From ESCO to LAAR

(white paper)

A reflection on the use of Augmented Reality and Learning Analytics.

Funded by the Erasmus+ Programme of the European Union

This project **LAAR** (2017-1-LI01-KA202-000087) has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Erasmus+ KA2 Strategic Partnership Project 2017-1-LI01-KA202-000087

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ISBN 978-3-03912-006-2

Publishing date: 30-09-2019

Publisher: Laurentius Verlag
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Feldkircher Str. 50
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Introduction

The document in front of you is the reflection of the Erasmus+ strategic partnership project LAAR, or Learning Analytics and Augmented Reality. With this text, we aim at the layman reader that is interested in education and training, without being an expert in the fields of education or training, neither as the field of digital learning platforms and applications.

In the first part of this text, we take you along our path to discover the existing knowledge, systems and visions that inspired us during the development of the project. In the second part you find the developments the project team added to these inspirations, the way we used them and the concrete results of the project.

We hope you will enjoy it and get inspired by it.

Project description

Augmented Reality (AR) has the potential to support effective learning in informal and non-formal learning environments and not only in school or higher education but also in professional education. Especially in the building/construction industry or in the Event Industry, trainings for safety and security are needed to protect workers at their workplace. One central issue hereby is, which elements must be taken in consideration (i.e. teaching and learning elements, design elements, etc.) when developing effective learning applications. Moreover, how can such applications support responsible persons at the workplace so that they can ensure, that each employee has been trained in safety & security and has understood the key elements of the training and has the ability to behave according the instructions.

This is where Learning Analytics (LA) comes into place. LA provides various tools and concepts to support learning, especially for people who are involved in learning processes (trainer, trainee, evaluator). The project aims to create a framework on the basis of LA insights, for implementing elements in AR learning applications which supports learners and trainers in their teaching and learning processes towards a higher efficiency and efficacy. At this point, elements from LA like functions and integration of analytical elements shall be implemented to receive feedback about handling and ease of use from the apps, as well as measures for learning performance. In various iterations, a series of pilot applications shall be developed and tested within specific training areas, like facility management, building/construction, and in the Event Industry (i.e. Hilversum test as developed by the ERASMUS+ project “ETTE” for traditional training). From the results and insights, key questions should be answered like how can AR and LA be used in professional training applications to create more effective learning experiences for learners on their individual path and pace. Additionally, receiving insights about data required for "big-data analysis methods" and how can they be processed in a small work environment, or which methods can be developed to derive knowledge from established, large learning environments. A concrete, desirable result would be to provide recommendations about how the transparency of learning services in the understanding of learning outcomes can be depicted with the aid of LA and AR in order to dismiss the responsibility for employers not only to offer the possibility to participate in safety briefings (consumption) but also to ensure that employees have understood and will behave adequately.

The consortium of leading European scientist coming from the areas LA and AR aims to establish a strategical partnership with VET partners, in which the conceptualisation of the topics LA and AR should be used to apply in the field of professional education, especially in informal learning environments and directly at the workplaces. Since one result should cover also a contribution to the research community, the project aims to develop new opportunities at workplaces and also for LA and AR to provide an added value and give answer to current questions from professional education.

The consortium consists of the partner organisations i-smARt (Coordination in LI), IT University Copenhagen (DK), Oxford Brookes University (GB), STEPP vzw (BE), VPLT (DE) and aims to establish a strategic partnership in which the indicated topics and aspects should be elaborated. Within a first development of a generic framework, current research results and their leading questions are included, also to develop the framework as a software application. In a second step, a first functional prototype of AR learning application will be developed for analysis and evaluation purposes, which then will be - according the design science approach - applied in various iterations within field experiments at workplaces. Finally, the goal of the project is to support a full session training and assessment (i.e. Hilversum test, project ETTE) on the basis of AR learning applications and the use of LA tools and measures.

The writers

Chris Van Goethem

Chris Van Goethem started working as a stage manager in the eighties and toured around Europe with several Belgian companies. In the nineties he started to work as a consultant and educator in technical theatre.

He consulted the creation of the Flemish professional profiles and standards for theatre technicians, and the start-up of several education programs in initial, higher, and adult education. Today, he consults the Social fund for the performing arts in educational matters.

Chris Van Goethem chaired the ESCO sectoral reference group for arts, entertainment and recreation and he is an active member of the TALQ research project. He is involved in several other projects using ESCO competences such as the ETTE project, which is developing a European safety passport, TeBeVat, which is researching validation and portfolio techniques, and LAAR, which is developing learning analytics and augmented reality applications.

He is responsible for the Expertise Centre for Technical Theatre of RITCS School of Arts, Erasmus University College Brussels, and is involved in research on education, competence management, and history of technical theatre. (www.podiumtechnieken.be/onderzoek/english)

He is member of the OISTAT Education Commission (Organisation international des scénographes, techniciens et architectes de théâtre) and the board of STEPP (the Belgian Technicians organisation).

Peter Sommerauer

Peter Sommerauer is a successful entrepreneur and founder of 7+ small size organizations with up to 25 employees. He grew up with the early development of IT and studied information science right after his first career as mechanical engineer. Later, he obtained a Bachelor's degree in Business Informatics, a Master's degree in IT and Business Process Management, and a PhD in Business Information Systems.

Peter initiated, lead and participated in outstanding and highly esteemed European projects for the Event technology, e.g. ECVAET, ETonTour, step2mice, LAAR. He has more than 11 years of experience in European project management. He conducts his research activities at the interface between vocational training and higher education and with a focus on media-based learning. With his technology-oriented focus, Peter is investigating digitization for brain-friendly learning.

Part 1

1 Introduction part 1

The LAAR project develops learning applications for the event and the performing arts sector. The choice for this specific sector is not arbitrary. The event and performing arts sector is a very flexible, international and fast evaluating sector. Therefore, it incorporates almost all tumbling stones occurring in other sectors. Solutions that work in this sector will easily be transferred to other sectors.

In this first part we introduce step by step the concepts that are behind the LAAR project. These concepts are mainly derived from the EU vision on competence management and a series of projects that have been developing these concepts into practical solutions. They support the vison of the project and underbuilt the application development from an educational / competence management point of view. The text includes the analysis and reflections made during the development of the project.

The ETTE project, a project that developed a basic European Safety Certificate, with supporting learning material, is used as a test case for the development of the LAAR applications. It shares a common vision and uses the different elements described below.
(https://www.podiumtechnieken.be/en/health-safety-and-sustainability/ette)

- The **first chapter** describes the specific **target group** and reflects on the learning context of contemporary learners. This chapter also introduces the scenario's used to clarify the concepts.
- In **chapter two** we describe the concept of **competence** in general, define the relation with knowledge and occupations, tackle common misunderstandings and conflicts with traditional learning systems.
- In **chapter three** we explain the structure and concepts of The European Skills/competence, Qualifications and Occupations (**ESCO**) and how the technical theatre competences are developed. We reflect on the possibilities and limitations, their relation with education and other transparency systems for VET.
- **Chapter four** explains the idea of a **sectoral layer**, on top of ESCO, as developed in the TALQ project. It details the information about the content of competences needed to create learning systems.
- **Chapter five** gives an overview of **tools and applications** that are developed based on the sectoral layer concept and can be (re)used in the LAAR applications.
- **Chapter six** describes the concept of a **learning wallet** or learning locker, the **xAPI** (Experience API) and it's use to exchange information between different applications and to integrate different learning methods into one coherent structure.
- **Chapter seven** reflects on how **teaching and training** is organised for the specific target group in a complex real-life working environment.
- **Chapter eight** reflects on how **measurement, evaluation, and assessment** in vocational education can be organised.
- **Chapter nine gives** an overview of existing **applications for digital learning environments** and how they can be used.

The second part of this work will elaborate on the development of the applications and the practical outcomes of the LAAR project.

1.1 Target groups

The target groups of the LAAR project are related with the event and performing arts sector, a sector interrelated with other industries and occupations like carpenter, electricians, scaffolders, light-/audio/media managers, … . The target group is also very diverse if we look at their background. This implies a large variety of learning contexts that apply in parallel of the traditional learning pathways. Even though every learner and his/her situation are unique, we can group them in typical learning situations:

Often formal training in a European educational (school) context attracts mostly **young learners** that are still in their "school career". The education is not only focused on sector specific skills, but also includes general education.

A specific form of formal training for **young learners** is Dual Learning. The combination of theoretical education in a school context and practical training in a work placement is very suitable for the theatre-technical and event field. It combines the "safe space" of a school with the complex reality of the sector that is hard to simulate.

Professionals that want to "**climb the ladder**" are a second target group. The organisation of crews, the tradition in the sector and the stepped relation between occupations makes this an obvious path. A worker starts as a stage hand, becomes a technician after some years, grows on towards a specialism and becomes crew chief. The difficulty with this target group is that it is hard to get them together. They have a lot of (waste/waiting) time while doing their job, but it is difficult to plan off days for training because they depend largely on the production planning.

A related group to the one before is professionals in need of **continuous education**. The rapid change in technology and production methods provokes the need for a permanent update of competence. Even though the principles of live entertainment have stayed the same for centuries, the technical means that are used change at high speed. The planning issues are similar to the group above.

Both groups above consist largely of **freelancers**. This is not only the result of an economic reality, but also a choice. High level professionals need to be challenged to keep their level, so they look for productions that challenge their competence. Moreover, high level professionals are not only asked for their skills, but also for their artistic taste. To be able to cooperate with artist they need to incarnated with the style of the artist and "feel" the underlaying artistic vision. This often means they "follow" artists to different productions. Most freelances work for several artists at the same time, making planning even more difficult. Freelancers in most countries are not very good protected and every day they don't work is a day they are not payed. As they don't have a permanent employer, a day of training is a day not worked.

Another specific group are adult learners that want a **career switch**. Often these are artists that want to get into the technical field. This can be because their career ended (for example dancers) or because they can't make a living out of their art. The advantage is they already understand the production process and the artistic environment. On the other hand, there are also people from other sectors that enter laterally in the field of technical theatre, often because they decide to make their dream come true or because they want to leave a purely competitive, commercial environment.

A last group are practitioners that need extra training because of **mobility**. This can be professionals moving to another country, refugees, … They need to adapt their skills to a new, local context and need to learn a new professional vocabulary. Often their general language skills are (still) limited and they need to adapt to the local culture. Especially in a sector where the artistic language requires

understanding of nuances in wording, describing feelings and emotions, this is a limitation. On the other hand, most artistic contexts are multilingual and multicultural.

For many individual learners, a **combination** of these definitions will apply. This asks for flexible, individualised solutions that adapt to the personal needs of the learner.

1.2 Learners of today

The learners of today haven't changed so much since the introduction of the internet, but their environment has. They are constantly exposed to large amounts of information, they live in a more complex, permanently changing world. This makes they have to develop a strategy to deal with this overload of incoming stimuli in an efficient way. One of these strategies is "scratching the surface", getting a basic understanding of the incoming knowledge by reading the headers or short descriptions. This strategy helps in daily life, but is not sufficient to build skills and competence on. They miss a framework to put all this information in and relate it.

In the event and performing arts sector, a more than average number of learners have been diagnosed earlier with all kind of learning difficulties like ADHD, elements of autism spectrum, dyslexia, … These difficulties have often limited their "school career", but they seem to adapt well in a creative sector, where the properties of these difficulties seem to become valuable gains.

Based on our experience, most learners attracted to the creative sector are active learners. They don't like to listen but they do like to do. They are hands on and like to learn on a "need to know basis", starting from the practice and then looking for the theory behind it. Often this coincides with a "renaissance man" type of interest, a combination of specialisation with a broad, wide angled view on the totality of the result and the elements that influence them. This attitude is needed for creative occupations that combine technical, social and artistical skills in a complex environment.

The learners of today have to adapt to a high-quality standard that is different from the daily life standard. Where in daily life quality is "what is acceptable to the majority", in arts and entertainment the standard is "the best possible". We are supposed to deliver the best show, not an acceptable show.

Most learners (in contradiction with a lot of pure artists) are instinctively proficient in digital media and don't like to be "beaten" by a computer, which is a strong motivation.

1.3 We are teaching "history"

The event and performing arts sector is based on century old principles and traditions, but encounters on the other hand an extreme fast technological evolution. New technology is brought out so fast that the debugging is "outsourced" to the users. This makes that whatever equipment or technology we teach, it is outdated by the moment students leave school. It becomes impossible to keep curricula and training with the latest, state of the art, insights and technology. We are almost per definition teaching "history".

This insight has an important influence on what we teach and train. It does no longer make sense to train learners for a specific device, technology or application, we need to train them to acquaint themselves with new equipment and master new technologies by themselves.

1.4 4 scenarios

To make the use of the different concepts, systems and methods more visible, we use four scenarios to follow the needs and labour status of four different people. These four people represent typical situations occurring in the performing arts and event sector.

- Nina Tiptoe, 38, a dancer at the end of her dance career, wanting to get into technical theatre or stage management. She wants to prepare for the transition during her last year of work as a dancer. She is originally Spanish, but lived and Worked in Germany, Austria, Belgium and Sweden for years.
- Tony Solo, 30, a freelancer in the peak of his career. He works 7/7 and tours all over Europe with different companies. In low season he works for events and trade shows.
- Ben Young, 21, is fascinated by the technical side of performance and the music scene. He didn't fit into the traditional education system, but his head was always into inventing and experimenting with new equipment. At the moment he is apprentice in a rental company. In his free time you can find him in the youth club.
- Mary Standard, 17, is at school to become a multiskilled technician. She has always been good in science and technology. But she has no experience in the real world of theatre or rock and Roll. In her free time, you can find her in the sports club, where she likes to climb.

1.5 ETTE as a test case

As mentioned above, the content developed by the ETTE project is used by the LAAR project as a test case for the concepts, tools and applications. Roughly we can say the project developed learning content and assessment methods based on a set of ESCO competences that were detailed in a sectoral layer. We will introduce all these elements step by step when describing the concepts behind them.

2 The concept of a competence

The LAAR project developed applications for learning in a vocational context. To describe and measure what is learned we need a common language that is related to the larger context of work and education in Europe. We use competences as descriptor for the learning outcomes. To define the exact meaning of the concept of competence, we looked into definitions that are adapted to vocational training, and are general accepted and used in the EU.

Cedefop defines competence as "*The ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development).*" Or "*The ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.*". Additionally, it comments that "*competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (including technical skills) as well as interpersonal attributes (e.g. social or organisational skills) and ethical values.*"

ESCO (European Skills/Competences, qualifications and Occupations) and EQF (European Qualification Framework) apply the same definition: "*competence means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.*" ESCO clarifies further that "*They are described in terms of responsibility and autonomy.*"

In relation to the difference with the concept of skills ESCO states: "*While sometimes used as synonyms, the terms skill and competence can be distinguished according to their scope. The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person - facing new situations and unforeseen challenges - to use and apply knowledge and skills in an independent and self-directed way.*"

The differences between the definitions are small and can be reduced to the different point of view of the makers. Where Cedefop focusses on learning, ESCO has a broader view and can also be used in Occupational Standards, HR, etc. This is reflected in the fact that ESCO states that the competence has to be proven.

