding of contents.
3D SEMI-IMMERSIVE / MIXED REALITY	A semi-immersive environment that blends digital 3D content with the user's real-world environment. The experience is not fully immersive like VR but still offers a heightened sense of presence and interaction with virtual objects. Generally, requires 3D glasses and a specialized equipment in a physical lab.	Supports the development of cognitive and technical skills. Allows to manipulate and interact with objects.
3D FULLY IMMERSIVE VR	A fully immersive 3D digital environment that allows emulating physical space, movement, and interaction. Users can feel a strong sense of presence in the virtual environment, as if they are physically present within it. Users can interact with virtual equipment, manipulate objects and perform experiments. Typically involves using VR headsets in a physical lab.	Supports the development of cognitive and technical skills. Hands-on practice that enhances muscle memory and emulates real situations at the workplace.



MORE IMMERSIVE EXPERIENCES ASSOCIATE WITH HIGHER STUDENT ENGAGEMENT, MOTIVATION, AND LEARNING



WHAT are the potential solutions?

WHAT HAS BEEN DONE IN OTHER COUNTRIES – CASE STUDIES



Rwanda
Polytechnic Maintain Engine Course

- **Lab Type:** 3D-visualization in 2D screen.
- **Objective:** maintain and repair engine systems of motor vehicles.
- **Target:** students pursuing a diploma in automobile technology, level 6.
- **Other:** four learning modules (identify engines; maintain the cooling system; service lubrication system; service exhaust system).



United States and Canada
International Training Institute (ITI)

- **Lab Type:** wide spectrum of options (VR and 3D simulation technology).
- **Objective:** provide hands-on training to apprentices.
- **Target:** more than 14,000 International Association of Sheet Metal Air, Rail and Transportation Workers (SMART) apprentices.
- **Other:** using [Interplay Learning](#)'s technology.



An MHRD Govt of India Initiative

India
Virtual Labs project (VLAB) - Video

- **Lab Type:** 3D-visualization in 2D screen.
- **Objective:** provide remote access to labs in various disciplines of science and engineering.
- **Target:** graduate and undergraduate college and university students.
- **Other:** includes web-resources, video-lectures, animated demonstrations, and self-evaluation. Accessible through internet on any PC/laptop or on a smartphone/tablet. No additional infrastructural setup.
- Labs designed by a consortium of eleven academic institutes, and free to use for everyone.
- Local agencies, known as Nodal centers, train centers across India to use the platform, promote usage of virtual labs, and prepare regular reports on platform utilization.
- **Impact** (April 2009 - November 2022): Over 120 Virtual Labs of approximately 700+ web-enabled experiments for remote-operation and viewing. 3,500+ workshops conducted by 1,200+ nodal centers.

WHAT are the potential solutions?

Type of virtual and XR labs

Country experiences

Private sector experiences

WHAT HAS BEEN DONE IN OTHER COUNTRIES – ECUADOR

LOCAL PARTNER:
MINISTRY OF EDUCATION

KOREAN PARTNER:
NAMSEOU UNIVERSITY

"Performance doubled on standardized tests, motivation increased and students were more engaged."



2
XR CURRICULA
Auto Mechanics
Industrial Risk Prevention

6
LABORATORIES
Fully equipped XR labs set up at six technical universities

44
PROFESSIONALS
Faculty and staff trained to implement XR technology into the curricula

320
STUDENTS PER SEMESTER
Every semester, more than 320 students benefit from the use of XR technologies in the classroom

ActiVaR

Pilot Program to Test **Virtual Reality Training Programs** for Technological and Technical courses in Higher education.

Financed by the **Government of Korea** through the **Korea World Bank Partnership Facility**.

Auto Mechanics

- [Curricula](#) (English)
- Pedagogical Guide ([English](#); [Spanish](#))
- [Promo-video](#)

Prevention of Industrial Risks

- [Curricula](#) (Spanish)
- [Pedagogical guide](#) (Spanish)
- [Information System](#) (Spanish)
- [Promo-video](#)
- [Laboratory](#)

Results & Lessons learned

- **Statistically significant learning gains** measured by the percentage increase in the post-test relative to the pre-test.
- Students reported **high levels of motivation** to continue to learn auto-mechanics, they found it **fun and engaging**, and they would like to use this technology again.
- **Female students are less prone to use technology and participate** in group discussions.
- AVR training reported **some concerns regarding the usability of technology**.



[Meta-Analysis Assessing the Effects of Virtual Reality Training on Student Learning and Skills Development](#)

[Value Added Evaluation for a Laboratory that Uses Augmented and Virtual Reality to Improve Student Learning in Auto-mechanics](#)

WHAT are the potential solutions?

Type of virtual and XR labs

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WHAT HAS BEEN DONE IN OTHER COUNTRIES – NAMSEOUL UNIVERSITY, KOREA

Glass Department

Lab Type: 3D-visualization in 2D screen.

Objective: create a set of apps to train students to use glass-blowing equipment safely. Uses a [zSpace](#) app that instruct students on how to operate a large glass-blowing furnace.

Target: University students.

Impact: Prior to implementing the virtual lab, only 2 students per year were selected to turn equipment on and off as well as conduct maintenance checks. Now, any student who wishes to operate the furnaces participates in the training program and is capable of using the equipment safely after program completion.



Tiling Department

Lab Type: wide spectrum of options (3D-visualization in 2D screen; 3D semi-immersive/ mixed reality (XRs); 3D fully immersive VR).

Objective: creation of three VR applications to allow tiling students to practice tile cutting and installation without waste of resources. The certification pass rates were low (averaging 60%) as compared to above 80% in other fields. This was attributed, in part, to the limited opportunities for students to practice.

Target: University students.

Other: One fully immersive application teaches the overall tile installation process and mirrors the certification exam; two non-immersive applications focus on developing skills, including cutting; mobile prototypes were also created to facilitate home learning.





are the potential solutions?

