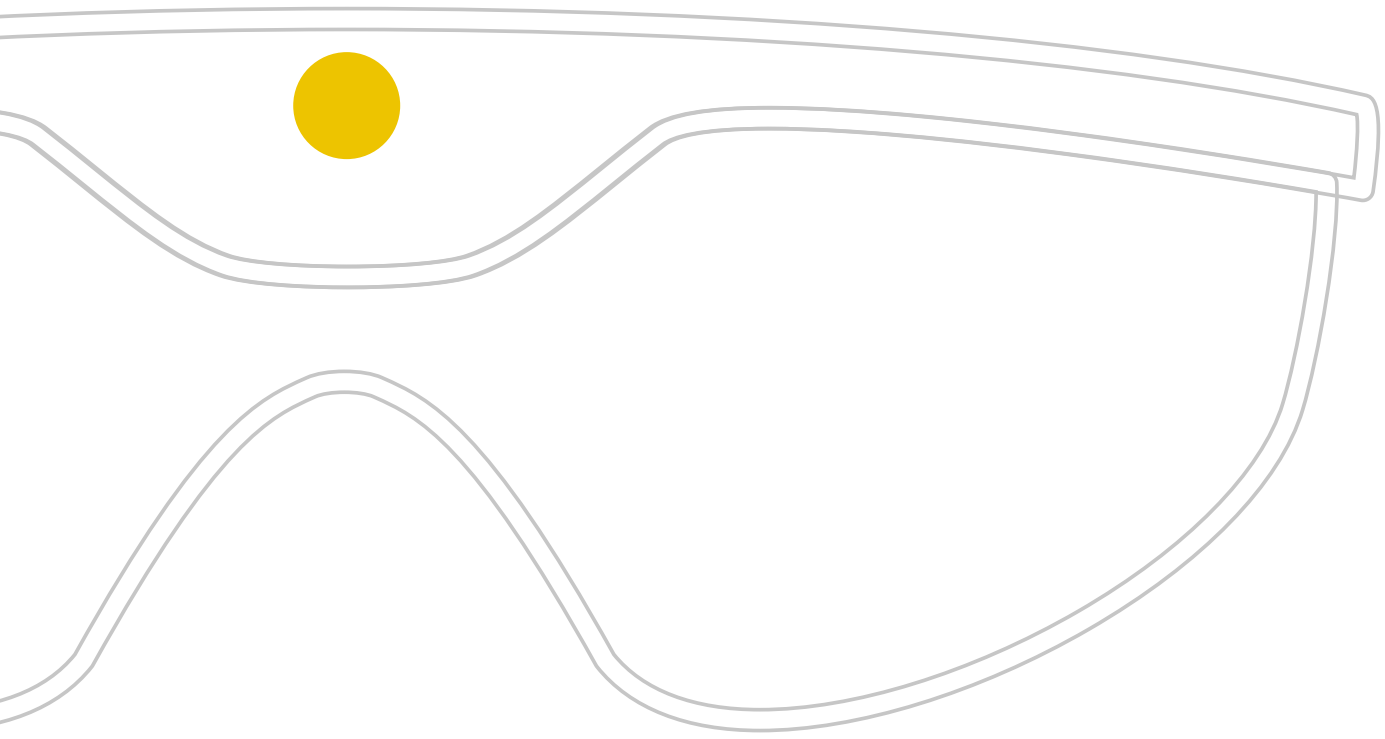
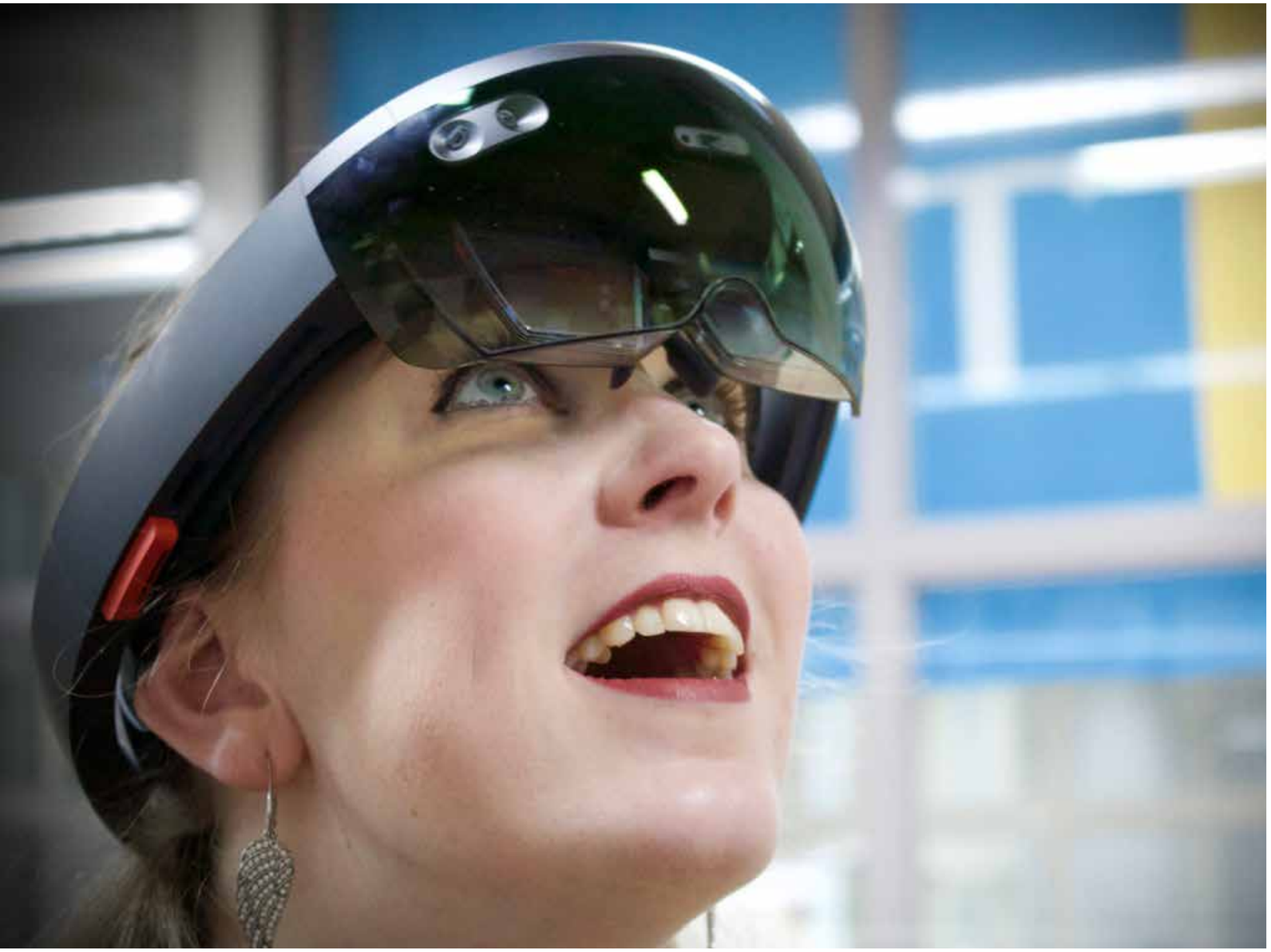
didactical guidelines for teachers and trainers