The above and the fact that that ESCO has an existing database of competences that can be used in the event and performing arts sector makes that we chose to use the ESCO definition.

In the side-line, we want to stress the importance of readability of the competence descriptions. They should not only be understood by educational or labour market experts, but also by workers that can use them to describe their own practice. This is especially important and useful for lower EQF level occupations. On a higher level, the descriptions will be, per definition, more abstract. But one can expect also from workers on this level to deal with this abstractness.

2.1 Occupations vs. competence

In an international context, common descriptions of occupations in the performing arts and event sector are not very workable. A stage manager is not a "toneelmeester" or " régisseur général ". A stage manager in an opera house needs other skills than his colleague in a theatre. The titles and the content vary depending on the organization of work, the type and size of organization, type of productions and the composition of the crew. Of course, all necessary tasks for a stage production are performed by someone. However, they are not always performed by the same function or in the same combination of functions.

This ascertainment makes that the focus for a workable system that can describe what is needed for a job or what a professional should know or learn, is more on the level of competence, rather than on the level of occupation. An additional advantage of this focus is that it honours the unique skills that are available in each person and that can be exploited in a creative/flexible organisation.

2.2 Confusion about competence descriptions

Describing competences is not abstract science. There are different views on how to describe an individual's competence or how to describe the needed competence for a job or activity. The descriptions occur in different sizes, using different language and with different amounts of detail.

These different views often derive from different uses. Job applications, HR, training, teaching, assessment, careers coaching, all use different shapes of descriptions. The reason for this is often that they have to match existing formats, systems or methods. These formats, systems or methods will often set technical standards and limitations on how competences should be written and on the amount of competences that are allowed. Sometimes, the descriptions are just a "translation" of existing material like school programs or job descriptions into a format fit for the requested use.

All this makes that competences are not very exchangeable or transferable between different services.

2.3 Competence vs knowledge

In daily life we often say things like "you have to know French", "you have to know your history" or "you have to know how to repair your car". Even if we all understand what it means, these sentences do not make sense when you analyse them. Knowing French without being able to speak it or to write it, is not very useful. Knowing history without being able to relate facts to each other or to the present does not help us. And knowing how to repair my car without being able to do this only leads to large frustration.

Knowledge is like a closed book, on its own it is not really helpful if you can't apply it. This does not mean knowledge should be limited to what is directly applicable in the labour market. Building a framework of knowledge to understand the context you are working on is a good and valid reason to gather knowledge. For example: understanding the world history or the history of the arts is crucial for people working in an artistic environment.

In relation to the term "competence" we could say the knowledge is "underpinning", it supports (and is an essential part of) the competence. In other words, if you are competent you have gathered the required knowledge.

2.4 The conflict with traditional school evaluation

To master a competence means that you are able to perform the described activity completely. You are able to do what is written down as "needed to fulfil a task". The result is yes or no, you are able or you are not able. In traditional school systems we grade students. We decide how much of the content we offer them is understood, how much competence they have gathered. We make a gradation between the performance of different students in relation to the targets set. And the students "pass" if they reach 50% of these targets.

In real life we don't expect 50%, we expect that you are able to perform in full. A fireman that is able to extinguish a fire for 70% fails in real life, but in most education systems he/she would be congratulated for excellent performance.

To compensate this, (most) education systems set their targets higher than what would be expected. The problem is that we don't know what the student is able to and what part is missing. A second issue is that if we compare "school" competences with "sector" competences we get a false image of the reality.

2.5 The conflict with a traditional "course model"

Many education programs are structured in courses or modules. These courses are still structured based on knowledge that is developed step by step. The result of this is that the relation with the competences that are supported by this knowledge is lost. The knowledge is presented in an abstract way, as if there is no relation with the final target of the training program.

In more technical programs, the knowledge is often taught independent from the practical application, the program component where competence is developed. For a student, competence and knowledge almost seem to be two elements that exist independent from each other. This way of working has several consequences:

- The student has no "framework", no context to put the knowledge in. The knowledge stays abstract without concretisation in practice.
- Teachers do not see the relation with competence needs, but teach an independent "knowledge unit", which sometimes shifts towards teachers' "fetishes" or elements that may be interesting, but not useful in practice.
- The knowledge education is not based on a concrete need, which is often an obstacle for students that are practice oriented and learn better when they understand the need and have a context.
- Knowledge is often repeated in different courses (In theatre technical education almost every course starts with the basic laws of electricity and physics). Moreover, the knowledge is presented in different, sometimes conflicting, ways, leading to confusion with students. Repetition and different presentation can be useful, but it should be a choice based on the needs of the students, not on unintended coincidence.
- Competences often overlap, as they are secondary to the knowledge.

An education program based on a set of competences with underpinning knowledge would provide a more clear structure. Teachers would be able to relate the knowledge to the competences they support. In this way the knowledge becomes more concrete. Reorganising the underpinning knowledge in logical units would improve the efficiency of the teaching process, as clear choices can be made on where this knowledge is taught and where it is useful to have repetition.

- Nina Tiptoe, the dancer, has gathered a lot of different competences during her dance career. She has worked on a stage for years, is able to make an artistic interpretation, reads music, developed a strong feeling for timing, worked with technical and artistic staff, speaks different languages, … All these competences will help her in the transition to a new job.
- Tony Solo, the freelancer, has a wide set of very specialised competences. He is able to work in different work environments and labour traditions. He uses the competences he acquired on tour also when he's working in events or trade shows. His technical skills need permanent updates because he needs to stay in the frontline of the technical evolution
- Ben Young, uses the competences he acquired experimenting with the technical equipment of the youth club and his inventive skills to shape his path through apprenticeship. Of course, the apprenticeship also provides him with new skills. He discovered the need for more theoretical background and subscribed in an online course about electronics.

- Mary Standards background in science and technology is a good ground to build the skillset for a multiskilled technician. Her climbing skills become useful now in a professional context. She visits concerts and theatre performances to get more artistic background.

2.6 How and why does this feed into LAAR?

The LAAR project uses competences as a starting point to develop applications and measuring / assessment systems. This guarantees a wide understanding and a connection with other European systems and visions.

The basic idea behind the ETTE Safety Passport was that the focus of safety training and certification needs to be on competence, rather than on knowledge. To work safe means “to be able to”, more than “to know how to” do things. Even if knowledge and understanding is essential to work safe, it is not enough. At the end we want practitioners to act and behave safe. This is best expressed in competence.

3 ESCO

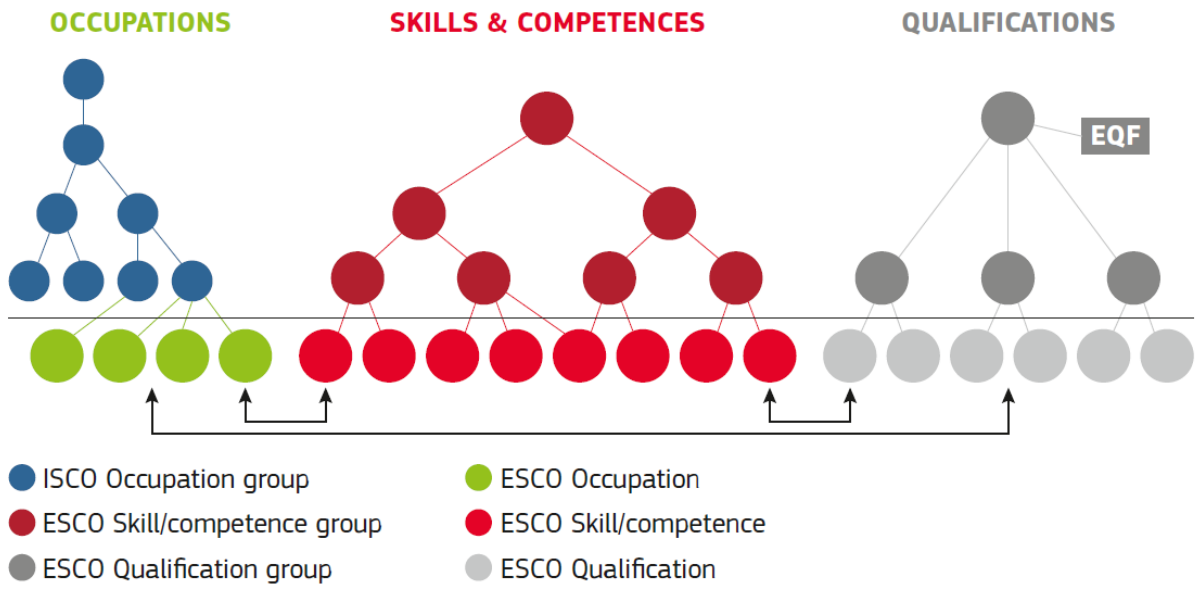
In order to exchange between (unemployment centres of) countries, the European commission developed a “translating tool” based on a common competence language.

On their website ESCO describes itself as:

> *ESCO (European Skills, Competences, Qualifications and Occupations) is the European multilingual classification of Skills, Competences, Qualifications and Occupations. It is a European Commission project, run by Directorate General Employment, Social Affairs and Inclusion (DG EMPL).*
>
> *ESCO works as a dictionary, describing, identifying and classifying professional occupations, skills, and qualifications relevant for the EU labour market and education and training.*
>
> *ESCO provides descriptions of 2942 occupations and 13.485 skills linked to these occupations, translated into 27 languages (all official EU languages plus Icelandic, Norwegian and Arabic). Over time, it will also display the qualifications awarded in the education and training systems from Member States, as well as qualifications issued by private awarding bodies.*
>
> *The aim of ESCO is to support job mobility across Europe and therefore a more integrated and efficient labour market, by offering a “common language” on occupations and skills that can be used by different stakeholders on employment and education and training topics.*
>
> (https://ec.europa.eu/esco/portal/howtouse/21da6a9a-02d1-4533-8057-dea0a824a17a)

3.1 ESCO structure

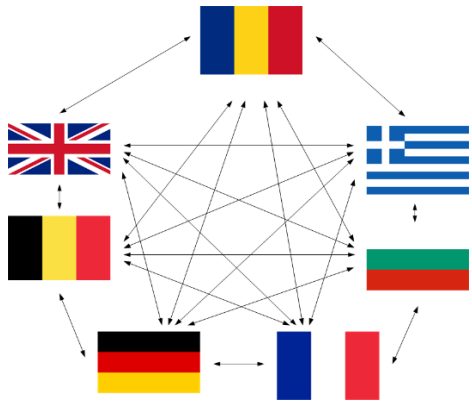
The structure contains 3 pillars representing skills/competences, occupations and qualifications. The 3 pillars are related to each other.



(ESCO structure)

The system makes it possible to compare skills/competences, occupations and qualifications by creating a “go between” that can be used by all countries to relate their national systems to.

A simple example shows the gain this system creates: the comparison between all countries of a single qualification.

Before ESCO	With ESCO
	
• 28 countries make comparisons with 27 countries • 756 comparisons to check 1 occupation	• 28 countries use 1 common (ESCO) qualification • 28 comparisons to check 1 occupation

(Overview or comparisons with and without ESCO)

ESCO is an open source database and can be used to develop different competence related tools and applications.

- Nina Tiptoe has worked in several different countries in Europe, she used ESCO to describe all her work experiences in her Europass CV.
- Tony Solo looks for jobs in different countries. The local unemployment office sends him offers they receive on a regular base. They receive these offers form their colleagues through the EURES-ESCO system.
- The qualification that Ben Young and Mary Standard receive is listed in the ESCO Qualifications database which makes it easier to get it recognised in other countries.

3.2 The ESCO theatre Technical competences

The team that wrote the theatre technical competences for ESCO based their work on an earlier project named TTT-LPT. In the documentation of the project we find the core elements for describing the competences:

> *To make skills useful in a European context, it is essential that the descriptions are language independent, independent of culture and independent of technology. This because they should be transferable to new local contexts. This puts a significant responsibility to the reader / user. He / she must interpret the content and put it in the local context.*
>
> *To translate existing job descriptions into a transparent, readable and comparable system, the competences have to be small enough. They should be smaller than or equal to the*

existing descriptions. Otherwise, an existing profile can never be described accurately. Within this project we like to make the comparison with the "lowest common denominator" to describe this.

The units should also be written in sufficient detail so that a user in a different context understands what the precise scope is. The description must indicate not only the content of the competence, but also the level at which it is governed.

Where possible we also sought the greatest possible universality. This creates a "reusability" of competences. The competences can be transferred from one profile to another. Because the competences are written as "lowest common denominator" the set designer and lighting designer will both have the competence "design" in their profile. The context of technical skills on light or set decide what kind of designer is meant.

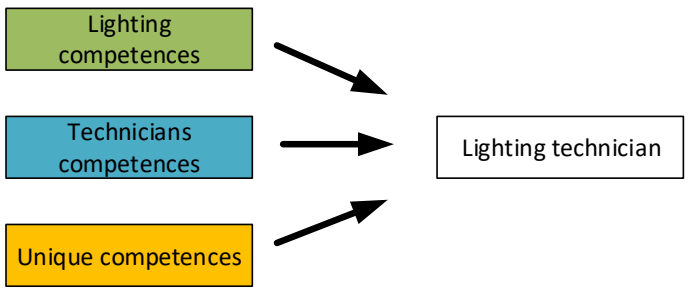
Because a large number of competences are created by this method, it is necessary to place them in a matrix or cluster to improve searching. Within this project we have chosen for a combination of both. The competences are classified in fields and subfields, but they are also placed on the timeline of a production.

Finally, we found it important that the descriptions were usable for different purposes. The same competency units must be useful for making individual profiles, portfolios, job profiles, training needs analysis, making of training programs, monitoring of learning progress, etc. We are convinced that these conditions contribute to more transparency between the various countries and organizations. Mobility is strongly facilitated in this way.

(Competence units for technical theatre, Mia Erlin, Tony Bond, Anders Larson, Chris Van Goethem, Umberto Bellodi 2013, TTT-LPT Leonardo project)

This way of writing in smallest common denominators facilitates the writing of the competences in a way that they are maximum reusable. The competences used in the occupations can be divided in

- level competences, these are competences that reoccur in different occupations on the same (EQF) level) for example design competences that describe the designing aspect of a designer, independent of what is designed.
- Field competences, competences that are related to a specific field and that reoccur on different levels. For example, using a light board is done by a technician, an operator and a designer.
- Unique competences, related to a specific competence, unique to a specific occupation.

