BEST PRACTICE GUIDE

FIGHTARs

http://fight-ar.com/

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The FIGHTARS partners are:

- SPSCH - Upper Secondary School of Chemistry Pardubice (CZ),
- Estonian Academy of Security Sciences (EE),
- Fire Fighters Training School (LT),
- University of Zilina (SK),
- SCP Academy – School of Certified Professionals (CY),
- SBG Dresden – Saxon Training Company for chemical and environmental professions (DE).

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1. INTRODUCTION

At the beginning of the Best Practice Guide (BPG) it is important to explain what the author means by the term modern tools. These are mainly immersion technologies, which are:

- Virtual Reality (hereafter VR)
- Augmented Reality (hereafter AR)
- Mixed Reality (hereafter MR)

Since the definition of mixed reality is not clear-cut and rather includes everything that between the purely real world and the virtual environment, the author is inclined to the view. According to the main advantages of using VR and AR to enable processes and trainings innovations are mainly:

- It creates a standardised environment.
- Creates the illusion of a (yet) non-existent environment.
- Creates the illusion of a hard-to-access environment.
- Replicability of experiments.
- Recordability.
- Possibility of parallel data processing.
- Attractiveness of the technology.
- Cost-effectiveness.

Within this document we will not be dealing with VR and it will be focused on AR/MR.

The BPG is focused on the FightARs project and the use of modern AR/MR technologies in the education of firefighters and crisis managers. The content of this publication is both an introduction to the project and a more detailed description of it, including individual scenarios as part of the FightARs application. The description also focuses on the established "Centres of Excellence" which represent the hardware basis for modern education and the exploitation of its potential. Positive and negative aspects of using HoloLens 2 used as the main training, educational hardware is identified.

Augmented Reality is the enrichment of the visible reality with computer generated, interactive holograms for purposes like guidance and explanation of non-visible processes. To see holograms, specialised technology, like smart glasses (AR glasses), smartphones or tablets are necessary. The use of smart glasses allows that both hands are free during live training, when interacting with the glasses.

360° video enables users to “dive into” a digital generated environment. It is used for the documentation of real environments and for the orientation of users in space. It represents a “simpler” form of Virtual Reality (therefore VR). Interactivity is created by the integration of buttons for accessing further information, such as videos, 3D objects, weblinks etc.

2. PROJECT ERASMUS+ FIGHTARS

It is an international project under the Erasmus+, which has been started in September 2020 and ended in April 2023. 6 partners from 6 European Union Member States participated in the project, represented by:

- SBG Dresden mbH (Germany);
- SCP Academy (Cyprus);
- Faculty of Security Engineering, University of Žilina (Slovakia);
- Secondary School of Chemistry Pardubice (Czech Republic - coordinator);
- Firefighters Training School - (Lithuania);
- Sisekaitseakadeemia - (Estonia).

The task of this project was to identify the possibilities of using AR/MR technology in the training of firefighters and crisis managers using specific scenarios and to increase capacity of 4 piloting organisations – Estonia, Lithuania, Czech Republic and Slovakia - to implement such technologies in training.

The content of the project was also a space to answer questions:

- What are the possibilities of implementing AR/MR glasses (HoloLens 2) in the training of firefighters, commanders and the students of crisis managers?
- What training scenarios should be created?
- What digital skills are needed to use AR/MR-based training materials in teaching and training? [1]

The very aim of the FightARs project was to create an application for the training and education of firefighters, intervention commanders and crisis managers using innovative technologies of tomorrow or to obtain the necessary information for the potential future creation of teaching materials with the implementation of AR/MR in educational practice. AR/MR education is future-focused, in which educators and technology work together to provide trainees with the knowledge and skills needed to perform professional roles. In the FightARs project, the following themes has been targeted, from which scenarios subsequently emerged:

- Rescue work (technical aspects of accidents involving electric vehicles);
- Handling of hazardous substances in an ADR tanker accident;
- First aid given in traffic accidents. [1]

3. SELECTION OF THE TRAINING CONTENT

As a basis for assessing current and future training requirements, an online questionnaire survey (Figure 1) was conducted in April 2021 among fire stations and educational institutions for training firefighters and crisis managers in the countries participating in the FightARs project (Czech Republic, Slovakia, Estonia, Lithuania).

Almost half of the 63 respondents already had experience with virtual reality (VR), but only about 10% had experience with goggles/glasses or applications in AR/MR.

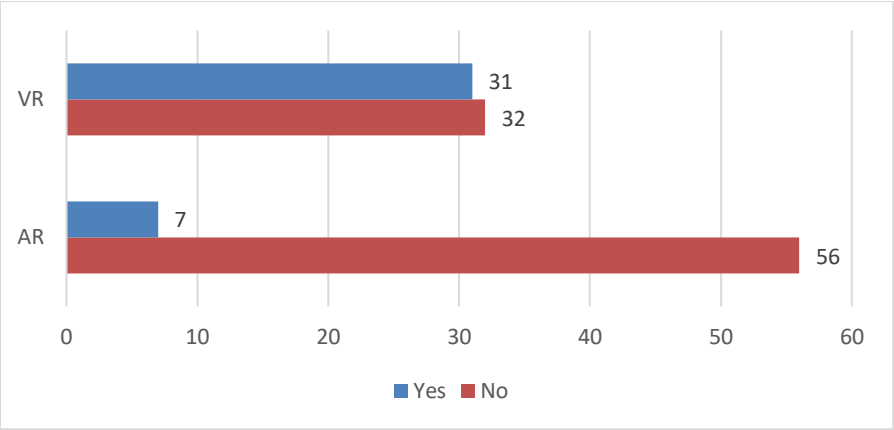


Figure 1 Experience with augmented/mixed (AR/MR) and virtual reality (VR) in education [1]

The dominant theme is the provision of technical and methodological - (procedural) skills through interaction with a digital object (hologram) or a digitally enriched real object in order to sufficiently exploit the potential of AR/MR. AR/MR is considered suitable for the fields of extinguishing burning cars, in terms of actuality electric or hybrid, or cutting persons out of a crashed car and subsequent rescue of injured persons. From the survey (Figure 2) and the processed graph, it is evident that 80% of the respondents are interested in AR and VR applied in different training formats.

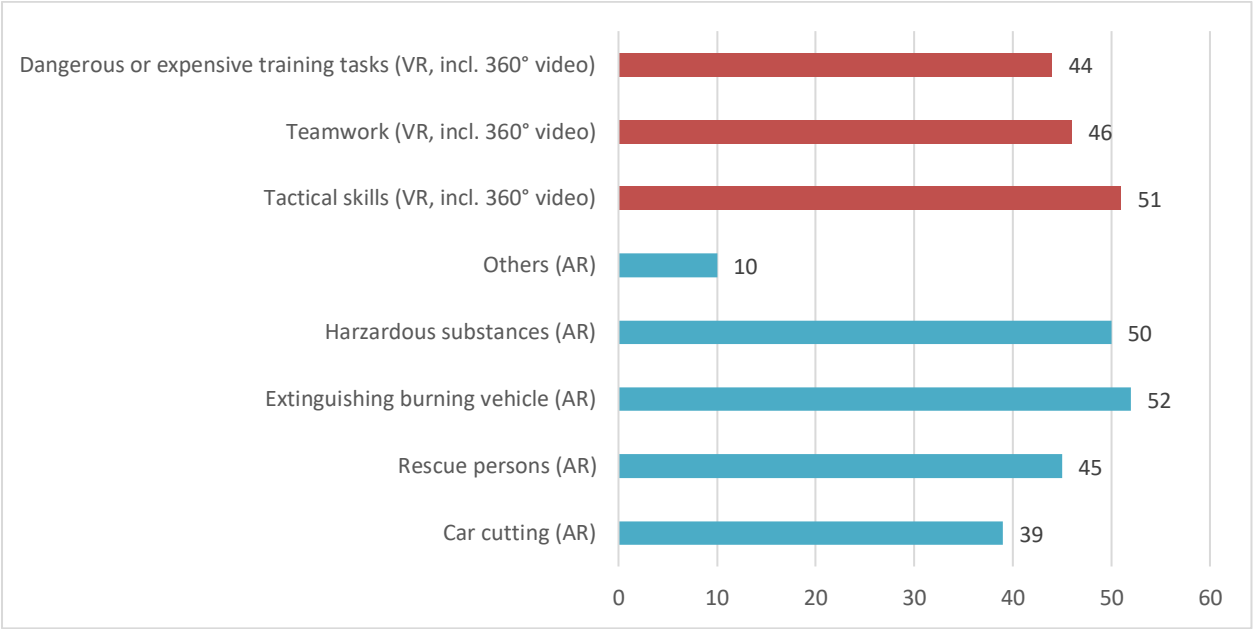


Figure 2 Graph of preferred training and education scenarios with augmented/mixed (AR/MR) and virtual reality (VR) [1]

The interest of professional firefighters and teachers in educational institutions showed (Figure 3) that 80% are interested in AR and VR applied in different training formats. The use of 360° video is considered appropriate by 75% of respondents. The combination of on- and off-line received the highest approval with almost 80%, followed by hands-on workshops with about 60%. Purely online meetings were only considered useful by around 50% of respondents.

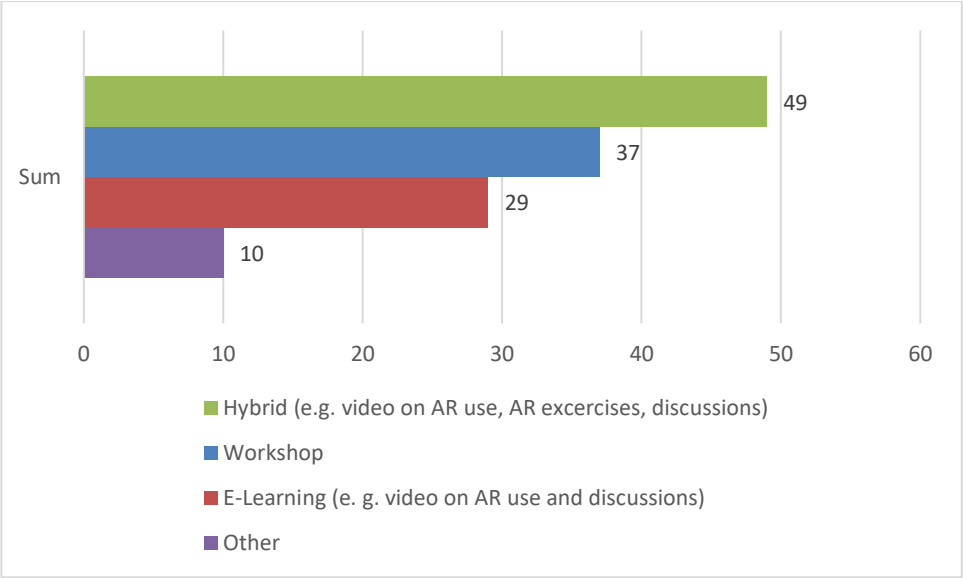


Figure 3 Preferred method of providing training [1]

Considering all the aspects of the preapplication research and analysis conducted during the project, the following scenarios have been created:

I. **Deactivation of the electric car:**

https://www.youtube.com/watch?v=VCK0cQPlZRQ
https://www.youtube.com/watch?v=XwPTkhXUo8M

II. **Stabilisation and cutting of the electric car while rescuing people:**

https://www.youtube.com/watch?v=Z2PSLtHbUps

III. **Providing first aid for selected injuries in a car accident:**

https://www.youtube.com/watch?v=UvAEuNCBPAI

IV. **ADR hazardous substance spill from a tanker truck:**

https://www.youtube.com/watch?v=x-L8rWmBdGY

V. **Complex scene of electric car and ADR tank truck crash with injured person:**

https://www.youtube.com/watch?v=x-L8rWmBdGY
https://www.youtube.com/watch?v=bPiZChA5XCE

In the following sections we will review a bit in details these scenarios or as we would like to present it – chapters of FightARs application.