When and when not to use Augmented Reality in practical and theoretical trainings?



Augmented reality – a new teaching and learning method arrives



Augmented Reality (AR), as a new technology is promising, but less or no prior experiences exist among teachers and trainers. They struggle to evaluate the potential for classroom and practical training environments. This originates from the currently high price of the relevant hardware (AR glasses), the currently little amount of existing teaching material, no applicable experiences concerning measuring the didactical value of AR simulations and the problem not to be able to easily produce tailor-made contents by themselves.

The white paper provides readers with practical hands-on advice on:

- Where AR is useful and where not? (Decision parameters)
- Which AR glasses are to choose? (Checklist of relevant specs)
- Sample AR scenarios for the classroom and practical training

The results base on insights of the needs of teachers and trainers in vocational education and training (VET; see attachment with survey results).

What is augmented reality?

Augmented Reality enhances one's current perception of reality by superimposing digital data and images on the physical world. In contrast, Virtual Reality (VR) replaces the real world with a simulated one. For both types of digital enriched or completely simulated realities, the term Mixed Realities (MR) was coined.

What for?

AR enables users to process the physical and digital simultaneously, eliminating the need to mentally bridge the two. That improves the ability to absorb information more precisely and quickly, make decisions faster and tasks are carried out more rapidly and more efficiently.

AR enriched teaching and learning scenarios can be applied to theoretical and practical training environments, when an exclusively technology centered approach is abandoned and didactical requirements are central (Didactics first, technology second).

The use of Augmented Reality can lead to higher motivated learners, who achieve faster better learning results. The following questions for AR use on theoretical and practical teaching and learning environments have to be answered upfront:

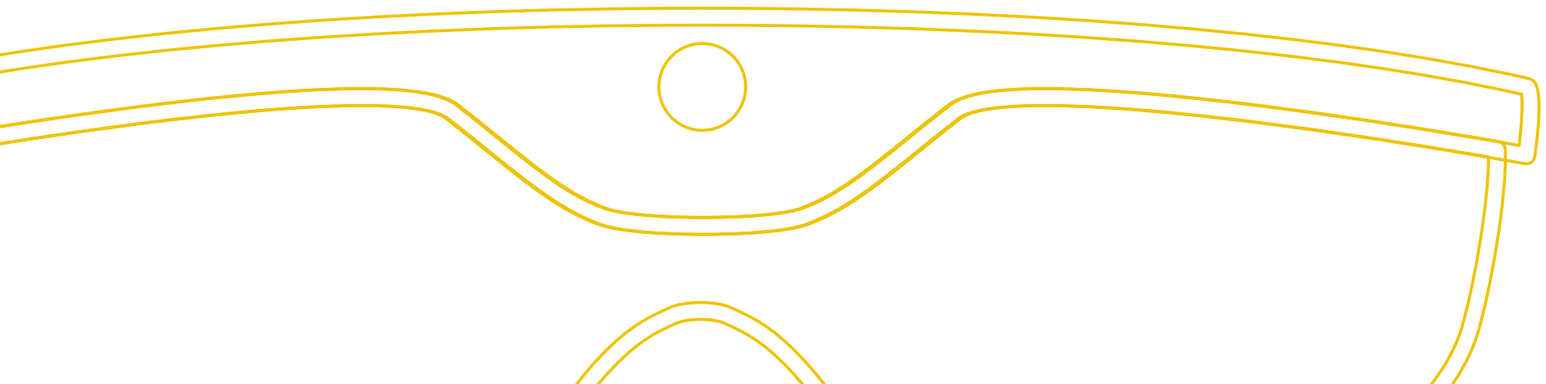
- What should be visualized (didactical needs)?
- Which Augmented Reality glasses are suitable?
- How can I create or obtain the relevant visualization?
- Where can I learn more about Augmented Reality use?

Application fields?

Augmented reality has a variety of applications, such as visualization, instructions, interaction and error simulation purposes. It helps to understand existing data and information more on a visual level, in order to reduce time on e.g. how something functions or not functions. Vocational education and training is, in general, a promising field for AR.

In theoretical based training environments AR can be used to visualize information. In practical based training environments instructions and error simulations are favored. The repairing of a broken car engine is such a practical learning scenario. The learning by instruction, by using AR glasses, are a way to transfer the knowledge on how to repair a broken car engine into the relevant skills. In addition, further learning effects can be reached by simulating errors on a car engine with an AR glasses solely digitally. The fixing of the digital errors support the transfer of knowledge and skills into real car engine repairing scenario.

AR helps to understand the principles of something is working. With a broader availability of hard- and software as well as contents, a shift from e.g. how a combustion engine works in general to how the Porsche Panamera engine works, is expected.



What do I need Augmented Reality for?

Frankly, you don't, except you are an early adopter of technology and you want to enrich your current teaching and learning methods in theoretical and practical training further to motivate your students/apprentices.

To introduce a new technology, in current teaching and learning environments, requires to face problems, such as availability of AR, due to high costs, creating of new and altering of existing AR content, selection of right teaching and learning approach. This problems can be overcome to use AR for self-induced learning and learning stations for your students/apprentices.

To enhance the potential of AR teaching and learning, in theoretical and practical training environments, the following commandments are essential.

Fit of Augmented Reality in existing teaching and learning methods – gaps to explain or experience:

- Functioning of visible parts of machines
- Functioning non-visible parts of machines
- Functioning non-visible chemical, biological or physical processes
- Work with hazardous substances
- Work with expensive equipment
- Error triggered learning on technical equipment etc. (error simulation)
- Individual instruction of many apprentices or students at the same time
- If one factor applies, Augmented Reality is useful

Definition of learning value – visualization of general principles of e.g. functioning of an electric car engine OR of specific processes e.g. functioning of different electric car engines of BMW, Tesla etc.

Supplementation of existing teaching and learning methods:

- Demonstration / Simulation – Presentation of visualizations of e.g. technical or principles in natural sciences
- Impartation of theoretical knowledge – Presentation of visualizations of e.g. technical or principles in natural sciences
- Project oriented learning – Instruction and simulation of tasks
- Assessment of competences – Instruction and (error-)simulations to test skills

AR Glasses to choose – Parameters:

- Price
- Weight
- Supported Software Platforms (Unity)
- compatibility with standard office software
- standalone or wired glasses
- field of sight
- battery duration (see page 7 below)
- tablet / smartphone based AR

Learning scenario planning

- Versatility of learning paths are important to ensure continuing excitement levels, which are impossible in showing only a linear functioning of a machines
- Learning setting: presentation by teacher / trainer and broadcasting over projector to the screen or individual experience in learning stations (caused by rather high price of current AR glasses) are possible

Measurement of impact among learners – better motivation (“recorded” by survey and talks) and/or better test results are expected

Best ways to delight teachers and trainers for AR use in theoretical and practical environments – Preferred forms: workshops and ready-made teaching & learning materials, less in class shadowing opportunities wanted

What AR glasses to choose?

The number of AR glass producers is confusing. To select the right AR glasses or smart glasses, relevant experiences or offers for users in education and training have to exist on the producer's webpage or social media channels. But this is not the case these days.