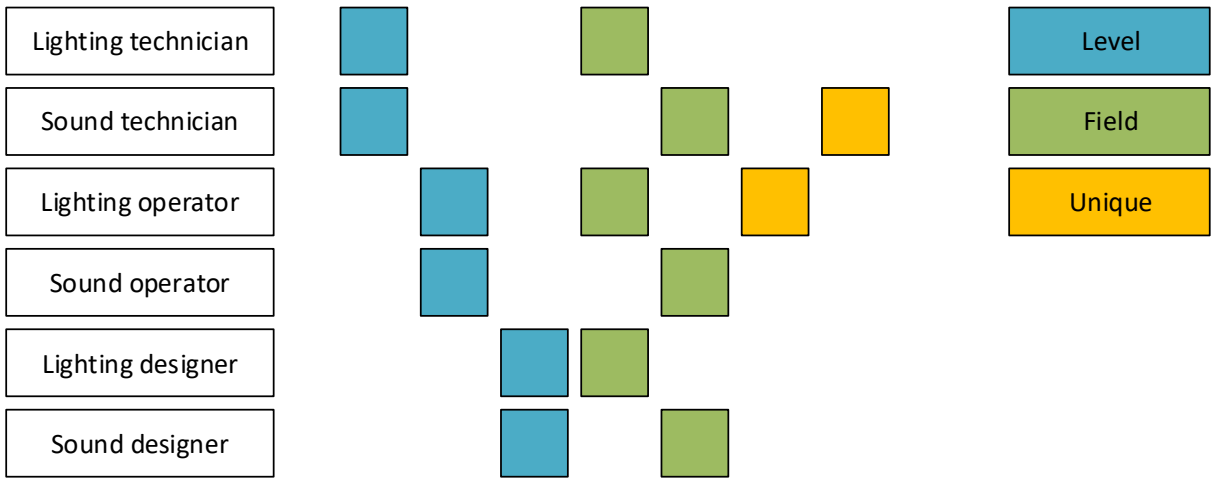


(Different types of competences in a theatre technical profile)

Moreover, this way of writing and organising the competences reflects the sectoral reality where a lot of occupations have “stepped profiles”, they are built on top of each other. For example, the

lighting operator will have the competences of the lighting technician, combined with higher level skills.

When the occupations are organised in a grid, the reusability of the different types of skills becomes visible.



(Combining different types of competences in different levels and fields)

3.3 Where it went wrong, a critical note

The first version of ESCO was written by groups of experts that worked independent from each other with only minimal guidelines. This made that the competences are not written in a consequent way or size and that often multiple occurrences of the same or similar competence occurred.

Some experts from other sectors developed a different approach, which included more knowledge elements. Often these knowledge elements were only a translation/adoption of existing competence. For example, the knowledge element “health and safety in the workplace“ described as “The body of rules, procedures and regulations related to safety, health and welfare of people in their workplace.“ can be seen as a translation of or underpinning the competence “work with respect for own safety”.

The system limited the possibilities to develop a clear content. For example, it was impossible to create a logical order in the competences (they are displayed alphabetical). The division between optional and essential skills was arbitrary, because a numeric relation between both types was demanded. For example, “work with respect for own safety” is an optional skill for a high rigger, one of the most dangerous occupations in the sector.

Based on the work of the expert groups, the results were adapted and translated by language experts that had no expertise in the field and didn’t consult the experts. A sector specific language is hard to translate and needs accurate wording to grab the exact span of the content.

The content of the ESCO taxonomy is not crosschecked with other European systems like the Regulated professions database.

Moreover, in the process leading to the first public version, decisions were made that didn’t help the clarity and transparency of the system. The scope notes and other additional information was lost (left out). Some examples:

The relation between the competences was made by non-experts, this results for example in "prevent technical problems with lighting equipment" being a narrower skill of "prevent technical problems with stage equipment" (mechanical lifting devices).

In the process of the language check **"Change-over** scenic elements during performance" became "**modify** scenic elements during performance" (change-over means changing the sets on stage by moving them on or off).

Alternative labels were given, without looking at the exact content or the description. For example "**use** personal protection equipment" has an alternative label "**oversee** personal protection equipment" (which is clearly a different level).

In some cases competences from other sectors were reused, that had a different meaning. "**working** on heights" became for example "**enforce safety procedures** when working at heights" (which is a different level and another content, moreover it reflects a different vision on safety).

Sometimes competences were linked to other sector's knowledge, which leads for example to a knowledge unit "Know and understand the structures located besides **railway** tracks known as signal boxes, interlocking towers, signal posts, and signal cabins, from which signals, points, and other equipment are controlled." connected to "distribute control signals" which is about **entertainment lighting** control.

The use of ISCO as a logical structure, instead of the structure that the sector developed, leads to confusion and difficulties in finding matching similar occupations. For example, the designers, all working in a theatre context, are found on different levels and in different fields.

- Set designer – interior designers and decorators (3432)
- Lighting designer – other artistic and cultural professionals (3435)
- Costume designer – industrial designer – product and garment designers (2163)
- Video designer – graphic and media designer (2166)
- Sound designer – audio-visual technicians – broadcasting and audio-visual technicians (3521)

All these elements have caused a certain reluctance by professionals to build further based on the system. Some other projects decided to use the non-published last version before the changes. The next version will be published in 2021 with input from experts of the field, so there is good hope that the above issues will be solved by then.

3.4 Limitations of ESCO

Due to its original purpose, ESCO has limitations in terms for a direct usable system for education, training, assessment or qualification. The system lacks detail to ensure required trust between different partners or countries in the description of qualifications or learning content.

For example, the competence "Use personal protection equipment" is used for the "armed forces officer" as for the "stage manager". One can imagine that, even if the concept is applicable to both occupations, the concrete learning content and the span of the competence are reasonably different.

The occupation descriptions are too open to be useful in practice.

3.5 ESCO and "General education"

ESCO focusses strongly on occupational competences. The occupations are written to be useful for the labour market, but do not include "general education". The European commission defined a set of key competences for lifelong learning (last updated in March 2019) but these are not included in the occupations.

Qualifications often include a set of general education competences, history, language, understanding of society, physics, math, biology, geography, … are an important part of our education. We do not only train people for a job, we also prepare them to active members of society. Identity building, functioning in society, entrepreneurship, democratic values, cultural awareness, … are key to this. These competences are essential for living together, being a human being, but not specific for an occupational context.

This discrepancy between occupational profiles and qualification including "general education" can cause a conflict in how we measure level and content of a qualification. If credits are time related and level is dependent on level of thinking, not taking in account general education would lower level of qualifications.

But there is more, every employer expects a certain amount of general education of his/her workers. These competences are needed for building relationships with clients, to work in a team, to understand context, etc. Leaving them out lowers artificially the level of an occupational profile.

3.6 ESCO as a backbone

On the other hand, ESCO comes as close as possible to a common language that spans all European countries. It gives, for a well willing reader, a good idea of what the competences mean within a specific context.

This common language can be used as a backbone, connecting more detailed sector specific descriptions. The first ideas about a backbone were developed in the OPTiV (PWO) project (see Building blocks for unique people, Chris Van Goethem, Expertise Centre for Technical Theatre RITS, Erasmus University College Brussels) and its successor "Backbone". The common descriptions of competences are "enriched" with extra information about skills, underpinning knowledge, attitudes, weight and level. The information is organised in a way that it can be used for occupational and educational profiles, structured portfolio's, self-evaluation, measuring training demand, etc.

3.7 ESCO in comparison with other transparency systems for VET

In the past several methods and taxonomies have been developed to ensure transparency between different countries and different uses. We focus here on developments that are focussed on vocational training and occupations.

The **DISCO** taxonomy provided a common language that could be used for CV's and job applications. These statements were more open and less defined than the ESCO competences and were focussed on the specific needs in HR application. (http://disco-tools.eu) The taxonomy can be used in combination the different Europass tools. (https://europass.cedefop.europa.eu/)

EURES, the European Job Mobility Portal used a HR based taxonomy, but is connected to ESCO now. (https://ec.europa.eu/eures/)

O*Net (https://www.onetonline.org) is a US based system that provides cross occupation connections, but use very generalist sets of technological skills, general skills, knowledge abilities and

work activities. On the other hand it is more concrete describing tasks, tools used and detailed work activities. This is an interesting starting point, but ignores the competence-based view.

The **VQTS** (Vocational Qualification Transfer System) (https://vocationalqualification.net) project developed a methodology to describe occupational profiles. The matrix concept they developed is based on Competence Areas wherein the competences are described as a fluidum of two and six successive steps of the competence development process, rather than defined level of competence. This is an interesting way to describe learning paths towards qualifications, but the concept also limits a more universal use of the competences.

- The competences are based on specific occupation, and strongly context related which limits (automatic) transferability
- The competences include multiple measuring criteria that are not necessarily related to each other, which makes it difficult to assess them with Yes of No, there is a lot of interpretation needed from the assessor.

The successive **ECVAET** (http://www.ecvaet.eu) projects have developed a competence matrix for Event technology worker (EQF4) and the Meister (master craftsperson, EQF6). The project also developed, based on the matrixes, a training program for technicians moving between the different partner countries of the project. These training programs adapt the existing competence to the different working context. Finally, the project developed a safety matrix, related to the both matrixes, and describing in detail the competence area's and the related objects of protection, including the skill level expected.

3.8 How and why does this feed into LAAR?

The LAAR project embraces ESCO as a concretisation of the competence concept. By using ESCO as a starting point to develop applications and measuring / assessment systems, we ensure a wide understanding and a connection with other European systems and visions.

The ETTE competences are written in ESCO competences, that occur in almost every technical theatre profile. The competences are:

- Working with respect for your own safety.
- Contributing to a safe and sustainable working environment.
- Working ergonomically.
- Use personal protective equipment.
- Fire prevention in a performance environment.
- Safe working at height.
- Work safely with mobile electrical systems under supervision.
- Work safely with tools.
- Safe working with chemicals.
- Fit up and rig stage equipment.

The LAAR project used a selection of these competences to develop test cases.

4 A sectoral layer

A competence model that not only can be used for exchange of employment opportunities, but also for education and training clearly needs more (sector specific) detail than can be offered by the ESCO taxonomy. This can be solved using the principles for detailed descriptions developed in the TTT-LPT (https://www.podiumtechnieken.be/wp-content/uploads/2018/05/Inleiding-TTT-NL-Tot-v8_0.pdf) and OPTiV project. (Building blocks for unique people, Competence profiles for theatre technicians, Chris Van Goethem, Erasmus University College)

If we also want to use the same model for mutual recognition of certification, competence, and qualification we need more than just descriptions of competences. This mutual recognition is essential to allow mobility in a context where regional or national governments want to keep authority over education and training. The TALQ project (Final Report, Umberto Bellodi, Chris Van Goethem, 2017, KA3 TALQ - Transparency in Arts Levels and Qualifications) identified 3 requirements for a workable model.

Transparency

To be able to accept each other's certifications and qualifications, we need to understand each other, we need a common agreed language, we need to grab the exact meaning and depth of each competence. For this purpose, ESCO as an international agreed taxonomy, is the preferred system to build on. The competences can be described in detail on a sectoral level, but keep their (one to one) connection with the ESCO taxonomy. Additional to this, EQF, ECVET and ECTS can be used as a reference to define the level and volume of the competences.

We also need a common sectoral profile, an agreed description of what an occupation or activity, covered by a certificate or qualification, exactly covers. These sectoral profiles can be developed based on the ESCO occupations, but making a more strict definition of the required competence set and organising the competences in a logic readable way.

Trust

The value of a qualification or certification is about trust. We need be sure that the holder is able to perform what is mentioned on the document. This can only be guaranteed by an objective, independent and standardised measurement that meets the highest quality standards. A sectoral layer should include the needed information needed to execute the measurement. Ideally this information is given on the level of the competences in order to reuse them in different profiles.

Freedom of education and organisation

Recognition of common definitions of competence and occupations should not interfere in the way education is organised. Every country, region, school, … should be free to organise their education as they want. This is the best guarantee for an education that is embedded in society and adapted to local needs, culture and traditions. Moreover, the primary stakeholders of education and training are local so it makes sense the decision making and quality control is organised on that level.

In the same logic of stakeholder ship, every learner as the owner of a learning process, should be free to choose the learning path of his/her choice. This can be formal school education, apprenticeship, self-learning, or any form or combination that suits the learner.

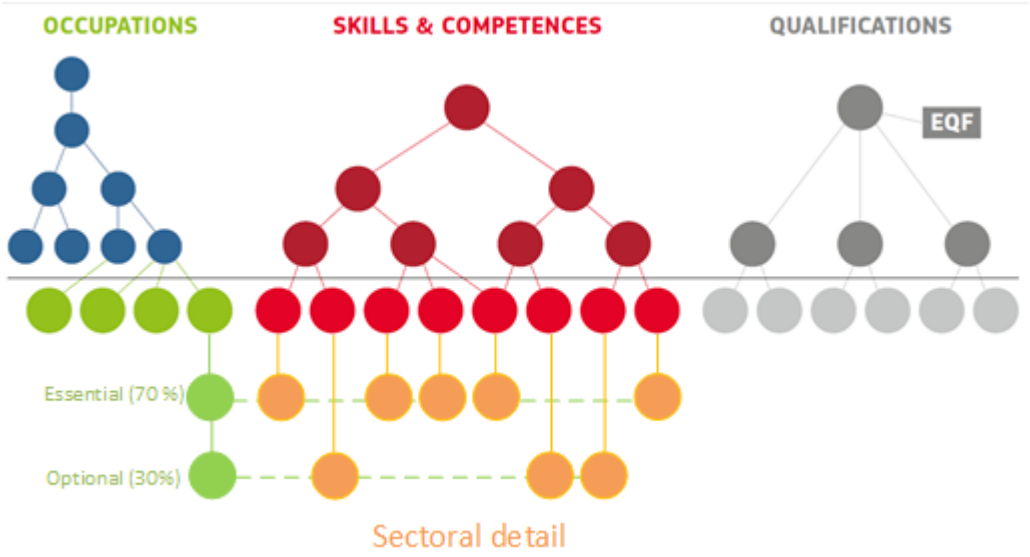
To allow enough flexibility for education organisers and learners, the TALQ project proposed a variable occupational profile with 70% fixed competences and 30% variable competences (out of a

predefined set). This 70/30 relation guarantees a common understanding of the content of an occupation and leaves enough possibilities to adapt to local occupational differences.

On the other hand, the stakeholders of certification and qualification are per definition international in a wold that promotes mobility. The value of a certificate or qualification can only be measured by the value given by the (international) users of it. Therefore, the definition of the competences, generic occupation descriptions, the used assessment methodology and the quality control needs to be on an international level.

The measures to guarantee transparency and trust described above should therefore be agreed on an international level in cooperation with international stakeholders. To ensure a high-quality standard of the assessment, the ISO/IEC 17024 standard could be used as a guideline.

This results in a model that relates ESCO with the components of the sectoral layer.



(ESCO with the sectoral layer)

4.1 Structure and information of a sectoral layer competence

The minimum requirements of a sectoral layer competence to comply with the demands of the 3 principals stated above are the following:

- **ESCO reference**, referring to the ESCO system. This makes it possible to reference them back to national systems. It also provides the opportunity to get more detail about the ESCO competence like the reusability level, in which occupations it is used, alternative titles, etc.
- **Competence title** retrieved from the ESCO nomenclature.
- **Description** retrieved from the ESCO nomenclature. The description gives a short definition to give the user better understanding of the competence.
- **Context** is a more free, sector adapted explication of where and in what context the competence is used. (This field has been removed of the ESCO nomenclature, but is useful in a sectoral context.)
- **Scope note** is used to draw borders where one can assume the title or definition is not clear enough. It can include or exclude specific complexity levels or situations. (This field has been removed of the ESCO nomenclature, but is useful in a sectoral context.) Examples: “Includes safety shoes, hearing protection, gloves, hard hats, fall protection, etc.”, “Includes protection

against occupational diseases", "Excludes climbing equipment", "Excludes the actual fire intervention and evacuation organisation."