3.1. DEACTIVATION OF THE ELECTRIC CAR

The scenario is intended to provide the trainee with an introduction to the important components of an electric car in terms of their location in the body of the electric car. And also, information on the procedures for the correct safe shutdown - deactivation of the electric car, which is part of a road traffic accident. The theoretical part consists of a 3D hologram of an electric car with the possibility of displaying individual layers focusing on a specific component (high voltage battery, electric circuit wires, charging port and electric motor). In the practical part, it is possible to perform a training deactivation procedure on the 3D hologram by clicking on the correct sequence of deactivation. [3] [2]

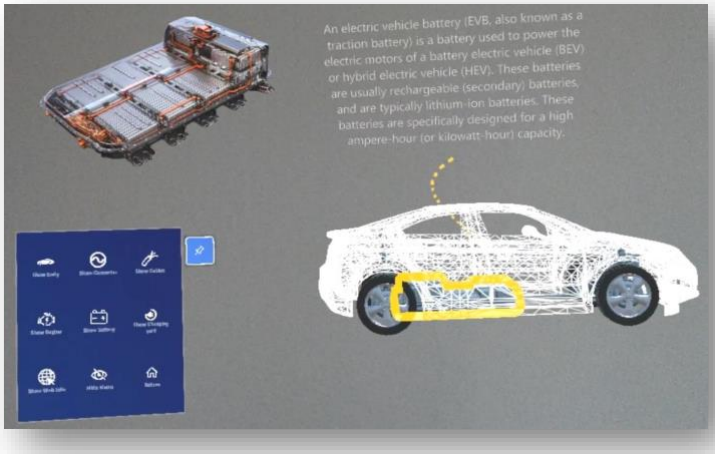


Figure 4 Designation of the layer with an integrated floor battery with a description and the most common location in an electric car [2]

3.2. STABILIZATION AND CUTTING OF THE ELECTRIC CAR WHILE RESCUING PEOPLE

The task of this scenario is to familiarize the trainees with specific stabilization elements to secure the crashed vehicle against unwanted movement during the intervention of the IZS units. And also, the places on the bodywork of passenger vehicles where the hydraulic spreader is used to stretch and the hydraulic cutters are used to cut the bodywork. These locations are graphically represented in the theoretical part on digital twin with specific information descriptions from the Learning Management System (LMS). The theoretical part still contains information about the meaning and functions of the different devices and tools used. The practical part consists of three variations of the position of the electric car as shown in the figures below. The task of the trainee is to carry out the correct methodical procedure using the 3D interactive holograms of the equipment and tools available within the scenario area. [4] [2]

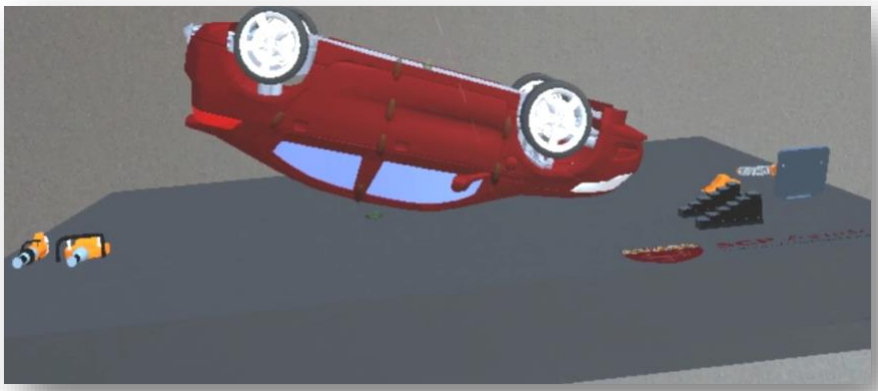


Figure 5 Scenario of stabilization and cutting variant no. 1 [2]

Figure 6 Scenario of stabilization and cutting variant no. 2 [2]

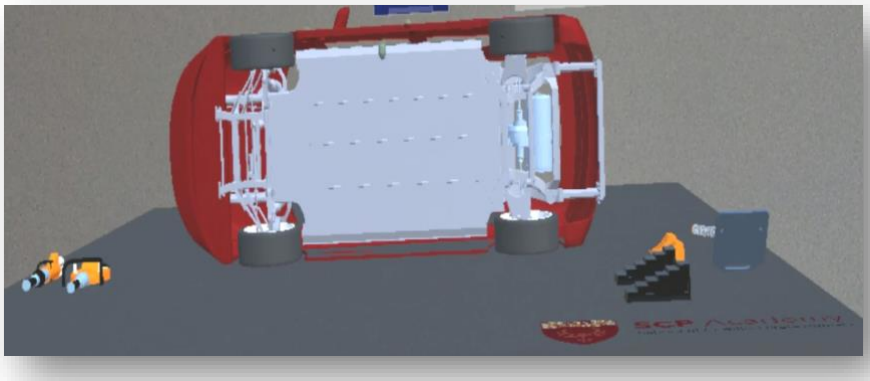


Figure 7 Scenario of stabilization and cutting variant no. 3 [2]

3.3. PROVIDING FIRST AID FOR SELECTED INJURIES IN A CAR ACCIDENT

In the scenario, trainees are familiarised with the specific types of injuries that occur most frequently in road traffic crashes. In the theoretical part, the trainee acquires knowledge about the specific types of injuries and how to properly treat them and what is possibly needed in terms of resources, materials. All examples of injuries are displayed on 3D holograms of people, which are displayed in front of the student after scanning a specific QR code. In the practical part, the student performs

these procedures for each injury and applies them to the 3D holograms of the injured persons. This scenario is designed to be combined with a physical training dummy or torso, where after scanning the QR code placed on this dummy, the HoloLens 2 device renders a digital layer of the injured person in the form of a 3D hologram. [5] [2]

Within FightARs application there have been created several scenes:

- female, sitting, no injuries visible
- female, sitting, leg amputation
- female, laying down, no visible injuries
- female, sitting, head injury right of head

Video presenting:
how to use HoloLens 2
how to use QR codes with FightARs application

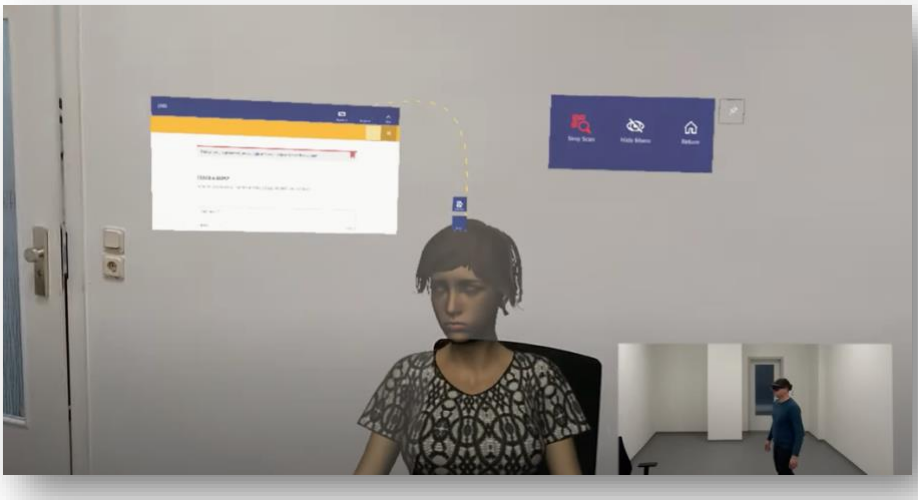


Figure 8 First Aid scene set up while using QR codes and visualised digital twins - victims

Specific **QR codes** can be found on the project website in the section “Downloads”: http://fight-ar.com/

Tip: *Print all the needed QR codes in advance and mark on the paper what exactly are those for better logistics.*

3.4. ADR HAZARDOUS SUBSTANCE SPILL FROM A TANKER TRUCK

The purpose of this scenario is to familiarize the trainees with the ADR tank truck carrying hazardous substances and the safety signs for the specific types of hazardous substances transported. The scenario contains within its variants 5 types of hazardous substances: Gasoline, Ammonia NH3, Chlorine Cl2, Sulphuric acid H2SO4, Liquefied Petroleum Gas LPG.

Figure 9 Hologram 3D tank ADR [2]

For each substance, the theoretical part of the scenario contains the necessary information from the safety data sheets in connection with the activities carried out at the scene of the emergency to deal with the consequences or to treat the affected persons, as well as the methodical procedure for firefighters to deal with the presence of a hazardous substance in the event of accidents in road transport. Other information of no less importance is on the possibility of stopping the leak, decontamination and recovery for each type of hazardous substance concerned. The theoretical part is concluded with a short case study of simulating a leakage of the hazardous substance Chlorine by means of the software tool ALOHA on the D1 motorway section between the towns of Žilina and Bytča. In the practical part, the trainee has to complete a test in which his/her task is to answer correctly the questions related to the theory. [6] [2]

3.5. A COMPLEX SCENE OF ELECTRIC CAR AND ADR TANK TRUCK CRASH WITH INJURED PERSON

In this final scenario, the trainee is in the scene of a traffic accident and should apply all the knowledge and skills learned. However, the final scenario itself is only in a state where it can only be used as training for "situation awareness; understudying" analysis and creating situational awareness and understanding. The experience is also supported by acoustic perceptions, where the individual phenomena present in the accident such as the leakage of a dangerous substance (hissing, spilling), the sound of the truck engine, the surroundings but also the moaning of the injured person are "immersive" to the greatest extent possible.