An alternative to AR glasses are smartphones or tablets optimized for AR use. They serve the best for theoretical learning settings as they occupy at least one hand. In practical learning and training settings two hands have to be free. The use in theoretical and practical learning settings favors AR glasses. See also the AR glass comparison sheet in Annex 1.

Checklist for AR glasses:

- Price
- Weight
- Supported software platforms (unity etc.)
- Battery duration
- Capabilities to track head movement („head tracker")
- Field of sight (e.g.130°)
- Control (voice, buttons etc.)
- Audio
- Camera (Megapixel)
- Connectivity (Wi-Fi, Mini USB etc.)
- Existing visualized objects (in e.g. free or fee-based databases)
- Compatibility with standard office software
- Standalone or wired glasses
- Customer support
- Warranty

Open List of producers (2017)

Microsoft: Hololens
https://www.microsoft.com/en-us/hololens

Google: Google Glass 2
https://x.company/glass/

Meta: Meta 2
http://www.metavision.com/

Epson: Epson Moverio BT-200
https://epson.com/For-Work/Wearables/Smart-Glasses/c/w420

Vuzix: Vuzix M100 Smart Glasses
https://www.vuzix.com/Products/m100-smart-glasses

Sony: Sony SmartEyeglass
https://developer.sonymobile.com/products/smarteyeglass/

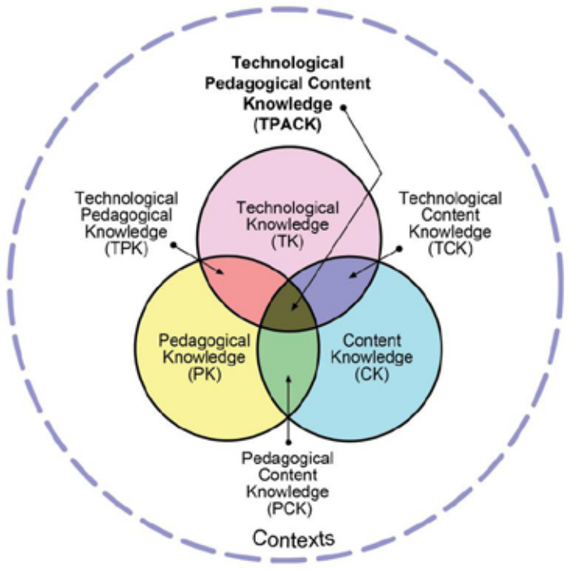
Daqri: Daqri smart glasses
https://daqri.com/products/smart-glasses/

Magic Leap: Magic Leap One glasses
https://www.magicleap.com/

Intel: Vaunt Smart glasses
https://www.theverge.com/2018/2/5/16966530/intel-vaunt-smart-glasses-announced-ar-video

Strategic AR application – Four use cases for vocational education and training (VET)

For the introduction of AR into theoretical and practical training environments the **TPACK** model can be used. The model is designed around the idea that content (what you teach) and pedagogy (how you teach) has to be the basis for any technology, that you plan to use to enhance learning among your students/apprentices.



TPACK Model
Source: http://www.tpack.org/ (21.01.2018)

The area, where the three circles overlap, where the three kinds of knowledge combine, is the desired state to fuse technology, pedagogy and knowledge together.

Technological knowledge, to work with AR in theoretical and practical training environments, requires e.g. the right use of AR-hardware and to take into account the existing infrastructure (Wifi etc.).

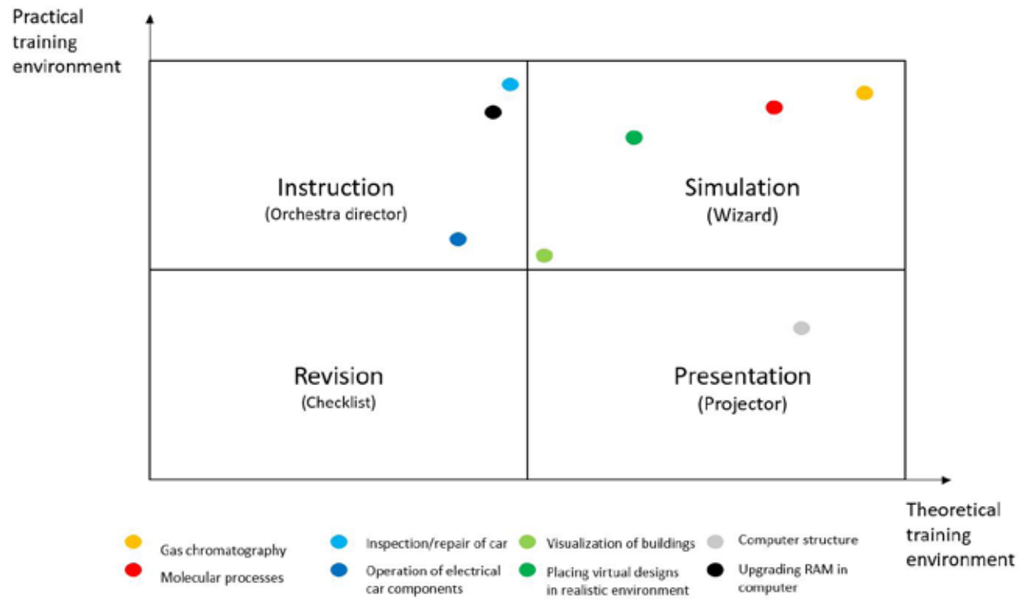
Pedagogical knowledge means knowledge about methods of teaching and learning, such as lesson planning and students / apprentice assessment. **Content knowledge** refers to teachers/trainers knowledge about the subject matter to be learned or taught.