- **Skills, knowledge and attitude**, a set of descriptors that define in detail the competence. (see further).
- **Assessment strategy/methods** describes in short what assessment methods are acceptable for this competence and what elements should be measured in an assessment setting. This will help coaches and trainers to prepare for a final assessment.
- **A level and a volume description** indicating the relation to EQF/SQF and to a credit system. (see further)

Next to this essential information, extra information can be added to support the teaching and training process. Some examples:

- Rubrics for self-evaluation and evaluation
- Links to further reading, References, National notes and Legislation
- Teaching material, tools, video's, apps, etc. that can be used
- Training good practices

4.1.1 Skills, knowledge and attitude

It is sometimes hard to make a clear distinction between skills, knowledge and attitude. All can be rewritten in one of the other forms. On top of this, sometimes they are all referred to in the educational terminology as learning outcomes or performance criteria, but in other cases these terms refer only to one of them. In a simplistic model, we could state from the teacher/trainers' point of view:

- Skills is what we train
- Knowledge is what we teach
- Attitude is what we stimulate by mentoring/coaching

Or we could state from the learners' point of view:

- Skills is what the learner is able to
- Knowledge is what the learner needs to know/understand to be able to
- Attitude is how the learner should behave to be able to

If we go more in depth, we can define them as follows:

Skill

The skills describe concrete and objective, observable, measurable actions that you would expect from a worker that masters a competence. Where possible, the skills are written in observable sentences. (In some countries, the term "performance criteria" is used for the skills.) Often, they are written with "the learner is able to" or "the practitioner" in front of the sentence, but leaving such obvious elements out improves readability. To get a better understanding of the level of mastering, "bloom like" descriptors are used.

Examples:

- Works according safety training and instructions
- Protects oneself against hazards
- Signals risks to responsible

In exceptional cases, knowledge is described as a skill. This is the case when it is necessary to measure the underpinning knowledge because it doesn't show in the skills.

Examples:

- Understands the risks in a performance environment and the mechanisms behind them.
- Understands own position in the safety chain and acts accordingly.

Knowledge

The knowledge refers to logical blocks of underpinning knowledge needed to perform the competence. The knowledge is limited to what is really necessary to master the skills and the whole of the competence. The blocks are divided and sized in a way that they can easily be reused for other competences. Often, they are written with "knowledge of" in front of the sentence, but leaving such obvious elements out improves readability. The knowledge blocks can be described in detail in a separate format.

Example: Accident theory

Attitude

The attitude section lists attitudes that will support the mastering of the competence. General attitudes that can be expected from every professional are not included.

Example:

- Awareness of long-term impact on personal health

4.1.2 Credit systems, ECVET and ECTS

Credit systems measure the "value" of (part of) a qualification of profile. This value is related to the effort it takes for an average learner to reach the qualification. Roughly we can distinguish two major systems:

- ECTS (European Credit Transfer System) is used in Higher Education. It is time based, a credit refers to the average time use for learning in a standard trajectory. A credit is 1/60th of an average year.
- ECVET (European Credit system for Vocational Education and Training) is used in in vocational education. The system is indirectly time based. It is recommended that the ECVET points refer to (1/60 of) a year of learning in a standard learning path.

In training, apprenticeship or recognition of prior learning this time-based approach does not really work, but even if time is not really related, it is a good and understandable reference to the effort that is supposed to be done to acquire the qualification and so of the "value".

Both systems are too large to measure the "value" of a single competence. But it would be possible to use a partial of a credit to (for example a centi-credit) to express this "value".

4.1.3 Levels and EQF

To define the level of a qualification, EQF (European Qualification Framework) is used. In the performing arts, sometime also SQF (Sectoral Qualification Framework) is used, which is an adaptation with descriptors that are more accurate for the arts, but do not change anything to the general concept or level of EQF.

The EQF is meant for measuring a full qualification. In theory it does not make sense to define a level for a single competence. On the other hand, defining a level helps to understand the span of a competence. In this case it works rather as an indicator than an absolute figure. In the TALQ project the choice is made to use the lowest level of occurrence in a qualification as the EQF reference of a competence.

4.1.4 Example of a sectoral layer competence description

This example is the first of the ETTE competences, as developed by the ETTE project. The knowledge elements refer to detailed descriptions of the knowledge required for the competence.

Work with respect for own safety

Description

Show awareness of risks related to activities in the performing arts and act accordingly to ensure the own safety.

Context

Understand the risks and prevention measures for your own personal health and safety on stage and apply the basic safety rules in your own practice, according to training and instruction.

Scope Note

- Includes protection against occupational diseases
- Includes the theoretical background of risk prevention

Skill

- Understand the risks in a performance environment and the mechanisms behind them
- Understand your own position in the safety chain and act accordingly
- Work according to safety training and instructions
- Protect oneself against hazards
- Signal risks to a responsible

List of Knowledge

- Accident theory
- Five steps to reduce risk
- Your rights and obligations

Attitude

- Safety awareness
- Awareness of your own behaviour

Level and volume

- occurs from EQF level 3 upwards
- 0.3 ECTS

Assessment

Measuring sentences

- I do not understand risks on stage or procedures.
- I don't feel completely competent to deal with risks on stage.
- I understand the risks and prevention measures and I apply the basic safety rules.
- I point my colleagues to riskful situations and promote the basic safetyrules.

Assessment strategy

- Can be assessed by observation in combination with other professional skills in a real life environment

ESCO reference

- work with respect for own safety
- https://ec.europa.eu/esco/portal/skill?uri=http%3A%2F%2Fdata.europa.eu%2Fesco%2Fskill%2Fb73035a9-bf06-412c-9796-db579f85995c&conceptLanguage=en&full=true

4.2 Structure and information of a sectoral layer occupation or profile

The minimum requirements of a sectoral layer occupation to comply with the demands of the 3 principals stated above are the following:

- **ESCO reference**, referring to the ESCO system. This makes it possible to reference them back to national systems. It also provides the opportunity to get more detail about the ESCO occupation like the alternative titles (labels), ISCO codes and hierarchy, regulation, etc.
- **Occupation title** retrieved from the ESCO nomenclature.
- **Description** retrieved from the ESCO nomenclature. The description gives a short definition to give the user better understanding of the competence.
- **List of obligatory competences,** these link to the sectoral layer competences. They are organised and clustered in a logical order. The whole set represents 70% of the occupation.
- **List of optional competences,** these link to the sectoral layer competences. They are organised and clustered in a logical order. The set is used to choose 30% of the occupation's competences that are variable.
- **A level and a volume description** indicating the relation to EQF/SQF and to a credit system.

Profiles can be used to describe (parts of) occupations that used in different countries, but that are not included in the ESCO database. This can be for example Health and Safety certificates or licences to use specific equipment.

4.2.1 The logical order of competences

Even if the competences are written to be used independent, it helps the reader to use a specific order in a profile. In the TTT-LPT project a logical order, combined with a numbering system was developed.

The system was based on 3 elements: the field, an additional subfield and the place in the process. Using this numbering system results in competences automatically clustered by field, with specialised subfields at the end. The order of the competences is the order "of appearance", in other words, competences that occur first in a process will also be earlier in the list. This helps the reader to understand the relation between the competences and so to understand better the whole occupation. (unloading a truck appears before setting up the stuff unloaded).

4.2.2 Example of a sectoral layer profile

The example below is the occupational profile for an assessor in the event and performing arts field, developed by ETTEC for the ETTE assessment process. In this case the profile has no level or volume assigned to it because the profile is not used in a educational context.

Assessor Occupational Standard

Description:

An assessor measures the competences of a candidate against a given qualification profile, according to a pre-defined standard or procedure and judges objectively if the candidate reaches the performance criteria of the competences.

Scope note:

Apart from the specific skills needed to assess candidates, the assessor also needs a profound understanding of

- The field, and the occupations
- The qualifications and standards for the targeted occupations
- The different standards, assessment methods and procedures of the targeted occupations

Assessors need to have substantial demonstrable experience in the targeted occupations they are assessing.

This is not further developed in this profile, as it depends on the type of field, education and assessment.

Competences

Assessment

- **administer exams** (Set the dates and policies for the exam session and make sure all accommodations and materials are provided)
- **prepare examinations** for vocational courses (Prepare examinations that test both theoretical and practical understanding of the content and the procedures imparted during a course or teaching programme. Develop exams that assess the most important insights that trainees should have gained from participating in the course.)
- **manage tests** (Develop, administer and evaluate a specific set of tests relevant to your activities or to the people who have to complete the tests)
- **conduct examination processes** for apprentices (Provide examinations to trainees and students on their practical knowledge. Follow procedures to assure transparency and accuracy in the assessment exercise.)
- **instruct on safety measures** (Provide instruction on the possible causes of accidents or sources of danger and explain the protective measures that should be taken to guarantee health and safety.)

- **assess students** (Evaluate the students' (academic) progress, achievements, course knowledge and skills through assignments, tests, and examinations. Diagnose their needs and track their progress, strengths, and weaknesses. Formulate a summative statement of the goals the student achieved.)
- **assist clients with special needs** (Aid clients with special needs following relevant guidelines and special standards. Recognise their needs and accurately respond to them if needed.)

Communication and feedback

- **show social competences** (Ability to interact effectively with other people.)
- **listen actively** (Give attention to what other people say, patiently understand points being made, asking questions as appropriate, and not interrupting at inappropriate times; able to listen carefully the needs of customers, clients, passengers, service users or others, and provide solutions accordingly.)
- **use different communication channels** (Use various types of communication channels such as verbal, handwritten, digital and telephonic communication with the aim of constructing and sharing information and ideas.)
- **use questioning techniques** (Formulate questions appropriate to the purpose, such as eliciting accurate information or supporting the learning process.)
- interview people (Interview people in a range of different circumstances)
- assess others (Assess, estimate and understand the feelings or temperament of others; showing empathy)
- **give constructive feedback** (Provide founded feedback through both criticism and praise in a respectful, clear, and consistent manner. Highlight achievements as well as mistakes and set up methods of formative assessment to evaluate work.)

Quality and ethics

- **follow ethical code of conduct** (Carry out workplace activities according to accepted principles of right and wrong, including fairness, transparency and impartiality in work practices and conduct towards other people.)
- **apply quality standards** (Follow procedures which prevent errors in creation and delivery of a product, a solution or a service to customers.)

Professional development

- **manage personal professional development** (Take responsibility for lifelong learning and continuous professional development. Engage in learning to support and update professional competence. Identify priority areas for professional development based on reflection about own practice and through contact with peers and stakeholders.)
- **reflect on practice** (Routinely evaluate own practice, critically evaluating and monitoring the practice methods and outcomes in consistent, coherent and appropriate ways, being aware of relevant methodologies and utilising feedback from managers, supervisors, other professionals, and patients/clients, in order to adapt the practice accordingly.)
- **monitor developments in field of expertise** (Keep up with new research, regulations, and other significant changes, labour market related or otherwise, occurring within the field of specialisation.)
- **develop professional network** (Reach out to and meet up with people in a professional context. Find common ground and use your contacts for mutual benefit. Keep track of

the people in your personal professional network and stay up to date on their activities.)

Administration

- **maintain professional administration** (File and organise professional administration documents comprehensively, keep customer records, fill in forms or log books and prepare documents about company-related matter.)
- **keep personal administratio**n (File and organise personal administration documents comprehensively.)

Knowledge

- **assessment processes** (Various evaluation techniques, theories, and tools applicable in the assessment of students, participants in a programme, and employees. Different assessment strategies such as initial, formative, summative and self- assessment are used for varying purposes.)

4.2.3 Occupational vs. educational profiles

Most countries make a distinction between occupational and educational profiles. Where occupational profiles only state the competences needed to perform a profession, the educational profiles include also more general competences that define the level of the education program. These general competences are transferable to other profiles of the same level. One can for example expect a certain level of abstract thinking from a bachelor level.

In technical theatre profiles the difference is minimal, as most “occupational” competences inherent include a general level of thinking.

For other fields there are two options, the educational profile could be a level higher or the educational competences are included in the 30% optional competences.

4.2.4 work focused profiles

In some cases, a specific task does not need an educational or occupational profile as a whole. But it needs a form of certification based on a common description. Examples are certificates for fork lift drivers or to work in a specific environment.

The ETTE basic safety competences are a other example of such a profile. It only contains 10 competences that are essential for safe working on stage and ensures mutual recognition between countries. The result is that every employer can be sure a worker can work safe on his stage.

- Nina Tiptoe, the dancer uses the sectoral layer to understand better what the exact meaning of the ESCO competences is in het (future) work context. This helps her to clarify which of her dance competences are transferable and which need some adaptation.
- Tony Solo, the freelancer, uses the sectoral layer to understand better what exactly is expected in different countries. He also uses the sectoral layer to show to employers in different countries what his exact skills are and where/if they differ from the local ones.
- Ben Young, the apprentice, uses the sectoral layer in his evaluation talks with his mentor. The descriptions help both to define what is gained and what need some work. The ETTE competences allow him to work is high risk areas.
- Mary Standard, school program is based on the sectoral layer, in this way it is easy to discuss international exchange, because everyone has a good understanding of the exact content and variations of her program.

4.3 How and why does this feed into LAAR?

The sectoral layer helps within the LAAR project to grasp the exact meaning of a competence and what needs to be trained or measured. The detailed description ensures that the competence is understood in all countries in the same way and that different developers use the same level and context to create training and measuring methods.

The description of the ESCO competences in ETTE follow the structure of the sectoral layer. Therefore, developers can get access to the extensive database that provides enough details about the context and the content and to develop applications. The assessment guidelines strengthen the understanding of the exact level that is expected.

5 Tools and applications based on a sectoral layer

Once a sectoral layer is developed with all the extra information and it is agreed on by the sectoral stakeholders, it can be used as a common language bridging different types of applications. These applications can be used for training, assessment, certification and qualification, but also for job application and matching, HR and Life Long Learning.

Because all applications can use the same language it becomes easier to transfer results from one application to another, from one organisation to another, and from one country/language to another. This improved transparency supports the learner/worker during his professional path.

Below we describe some examples of good practices, applications and tools that can be integrated in the concept of a sectoral layer.

5.1 Developing occupational and educational profiles

Aside from the profiles developed in ESCO, extra occupational or educational profiles can be developed to serve specific local needs. Because these local profiles reuse competence descriptions from the Sectoral Layer, they are easily connectable to the existing profiles. Moreover, the presence of agreed assessment methods and detailed information about the content will facilitate the acceptance of the profiles in an international context.

5.2 Developing curricula and courses

Using a Sectoral Layer for the development of curricula and course increases the efficiency of the course setup. There are several elements that improve the efficiency:

- Often competences share the same knowledge by using the Sectoral Layer (on the level of skills and knowledge), such overlaps are detected. Based on this, clear decisions can be made on who teaches the knowledge and if it is needed to double the knowledge in several courses.
- Teachers know from each other what knowledge is taught.
- Teachers know what skills are served by the knowledge and can focus on relevant issues related to these skills.
- Knowledge elements can be clustered and planned in relation with the practical training.
- Teaching and training material can be reused easily (in case of stepped profiles even over different levels).