Figure 10 Scenario of a traffic accident of an electric car with an ADR tank truck [2]

One of the 5 loads and one of the three accident/collision types can be selected when simulating the situation (Table 1). Thus, in case of exercises we are having a total of 15 different exam options.

Table 1 Case and Load descriptions in Accident scene for FightARs application

Scenario no	Case no in app	Dynamics in the FightARs application	Load no	Load CMR	Substance (SDS)
1	1	Smoke from car	5	Load 5 CMR	LPG
2	1	Smoke from car	1	Load 1 CMR	Gasoline
3	2	Nothing dynamic	2	Load 2 CMR	Ammonia
4	3	Yellow puddle	4	Load 4 CMR	H_2SO_4
5	3	Yellow puddle	3	Load 3 CMR	Chlorine

Figure 11 360° video while testing FightARs application (Accident scene) and MS Remote Assist programme

3.6. OVERALL FIGHTARS APPLICATION TRAINING CONTENT - LMS

Overall partners have developed FightARs application that has several sections that covers above mentioned chapters – scenarios.

FightARs application overview

Figure 12 YouTube video: FightARs application introduction [https://youtu.be/CWBk5PYkKDA]

You can join developed course textual content on project website Learning Management System – LMS (piloting partners languages are going to be redirected to specific partners MOODLE systems): http://fight-ar.com/courses/

Main content is in English. Other piloting partners languages (Estonian, Lithuanian, Czech and Slovak) are available as well.

What are the steps to join the FightARs Course?

1. Go to the website: http://fight-ar.com/courses/
2. Register or Log in to your account
3. Choose FightARs course and start

There is no limitation on registration. It is open for anyone for free.

It can be used also even without HoloLens 2 as a training content though it is going to be not so immersive and some parts, especially Accident scene and First aid, are mainly dependant on the developed HoloLens 2 digital twins: accident scene, visualised injured persons, where trainee has to immerse into situation.

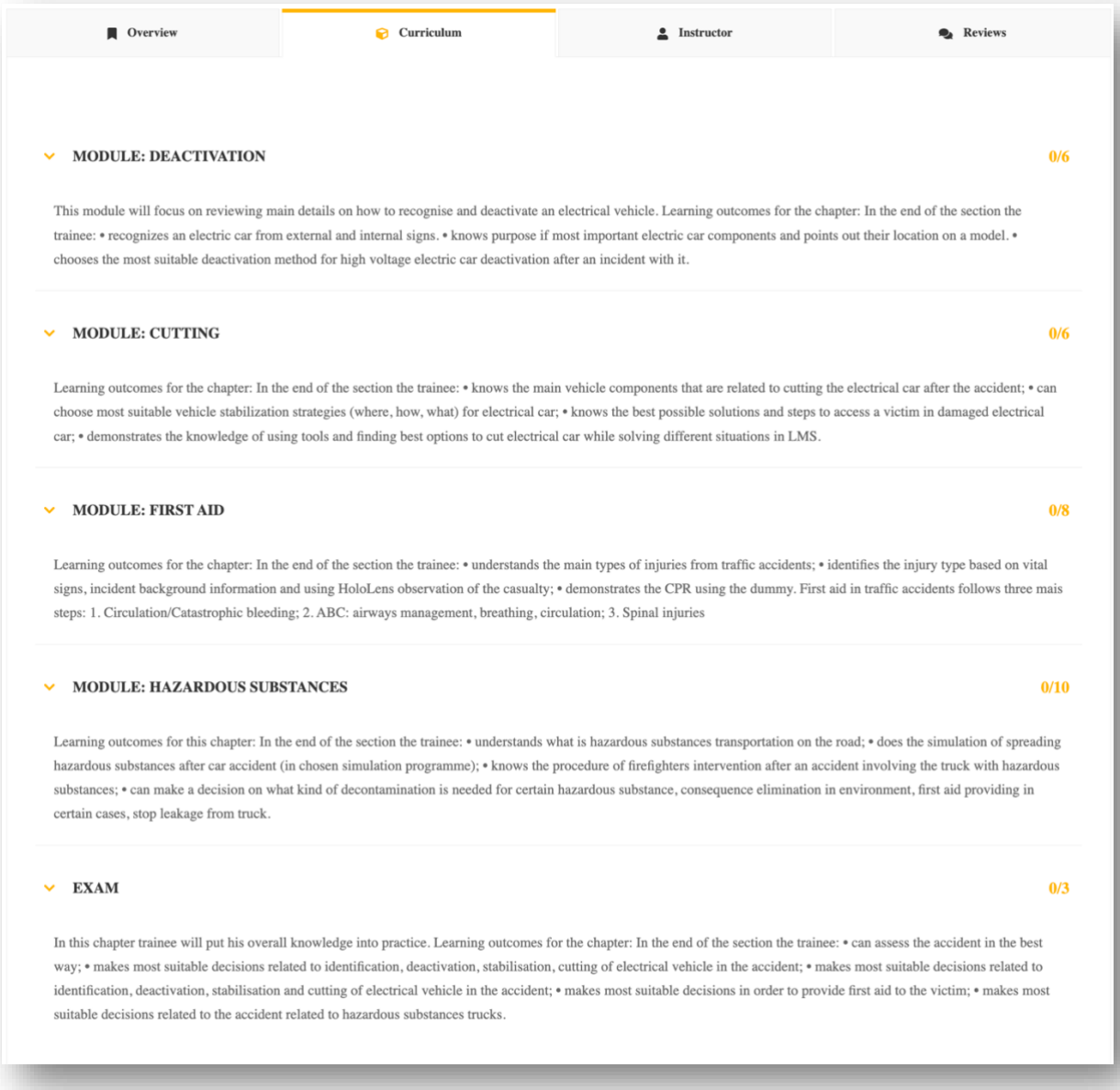


Figure 13 FightARs Course overview on the project website [http://fight-ar.com/course/fightars/]

Each chapter – MODULE – has been divided in smaller Lectures (Fig. 13). Some parts have self-reflective tests, but overall it was developed with intention that trainee can be supported or monitored by trainer time to time. But it all depends on the trainers wishes how to create the procedure and what would be the main goals of the training: whether to have the basic understanding of the steps or to analyse more advance knowledge on situational awareness and understanding. Therefore, this material is flexible in that sense. However, programmed actions or visualisations (digital twins) are fixed and it can be adjusted only by developers – programmers[1].

While in practice if trainee wants to go through all the course, it has to be divided in time periods or general in parts. Following there is demonstrated couple of options how trainer can plan his training process. We do not exclude some other options, but we tested these options.

[1] Partners have some ideas to update the programme / FightARs application in the future (depending on the availability of the programmers, financial resources and trainers)

OPTION #1

All content goes through while using only HoloLens 2

Main remarks:

- It means that trainee will be watching content, reading all the needed theoretical part on HoloLens 2.
- This way training has to be divided in time sections as recommended to use HoloLens 2 glasses for a maximum of 50 minutes duration. Trainee can get tired and glasses battery can ran out.
- If there are more HoloLens2 glasses, trainer can monitor several trainees.

OPTION #2

Part of theory is going through using computer/smart device and when needed using HoloLens2

Main remarks:

- HoloLens 2 battery can be used longer (using breaks).
- Trainee will need time to time switch on again FightARs application (as it shut downs after not using it).
- Need more constant guidance for each trainee from the trainer.
- It would be more fruitful training content.

There is a function to monitor your progress to finish this course.

Some parts of the content from LMS appears in HoloLens 2 FightARs application. In this way trainer has more flexibility to adjust content on the LMS without the need to make adjustment in programming of application. It saves time, energy and financial recourses.

Each language version can have its own needed adjustments in theory as well considering small differences in teaching methodologies, etc.

Partners would recommend these procedures:

Training procedure:

- Trainee has to register/log in to the FightARs course.

- Trainer has to plan ahead what scenes will be used in different chapters: Hazardous substances, Accident scene.
- Trainer has to choose which option to follow (#1 or #2) and prepare for it.
- Trainer can prepare specific additional questions in order to evaluate trainee's situational awareness / understanding in the Accident scene.

Equipment:

- HoloLens 2 (AR/MR) glasses (preferably charged, as the charging cable does not allow for free movement at the whole scene).
- If option #2 is chosen: computers, tablets or smartphones (depending on the number of trainees) with internet and power network connection if you want that theoretical part would be presented on these devices.
- Suitable space/indoor room for training.
- If QR codes are used, do not forget to print them on paper and place it in wanted location in space to construct accident scene.
- Useful to have a measuring device to measure the light in the room or outdoors to see how bright it is.

Some feedback from testing FightARs application:

- As of the content of the information, anything regarding the recognition of hybrid and electric cars as well as their deactivation was really useful. There is also some unnecessary information about working tools in LMS, which is redundant to people who already work in the rescue field and there is no need to double it.
- The main issue regarding the FightARs app is that the holograms are static and the user (either the teacher or the student) cannot change them however they need or in regards to what is happening in the study work. The simulations are fine only for the initial assessment of a situation.

Follow these tips to get inspiration how to prepare and improve process of training with immersive technologies.

Tips

- Give to your staff first to read the **FightARs Pedagogical Guide** that will give overall understanding of this immersive technology and how it can be used in pedagogy. You can download it in various languages from the project website: http://fight-ar.com/fightar-app/;
- Make sure that you have a good **insurance** for your hardware as it is a not cheap equipment and many users will use it;
- Instructions on how to **install FightARs application** can be found on the project website: http://fight-ar.com/fightar-app/
- Trainer can **download QR codes** of developed holograms / digital twins for FightARs application on the project website: http://fight-ar.com/fightar-app/
- Textual content of **FightARs application course** can be found on the project website: http://fight-ar.com/courses/ - it is easy and free to register.
- Get **educational/faculty** status for your Microsoft account for a better price;

- It helps to have **staff that knows well Microsoft package** solutions and who can provide support;
- Every user needs to have some level of **patience** while using the HoloLens 2 as time to time it does not work perfectly with sensitivity, reaction, voice commands, but there is a great potential for future to get more advanced solutions for overall AR/MR market;
- In order to take the most out of developed 360° degree videos you can upload videos on **YouTube account** and then use it with **VR glasses;**
- You can use **Mirroring function** while using HoloLens2. In that case you would not need to use other programmes to see what user is seeing. In such case, you can see it through a laptop (+ if needed broadcasted through projector) or LCD screens (with condition to have such option). This way trainer can show functionalities while using HoloLens 2 for a wider audience in the room.
- Trainer can ask to **record** the process of training from HoloLens 2 (with voice command) and afterwards use this material for individual reflection or overall training material. Do not forget to download recording and mark it.
- **Give a break** between the chapters so that trainee should be able to learn between two scenarios. A time gap of about two weeks is recommended so that he/she can learn and forget a little.