To combining content, technological and pedagogical knowledge (TPACK) the relevant courses, content and didactical methods have to be selected.

The following graph is an overview, with examples from Automotive, Architecture, Chemistry and IT, where the teaching of certain principles or working steps has the most benefits.

For AR use in **automotive**, e.g. for learning on how to inspect a car, instruction-based scenarios in practical training environments are the best teaching and learning method. For **IT**, e.g. upgrading the RAM of a computer, AR instructions are the best choice. In comparison to the field of **architecture**, simulations are preferred.For the training in the **chemical laboratory** error simulation (right measurement with gas chromatography) have the best impact on achieving the learning goals.

In brief, the benefits of using AR are more in instruction and simulation based learning scenarios, when they enrich and not cannibalize existing teaching and learning methods.



Below four brief examples, on how to integrate AR in training:

Planning AR visualization in Chemistry (practical training)

- Learning scenario: Error simulation of equipment of gas chromatography
- Learning contents: Functioning of gas chromatography – measurement principles and simulation of different errors virtually (different learning paths)
- Teaching and learning method: group work / learning stations
- Measurement of impact: small quizzes, lab records, presentations

Planning AR visualization in Automotive (practical training)

- Learning scenario: Instructions on how to repair electrical car engine
- Learning contents: Functioning of electrical car engine – general principles, repairing selected parts (with AR glass instruction or remote expert advice)
- Teaching and learning method: single work / learning stations
- Measurement of impact: small quizzes, functioning of machine

Planning AR visualization in Architecture (theoretical training)

- Learning scenario: Placing a virtual designs in realistic environment
- Learning contents: Creation of design and placing it in realistic environment with relevant software
- Teaching and learning method: single work / learning stations
- Measurement of impact: small quizzes, presentation

Planning AR visualization in IT (theoretical training)

- Learning scenario: Computer structure
- Learning contents: Presentation of computer structure / components
- Teaching and learning method: single work / learning stations
- Measurement of impact: small quizzes

Interested in more information on AR for teaching and training?

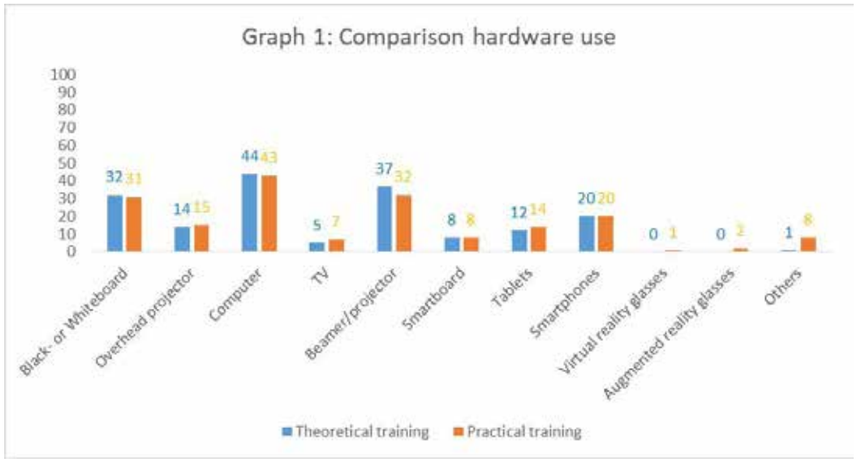
Interested where to get AR-content for teaching and learning processes, for you course / class?