5.3 Training needs analysis

The Sectoral Layer can be used as a starting point to make an inventory or the needed vs. the available competences in an organisation. This inventory can be used to develop training for staff. The smallest common denominator structure makes that short, very focussed training can be provided. The training needs analysis can be combined with a permanent competence follow us system for the employees.

5.4 Follow up of apprentices

The Flemish Cue-One-go (https://www.podiumtechnieken.be/en/competentions/cue-one-go/) project uses a set of competences, similar to ESCO, to follow up apprentices. In a first phase, the company uses the competence set to describe what they can offer, and the apprentice describes what competences he/she already har acquired. Based on the combination of this information, a learning path is set out. From this learning path, a selection of competences is made for the first period of learning.

At the end of the first learning period, apprentice and learning coach both evaluate the work done with a set of rubrics, connected to the competence set. In the following evaluation talk, they can focus on points that they interpret differently, which improves the efficiency of the evaluation. At the end of the evaluation new goals are set for the next learning period.

As snapshots are kept of the evaluations, the learner and the coach have a good view on progress made.

5.5 A structured portfolio

A traditional portfolio is a collection of evidence pieces of previous work that can be used to accompany a CV or job application. In reality it is hard for a reader to relate these documents to a specific job or occupational profile.

The TeBeVat (https://tebevat.eu/) project built further on the portfolio developed by TTT-LPT. This type of portfolio is structured based on the competences of the Sectoral Layer. Each evidence piece is linked to one or more competences and the relation is commented. The user is now able to document his/her career in a structured way, connected to the sectoral Layer and ESCO.

The portfolio also implements other tools, developed by the EU.

- It gathers information that can be used by the European Curriculum vitae
- It implements the European Language Passport (a self-assessment tool for language skills and qualifications.)
- It implements the European Digital Competence Grid
- The Europass Mobility, the Certificate Supplement and the Diploma Supplement can be translated into ESCO competences and used as evidence pieces.
- Use of other EU tools

The fact that all evidence is related to competence also means one does not have to redo all the work in case of a recognition of prior learning procedure. It is enough to verify if all the competences are covered by convincing evidence.

Further, the portfolio includes some sector specific elements that are not common in other sectors:

- A job list, specific for freelance workers, to collect information of their work
- A technology list, specifying what equipment one is able to operate.

The portfolio does not integrate tools like DISCO (http://disco-tools.eu) or the regulated professions

5.6 Personal Development plan

Based on the Cue One Go methodology, a Personal Development Plan can be set up in which the professional can set goals, described as a set of competences and keep overview on his/her progress in learning by gathering evidence for these personal goals. Based on rubrics the professional can easily follow up his/her progress.

5.7 Combining tools

One of the main advantages of this way of structuring tools is that existing content and parts of tools can be reused. The fact that the same descriptions are reused in all labour related applications also improves the acceptance and habituation for the staff.

- Nina Tiptoe, the dancer has made a structured portfolio of her previous career. She compared the competences she acquired with different occupational profiles and developed based on the differences a Personal Development plan.
- Tony Solo, the freelancer uses the portfolio to keep track of his work and related competences. He uses this portfolio to present himself to different employers. These employers get the basic information in their own language due the link to ESCO.
- Ben Young, the apprentice has used his prior learning, recorded in his portfolio, at the start of his apprenticeship. In the portfolio, he also notes his voluntary work at the youth club. He uses the follow up tool to discuss his progress with his mentor. Based in this talks they set new targets every month.
- Mary Standard, the student studies a program developed based on the sectoral layer. At the end of her studies, she will transfer all the acquired competences in het portfolio. She already has done a first work experience and could add some competences already, together with her climbing skills that will be useful for rigging.

5.8 How and why does this feed into LAAR?

The LAAR project uses the same methodology to develop the applications. More specifically, all applications will provide information in a format that fits into the portfolio.

The size of the ETTE competences is based on the “smallest common denominator” concept. Therefore, they can easily be integrated in different curricula. Based on the ETTE profile, (traditional) course material is developed for learners and teachers. This material is modular, so it can be used in different training strategies. The integrated rubrics can be used for training needs analysis and follow up of apprentices. The competences can be used as a backbone for a structured portfolio and a personal development plan.

6 The learning wallet

The different tools above use the same taxonomy, derived from ESCO and the Sectoral Layer, but work still independent of each other. The information about the achievements of the learner are kept in different systems and formats. A learner has no common place to safe/store all his/her achievements. This becomes an issue when a student leaves school, an apprentice changes organisation or even more when a Lifelong Learner learns in different contexts. The learner loses information about his learning that could be reused in other contexts.

A similar issue occurs using different digitalised tools to support learning. They all use and keep information about the learning activity, retrieved from the tools, but there is no way to combine or exchange information between the tools.

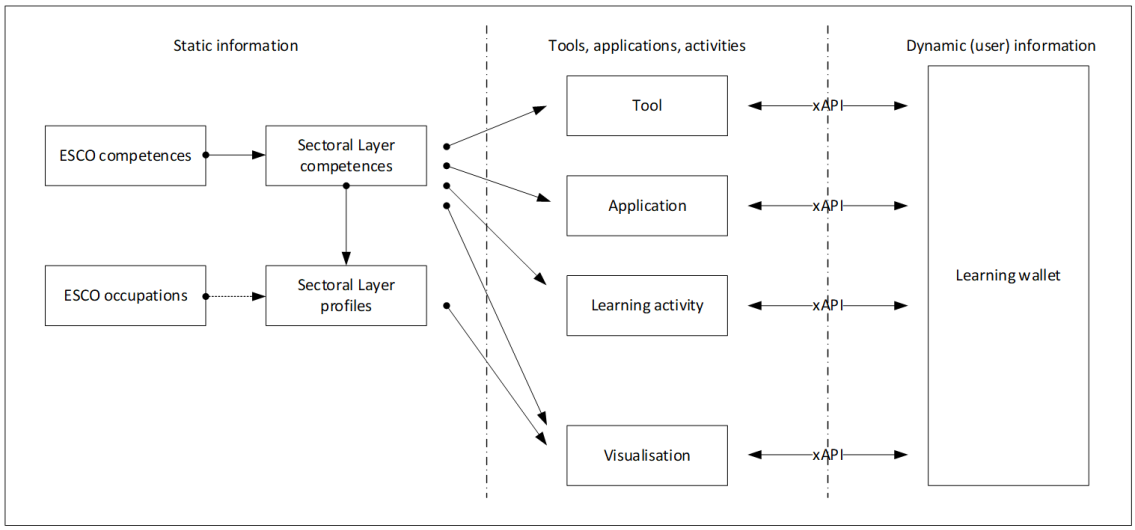
Moreover, the ISO/IEC 17024 quality standard for bodies operating certification of persons (and other similar standards), states that the information about the leaning and certification is owned by the learner. He/she is entitled to decide who has access, what the information is used for, etc.

Where the Sectoral Layer provides us with static information and the different tools and applications provide us with information about what a learner has achieved, we need a centralised place, owned by the learner, to store this information and connect it with the taxonomy of the Sectoral Layer. A Learning wallet, a Learning Record Store or a Learning Locker is such a place. It is defined as “a type of data repository designed to store learning activity statements” (http://v1docs.learninglocker.net/welcome/) .

To be able to exchange information between the different tools and applications and the learning wallet, we need a standardised language that is understood by all entities in the system. Such a language is e.g., specified by the Experience API (or xAPI).

Experts define the Experience API as: “a new specification for learning technology that makes it possible to collect data about the wide range of experiences a person has (online and offline). This API captures data in a consistent format about a person or group’s activities from many technologies. Very different systems are able to securely communicate by capturing and sharing this stream of activities using xAPI’s simple vocabulary.” (https://xapi.com/overview/)

The information model looks like this:



(Overview of the information model)

The principle of the xAPI language is described as follows:

> *The xAPI provides a normed set of services for storing and retrieving statements about learner activity. These packets are logged in the form <Actor, Verb, Object>. An example is "John found the exit". Further fields can be added to these statements, like 'result', 'context', 'authority' and 'attachments'.*
>
> *(Learning Analytics in Augmented Reality, Blueprint for an AR / xAPI Framework)*

The place where the information about the learning activities is stored (or retrieved from) is the learning wallet, or more technically, the Learning Record Store. This can be defined as follows:

> *The Learning Record Store (LRS) acts as the streaming database for xAPI statements. In our case, we deployed the Open Source project LearningLocker [12].*
>
> *(Learning Analytics in Augmented Reality, Blueprint for an AR / xAPI Framework)*

6.1 The learning wallet and the Sectoral Layer of ESCO

Every learning activity has a link to a (part of) a competence. After all, the learning activity is set up to develop this competence. This relation should be reflected in the vocabulary of the learning wallet.

As every tool and application already has a relation with the competences described in the Sectoral layer, the most logical way to include the competence in the learning statements is to refer to the Sectoral Layer. This makes it possible for every tool and application to retrieve information originating from other tools from the Learning Wallet.

Most tools and applications will only cover a part of a competence, mostly one or more skills. If the tools or applications are also measuring performance, the "observations" need to be described. In this way, we have exact information that can be reused for further analysis.

When the "observations" are done by human interaction, it is preferable that they are described in Objective Observable Statements. In other words, actions that can be observed in an objective way. For example, "uses gloves" is an objective observable action, there is no interpretation needed. While "uses Personal Protection Equipment" is less or not observable, the observer needs to interpret the situation and decide by him/herself what Personal Protection Equipment is needed in this situation. The reason to avoid interpretation or decision-making is that it influences the bias of the observer. Ideally the interpretation is only made at the end when all activities are finished. Such a tool or application should deliver information about Skills and eventual also Objective Observable Statements to the learning wallet.

6.2 Lifelong Learning and the Learning Wallet

Once we have a central repository in place, it can be used by different actors, and for different uses. The repository is independent from the application that provides or retrieves the information. It is also independent from the training provider or the type of learning chosen by the learner. The information is owned by the learner, be it that some restriction concerning assessment and certification have to build in (see further in future use).

In the first place the Learning Wallet is used to gather information about the learner. This information can be sent by applications that generate statements, but also applications that translate more conventional information form about off-line activities, training, etc. into objective statements.

Secondly, the information in the Learning Wallet can also be used to monitor the performance of the learner. Learner and trainer who know about the actual state of the students' achievements, they

can evaluate the students' performance based on objective recorded information. Since the information is connected to the Sectoral Layer of ESCO, it can be presented in a logical format that is understandable by the end user.

Finally, the information can be retrieved by applications to steer learning. Based on previous achievements, the application can decide to repeat a learning experience, give another experience for same purpose or skill, present more background or theory, or raise the level. This can be done within a single exercise or on the level of a sequence of exercises.

Trainers or supervisors can follow up the performance of a group of learners. In this way, the learning process can be evaluated and adjusted additionally.

6.3 Future use

In the frame of lifelong learning more functionalities could be added. The Wallet also could hold traditional evidence sent by the learner in the form of a portfolio. Or it could include self-assessment. All these elements can be linked to the sectoral layer.

The Learning Wallet now contains all the information needed to assess prior learning. This assessment is based on interpretation by a human being (ideally at least two) and can't be replaced by automated response. The learner can give access to an assessor to verify the information, assess the level and "sign of" competences. Here a conflict raises with the ownership of the information of the learner. The learner still owns the information, but can't be allowed to change it for reasons of integrity of the assessment. Once the competences are assessed, we have to be sure the underpinning information isn't changed.

A learner (or professional) can also use this information to build and send out a CV to an employer. Therefore, a learner can select what information is send to an individual employer and restrict access in time. In principle, the information could also be used in a first step of selecting appropriate candidates in a selection procedure.

6.4 Badges and virtual certificates

The assessment of the competences of a learner could lead to certification. Based on the idea of a more competence (and less qualification) focused labour marker this could take the shape of badges, connected to the sectoral layer. Ideally it would be connected to an accepted standard like Open Badges. (https://openbadges.org/)

For Certificates and qualifications, the security and integrity demands are even more stringent, thus a block-chain based system could be connected (e.g., https://www.bcdiploma.com/).

- Nina Tiptoe, the dancer recorded all her prior learning in the Learning Wallet. Based on this, she discovered the missing links that needed an update. She trained and learned by different providers, that all recorded the information in the Wallet. At the end of the year, she will look for an assessor that will verify all information and she hopes to get a qualification for stage management.
- Tony Solo, the freelancer trains mostly on line and through applications, as he is always on the road. His training sessions are recorded in the wallet. Depending on where he is, he also follows product training with different providers that are recorded. He uses the badges, portfolio and CV to prove his capabilities in different countries.
- Ben Young, the apprentice, gathers badges bit by bit, in his workplace, but also in the youth club. He feels good that he can show what he is already acquired.

- Mary Standard's school uses the learning wallet to record all her activities and achievements. This makes that she, but also all her trainers have a good overview of her strengths and weaknesses. The learning system sends her on a regular base extra exercises on het phone to keep her level up and to work on things that need improvement.

6.5 How and why does this feed into LAAR?

The LAAR project uses the ETTE competence descriptions as identifiers for different xAPI statements in the learning wallet. A series of application specific xAPI statements were developed for the LAAR project. By doing so, the learning statements can be mapped and, if the competence is proved, reused in other certificates. This makes it possible, for the long run, to create an open badges system or even a virtual certificate.

7 Teaching and training

The target group of young initial learners, professional lifelong learners and transition learners as described in chapter 1 asks for a specific approach. Their hands-on, active learning style asks for a learning path starting from real live practice and adding theory and knowledge on a "need to know" basis. They need a framework to relate and connect the acquired knowledge and skills that is adapted to the unique "renaissance" approach of learning that is typical for the sector.

Their disappointment in and sometimes aversion for traditional education makes that their intrinsic motivation needs to be addressed to make them perform towards optimum results. Important elements for this are the relation to the actual needs and the immediate usability of the things learned.

Without going in depth into learning theory, there are some points that are essential to develop teaching and training for this target group:

7.1 Different types of learning content

Even if the target group prefers to start from practice, there is a need for a different approach to support different types of learning contents. It is not evident to train each content type starting in practice, but it is important to link each type to the practice. We can roughly define five groups of content:

- Underpinning factual knowledge, needed to recognise tools, equipment, safety signs, etc. This can partly be trained, but will also develop further by presence of the learner in a real live environment.
- Theoretical background, needed to understand and apply electrical principles, make mechanical calculations, etc. This may need a more traditional teaching approach, but the link to the sectorial reality has to be guarded.
- Procedural problem-solving strategies, to be able to find errors in systems, but also to comply with the demands of artists for example. These can be trained and developed by confronting the learner with different types of situations and problems.
- Practical procedural knowledge (skills), to be able to perform routine tasks in a changing environment. This type of knowledge can be trained in a step by step approach towards full mastering of the skill.
- Artistic/creative understanding, to be able to work in an artistic environment. This includes the "language" of the artists, a background in the arts, a critical sense and developing a personal "taste". This type of knowledge is not objectively measurable and is less important on lower levels as communication about artistic results is limited.