WHAT HAS BEEN DONE IN OTHER COUNTRIES – OTHER CASE STUDIES

COUNTRY	NAME	LAB TYPE	OBJECTIVE	TARGET	OTHER
 Ghana	OpenSTEM Africa	3D-visualization in 2D screen	Improve practical science knowledge	Upper secondary level	Partnership between Open University and Ghana's MoE
 Morocco	Design and Implementation of a Virtual Laboratory for Physics Subjects in Moroccan Universities	3D-visualization in 2D screen	Develop a low-cost virtual laboratory integrated into an interactive learning environment based on the Moodle platform	First year of Bachelor's degree students for physics subjects	Use of computer simulation combined with the JavaScript programming language
 Nigeria	StanLab	3D-visualization in 2D screen (lab on a screen, like a movie, but possible to interact. E.g., touch the objects, lift them and put them down on a surface)	Democratize access to quality STEM	Secondary school students	Linkedin

WHAT are the potential solutions?

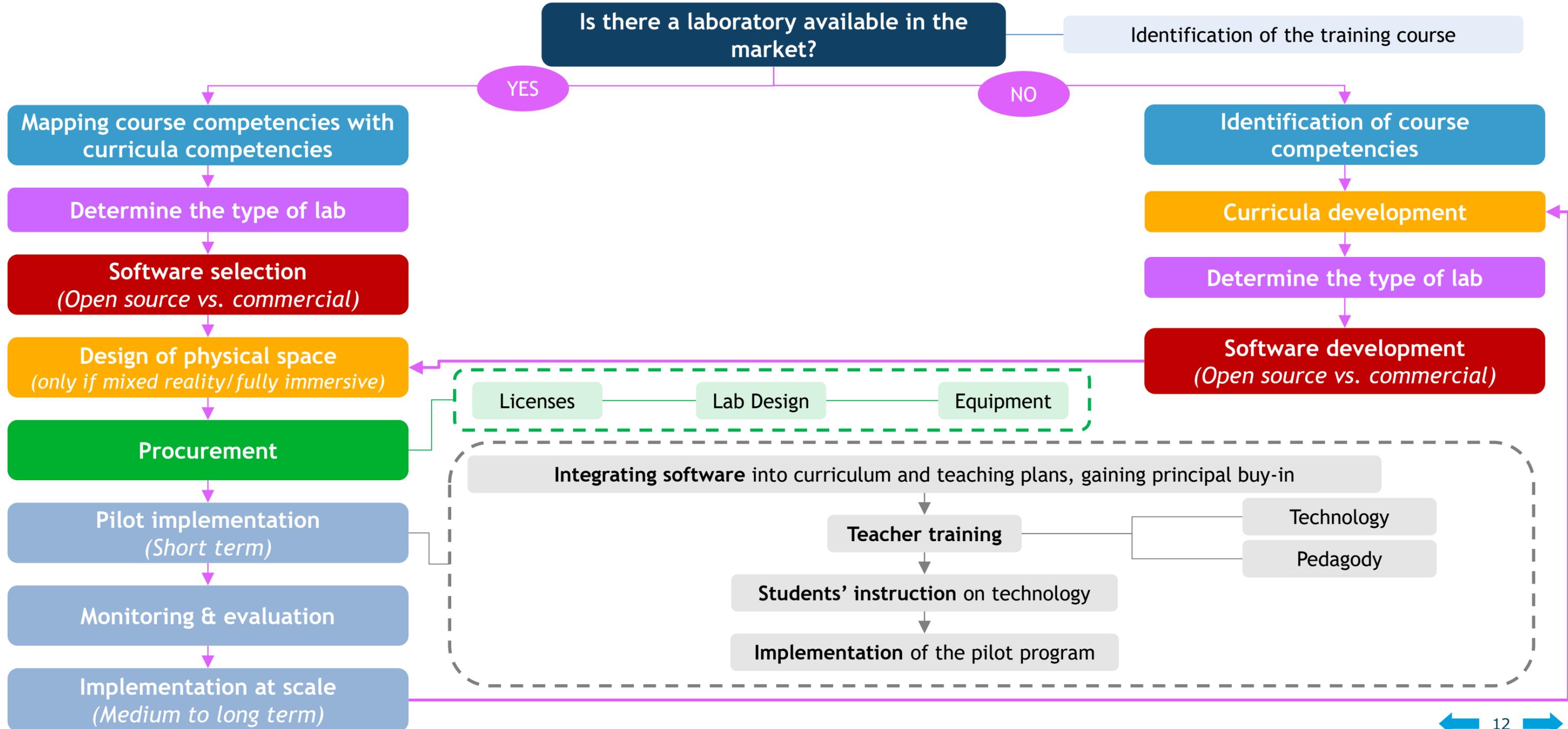
WHAT HAS BEEN DONE IN THE PRIVATE SECTOR – CASE STUDIES

	COMPANIES		BRIEF EXPLANATION	LINKS OF INTEREST
AIRLINES		KLM	<ul style="list-style-type: none"> VR training ensures the effective use of time and saves costs by keeping aircrafts clear from training. Moreover, pilots can train outside of the classroom or simulator. 	Article / Video
AUTOMOTIVE		BMW	<ul style="list-style-type: none"> AR training for assembly line workers. 	Video 1 / Video 2
		Volkswagen	<ul style="list-style-type: none"> VR simulation for assembly training, such as installing a door or brake. 	Article / Video
LOGISTICS		DHL	<ul style="list-style-type: none"> VR training to teach employees how to efficiently organize parcels. The technology optimizes the loading process and space as well as reduces CO2 emissions and costs. 	Pilot project / Article / Video
		UPS	<ul style="list-style-type: none"> VR simulations help students practice driving skills, demonstrate their ability to identify and handle driving hazards, as well as improve the efficiency of sorting facilities. 	Article / Video
MEAT PROCESSING		The Australian Meat Processor Corporation (AMPC)	<ul style="list-style-type: none"> Specialist R&D provider for Australian meat processors. In conjunction with Think Digital, it uses collaborative virtual reality to train their staff. Experiences cover a wide range of industry practices, from dressing appropriately to decontaminating procedures and the operation of equipment. 	Article / Video
WELDING SCHOOLS		The Refrigeration School	<ul style="list-style-type: none"> It uses an innovative VR technology that simulates the experience of welding. 	Video
		Tulsa Welding School	<ul style="list-style-type: none"> It developed OcuWeld, a virtual reality welding training program. 	Video 1 / Video 2
		International Training Institute	<ul style="list-style-type: none"> VR and 3D-simulation technology to assess, train, and manage skilled trade workers. 	Article / Video
OTHERS		KFC	<ul style="list-style-type: none"> VR training support for cooks on how to make its chicken better. 	Article / Video
		Verizon	<ul style="list-style-type: none"> VR/ AR training help improve operational readiness and enhance the customer experience. 	Article / Video
		Walmart	<ul style="list-style-type: none"> VR training includes multiple scenarios, such as tasks for managers, customer service, sales in stores, or the Black Friday experience. 	Article / Video 1 / Video 2