4. A REPORT ON THE DIGITAL POTENTIAL OF ORGANISATIONS IN FIGHTARS PROJECT

4.1. INTRODUCTION

The project FightARs aims to priorities specific skills /competences for an immersive rescue environment in fire fighters training, by providing guidance concerning pedagogical suitable options as well as by developing, testing, evaluating and transferring several digital enriched training scenarios. The most added value through augmented and mixed reality is the same as for face-to-face didactic methodology: provide for firefighters an excitement to learn, engage and seek knowledge. Educational magic books, simulations, and story books to be developed with AR technology could be enriched with 3D models, videos, animations, and audios

The questionnaire, which results are presented in this report, is related to the TASK 1 - Analysis of the organisational capacity for establishing excellence centres for immerse firefighters training. This ensures to determine the current and derived future digital organisational capabilities. The purpose and focus of the questionnaire are to discover the digital potential of schools within the FightARs project - teasers for firefighters training in immersive rescue environments project. The questionnaire was based on the principles of the **SELFIE tool**, which help schools assess where they stand with learning in the digital age. You can find more information and guidance on the SELFIE website: https://ec.europa.eu/education/schools-go-digital

Questions were divided into sections and answered on a five-point scale:

1. Strongly disagree (we do not do this; in our experience, this is not true at all)
2. Disagree
3. Slightly agree
4. Agree
5. Strongly agree (we do this really well; in our experience, this is very true)

In this analysis 4 piloting organisations – from Estonia, Lithuania, Czech Republic and Slovakia – took part as they would be implementing training solutions using immersive technologies. Focus was to include professional firefighters, trainers and teachers in this analysis.

20 respondents (teachers) filled the questionnaire in. There were 7 teachers from University of Žilina (UNIZA), 2 teachers from Estonian Academy of Security Sciences (EASS), 5 teachers from Fire Fighters training school (FTS), 5 teachers from Střední průmyslova škola chemická (SPŠCH).

The survey was conducted from end of February 2022 till end of the March 2022.

The questionnaire can be found at: https://forms.gle/tBPFKaUasutfypYPA

4.2. OVERVIEW OF CURRENT DIGITAL POTENTIAL OF PILOTING ORGANISATIONS

Analysis of answers is divided into several parts related to the different parts of digital potential of the school:

- Leadership,
- Collaboration and networking,
- Infrastructure and Equipment,
- Continuing Professional Development (CPD),
- Pedagogy: Supports and Resources,

- Pedagogy: Implementation in the classroom, Assessment practices, Student digital competence.

Finally, conclusions are formulated resulting from the evaluation of the questionnaire.

Leadership

The leadership towards the use of digital technologies is a weak point of all surveyed schools. There is an evident support for teachers in teaching with digital technologies, but there is a lack of a conceptual and strategic framework in the given area, resp. it is only partially created (Fig. 14). The results are very similar for all schools. UNIZA expressed the highest support of teachers in the use of new digital technologies, EASS school sees the biggest shortcomings in this area (Fig. 14).

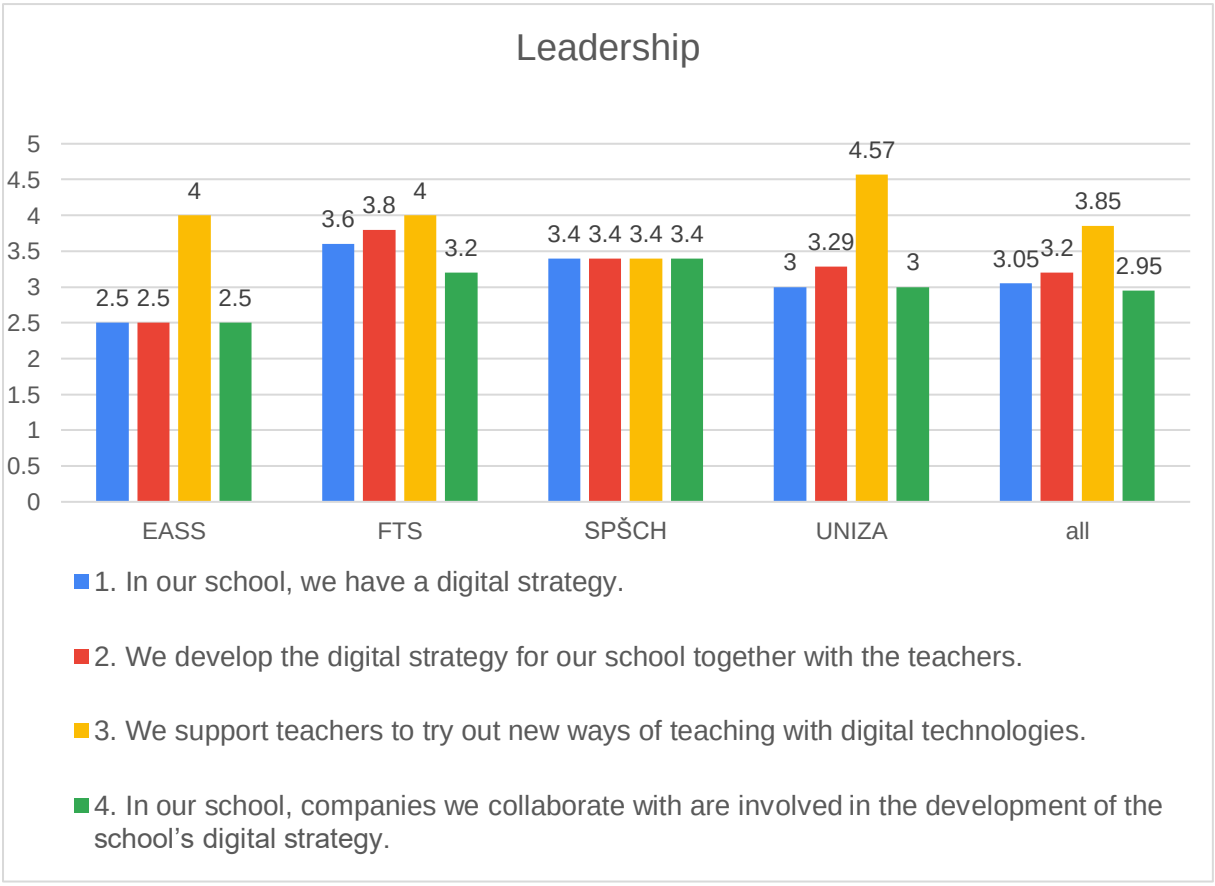


Figure 14 Digital potential of schools related to the part: Leadership

Collaboration and networking

Greater differences between schools can be seen in the area of Collaboration and networking. FTS evaluates its current conditions above average (best results) and EASS below average (Fig. 15). SPŠCH and UNIZA have results slightly above average. In several schools (except for EASS), the untapped potential in the given area is noticeable and there is space for improvement.

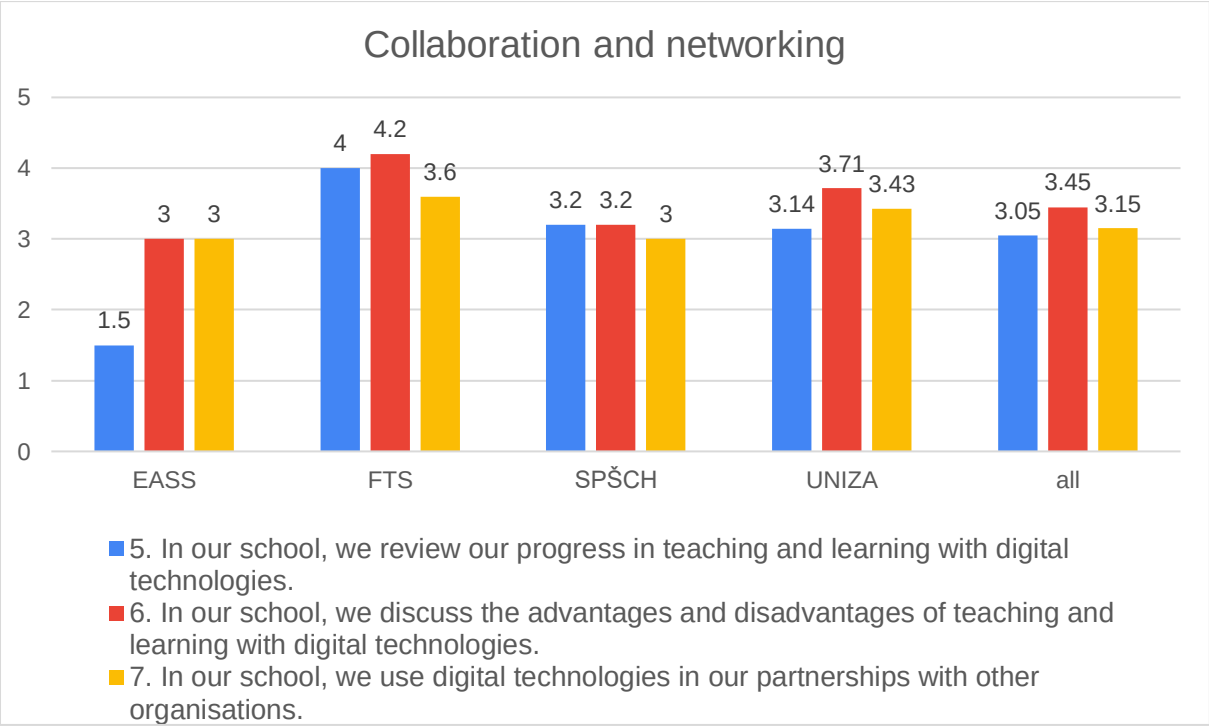


Figure 15 Digital potential of schools related to the part: Collaboration and networking

Infrastructure and Equipment

Infrastructure supporting education through digital technologies is available at all surveyed schools (above average) (Fig. 16). There are digital devices at disposal for teaching and internet access is provided is every school, also school-managed devices are at disposal for students when they need them, teachers are supported in using of digital technologies, there are online libraries for students with materials (Fig. 16, Fig. 17). Good situation is also within data protection (average is above 4 from 5) (Fig. 16).

The situation is slightly worse in terms of: students have access to a database of in-company training opportunities and school owned devices are at disposal for students to take home when they need them (except EASS and FTS). Schools have measures in place to identify challenges in area of using digital technologies, plan for teachers in need of help, there is adequate physical space for using digital technologies (expect EASS and UNIZA) (Fig. 16, Fig. 17). Clearly the worst evaluation is achieved by schools in part related to the access to assistive technologies for students with need of special support (Fig. 17).