7.2 Different pathways to competence

The modern technical theatre field is - educationally spoken - a very young field. Formal learning paths only exist since the 90's and are not even developed in all European countries. Traditionally, the path to a competence was defined by "trial and error", informal peer learning and manuals, instruction sheets and documentation. Later, this concept was transformed in a more formal way of apprenticeship, supported by (some) formal education and certification. The development of formal training, based on traditional education is a rather recent phenomenon.

In most countries, a mix of traditional learning and a strong practical component, often in the form of apprenticeship, is used to deliver competent practitioners. In fact, this kind of blended learning "avant la lettre". It uses methods out of the best of both worlds to train starting practitioners. This

training is later on followed by continuous training, partly in the form of product training, delivered by the manufacturers.

7.3 Complexity of a real-life working environment for training

The real live working environment is a complex combination of factors that surround the actual activity to be trained. Specifically, in the technical theatre sector, external influences to the task or competence that has to be trained are significant. This often results in the need of a higher level of competence than would be expected for a similar task in other sectors.

The activities to be trained are supporting to the arts and making art is, per definition, making new things. This means procedures, standards, safety regulations, … need to be evaluated, questioned and adapted where needed to the demands of the artistic result. So, the activity does not occur in a standardised environment, nor will the activity itself be standardised completely.

The environment (the stage) where the training has to take place is permanently changing. In contradiction to other work places, where every activity has a designated place that is adapted to the needs of this activity, the stage as a working post is permanently changing. One moment it is dark, another moment hanging loads are above the learner, the next moment sound levels are high, … Secondly the work is a cooperative action, every worker depends on the result of the other. On top of this, some of the activities to be trained only occur once in the production cycle. Where, for example, in a car workshop the same activity is performed every day it is not unusual that a specific task on stage is performed only once every three months on a stage, with several consequences:

- A learner needs to be conscious of the environment that influences his/her work.
- The safety situation is constantly changing, this requires a permanent attention.
- There is little room for failure, as this would compromise the whole organization.
- The training possibilities depend on strict planning and deadlines.
- The priority is often put on the direct deadlines that have to be met and less to the long-term goals like training.

In this type of situation, the unexperienced learner is subject to and forms a risk at the same time. Therefore, a training program should start within a “safe environment” where one is allowed to fail and gets the time to build a certain routine. After this, the learning path can introduce more complexity until the learner is ready to enter the complex environment.

7.4 The importance of repetition

To be competent, it is not enough to be able to perform a specific set of tasks, one needs to be able to do this within acceptable time limits and in different contexts. The activity has to become part of unconscious behaviour, which means a certain level of automation of actions.

Often the path to mastering a competence is based on building complexity step by step. In a first set the learner will perform the different steps several times under supervision and in a controlled and safe environment. In a next step, he/she will repeat the whole of the activity. This is done till a certain routine has been developed. In further steps, the complexity is augmented by adding external factors or additional activities. The “safe zone” is build off towards the level of a real live activity. Finally, when the competence is mastered, it becomes part of a larger activity and performed/repeated continuously. It becomes unconscious behaviour. Repetition is essential to this process.

- Nina Tiptoe, the dancer, has a lot of general underpinning knowledge and is used to work in the complex environment. Her focus will be on more technical knowledge, procedural and problem-solving skills. She agreed with the crew to do some informal apprenticeship while she is still working.
- Tony Solo, the freelancer, often uses the "waste time" when waiting for sound checks, to train new skills and lightboards. He already has a deep understanding of the underpinning knowledge, but needs repetition to get these skills to the level he can use them in a performance.
- Ben Young, the apprentice is trained by his mentor. He will first make him train with equipment when the stage is free and outside of a production process. When questions occur, the mentor will lead him to the underpinning knowledge. Once he reaches a certain level of mastering a competence, this will be deployed in rehearsals and later in performances. He is now used to look up the underpinning knowledge, a skill he uses also in the Youth Club.
- Mary Standard's school program starts from a theoretical background. Once the knowledge is processed, they do simple practical exercises in a studio environment. Bit by bit the complexity is increased until they are ready to run a performance.

7.5 How and why does this feed into LAAR?

The LAAR project takes this needs and specificities in account while developing applications. The developed applications focus on the first steps of the learning process, creating a safe environment where the learner can experiment without external influence, but in a real-life environment, and supporting collaboration. The larger concept of the learning analytics combined with the ESCO competence framework and the sectoral layer are used for the whole of the learning process.

The ETTE learning content is structured based on competence. The underpinning knowledge supports one or more competences to maximise efficiency. The competence elements focus on the "how to" aspect, the procedural knowledge and problem-solving strategies. The underpinning knowledge delivers factual knowledge and a theoretical background. This supports the LAAR approach.

8 Measurement, evaluation and assessment in vocational education

A lot of the applications above depend largely on measurement for evaluation and assessment. We have to make a clear distinction between these different types of measurement, their use and the consequences of this differences.

Measurement for **evaluation** is process measurement, in other words we measure an intermediate state of competence of a learner in order to be able to steer, support, evaluate, … the learner and the learning process he/she passes through. This measurement is relative to the expected level, and can even go beyond the expected level. A learner that performs well will surpass the expected level. This is a good thing, because otherwise we would train for average performance and would fail to appreciate the possibilities of a learner. Often the grading is also used to reflect progress. A student that started with a low level will be scored higher than one that already had a relatively high level. This motivates and rewards learning efforts.

The “client” of this type of measurement is the learner. It helps him/her to understand how they have performed. This also means the quality of the measurement has to relate to the learners (and secondary to the process owner’s) expectations.

A typical example of process measurement is grading in a traditional school system. A student is graded on a scale from 0 to 10, where a grading of 5 means that the student has enough knowledge or competences to fulfil the expectations.

Measurement for **assessment** is result measurement. In other words, we measure if a learner complies to a set standard. This can be a curriculum or an occupational standard. The measurement is absolute to the expected level. The assessor decides if the learner has the skills yes or no. This demands a higher level of objectivity.

The “client” of this type of measurement is the society as a whole. Society, in the form of employers or users of a service, has to be sure the standard is reached. The result of the assessment also influences the result of other individuals with the same certificate or qualification. The public perception of the qualification is reflected by the level of the lowest performer that passed.

A typical example of this type of measurement is the test for a certificate or a drivers’ licence. The assessor will state if the candidate is capable to perform the tasks described in the certificate or is able to drive a car.

There are some **issues** when we mix these different types of measurement. Within our traditional education, the occupational standard is often used as a base for the development of a curriculum. Progress, performance, but also result is measured based on grading. The result of the school career is a qualification referring to the standard. The society, the “outside world” expects the graduated student to be able to perform all competences which are stated in the qualification. But in reality, a student that reaches 50% of the goals mentioned in the qualification will pass.

A secondary issue is that the assessment is done often by individuals that have a working or authority relation with the assessed person. This lowers the objectivity level of the measurement. A teacher for example that grades a student will take in account the learning process and will at the same time assess his personal achievement in bringing the student to the required level. These elements influence the bias of the teacher as assessor.

8.1 Developing evaluation measurement

Evaluation measurement can take different forms and shapes. In a traditional, knowledge-based education, this will often take the form of a **paper test** or a **written assignment**. For our target group, this type of testing often has some disadvantages. One of the most important ones is the fact that one needs written expression skills to be able to perform the paper tests. The lack of these skills will bias what we really want to measure. On the other hand, a student that is very good in expressing him/her in writing will probably have an advantage, especially in a group of low skilled writers.

When we want to evaluate concrete skills, the best way seems to be to make a learner perform the skill and to **observe** is the learner is capable. To support objectivity in an observation, we can translate the skill into concrete and objective observable criteria or actions. In this way we can be sure that the same things are measured for each learner.

An example of these **observable criteria** or actions for the skill "Inspect the technical performance equipment visually for damage" of the competence "Fit up and rig performance equipment" in an exercise where the learner has to connect a truss are:

- Checked for damage on outside
- Checked damage in holes
- Checked pivot for damage
- Checked if pivot fits
- Checked if split pen closes properly

These objective criteria can also be used as part of an xAPI statement. In this case the observer can mark if the actions are observed and this is sent to the xAPI, in combination with information about the competence and the skill.

Concrete situations need to be created that incorporate the expected level of complexity. This complexity can be raised bit by bit during the training process.

For other competences, the **result** of the actions can be verified. We do not look at the process, but only to what was expected as result. For example, a learner is asked to build a lighting rig, and we will verify if the rig is built according to the set standards. These results can be incorporated also in xAPI statements, but we can't be sure if the process of building has been done properly.

Evaluation can also be done with a system of **rubrics**. Rubrics are statements that describe the level a learner has reached towards a specific competence. They can be used by the trainer, but also by the learner in the form of a self-assessment. Often rubrics are generalised statements. The problem with this generalisation is that it almost always includes an appreciation, which is conceived negative by the learner. An example of generalised statements is:

- I have never done this
- I am still learning how to do this
- I am able to do this
- I am more than able to do this.

In the ETTE project the rubrics are based on a four-level scale in which the third level is what is expected. Learners reaching the fourth level are appreciated in this way to perform better than expected. The lowest level is the starting level, this is what you expect from a person without training. The second level reflects a learner that is on his/her way, but didn't reach the expected level yet.

The ETTE rubrics are written concrete and specific for a competence. Describing the concrete situation seems to ensure a “more honest” answer from both learner and trainer. An example of the ETTE rubrics is:

- I do not understand risks on stage or procedures.
- I don't feel completely competent to deal with risks on stage.
- I understand the risks and prevention measures and I apply the basic safety rules.
- I point my colleagues to risk-full situations and promote the basic safety rules

The highest level reflects here “more than expected”. The fact that one is not only working on ones’ own safety, but also tries to ameliorate the safety of ones’ colleagues is a benefit, but not needed for this competence.

The final result of a process evaluation is always focussed on the next step. We steer the training process based on where the learner is in the process, on what he/she has achieved. The fact that we give insight to the learner about goals reached or not reached is supporting and motivating the learner.

8.2 Developing assessment

When developing an assessment situation, we need to ensure that all elements required for an independent and objective procedure are met. These elements can be derived from the ISO/IEC 17024 standard.

The type of assessment will depend on what we are measuring.

- An **observation in a simulated environment** is appropriate for concrete skills. A real-life situation is simulated, including all elements that reflect the complexity. Of course, not all elements of a skill or competence can be measured in all their occurrences. During the development of the assessment, one needs to pick specific occurrences that reflect the whole of the competence. The observation is objectivised by using observable actions.
- An **observation in a real-life environment** is more difficult to objectivise. The environment complexity depends on actions of other practitioners and other elements that are not under control. But in some cases, where influences like audience behaviour are important, this can be used.
- **Role play** can be used for skills where human interaction and communication is essential. We have to be sure that the assessed individual understands the concept of a role play.
- **Post-box assignment** is an assignment that is also in real live done by the individual alone, without any influence from the outside. One can think of developing a planning or a light plot. The assessed person gets all the information needed and at the end the result is checked against clear criteria.
- In the case of **recognition of prior learning, based on portfolio** the assessor will not observe the actions, but will assesses the evidence that a candidate has brought together about his prior learning. The evidence will be matched with the competences to be proved. The difficulty here is that one has to ensure that the evidence can be traced back to the candidates’ performance.
- **Traditional tests or multiple-choice** test can be used if the underpinning knowledge cannot be successfully assessed based on the testing of the skills. But even in this type of testing, a focus on the competence rather than a pure reproduction of the acquired knowledge is recommended.

In all the different types of assessment we need to try to make the assessment as objective as possible. This can be done in the development of the assessment itself, using exact defined criteria, limiting bias, not taking in account skills that are not part of the assessment, … But it can also be done in the organisation of the assessment by smoothing the influence of an assessor or by limiting the possibilities for a "lucky shot" for example.

The ETTE assessment procedure for example foresees two assessors observing independently from different positions (**two times two eyes principle**). Every skill is at least measured twice in different situations to **avoid "lucky shots"**.

One of the specific problems in the event and performing arts sector is that some, more artistic, skills can't be objectivised fully. In this case the principle of **intersubjectivity** is used. A group of, by definition subjective, assessors will discuss and try to reach a consensus.

- Nina Tiptoe, the dancer, asked an assessor to look into her portfolio. Based on the evidence of her prior career a set of competences was assessed. In her lifelong learning process het mentor evaluates her achievements on a regular base to steer her learning.
- Tony Solo, the freelancer, gathers evidence about his career. When he gets product training, the achievements are assessed and added to his portfolio.
- Ben Young, the apprentice, is evaluated on a permanent base. At the end of his learning period, he will take an assessment by observation in a simulated environment.
- Mary Standard's school combines traditional tests with elements of different assessment methods.

8.3 How and why does this feed into LAAR?

The LAAR project incorporated the principles for good process and result measurement. The ETTE assessment procedure is used as a good practice.

9 Generic types of applications for digital learning environments

In this chapter we give, without being complete, a short overview of existing applications that are used in a digital learning environment. And we introduce specific learning environments itself. Central in the choice of the applications and the way they are used is the motivation based on the type of learner. In other words, we need to find the application which fits the purpose based on learner type, situation, …

9.1 Digital paper books

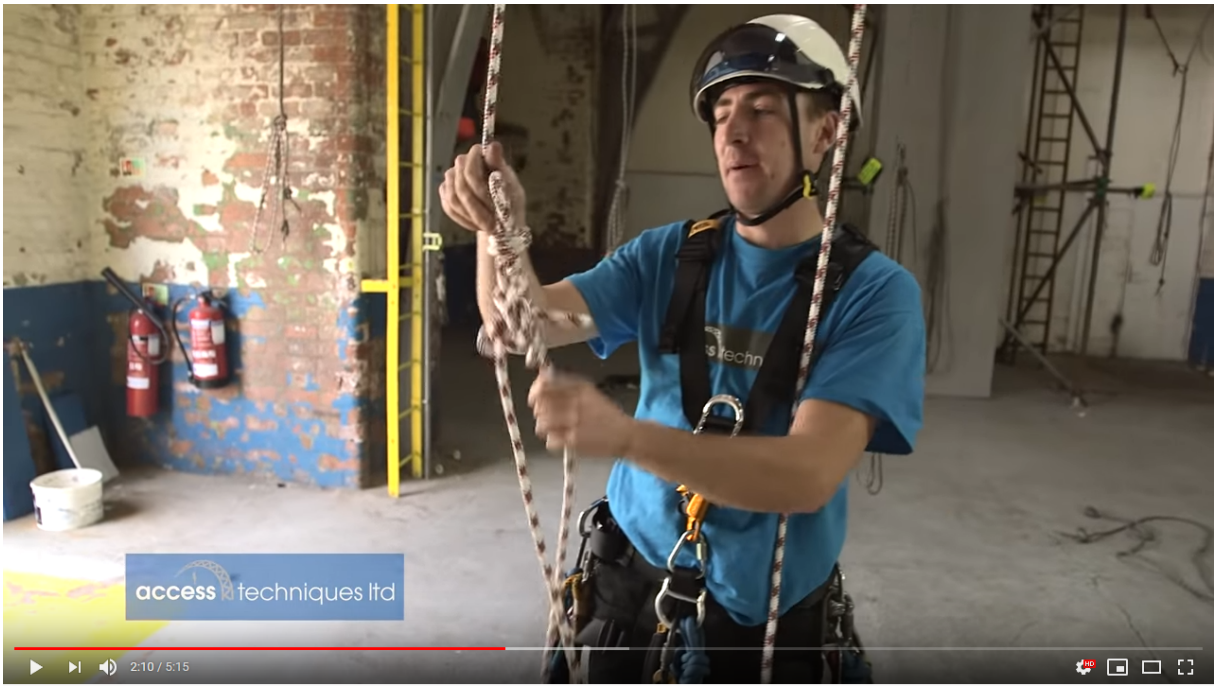
Often, digital learning platforms are filled with “digital paper books”. In fact, this is the concept of a traditional book in a digital version, without extra functionality that motivates or challenges the learner. It is just an easy way to distribute information, the learner still has to find a way in the whole of the book but the advantage is the learner has access at any moment in any place.