www.AR4VET.com

Survey results: Snapshot on augmented reality needs

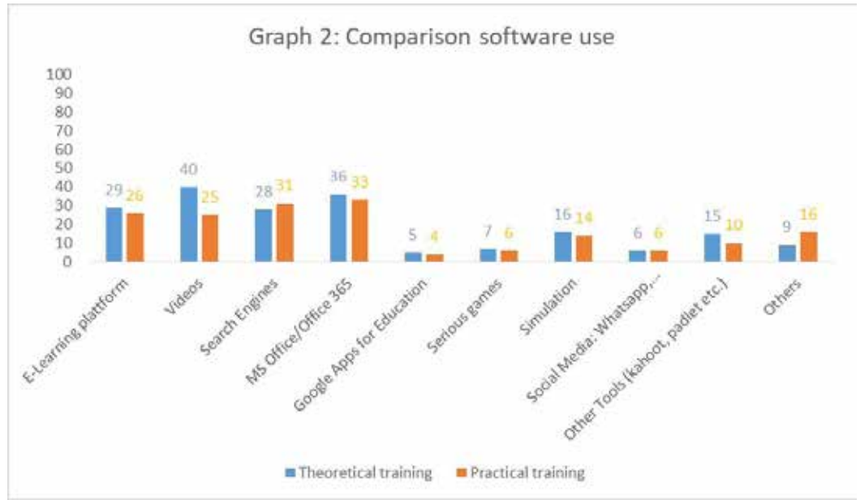
The industry survey was carried out in autumn 2017, in five EU-countries (Cyprus, Finland, Germany, the Netherlands and Slovenia), among roughly 100 (company) trainers and teachers, as well as managers, in the field of vocational education and training. The needs on using Augmented Reality (AR), as a new teaching and learning methods, differ a lot between IT, automotive, architecture and chemistry.

The starting point (STEP 1) was the analysis of the **current use of typical hard- and software** in theoretical and practical training. Surprisingly was, that there is no real difference of hardware and software use between theoretical and practical training (Graph 1 and 2). This might be due to the fact, that proven equipment and programs have a hybrid use in both kinds of training. This hybrid approach of using the existing infrastructure is reflected by the extensive use of computers, black- and chalkboards as well as beamers/projectors and the rise of new equipment such as tablets as smartboards. VR and AR glasses were only used in practical training environments.

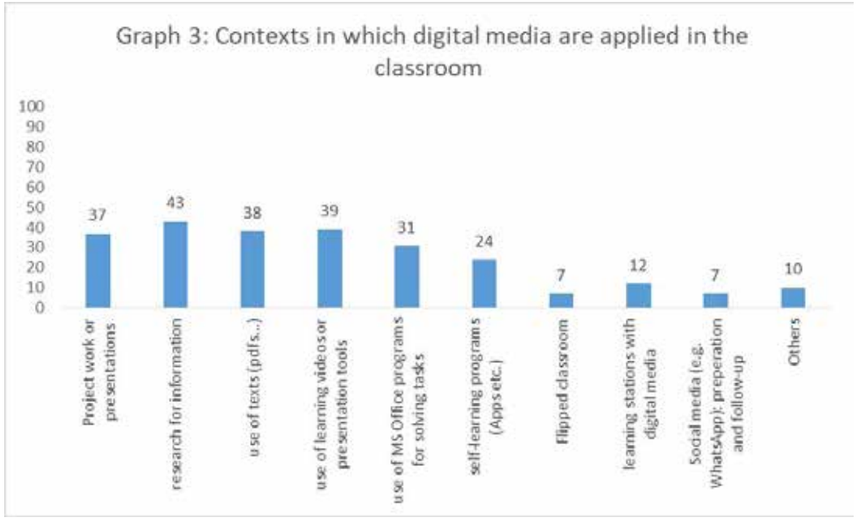


X-axis: option, Y-axis: no. of answers; same structure applies for all following graphs

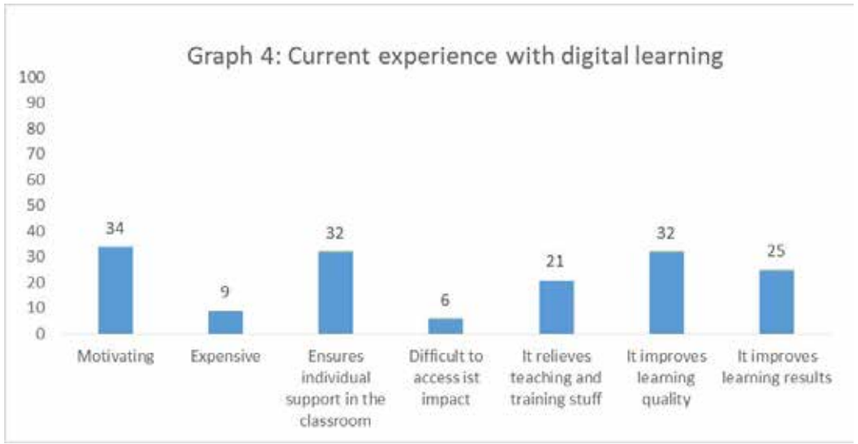
The use of standard software, such as MS Office / Office 365, in conjunction with videos and search engines and e-learning platforms, defines the application of software for research, visualization and so called "storage learning"- purposes, such as e-learning. Additional, freely available software, such as WhatsApp and Kahoot, is used for special single needs.