HOW to implement next steps ?

DEPLOYMENT PROCESS – DECISION TREE





to implement next steps ?

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[Monitoring and evaluation](#) |

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DEPLOYMENT PROCESS IF LABORATORIES ARE AVAILABLE IN THE MARKET

MAPPING COURSE COMPETENCIES

- **Align** course competencies with curricula competencies. Then, **determine the type of lab**.

SOFTWARE SELECTION

- Is the virtual or XR lab **cost-effective** for training in specific subject area? Creating these educational applications could be laborious and costly, and of low value-added in certain subjects.
- Does the **software exist**? Is the **software available** (open-source or commercial) in the market in the **language** I need?
- What is the **budget availability**?
- Identify **software options** in the desired field already in the market (check how much they align to course curricula), and the device requirements.

DESIGN OF LABORATORY

- **Minimum technical specifications** to ensure satisfactory implementation: space, furniture (“collaborative furniture”), internet connectivity, IT support, human resources, and security.

PROCUREMENT

- **Software/Licenses**
- Laboratory **design and equipment** (for 3D semi-immersive/ mixed reality (XRs) and fully immersive)
- **Technical support**
- It is recommended to **‘bundle’ procurement in a “service contract”** that includes provision of goods and services (licenses, hardware, training of teachers, technical support)

IMPLEMENTATION

- **Integrate the content** provided through the software into the existing course curriculum and lesson plans.
- **Gain buy-in or operational support** from principal.
- **Teacher training on technology and pedagogy**: coach teachers on how to use the software as intended in the classroom. Teachers should be willing to change their roles and become facilitators of the learning process instead of being the primary source of information.
- **Instruct students** on how to use technology before using the virtual or XR laboratory for instruction. Give special attention to students who are less technology savvy.
- **Technical support** to maintain laboratories and help teachers debug technical issues with the labs’ hardware/software.
- **Monitor & Evaluate**: establish an information system, indicators, pre-test vs. post-test, and conduct an impact evaluation, if possible.



to implement next steps ?

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DEPLOYMENT PROCESS IF LABORATORIES ARE NOT AVAILABLE IN THE MARKET

IDENTIFICATION OF TRAINING COMPETENCIES

- Determine whether **the subject area of training aligns well with the implementation of a laboratory**. Virtual and XR laboratories may not be cost-effective in some fields.
- Identify **the competences that would be developed** through the implementation of labs.

TYPE OF LAB

- Virtual and XR laboratories require **minimum technical specifications** to ensure satisfactory implementation (space, furniture, internet connectivity, IT support, human resources, and security).
- Select the type of laboratory that **best adapts to the course curricula and training needs**.

CURRICULA DEVELOPMENT

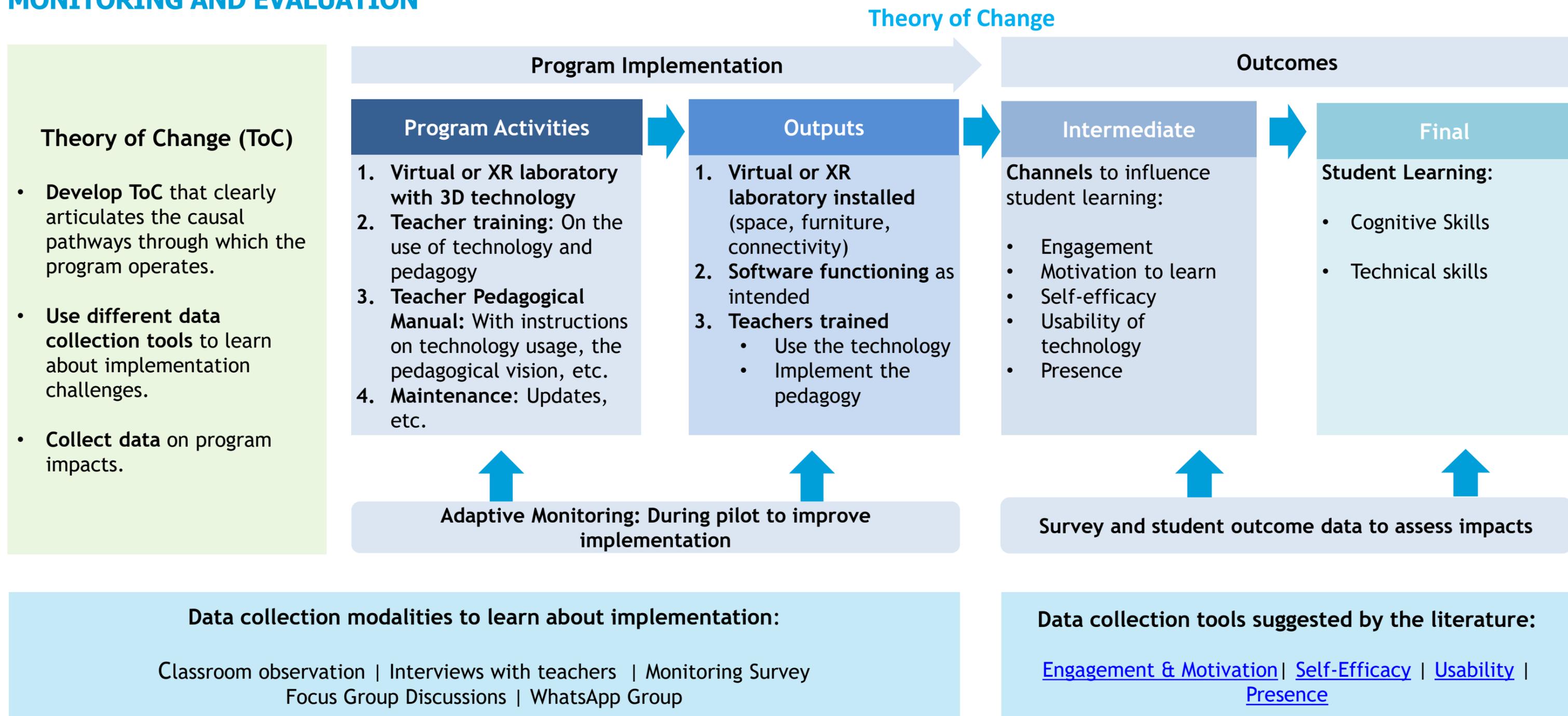
- **Develop a competency-based curricula** stating clear objectives and competency standards (if possible, aligned with national qualification frameworks or industry certifications).