This “digital paper book” is often the first step in the transfer from analogue to digital. In a next step, the texts often become more website style text. The text is split in smaller parts, fitting a single screen and are reinforced with links, visual content, etc.

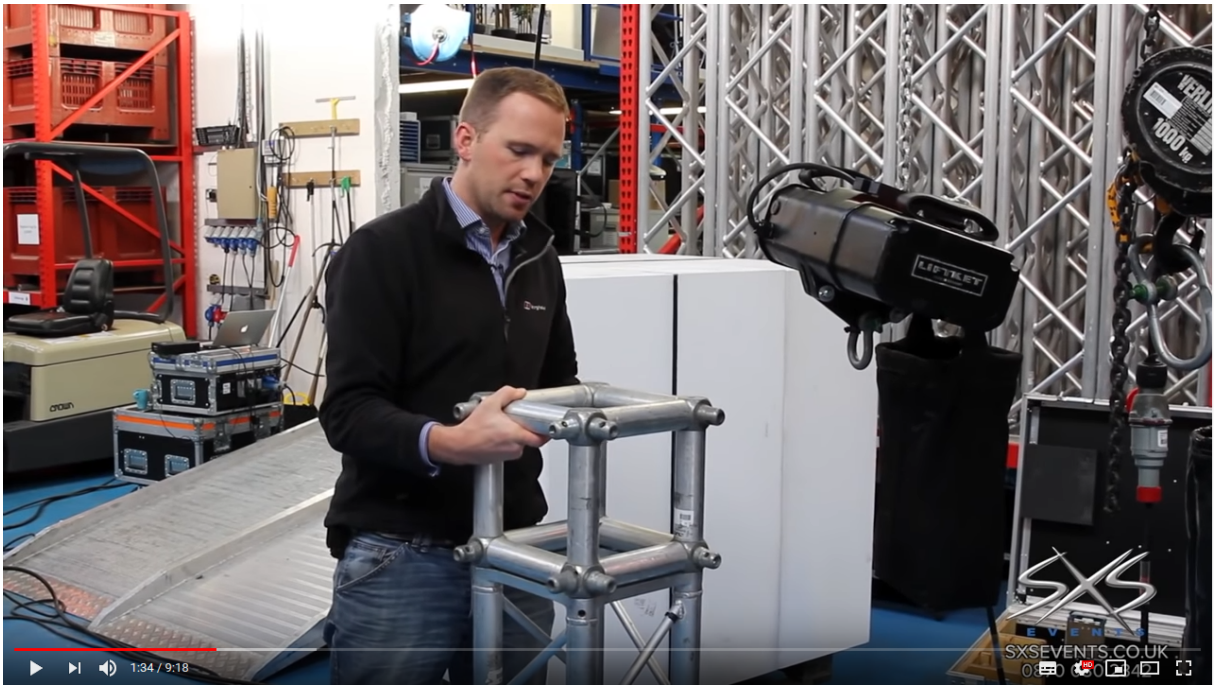
9.2 AV-Media based content

The use of (audio-visual) media strengthens the understanding of the content, especially when both visual and auditive stimuli are used. We use “multiple inputs to the brain” which leads to a longer retention of knowledge and a deeper understanding.

The range of audio-visual tools varies from recorded lectures, over instruction video’s, towards animations and purpose made documentaries.



(Screenshot Youtube Rigging a pull through for access from the ground, Access Techniques Ltd)

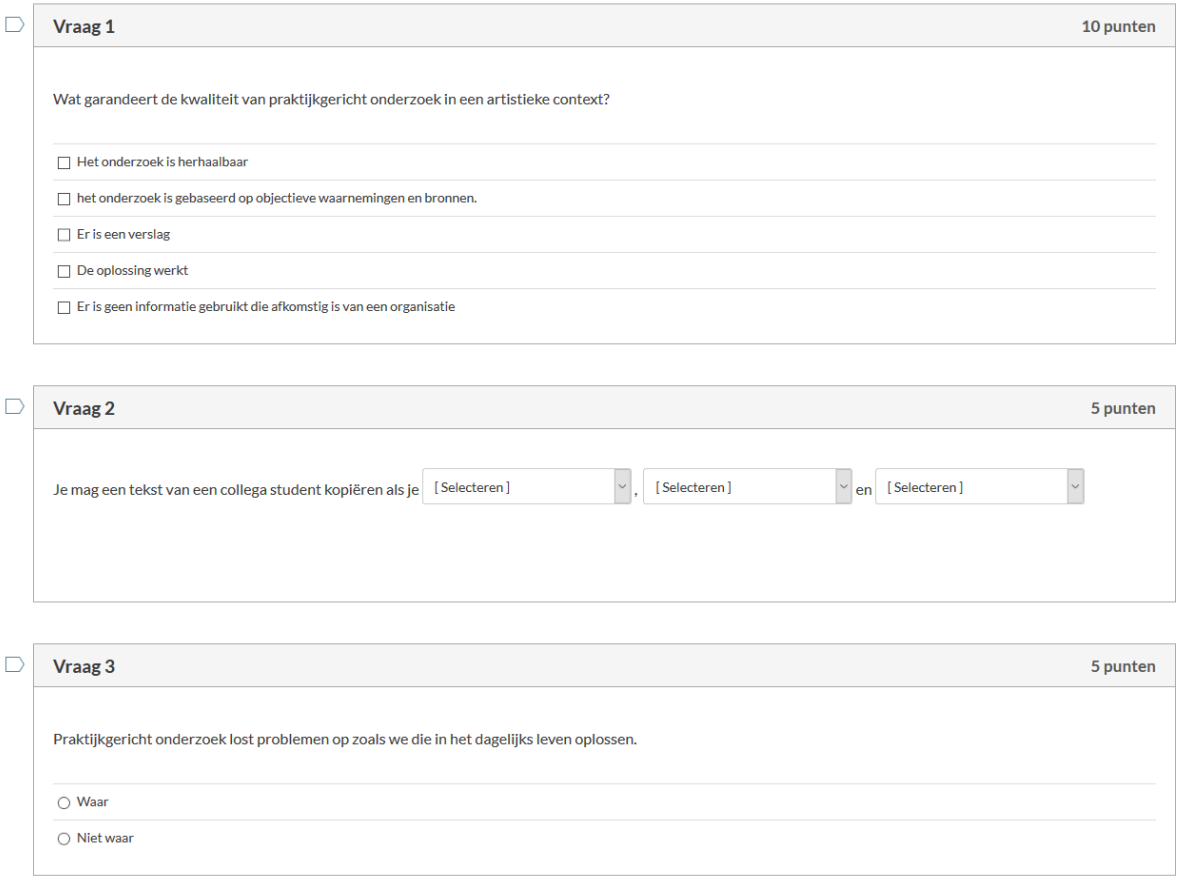


(Screenshot, Youtube, Basic Event Rigging Techniques and Equipment, SXS Event Production Services)

(screenshot www.napofilm.net)

9.3 Interaction tools

The above content delivering tools can be reinforced with secondary tools that add interactivity. The content is still passive, but at the end of the "consumption" of the information, the learner is challenged or tested. Question banks with different types of multiple choice, matching, … and questions giving automated feedback help the learner to check if the content has been understood.



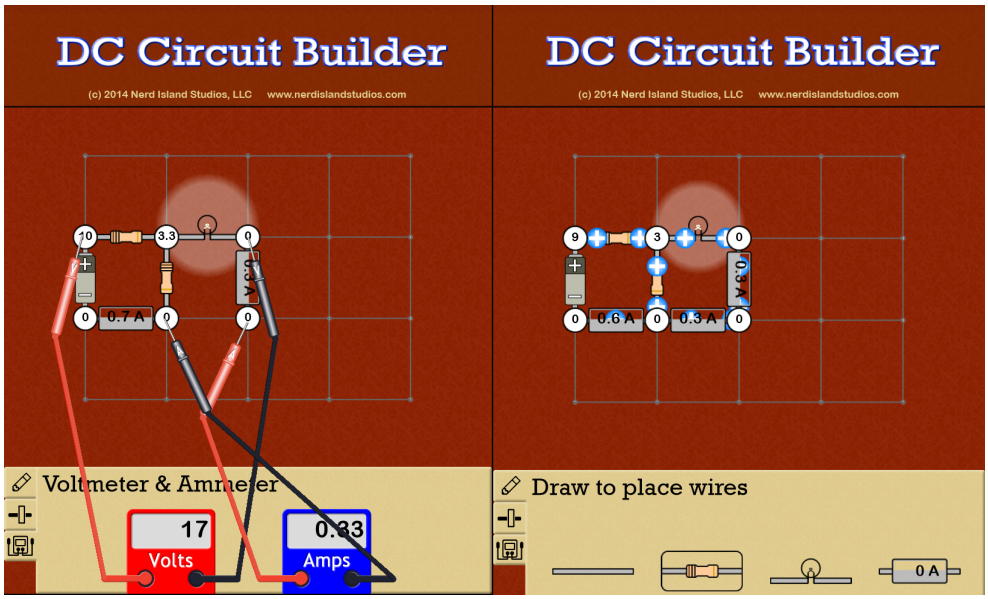
(Canvas questionnaire)

Other interactivity tools include discussion fora that can be used in groups of students or professionals, peer evaluation tools, etc.

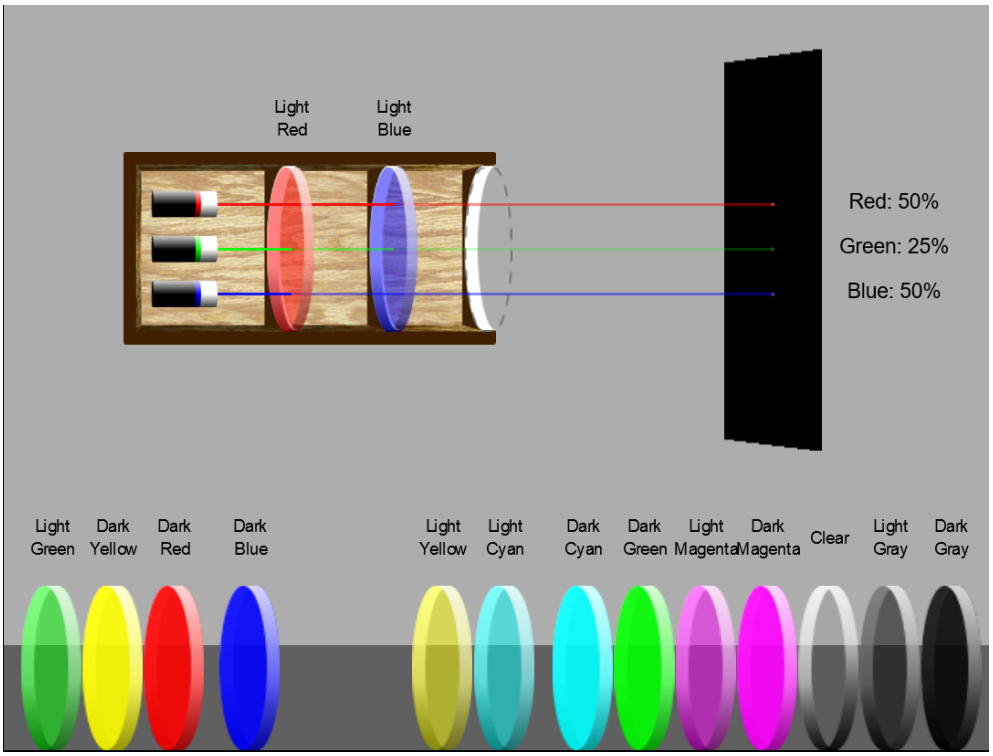
9.3.1 Simulation tools

Simulation tools are built to give better insight in physical principles or phenomenon. The advantage is that they need an active involvement of the learner that can give one or more inputs and gets a simulated visual result.

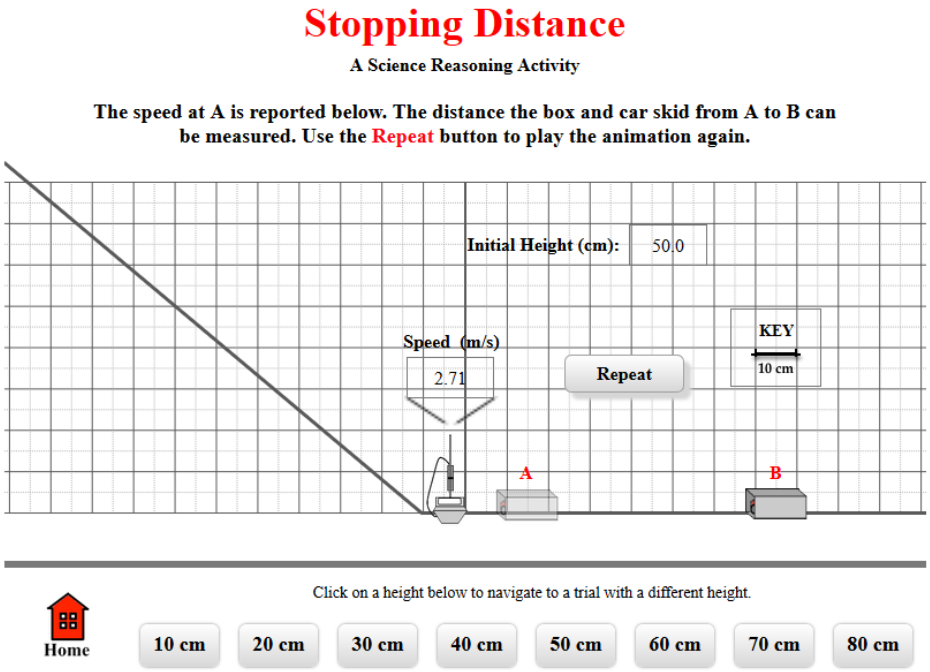
These simulation tools are built for one specific principle. Below some examples for electricity, lighting (colour gel filtering) and stage mechanics.