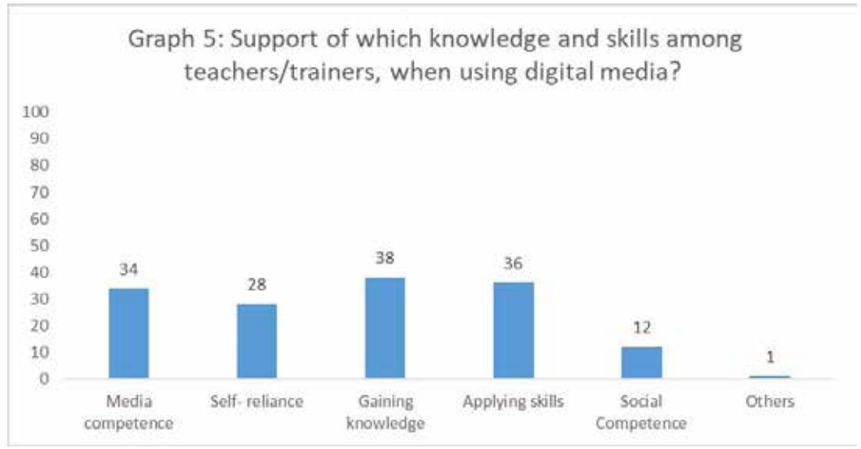
The view on the contexts, where digital media is used in the classroom shows that, research, presentation and task solving purposes dominate. Learning stations are rather less in use (Graph 3). These might be due to the fact, that software is available to all learners on their relevant devices. The learning station approach is feasible for rather new or expensive or special equipment, such as VR and AR glasses.



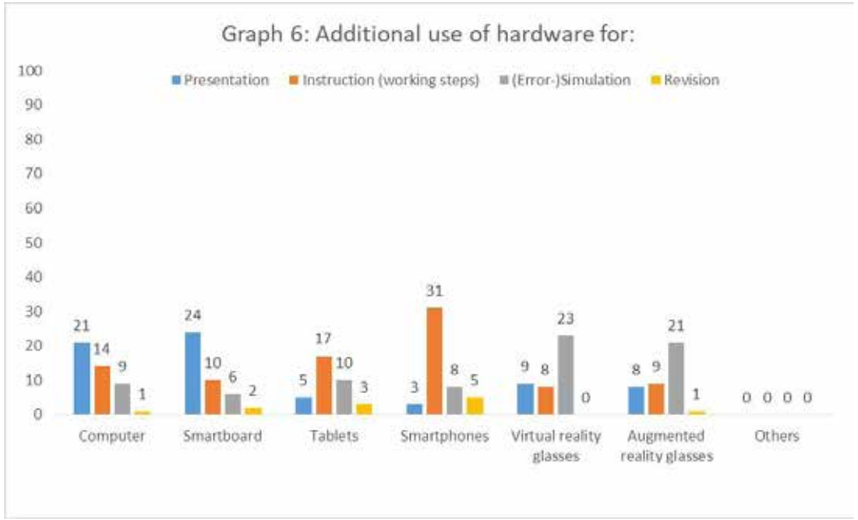
The use of new teaching and learning methods, such as AR, requires prior experiences with digital media. Surprisingly the current use is rated very positive and the impact on the learning quality and results is seen beneficial (Graph 4).

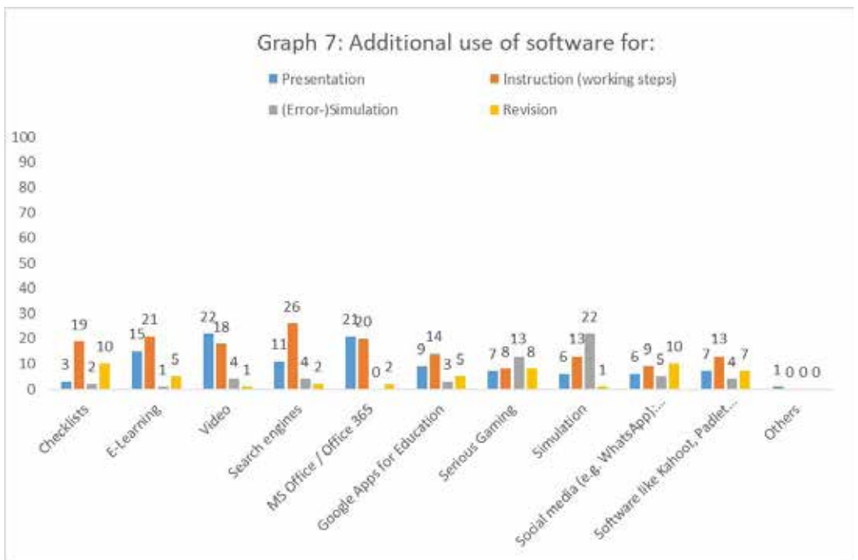


The benefits for teachers and trainers are mainly related to the field of gaining knowledge, applying skills and obtaining media competence (Graph 5). The knowledge and application effect is very important when introducing a new teaching and learning method, as the impact can be measured cognitively and practically.