SOFTWARE DEVELOPMENT

- **Contact a regional or global firm** to start designing the software.
- Envision needs for **updates and improvements**.
- Decide whether to use **open source vs. commercial software**.
- It is recommended to **'bundle' procurement in a "service contract"** that includes provision of goods and services (software development, hardware, training of teachers, technical support, and updates).

HOW to implement next steps ?

MONITORING AND EVALUATION





to implement next steps ?

ADAPTIVE MONITORING AND EVALUATION

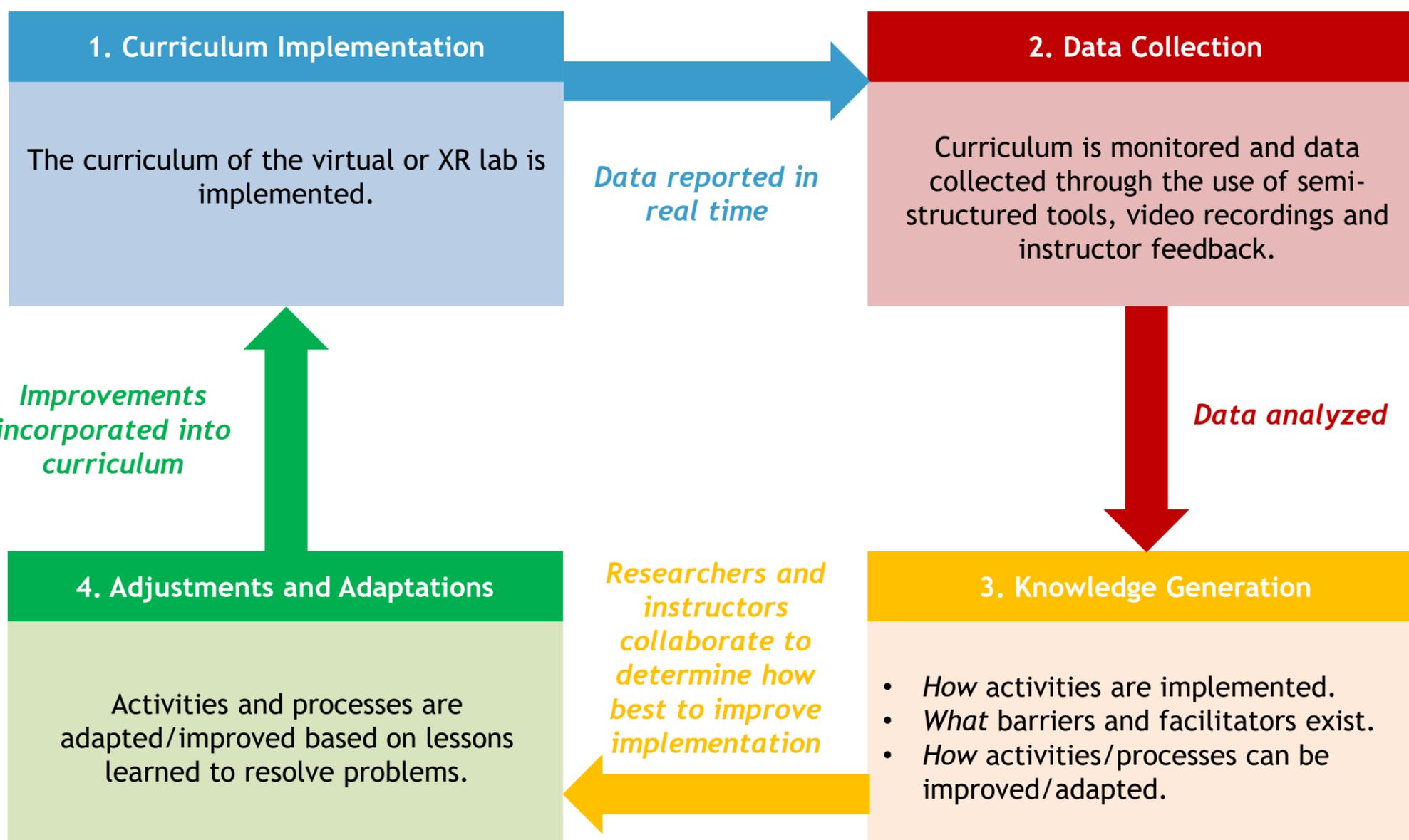
Before implementing at scale

Conduct a **small pilot** to identify implementation challenges, program alignment and fidelity, compliance and take up, problems with the use of technology, connectivity, and electricity.