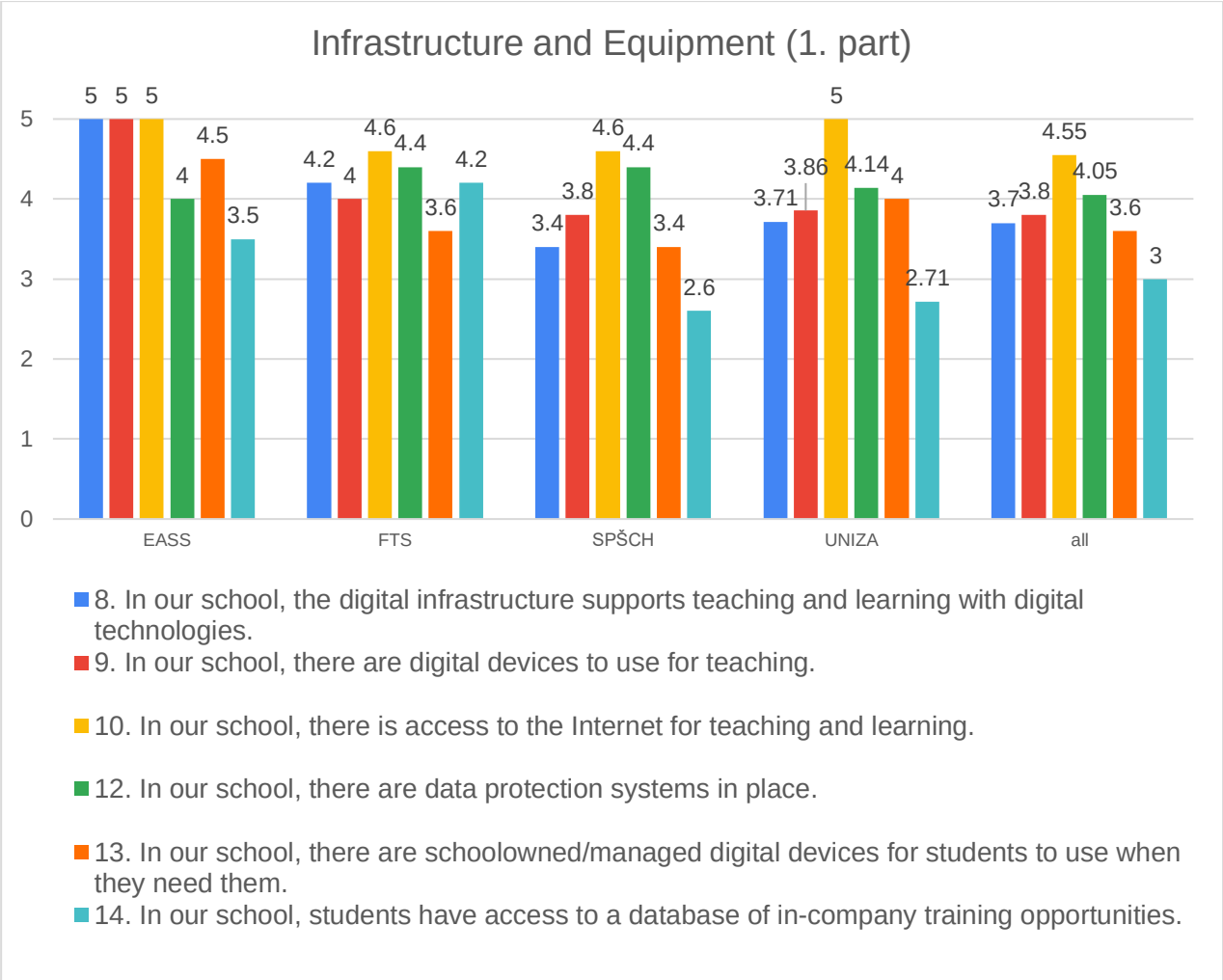


Figure 16 Digital potential of schools related to the part: Infrastructure and Equipment (part 1)

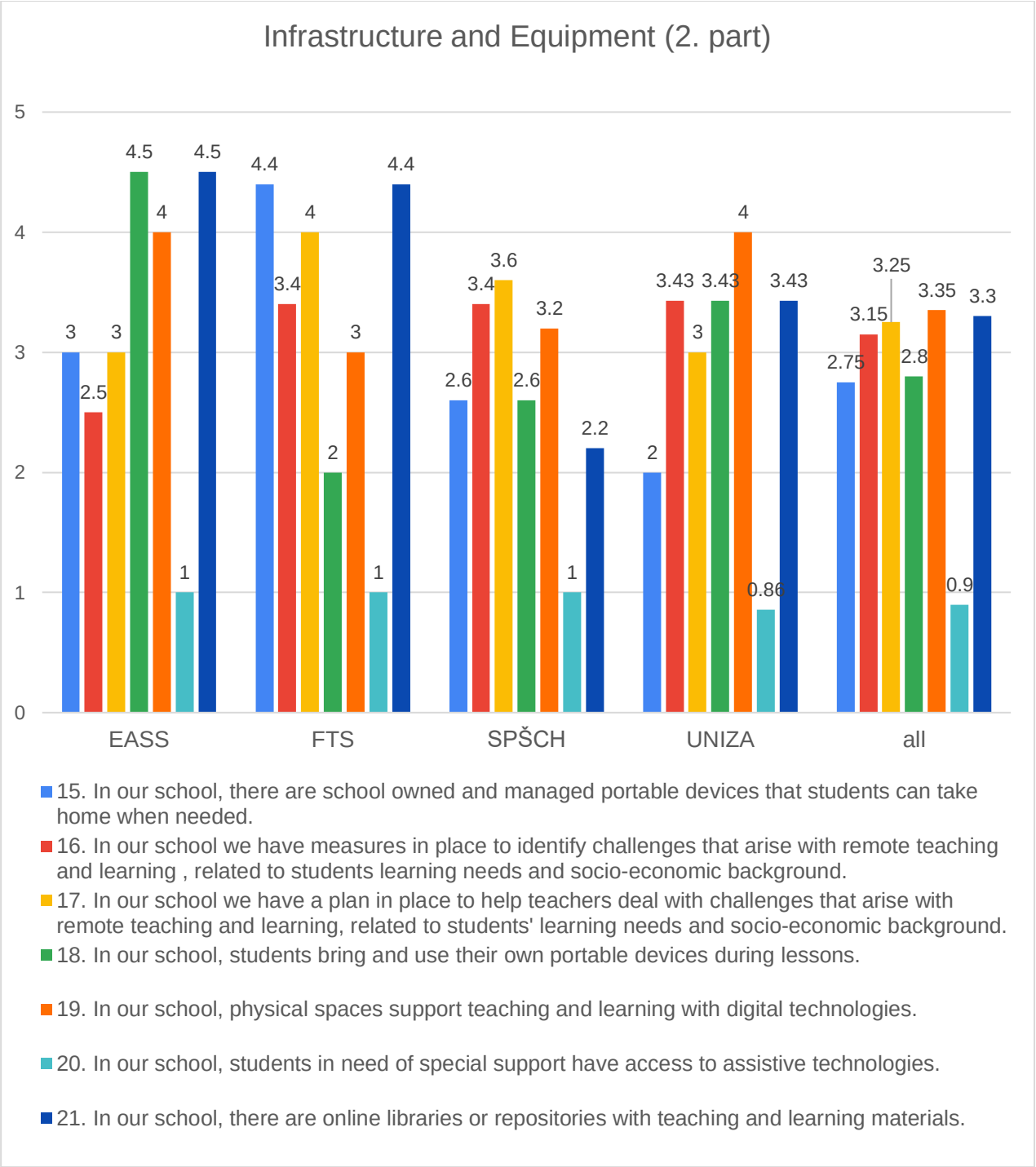


Figure 17 Digital potential of schools related to the part: Infrastructure and Equipment (part 2)

Continuing Professional Development (CPD)

Continuing Professional Development is slightly neglected by all schools in assessed areas (evaluation is slightly above average) (Fig. 18). There are some exceptions but all schools need to work on this CP development.

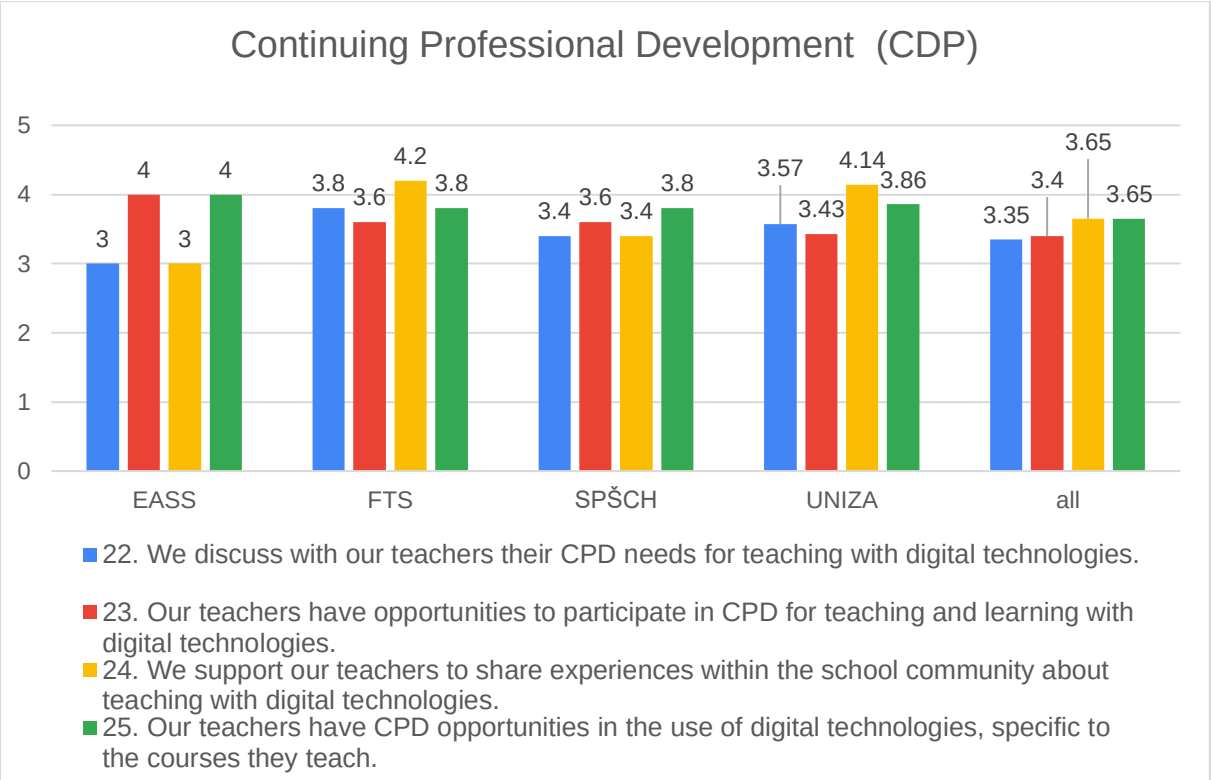


Figure 18 Digital potential of schools related to the part: CPD

Pedagogy: Supports and Resources

Within support and resources in pedagogy, there is situation very good almost at all schools. Slightly lags behind SPŠCH and UNIZA within creation of digital resources and using of virtual environment with students (Fig. 19).