In STEP 2 we analyzed **the potential value added of new hardware**, which use is **didactical induced**, in the fields of presentation, instruction of learners, (error-)simulation and revision needs. The value added of AR is seen more in the field of (error-)simulation, less for presentation and instruction, where hardware like Computer, smartphones, smartboards and tablets dominate (Graph 6).



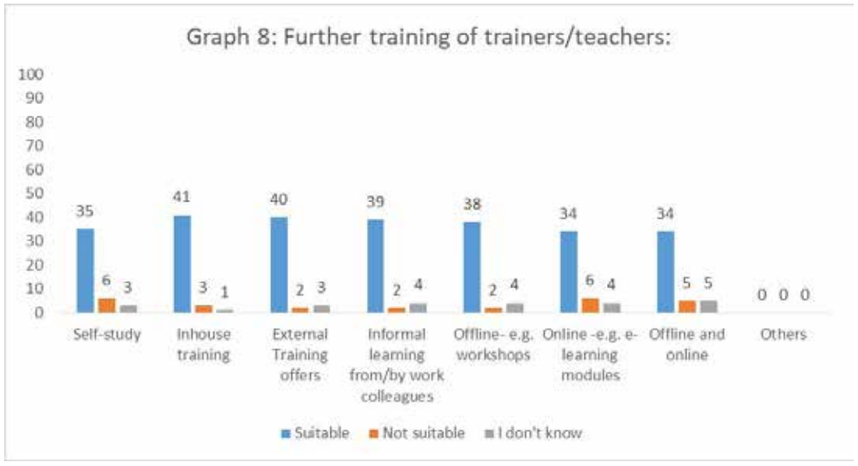


When dealing with (error-) simulation needs, in the field of additional software use (Graph 7), serious gaming dominates and not standard software, such as MS Office/Office 365. This shows that there is a gap, which is currently not served and AR related software can provide a good value added.

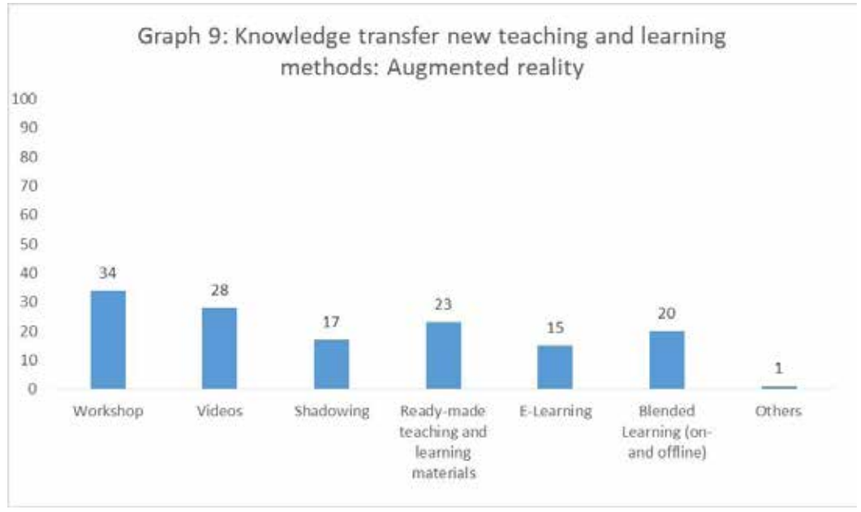
The relevant visualization needs are quite broad. This is due to the fact, that most teachers and trainers have not worn any AR glasses before. So out of their imagination, they figured out-fields, where a good value added to current teaching and learning methods, could be expected.

Field	Visualization for	Preferred Teaching- and Learning form
Architecture	placing virtual design in realistic environment, assembly and repair with remote instructions from specialist, show building how it looks like	Simulation Instruction
Automotive	inspection and repair of car engines, structure and locating components in different locations	Instruction
Chemistry	functioning of molecular process and of technical equipment (e.g. gas chromatography)	Simulation
IT	computer structure, programming, database, basics to algorithm	Presentation Instruction Simulation

In STEP 3, we analyzed the qualification needs and forms for teachers and trainers, to cope with Augmented Reality as a new teaching and learning method. Mainly all forms of training (on- and offline) are wanted (Graph 8).



Workshops, videos and ready-made teaching and learning materials as well Blended learning offers (Graph 9) are the desired forms to get in touch with AR. This rather hands-on and hybrid approach, shows that AR has to be experienced at foremost haptically and visually.



Arthur C. Clarke said once, that "any sufficiently advanced technology is indistinguishable from magic." The use of augmented reality in classroom and practical training environments is still magical for teachers and trainers, due the fact that AR is a new technology. However every magic can be dealt with. AR4VET wants to train teachers and trainers to be able to perform some magic.

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