Monitor

1. **Implementation of the Pedagogy:**
 - Integration to the course curriculum
 - Access and use of the technology
 - The role of the teacher
2. **That enabling conditions are in place:** equipment, connectivity, electricity, maintenance.
3. **Student utilization, learning, motivation, and adaptation to the technology.**

Iterative Monitoring and Evaluation System to Track the Implementation of the Virtual and XR Laboratory

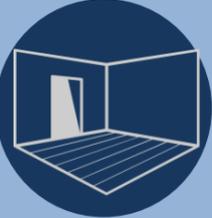


HOW to implement next steps ?**COST INGREDIENTS: ITEMS TO BUDGET****SOFTWARE**

- Cost of development of a **new software** (if lab not available in the market)
- **License costs:** Vary based on the number of licenses purchased and their duration.

**HARDWARE**

- PCs / laptops / headsets (type of headsets) / accessories (controllers, speakers, headphones) / import costs (if any)

**LABORATORY**

- **Design of laboratories:** Classroom size / connectivity / electricity outlets / furniture / lightning / curtains (for darkness) / tables and chairs / projector / cleaning supplies / bio-safety protocols

**IMPLEMENTATION**

- Teacher training (in-person vs. virtual) / student training / data collection and monitoring / technical support (maintenance, updates) / security of the laboratory

HOW to implement next steps ?

BRIEF CATALOG OF POTENTIAL SOFTWARE PROVIDERS: AUTO-MECHANICS

PROVIDER	TYPE OF VIRTUAL / XR LAB	BRIEF DESCRIPTION	RESOURCES/ VIDEOS
ActiVaR	3D semi-immersive / mixed reality	Augmented and Virtual Reality (AVR) to deliver training in auto-mechanics. This virtual lab seeks to improve learning of students who are being introduced to the basic principles of the operation of internal combustion engines for the first time. The pedagogical approach includes blended learning modalities.	Video (promo)
Automotive Mechanic by GTAFE for Zspace	3D semi-immersive / mixed reality	Safely practice the assembly and disassembly of an automobile in a virtual mechanic shop.	Videos here
Electude	3D-Visualization in a 2D screen	Automotive e-learning solutions. Platform that uses gaming technology to teach automotive technology students.	Video about the company
MIMBUS	3D semi-immersive / mixed reality	SimSpray is a VR solution that helps students master the motion needed to be a successful painter. They learn step-by-step and through practice auto body painting and sandblasting. Niche solution.	Brochure Video of spray-painting demo
PTC	3D semi-immersive / mixed reality	Use of AR to maximize revenue, reduce costs, and drive efficiency across manufacturing, service, and sales and marketing. The product requires a suite of essential AR apps. It partners with companies like Volvo and Toyota, among others.	Download 'Use Case Guide' here Case studies available here (Toyota, Infiniti, Brembo, Volvo) Video on AR
Uptale	3D semi-immersive / mixed reality and 3D fully immersive VR	Immersive Learning platform to create, share and track. Operational managers can take 360° pictures/videos of the workstations and use them to create realistic and explicit training experiences. These experiences help newcomers visualize their future work environment while getting trained by actively interacting with visually/spatially contextualized information.	Case studies available here (Alstom, DS Smith, Stellantis, Delfingen, etc.) Video (demo) Video (case study)

HOW to implement next steps ?

BRIEF CATALOG OF POTENTIAL SOFTWARE PROVIDERS: NURSING

PROVIDER	TYPE OF VIRTUAL / XR LAB	BRIEF DESCRIPTION	RESOURCES/ VIDEOS
3D Organon	3D fully immersive VR	3D Organon is a medical & healthcare education platform for teaching and learning anatomy. Shared anatomy learning experiences where students can interact in the same virtual space.	Video (more here)
Acadius by Arch Virtual	3D-Visualization in a 2D screen, and 3D fully immersive VR	Hands-on clinical training in a safe virtual environment with a high-fidelity simulation. Modes: VR, Non-VR Viewer, or Screen Share.	Demo overview here
BioDigital	3D-Visualization in a 2D screen and 3D semi-immersive / mixed reality, and 3D fully immersive VR	Interactive 3D software platform for visualizing anatomy, disease, and treatment. It also offers AR/VR for an immersive experience. Sectors: consumer health, Ed Tech, health IT, medical device, pharma, schools.	Customer stories here
Conquer Experience	3D-Visualization in a 2D screen, 3D semi-immersive / mixed reality, and 3D fully immersive VR	Digital Simulation Platform that combines of technical smarts with UX and gamification to create engaging apps and bringing complex scenarios to life. Award winning product: PeriopSim teaches OR nurses instrumentation and procedures before they set foot in the OR.	Case studies here Video (PeriopSim)
UbiSim	3D fully immersive VR	The World's First VR Training Platform for Nursing. Learners can practice specific clinical scenarios and receive instant feedback. Pre-built scenarios that can be customized to fit clients' needs.	Video (VR example) Request case study here
VRpatients	3D-Visualization in a 2D screen, 3D semi-immersive / mixed reality, and 3D fully immersive VR	Virtual Simulation Training for Emergency Responders & Nurses. Access to limitless case scenarios, create content tailored to specific training objectives or use or modify dozens of pre-built cases. Diverse avatars that represent realistic patient population.	Request brochure here Case study here Video (demo)



to implement next steps ?

BRIEF CATALOG OF POTENTIAL SOFTWARE PROVIDERS: WELDING

PROVIDER	TYPE OF VIRTUAL / XR LAB	BRIEF DESCRIPTION	RESOURCES/ VIDEOS
Fronius	3D-Visualization in a 2D screen, and 3D semi-immersive / mixed reality	Mobile App (here) with training, quizzes and challenges and Welding Simulators (here). The user can practice welding various weld seams in various positions using different workpieces. The simulator software is self-explanatory, easy to use and boasts a sophisticated design and clear menu navigation. Virtual Welding is available in two variants: as a fixed terminal or as a compact carry-case for mobile use	Brochures available here .
Lincoln Electric	3D-Visualization in a 2D screen, 3D semi-immersive / mixed reality	VRTEX 360 virtual reality welding trainers for dual users that simulates welding for hands on welding training. It does not require internet connection, only electricity.	Video (company) Video (demonstration)
MIMBUS	3D semi-immersive / mixed reality	Designed to teach and evaluate the professional gesture of the welder. It allows learners to perfect the precision of their gestures and their concentration without risking injury and minimizing the risk of breakage or premature wear of equipment. VRTEX 360 Compact is a VR simulator for mobile use in multiple environments to master welding training.	Brochure Video (zSpace)



to implement next steps ?