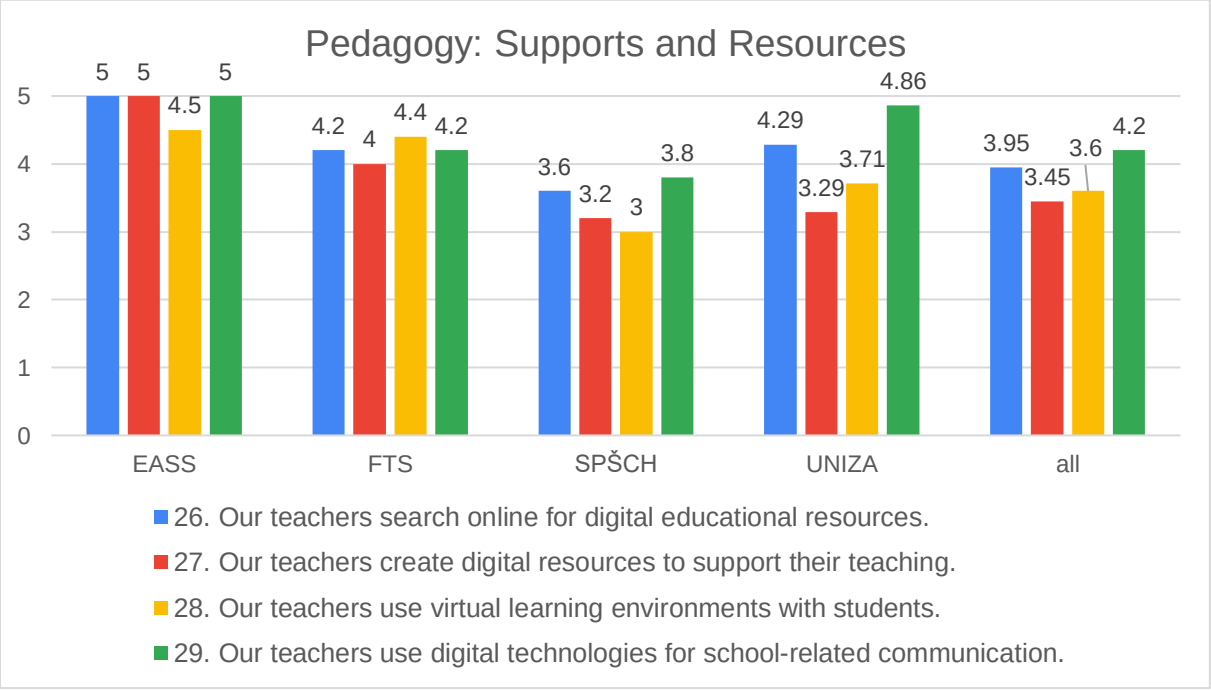


Figure 19 Digital potential of schools related to the Pedagogy: Supports and Resources

Pedagogy: Implementation in the classroom

Implementation of digital technologies lags behind “support and resources in pedagogy” almost all related questions. Answers are slightly above average (with exception for EASS in setting digital activities to engage students and engaging students for cross-curricular projects) (Fig. 20).

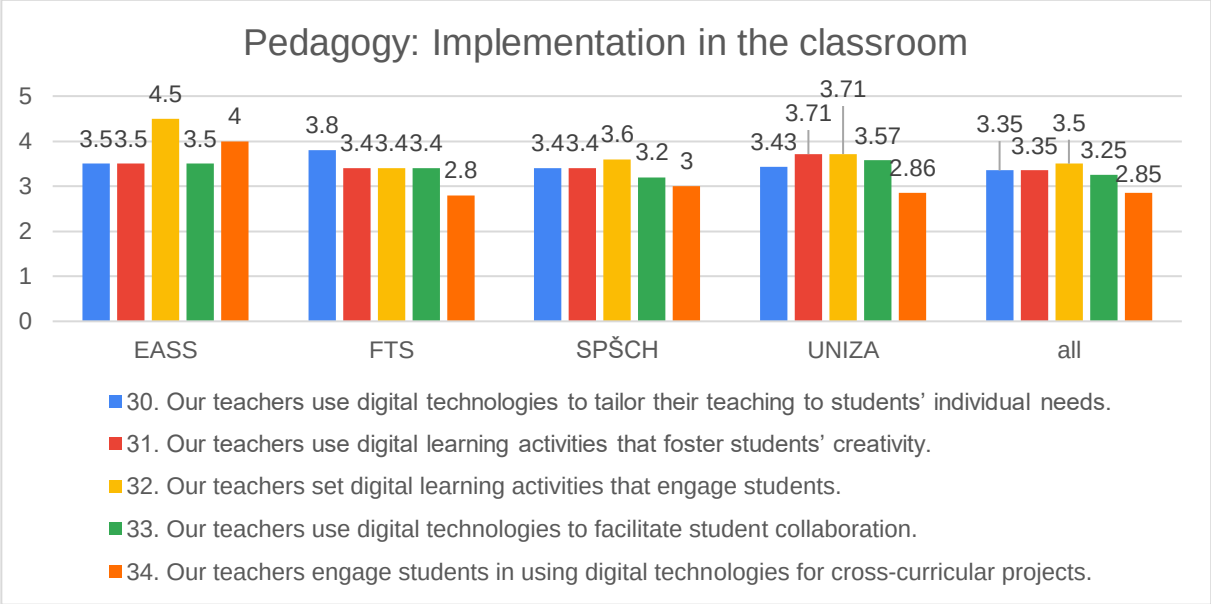


Figure 20 Digital potential of schools related to the Pedagogy: Implementation in the classroom

Assessment practices

Assessment practices related to the use of digital technologies are most common is EASS (assess students’ skills and providing feedback for students is 4,5 from 5). Other schools also use digital technologies to assess students’ skills, provide feedback for students but not so often or not by every teacher. Less often are used digital technologies to enable students to reflect on their own learning and to provide feedback on another students’ work (Fig. 21).

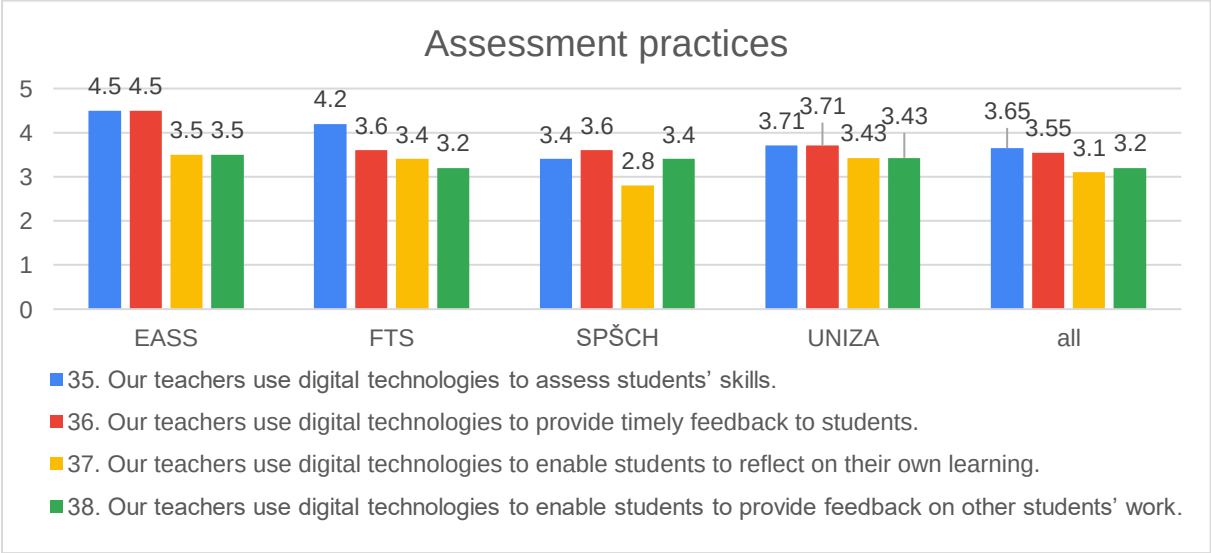


Figure 21 Digital potential of schools related to the part: Assessment practices

Student digital competence

From results of the questionnaire is evident that students at all schools are competent in using digital technologies. Across the spectrum of questions, the situation is on average the best for UNIZA students, but on some issues EASS (creation of digital content) stands out. The SPŠCH should make every effort to strengthen the digital competence of students (Fig. 22).

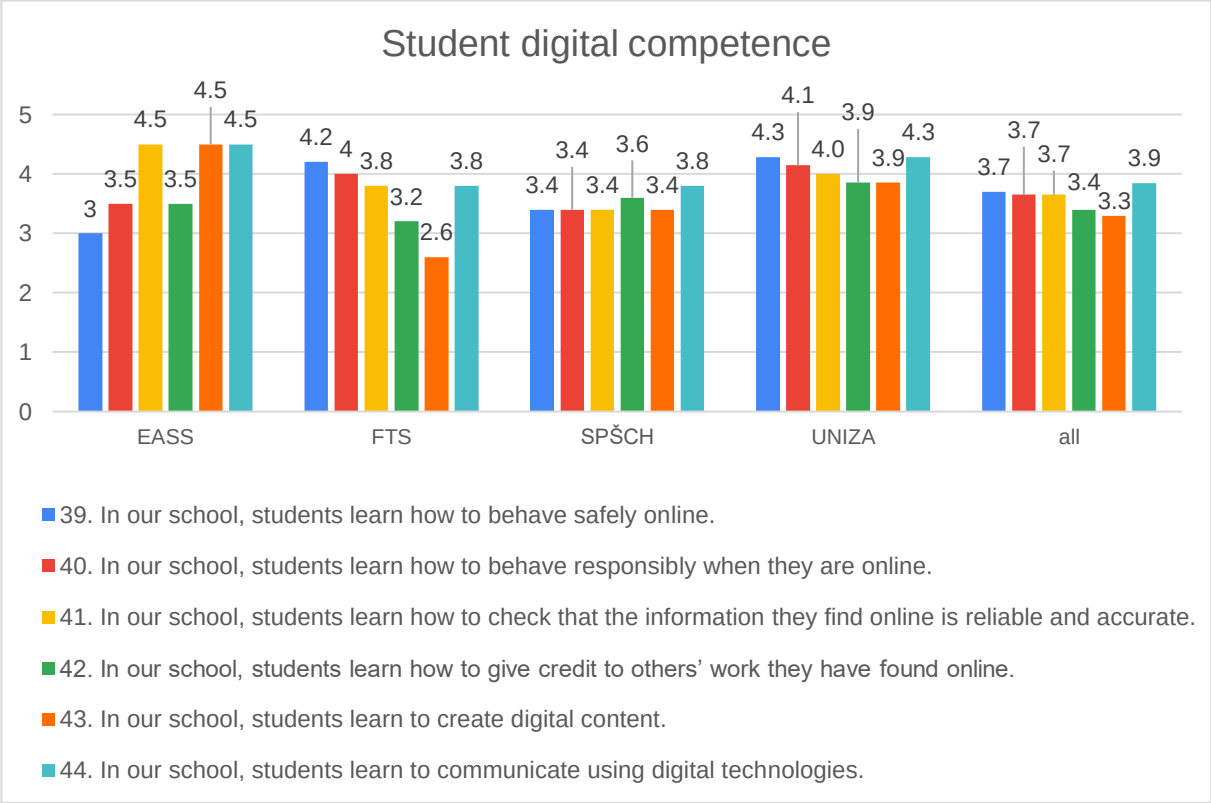


Figure 22 Digital potential of schools related to the part: Student digital competence

4.3. THE OUTLOOK

Organisations within FightARs project report from 3,34 to 3,76 (from 5) digital potential. Although the results are on average similar for all schools (Fig. 23), this is due to different areas of digital potential.