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BRIEF CATALOG OF POTENTIAL SOFTWARE PROVIDERS: OTHERS

PROVIDER	TYPE OF VIRTUAL / XR LAB	BRIEF DESCRIPTION	RESOURCES/ VIDEOS
Aatral	3D-Visualization in 2D screen, 3D semi-immersive / mixed reality and 3D fully immersive VR	AR and VR to enhance production efficiencies, process training, remote assistance, product showcase, troubleshooting, eliminate safety-incidents, increase profitability and become a Smart Factory. Fields: automotive, machinery, defense, energy, aerospace, education, architecture & planning, retail, entertainment.	Case studies here Videos (products and modules)
ActiVaR	3D fully immersive VR	VR to prevent industrial risks through immersive scenarios. Contract with Visyon360 , specialized in immersive 360 video pieces in monoscopic and stereoscopic formats.	Video / Videos (modules) 3D Digital Twin here
Apprentice	3D semi-immersive / mixed reality	Tempo is a cloud-based platform that works seamlessly across all stages of drug production. It allows resource definitions, master recipes, and production data to be shared instantly. Field: medicine	Video (Tempo)
Arvizio	3D semi-immersive / mixed reality, and 3D fully immersive VR	AR and MR Digital Twins. Fields: healthcare and medical devices, manufacturing, field maintenance, industry 4.0 (engineering and design process), construction, energy, and mining.	Video (Immersive 3D) Video (AR instructor)
CareAR - A Xerox Company	3D semi-immersive / mixed reality	It focuses on improving the service experience while delivering significant operational efficiencies, real business value, and enhanced safety. Sectors: manufacturing, telecom, IT services, and healthcare.	Video (CareAR Assist)
Cloudberry	3D fully immersive VR	Adaptive learning platform or turnkey solution to adapt to existing training programs (fire drills, tackle difficult conversations, engine assembly, etc.).	Video (engine assembly)
Cognitive3D	3D-Visualization in 2D screen	Analytics platform that collects spatial data from immersive experiences, enabling brands to develop better product strategies, and understand consumer behavior. It allows to conduct training situations with clearer results to reduce injury, improve safety, and measure efficiency. Variety of fields.	Pricing options here Video
Dimenco	3D semi-immersive / mixed reality	Simulated Reality (SR) technology that delivers 3D experiences without the need for glasses. Variety of fields.	Video (what is SR?) Video (Simulated Reality)
Embodied Labs	3D fully immersive VR	Immersive training for healthier aging to embody the perspectives and conditions of others. It empowers more effective, empathetic care for patients, customers and family members. Fields: senior services, academic programs, local government, corporate partners, homebased care.	Video (overview) Video (Alzheimer's)
EXXAR	3D-Visualization in 2D screen, 3D semi-immersive / mixed reality, and 3D fully immersive VR	VR/AR for training, allowing for virtual collaboration, design reviews and training. The platform can be used in different devices (VR, AR, MX, desktop). Fields: construction, industrial, manufacturing.	Videos here
Festo Didactic	3D-Visualization in 2D screen	Holistic solutions and equipment for all areas of technology in factory and process automation, such as pneumatics, hydraulics, engineering, production, mechatronics, and telecommunications.	Brochures and Catalogues here Video / Video (software)



HOW to implement next steps ?

BRIEF CATALOG OF POTENTIAL SOFTWARE PROVIDERS: OTHERS

PROVIDER	TYPE OF VIRTUAL / XR LAB	BRIEF DESCRIPTION	RESOURCES/ VIDEOS
Holo-Light	3D semi-immersive / mixed reality, and 3D fully immersive VR	AR and MR to speed up product development (prototyping, design reviews, factory simulation, immersive trainings). Sectors: automotive, mechanical engineering, aerospace & defense.	Case studies here Video (XR) / Video (AR)
Immerse.io	3D-Visualization in 2D screen, 3D semi-immersive / mixed reality, and 3D fully immersive VR	Content aggregation, distribution and reporting platform that utilizes an enterprise-grade cloud service for management, deployment and reporting of collaborative VR training applications. Variety of fields.	Case studies here Video here
Innoactive	3D semi-immersive / mixed reality, and 3D fully immersive VR	Enterprise XR CMS with cloud streaming for training and visualization. Technology used by large enterprises to deploy VR training to employees, customers and suppliers. Variety of fields.	Pricing options here Video (demo)
Interplay Learning	3D-Visualization in 2D screen, 3D semi-immersive / mixed reality, and 3D fully immersive VR	VR training provider in skilled trades to create job-ready skilled trade workers faster and easier. Fields: HVAC, plumbing, electrical, multi-family and facilities maintenance, safety, solar, electrical, and hospitality.	Video / Video 2
iQ3Connect	3D semi-immersive / mixed reality, and 3D fully immersive VR	Real-time 3D spatial training and collaboration. It offers instant VR experiences, allowing access to immersive experiences and VR workspaces. Variety of fields.	Video
LabTech	3D-Visualization in 2D screen, and 3D semi-immersive / mixed reality	TVET systems designer and manufacturer that aims to provide 21 st century skills infused technical and engineering learning solutions for TVET schools, polytechnics, and universities. Sector: education.	Video
Metadome	3D-Visualization in 2D screen, and 3D semi-immersive / mixed reality	Solutions for creating and deploying XR experiences at scale. It offers Autodome , an immersive automotive platform for 3D and XR applications. Variety of fields , including automotive, home decor, fashion, cosmetics, and accessories.	Video
Sim Insights	3D semi-immersive / mixed reality and 3D fully immersive VR	AR/VR/AI cloud-based SaaS software and services to transform training and operations with immersive, interactive and personalized (AI-powered) training content. It also offers HyperSkill , an innovative tool to author, publish and evaluate AI-powered training content. Fields: healthcare, manufacturing, education, retail, etc.	Pricing here Video (simulation)
Talespin	3D fully immersive VR	Immersive learning for the future of work. It helps use XR to learn faster, validate skills, and find upward mobility in the workforce. Fields: leadership, healthcare, insurance training, etc.	Video
VRdirect	3D-Visualization in 2D screen and 3D semi-immersive / mixed reality, and 3D fully immersive VR	VR platform that enables enterprises to create use case-driven VR solutions that support real-life business processes and deliver concrete business value. Variety of fields.	Client examples here Video
VSight	3D-Visualization in 2D screen, and 3D semi-immersive / mixed reality	Increase operational efficiency and expert utilization as well as empower frontline workers with interactive digital instructions (solve mechanical problems, monitor assembly lines). Fields: machinery and equipment, manufacturing, mining, healthcare, construction.	Case studies here / Video