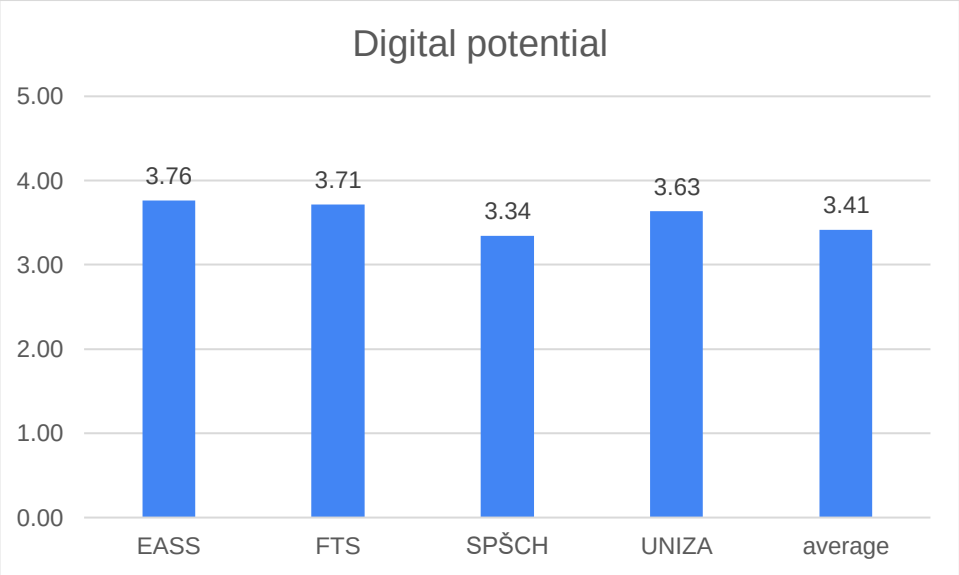


Figure 23 Overall evaluation of digital potential of the schools in FightARs project

At schools there are no areas that would be fundamentally neglected. The problem is mostly digital strategy and conceptual and systematic support of the use of digital technologies in schools. All areas from infrastructure and resources, through CPD, education to the evaluation of students and the support of their digital competence need to address in order to enhance overall digital potential of each school. The worst situation is evident in the area of providing devices for students for using at home. Some areas of assessment with shortcomings can be reflected in short time, but some areas need to be reflected within longer time period in order to see results in the future.

According to the results of the survey, the use of VR and AR in the conditions of the evaluated schools is possible, as they have an adequate infrastructure and also teachers who have experience with the use of similar digital technologies.

Explore, ready to use, ready to try, innovative.

5. IO3 – CENTRES OF EXCELLENCE

The FightARs project did not only include the creation of the software application solution, but also the creation of "centres of excellence", which refers to the spaces in which the hardware (HoloLens 2, PC...) will be used to run the software application in the context of teaching and training. It will become as a platform for trainers to share their knowledge with others, organise training sessions while using immersive technology solutions not only with AR/MR or 360° videos, but other hardware or software. It will become as a hub spots in Estonia, Lithuania, Czech Republic and Slovakia.

More information about the centers: www.fight-ar.com

Below in Table 2 there is indication of overall evaluation and planning details for establishment of Centers of Excellence within Erasmus+ KA2 FightARs project and beyond. This discussion has been during the staff training (Lithuania) where decision makers, experts, trainers and project managers took part in order to create sustainable solutions.

Table 2 Planning details of Centers of Excellence in Estonia, Lithuania, Czech Republic and Slovakia

	Online (e.g. webinars..) or offline training (e.g. hands on, live trainings)	Preliminary content (which chapter will be trained)	Target group (trainer, student, firefighter...)	Placement of Excellent center in organization (class, new room, infrastructure requirements...)	Responsible person(s) for running Excellence center	Resources needed
SK	Hands on, live trainings (webinars - appetizer)	Mainly focused on Hazardous substances (+ additional First Aid)	• University students • High school for Fire protection • Firefighters	Existing Classroom (MA 104) - Special classroom with added router for better connection VR +AR centre Risk prevention training hub	Katarina Holla - head • 2 employees from emergency services department • 2 employees/ doctoral students from Crisis management department	• Financial resources (no personnel, 2 notebooks, 1 HoloLens 2 glasses, licence for programmes) • Human resources (5 in total - 1 head)
CZ	Offline – face-to-face	All of the app	• Our learners; • Outside learners; • Volunteers - firefighters; • Professional firefighters • Trainers (professionals, other firefighting schools' trainers)	Current rooms will be identified that could be used with FightARs (logo) + outside (mobile, internet)	• Head: Jakub Navesnik; • Staff for finances • Projects & Coordinator of iCoaches: Justina Pluktaite • Leaders of initiatives/ projects • Representatives from 4 study programmes	• Financial resources • Technology: hardware (HoloLens 2) • Technology: software • Human resources: ○ managements ○ trainers ○ developers • Further training of trainers • Running mobile solution • Promotional

EE	Mainly hands on, live trainings. Right now, it would be one-on-one, connectivity with screens	First aid + all other situations	● Students ● Private companies ● Fire fighters + unit leaders ● Additional training participants	Tallinn study center Simulation center + Väike-Maarja training center, Narva study center	Kristjan Sepp - simulation center coordinator	● Financial resources ● HoloLens 2 glasses ● Human resources ● Briefings, introductory trainings
LT	Hands on, live trainings	Deactivation (+additional Cutting)	Firefighters courses students	Practical training division	Heads of Education and Training Division	● Financial resources ● HoloLens 2 glasses ● Human resource

This was a starting point for all organisations for the following next steps to establish centers in piloting countries.

5.1. INNOVATIVE EDUCATION AND RISK PREVENTION CENTRE – SLOVAKIA, ŽILINA

UNIVERSITY OF ŽILINA
Faculty of Security Engineering

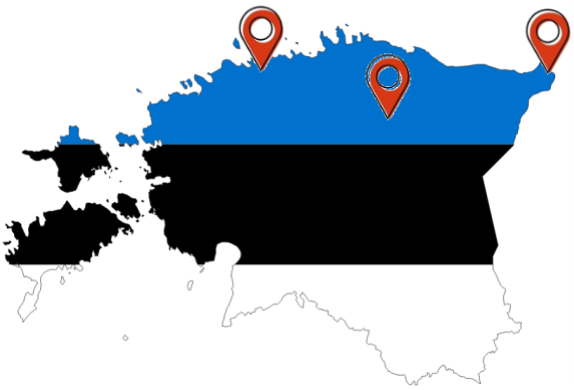
The FBI UNIZA Centre of Excellence is focused on crisis management and firefighting and on occupational health and safety training. It integrates several possible modes of scenario-based virtual training in different safety areas.

The main target group is university students of the crisis management and emergency services study programme. In the same way, this type of training is also intended for professional, volunteer firefighters and crisis managers.

The primary focus of the training is on ADR hazardous substances in road transport.

Figure 24 FBI UNIZA Center of Excellence during scenario testing [2]

5.2. EASS SIMULATION CENTRE - ESTONIA, TALLINN / VÄIKE-MAARJA / NARVA



VERBIS AUT RE

SISEKAITSEAKADEEMIA
ESTONIAN ACADEMY OF SECURITY SCIENCES

The Centre of Excellence of the Estonian Academy of Security Sciences has been integrated into what the EASS already uses. They now have a well-functioning simulation centre as well as a new centre for remote sensing research and development. Training in this centre is focused on practicality. Primarily the first aid scenario is used and secondarily other scenarios from the FightARs application are also used.

The target groups are several: students, private companies, firefighters and unit commanders.

The centre is mostly located at the Tallinn Study Centre, as well as at the Väike-Maarja training polygon and the Narva Study Centre. [7]

Figure 25 External EASS Center of Excellence at Väike-Maarja training ground [7]

5.3. FFTS IMMERSIVE TECHNOLOGY CENTRE – LITHUANIA, VALČIŪNAI

The Centre of Excellence of the Lithuanian Firefighting Training School is integrated into the practical training division area in Vilnius. Training in this centre is focused on practicality.

The primary scenario is electric car deactivation and first aid.

The target groups are: student firefighters, firefighters and unit commanders, private companies. [8]

Figure 26 Centre of Excellence at the Firefighter Training School in Vilnius [8]

5.4. EDTECHLABORATORY PARDUBICE – CZECH REPUBLIC, PARDUBICE

Střední průmyslová škola chemická Pardubice

The Immersive technology center for firefighters in Czech Republic was created at Upper Secondary School of Chemistry Pardubice (SPSCH Pardubice). It has been named EdTechLaboratory Pardubice. This center will unite various innovative technologies that will be tested in education and focused on vocational education. Among the areas it will be also for firefighters. The FightARs project has become a push to create such center and initiate iCoaches programme which will identify teachers or staff at SPSCH Pardubice who has technological knowledge and can share it with other colleagues (internally/externally).

The target groups are: student firefighters, firefighters and unit commanders, private companies.

Figure 27 SPSCH Pardubice Center of Excellence during scenario testing - EdTechLaboratory [9]

One of the main purposes of these established Centers of the Excellence is to share our gained knowledge while testing, using modern technologies in education. Therefore, the following summary describes the findings from the FightARs project, focusing on the positives and negatives of applying the HoloLens 2 technology, 360° videos, various software options and testing the FightARs application. The tips bring small insights that helps to start or use developed training solutions, prepare before deciding on using such technologies.