Conclusion

WHO

This KP can effectively support **project managers, policymakers** in the Ministries of Education and Labor, **donors, NGOs, social partners, training providers**, and **education** to enhance student's learning experience in workforce development programs by implementing virtual and XR laboratories.

WHAT

There exist **different types of virtual and XR laboratories** (3D-Visualization in 2D screen; 3D semi-immersive/mixed reality (XRs); 3D fully immersive), with **varying effects on learning**. **More immersive experiences** are linked with **higher student engagement, motivation, and learning**. Several countries, such as Ecuador, Korea, Rwanda, India, and the private sector, are already using this technology to enhance workforce development training programs.

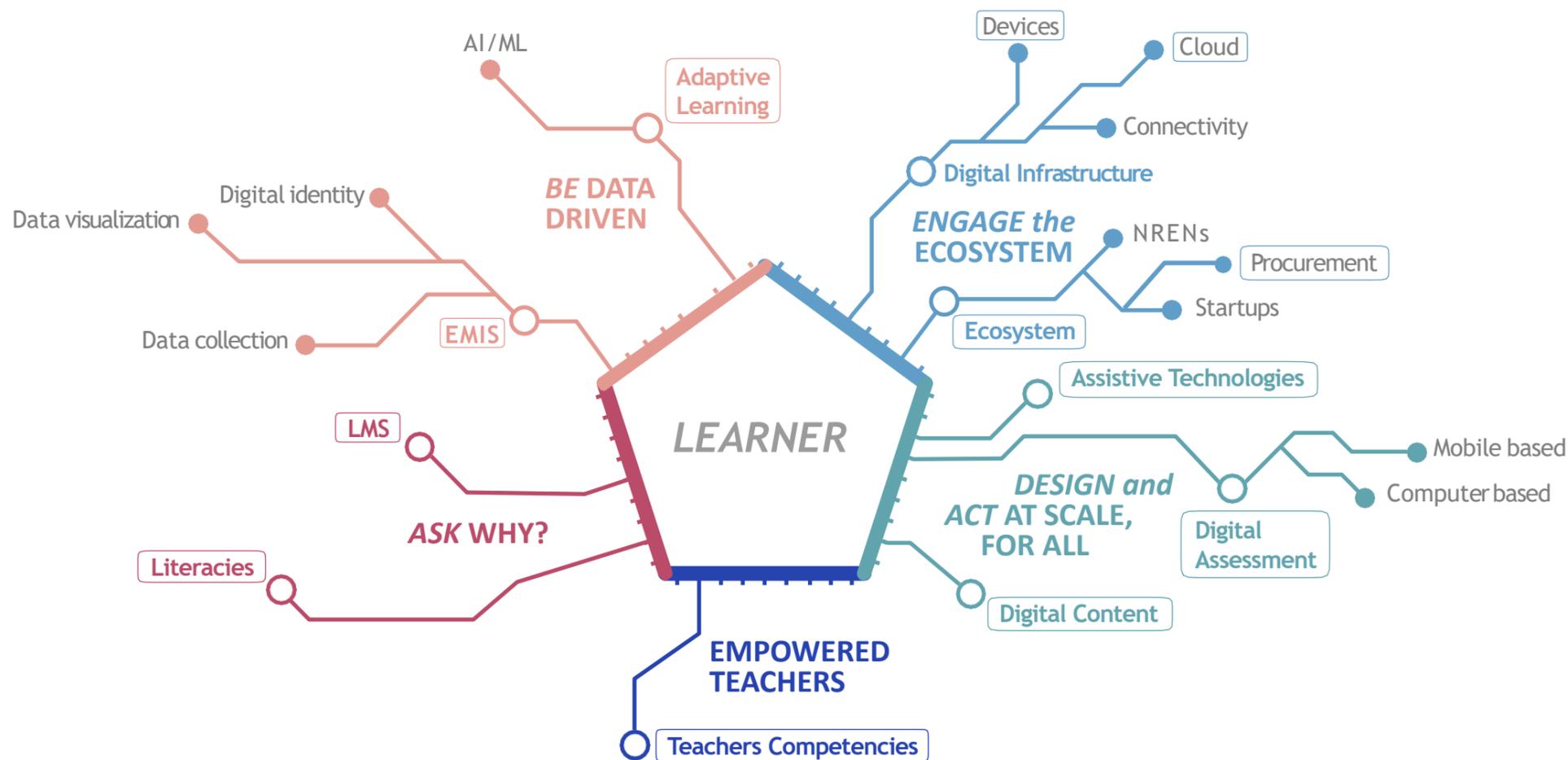
Virtual and XR labs could be a **cost-effective alternative** to traditional laboratories in terms of investments, risks and safety, proficiency development and mentoring, and pedagogy. Moreover, virtual and XR labs can potentially **accelerate students' learning curve** and **provide significant learning gains**.

The **deployment process is contingent upon the market availability of the software** (on whether it has been developed or not). Before integrating the technology into the course curricula, it is essential to **ensure the software and hardware are reliable**. **Costs vary greatly**, depending on software, hardware, laboratory, and implementation. A **wide range of software providers** exists in the market in many different fields, including auto-mechanics, nursing, and welding.

WHY

HOW

To go further CLOUD OF KPs



OTHER EXISTING RELATED KPs



RELATED SOURCES



Podcast: [Employing Virtual and XR Laboratories for Workplace Development](#)

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Annexes

GLOSSARY

Operational definition of TVET:

Technical and Vocational Education and Training. Formal (conducive to an academic degree) and non-formal TVET (workforce development and vocational training).

Virtual and XR Laboratories:

Interactive computer simulation of a laboratory. Its purpose is to give students training opportunities conducive to practical learning for skills development.

3D-Visualization in a 2D Screen:

3D objects or environments presented in a two-dimensional display, such as a computer screen or a mobile device. Requires input devices such as a keyboard and a mouse for navigating and interacting with software tools. Useful for remote education or when physical access to a laboratory is limited.

3D semi-immersive/ mixed reality:

A semi-immersive environment that blends digital 3D content with the user's real-world environment. The experience is not fully immersive like VR but still offers a heightened sense of presence and interaction with virtual objects. Generally, requires 3D glasses and a specialized equipment in a physical lab.

3D fully immersive VR:

A fully immersive 3D digital environment that allows emulating physical space, movement, and interaction. Users can feel a strong sense of presence in the virtual environment, as if they are physically present within it. Users can interact with virtual equipment, manipulate objects and perform experiments. Typically involves using VR headsets in a physical lab.

XRs:

An umbrella term that encompasses various extended reality technologies, including virtual reality (VR), augmented reality (AR), and mixed reality (MR).

Quest:

The most used VR headset for education. It doesn't require to be connected to a computer/laptop.



Annexes

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Annexes

FAQs



- Are there any concerns regarding the effectiveness and usability of virtual and XR labs?
- Are virtual and XR labs an adequate mechanism for instruction in all education fields?
- What methods can be employed to access and monitor the effectiveness of virtual and XR labs?
- Are virtual and XR labs affordable and cost-effective?



Annexes

Glossary | References | [FAQ](#)

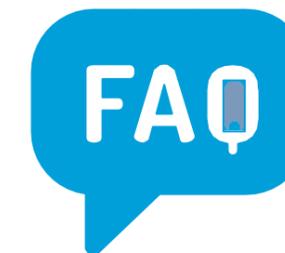
Are there any concerns regarding the effectiveness and usability of virtual and XR labs? – Caveats

CAVEATS	DESCRIPTION
CONNECTIVITY	Reliable and robust internet connection is required to download the solution and/or to use the platform effectively. It is essential for institutions to assess their capability in this regard beforehand. For instance, some applications can be used offline and internet connection may not always be necessary.
DATA PRIVACY	AR/VR raise new concerns regarding user privacy due to the scope, scale, and sensitivity of the personal data involved.
HYGENE (*)	It is important to assess the capacity of the technology to accommodate multiple users simultaneously. Also, maintaining proper hygiene is crucial due to shared equipment, contact with face, eye health, allergies and sensitivities, and health and safety compliance. You may find some best practices here .
INFORMATION OVERLOAD (*)	Avoid including more elements than necessary to the software experience, as it may expose students to visual distractions and hinder learning (e.g., do not include animations that don't contribute to learning).
SICKNESS (*)	AR/VR can sometimes induce motion sickness due to a phenomenon known as " simulator sickness " or " cybersickness ". It is important for users to take breaks, gradually adjust to the technology, and discontinue use if they experience discomfort.
OPTICAL EYEGLASSES (*)	AR/VR need to be accessible, safe, and comfortable for every students, including those who wear glasses. Consider buying clippers or spacers that facilitate the use of the equipment among students with glasses.
RESISTANCE TO CHANGE	Teachers play an essential role for implementing AR/VR in education, but they can sometimes be resistant to implement this technologies due to lack of familiarity, limited training and professional development, curriculum alignment and technical challenges. Make sure teachers are involved in the process and properly trained.

(*) Only apply to 3D semi-immersive / mixed reality (XRs) and fully immersive VR

Annexes

FAQ



Are virtual labs and XR labs an adequate mechanism for instruction in all education fields? What methods can be employed to access and monitor the effectiveness of virtual and XR labs?

Virtual and XR labs may not be universally applicable across all educational disciplines. While they can be highly beneficial, VR training has the potential to overwhelm students with excessive information, diverting their attention from the essential aspects of the curriculum. However, virtual and XR labs can be particularly advantageous for subjects that necessitate visualizing learning materials in three dimensions. It is crucial to recognize that technologies alone do not facilitate learning; rather, they provide experiences that, in turn, can foster the learning process.

Are virtual and XR labs affordable and cost-effective?

Costs of virtual and XR labs vary significantly, and there are affordable options in the market.

Governments may promote the development and adoption of open-source software to provide access to virtual and XR labs (3D-Visualization in 2D screen). India and Rwanda are examples of countries that have taken these initiatives.

Regulation is also emerging to promote the use of virtual and XR laboratories. An approach is to award grants to SMEs and education institutions to conduct immersive technology education and workforce training programs or career pathways that use immersive technology. This is the case of the bill proposed in the U.S. Congress ([H.R.9674 - Immersive Technology for the American Workforce Act of 2022](#)) in December 2022. This legislation seeks to facilitate the provision of financial resources to colleges, educational institutions, and other workforce training programs, enabling them to incorporate augmented, virtual, and mixed reality devices into their training initiatives for both current and prospective workforce development.

Virtual and XR labs can be costly to set up and maintain. Failure to invest in keeping the technology up-to-date can result in diminished educational outcomes and limited impact on student learning. Virtual and XR labs often require continuous investments to ensure that the technology remains up to date. Without regular updates, the impact may be minimal or even negligible. Therefore, institutions must be prepared to allocate sufficient resources not only for the initial implementation, but also for ongoing maintenance and updates to maximize the effectiveness of virtual and XR labs.

In addition, in some cases other technologies may be more cost-effective. Alternative digital tools such as videos, interactive games, and online tests could provide engaging and interactive learning experiences to students when VR/AR technology is not feasible due to budget constraints.



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