Of course, these points are presented from FightARs project partners' experience and should not be taken as absolute true. Overall, partners had a chance within 2,5 years to test solutions briefly and would like to continue such an exploration further. As this project intended – it was a teaser to these immersive technologies. In the end, we have succeeded to achieve all targets and beyond. Partners has a strong base and interest to further investigate modern technologies in fire fighters, incident commanders' trainings. Meanwhile, let's review what are the discoveries from FightARs project partners.

Advantages

- The FightARs project is the **only one of its kind** that is currently looking at the potential usability of the HoloLens 2 (AR/MR glasses) device with digital twins training firefighters, crisis managers and students**;**
- The FightARs application is programmed in the **Unity 3D cross-platform** game engine;
- **Positive feedback** from test subjects on the concept of training through holograms and scenarios;
- According to the overall feedback, we can confirm that such educational solution **increases understanding** of the topic better as it gives easier visualisation, trainee gets more **immersed in the scenes / situations**, it increases **motivation** in learning;
- We have noticed that for the trainers it is quite useful **to use this kind of programme to train situational awareness / situational understanding** of the trainees;
- Using the "Microsoft Dynamics 365 Remote Assist" tool, trainees can be navigated by an expert **from the distance** in real time around the scene by drawing holographically in space [11];
- Using the "Microsoft Dynamics 365 Guide" tool, trainees can **follow instructions** on his/her own without the interference of trainer [12]. In such way, trainee can have **free hands** and do needed actions. This way trainer can give such tasks for more trainees and not to worry of guiding them all individually. Of course, in that case it would be better to have several HoloLens 2.
- **Wide range of variability for testing** - heavy reliance on setting precise objectives and tasks to be fulfilled by the scenarios;
- Ability to **recognize objects and anchor holograms** to physical objects and then display layers with marked parts or components;
- **QR codes** helps to make it easier to place developed holograms over various locations (without the need to fix it to the location);
- The application can be **controlled by voice commands;**
- By including internet windows (we have included LMS) to the application we had a chance to bring **flexibility for trainers** to adjust training content without the need to make changes in the programming;

- **Cooperation with programming schools or universities** can bring opportunities of reciprocal benefits: users get training software content, students work has concrete end users and content to practice programming for AR/MR devices. This way we can reduce costs for creating new content for this hardware;
- 360° videos are **not too difficult to film** and quite **useful** in the situational awareness training, to bring trainee in the training action (even to the limited access), to have reflection on participation in the training (after filming it).

Challenges

- The potential of the project results has been affected by the global pandemic of COVID-19 **as it has delayed physical meetings and therefore, fruitful discussions in person**;
- There is very much **limited or no other software** that is developed - tailormade for firefighters, rescuers, incident commanders to use AR/MR in trainings;
- The **AR/MR glasses market** at the moment is **limited**. The HoloLens 2 gives the best solutions, though it is very expensive (around 4 200 Eur with VAT). There are coming up other solutions (e.g. MetaQuest, Apple Vision);
- In order to use the HoloLens 2, you need to have an active **Microsoft account**;
- In order to install FightARs application, it is needed to set **developer's mode** on your HoloLens 2 that made some challenges for most of the partners with their professional / personal Microsoft accounts;
- Easy to use training solutions: Microsoft Dynamics 365 Remote assist or Guide – are **subscription-based** and it can be **pricy** for some organisations (with educational Microsoft account you can get for 36 Eur/monthly for each programme / each device; without educational account it cost 80 Eur / month);
- The HoloLens 2 can only be used effectively for a maximum of approximately **50 minutes at a time**, after which the battery runs out (overall battery lifespan is 2 hours);
- HoloLens 2 tends to **overheat** sometimes after 30 minutes of use depending on the air and usage conditions;
- Some people may react **neurologically** - feel dizzy or have a burning sensation in their eyes**.** However, it is much better solution than using VR or closed solutions for MR;
- If you have **insufficient number of AR glasses**, it makes it difficult for many people to use them at the same time;
- **Methodology**: there is a need for a clearer order how to proceed with the chapters, how to use in mix with HoloLens 2 and theory. Trainers need to get more familiar with it and decide on their own pace;
- There is a bit of a **learning curve** for trainee – first time users;
- Using the device in areas with minimal lighting causes the sensors to become confused. Therefore, you need to take in mind about **light conditions** in the training rooms;
- Using the device **outdoors** on a sunny day - bright or indoors under a stronger source of artificial light makes the user environment difficult to see the holograms. Therefore, test best conditions for training in advance;

- There is a need to understand how the HoloLens 2 works for the new users. Therefore, before using FightARs application it is advisable to introduce trainee with the **basics of using the HoloLens 2** features**;**
- 360° cameras are not too expensive, but **needs some work** to understand the best way how to use to film training material and afterwards to use it in the training.

6. CONCLUSIONS

The educational process is inevitably important for the sake of maintaining the functionality of society as a whole but also for its sustainable progress in every field. There are many ways in which people can be educated or trained in relation to specific information and skills. These ways (methods) can be grouped from the conventional ones where the medium of information is paper, book or the newer electronic variants of these mentioned methods through computer technology.

The choice of innovative methods in education depends on the approach of the individual or primarily the institution to technology and innovation. Defining today's age as dynamic with a great deal of information and knowledge is essentially a well-established phrase, which has its justification. It is important to receive the right information at the right time, but it is equally important to deal with it effectively. Technological advances in sensor technologies such as spatial position recognition or depth sensing, combined with powerful graphics processors, have opened up opportunities for the development and subsequent commercial sale of affordable but also dimensionally (hardware) affordable augmented (AR) and mixed reality (MR) devices. In terms of market availability, this is a relatively new technology whose potential for effective use is still being explored. This is evidenced by the number of scientific articles in bibliographic and citation databases dealing with this topic with a view to effectively applying this technology to various sectors or human activities. The activity at FightARs project piloting organisations, where the activity was developed in the search of possibilities of implementation of AR/MR scenarios, also viewed virtual reality solutions in teaching. This document discusses the FightARs project, which represents a "pioneer" in the field of training crisis managers and firefighters through AR/MR, where the learning process is based on "immersion" in the scenario through 3D holograms and acoustic sensations in order to maximize the sense of realism. The role of this training is not to replace conventional training and educational procedures on the contrary it is to form as the name AR implies an expansion of the possibilities and variety of information and sensations to be received as well as to try out methodologies in scenarios that would be costly or dangerous to simulate on a polygon. The FightARs has provided valuable insights into the development of scenarios for such training as well as information from surveys that there is interest in this type of training in practice. In conclusion, therefore, it can be assessed that AR/MR has potential in practical training and the issues raised by the FightARs project are not insurmountable and will be taken forward by the SAFAR project as starting points for further resolution [10].

APPENDICES

APPENDIX 1 – OPERATIONAL CONCEPT

Business model planning was used to create operational concept for Centers of Excellence in piloting organisations. Following questions or features were reviewed.

<table>
<tr>
<td rowspan="2">KEY PARTNERS
The network of suppliers and partners that make the Business Model (BM) work</td>
<td>KEY ACTIVITIES
The most important things an organization must do to make its BM work</td>
<td rowspan="2">VALUE PROPOSITIONS
The bundle of products and services that create value for a specific Customer segments</td>
<td>CUSTOMER RELATIONSHIPS
Types of relationships an organization establishes with specific Customer segments</td>
<td rowspan="2">CUSTOMER SEGMENTS
Different groups of people or organizations an organization aims to reach and serve</td>
</tr>
<tr>
<td>KEY RESOURCES
The most important assets required to make a BM work</td>
<td>CHANNELS
How organization communicates and reaches its Customer segments</td>
</tr>
<tr>
<td colspan="2">COST STRUCTURE
All costs incurred to operate a Business Model (BM)</td>
<td colspan="3">REVENUE STREAMS
Revenues an organization generates from each Customer segment</td>
</tr>
</table>

APPENDIX 2 – OPERATIONAL STRATEGY

In order to plan and prepare for the establishment of Centers of Excellence, partners followed below methodology connected to business model creation to review most important details. It gives overall overview and consider capacity for each organisation.

BM ELEMENTS	LIVING LAB BUSINESS MODEL ATTRIBUTES								
KEY PARTNERS	Research org.	Regional public org.	Municipals and cities	Networks and Clusters	State level org.	Digital service providers	NGOs, and third sector org.		
	Education org.	Secondary care org.	Device manufacturers	Tertiary care org.	Primary care org.	Preventive health / wellbeing service providers			
KEY ACTIVITIES	Project mgmt.	Testing and co-creation	Funding support services	Marketing and sales	End-user services	Support services to state authorities			
	Education and training	Ecosystem orchestration	Support services to regional authorities	Support services to local authorities	Funding				
KEY RESOURCES	Personnel	Infra and technologies	Partner(s)	External networks	User and patients panel	Students	Data and publication databases	External experts	IPR-portfolio
VALUE PROPOSITIONS	R&D Services	With real end-user	Customized services	Ecosystem and project mgmt.	Funding support	Method development	Funding		
	Unique infrastructure	Various positive arguments	Multi-disciplinary	Value and impact evaluation	Education and training	Marketing Support			
CUSTOMER RELATIONSHIPS	Long-term relations	Project based	Direct personal contacts	Networking	Events	Internal	Co-Creation with various stakeholders	Steering	Advisory
CHANNELS	Co-operation projects	Regional channel	Educational channels	Events arranged by LL	Professional publications	Scientific publications	Online, mobile and social media	Paid media and marketing	
	Direct channels	Event participation	Networks and cluster	Owners or key partners channels	Municipal and city channels	Lobbying and policy channels	State level channel		
CUSTOMER SEGMENTS	Education org.	Device manufacturers	Research org.	Municipals and cities	State level org.	Tertiary care org.	NGOs, and third sector org.		
	Regional public Org	Digital service providers	Secondary care org.	Primary care org.	Networks and clusters	Preventive health/wellbeing service providers			
COST STRUCTURE	Personnel	Infrastructure and facilities cost	Internal R&D development	Travelling costs	Consulting fees for external experts	IPR-protection	End-User fees and other variable costs	Outsourced services	Marketing and sales
REVENUE STREAMS	Project grants	Fixed or permanent funding	R&D project and consulting service sales	Education and training services	Device and infrastructure rental	Donations	Royalties	Event and site visit fees	Equipment and device retail

Partners followed previously shown template, but just added timeline for actions (see below).

High relevance	Medium relevance	Weak relevance	No relevance

Elements	FIGHTARs Immersive Lab Attributes – Operational concept
Key partners	
Key activities	
Key resources	
Value preposition	
Customer relationships	
Channels	
Customer Segments	
Cost Structure	
Revenue Streams	

APPENDIX 3 – REFERENCES

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