(Pictures from www.physicsclassroom.com)



(Pictures from www.physicsclassroom.com)



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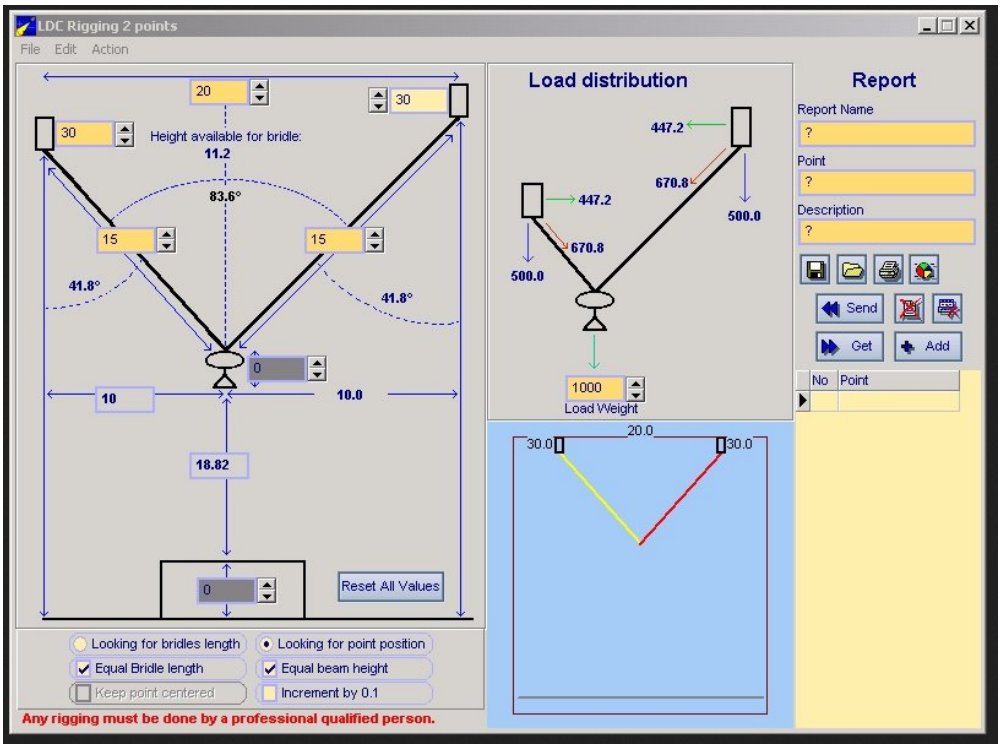
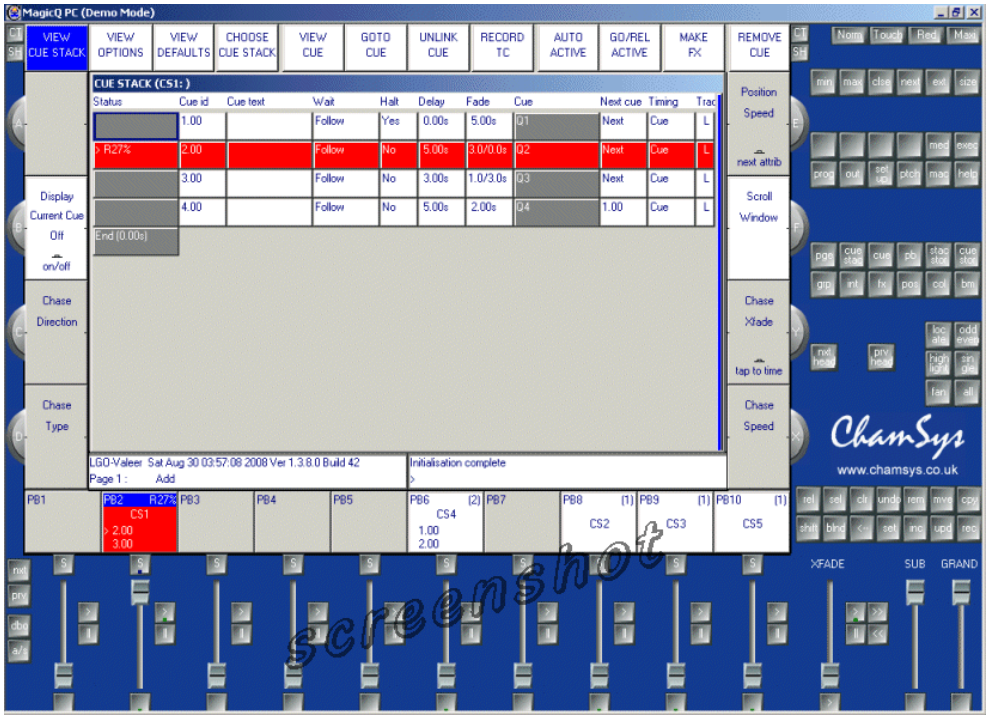


(Picture from http://www.paul-pelletier.com)

9.4 Simulating real equipment

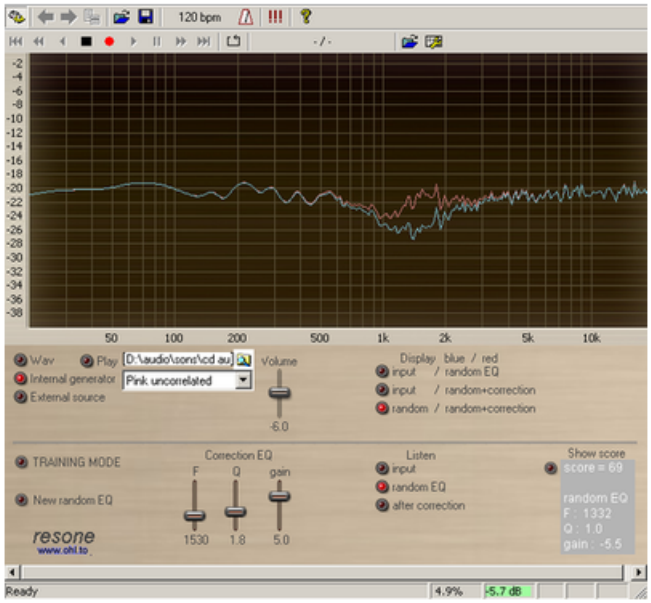
Simulation tools for equipment or for results are often developed for preparation or visualisation of use, rather than for training. Depending on the type of product, they can be developed as a service to the customer (product training) or as a specific product.

As the simulation tools are not developed for basic training as such, they often need some extra preparation before they become useful. Specific content needs to be developed using these tools. For example, a prepared light set to learn how to make cues, or a multi-track recording to learn how to mix the sound.



(Pictures from www.lgo.be)

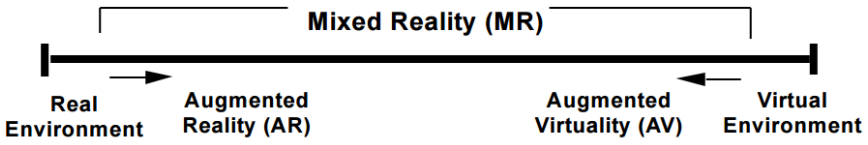
(Pictures from www.lgo.be)



(Picture from Resone (www.ohl.to/about-audio/audio-softwares/resone)

9.5 Augmented Reality and Virtual Reality (VR) applications

Augmented Reality refers to technologies that dynamically blend virtual/digital information into the real environment by the use of devices like smartphones, tablets, goggles, etc. What makes AR so special is that it is a variation of VR that creates digitally enriched experiences in the real world with which users can interact in real time. VR is defined as a real and a simulated environment in which a perceiver experiences telepresence and as a fully computer-generated virtual environment. VR's associated hardware provide the user with the illusion of physical presence within those environments. The difference between AR and VR is that VR completely immerses a user inside a synthetic environment such that the user cannot see the real world around him, while AR allows the user to see the real world, with virtual objects superimposed on or composited within the real world. Such information can be overlaid (e.g., on recognized objects) using smartphones, tablets or AR goggles as user interfaces between the real and the virtual world. AR also allows a full three-dimensional (3D) view of virtual objects and enables users to interact with them in the real environment. In that way, AR supplements reality, rather than replacing it (Azuma, 1997).



(A Taxonomy of Mixed Reality Visual Displays; Milgram & Kishino, 1994)

Both AR and VR applications bring in an interactive, enhanced environment that offers both, learners and teachers to receive feedback and status reports about the own learning / teaching track and therefore enables to put quality aspects into learning and teaching processes, emphasizing self-evaluation on individual learning / teaching tracks. Hence, teaching and training will become much more transparent, this enables access on collected data and information for identifying individual key performance indicators for these processes.

Moreover, these types of applications introduce opportunities for game-based learning (gamification) as a motivational aspect of learning. On the other hand, more traditional applications for digital learning can be integrated in the AR and VR applications.

9.5.1 Augmented Reality (AR) applications

Augmented reality (AR) applications create an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. In other words, the user/learner is still connected with the real world, but gets extra information superimposed on the real world and related to what he/she is looking at.

In such an augmented reality one can introduce interactivity. A user/learner watching an object can be questioned or be asked to perform a task. The application on its turn can respond to the actions taken by the user. This creates opportunities to integrate motivational aspects and competition. Object recognition can be based on tags placed on the object or it can be based on machine learned recognition.

9.5.2 Virtual Reality (VR) applications

Virtual Reality (VR) applications create a virtual world, independent from the real world. The objects in the virtual world can also be annotated with extra information, questions or tasks to perform ensuring interactivity.

The VR applications can be screen based, and sensor or tracking controlled. In a sensor-controlled environment, the learner uses controllers to move around, zoom, point, act, … In a tracked environment, the movements of the user are tracked and analysed.

9.5.3 Learning analytics (LA)

Learning Analytics (LA) supports the measurement, analysis and reporting of data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which it occurs. LA focus on learning and teaching activities in digital supported learning environments such as Learning Management Systems (LMS) and increasingly will be used in connection with AR- and VR-applications. Learners, teachers and trainers, and organisational entities can draw conclusions based on feedback provided by LA, thus are able to e.g. reflect on a learner's performance, the results from learning groups and aspects for training programs.LA often implements aspects from big data analytics.

9.6 Learning Management Systems (LMS)

A **learning management system** (**LMS**) is a software application for the administration, documentation, tracking, reporting, and delivery of educational courses, training programs, or **learning** and development programs. The **LMS** concept emerged directly from e-**Learning**.

In that sense, the LMS acts in the first place as a container for the different types of content/applications above. It also makes interaction with and automated response to the students possible. And it helps the learner and the teacher to keep control over the process and the logical order of learning events/activities. This becomes more important if learners have individualised, customised learning paths, like in lifelong learning pathways.

LA is often implemented on a LMS, in that way supports the steering of learning, providing a flexible pathway, adapted to the specific learner at the specific point of the learning path.

Depending on the type of learner and his/her situation, learning can be steered “Pulled” or “Pushed”. In the Pulled steering version, the learner is responsible for the progress, for actively look for the content, but the LMS can propose priorities based on past activities. In the Pushed steering mode, the LMS will actively bring content to the learner in a predefined way, but based also on past activities.

9.6.1 Micro learning

Micro learning is a typical, but specific type of Pushed learning. The content is divided in small parts, that can be learned in ten- or fifteen-minutes sessions. The LMS pushes these parts on a regular basis to the learner. The learner can use “waste time”, time in between other activities, to learn the parts. The advantage is that these smaller parts can be learned with a high focus.

9.7 Virtual Learning Environments (VLE)

A VLE can be an integrated distance learning platform that typically incorporates course materials, homework, tests, assessments, and other tools that are external to the classroom experience. VLEs may also include social media tools that allow learners and instructors to interact via chat or online discussion boards. VLEs generally use Web 2.0 tools, and also include a content management system. VLEs are often integrated with an enterprise’s LMS/LCMS, or ERP systems. Virtual learning environments may provide for both synchronous and asynchronous learning programs. Some VLEs now incorporate social gaming environments as an extension of the platform.

With the rise of AR and VR, VLE incorporates AR and VR content or were directly build upon these technologies. In that way, VLEs contain one or multiple applications in a virtual context that relates to them. The learner moves from one application to another in the same way he/she moves in a game environment. Interaction with other learners or trainers is possible in a similar way.

(Screenshot from Learning through falling: Second Life in UK academia. April 2009 keynote presentation at the JISC RSC Northern conference on virtual worlds in education.)

- Nina Tiptoe, the dancer uses her free time between warming up and performance to read short texts and watch instruction videos. When running to keep in condition, she listens to recorded lectures.
- Tony Solo, the freelancer uses his free time during rehearsals to read short texts, send by a micro learning system. After the show, he likes to wonder around in the virtual learning environment in his hotel room. He chooses instruction videos based on the issues he encounters in the daily work.
- Ben Young, the apprentice, gets text, simulations and instruction videos from his mentor, based on the needs of his training path. He also trains at home on different simulators to master new equipment.
- Mary Standard, the student, has access to a traditional LMS, where all her courses are gathered in order of het school program. She uses the questionnaires as feedback of her learning activity. In her free time, she trains het ears with a sound recognition software.

9.8 How and why does this feed into LAAR?

The LAAR project developed prototypes of Augmented Reality applications and a virtual learning environment based on the above concepts. Aspects from LA are integrated and systems like a LRS (e.g. to record a learner's experience), a LMS (e.g. to analyse and prepare a learner's experience data) and a dashboard (e.g. to show a trainee's performance) are used in combination. The ETTE content was used as a test case.

Part 2

Introduction

Where the previous chapters in part 1 describe the underlaying background and research that is used in LAAR, part 2 focuses on the developments of the project.

Chapter 10 describes the developed design framework, the choice of the scenarios, and the different applications developed during the project.

Chapter 11 goes deeper into the developed learning analytics application, the learning locker and the educational dashboard used.

Chapter 12 describes the prototype testing and the user experiences

Chapter 13 concludes with a critical analysis of the strengths and limitations of the use or AR in workplace training and looks at the future.

10 Preparation and implementation in LAAR

The LAAR project aimed to create new learning tools for work-based training and learning in form of Augmented Reality (AR) applications. Within the project, different apps are developed to train learners by interaction with AR technology in a real live environment. In addition to this, tools for analysing and tracking learning progress (LA, learning analytics) were developed. The developed tools were tested with different target groups.

10.1 The choice of training scenarios

A scenario is the description of a block of learning content that can be trained in a practice environment. The size of the scenario is chosen so that it includes a set of actions that need to be trained as a whole and that have no or insufficient meaning on their own. On the upper side of the size the scenario is chosen so that it can't be split without losing meaning.

To select possible scenarios that could be useful for the LAAR project, we developed a series of criteria. These criteria ensure that the scenarios are within the scope of the project and provide the opportunity to verify the developed solutions for the chosen target group.

We defined the criteria as follows:

- The competences to train with the scenario are part of the ESCO taxonomy.
- The scenario offers the possibility to incorporate the principles of the sectoral layer and the assessment requirements.
- The scenario's competences are part of the ETTE content
- There is existing conventional training material and methods to compare with.
- The competences incorporate different learning types/levels of complexity
- The scenarios are sector specific, but at the same time they are transferable or at least understandable for other fields.
- The focus of the scenario is on hands on training
- The scenarios are simple, the focus is on the implementation of AR and LA, not on the complexity of the content.
- Of course, the scenarios need to provide the opportunity to use AR and LA
- It must be possible to use them on different types of devices (Phone, Hololens, …)
- The scenarios have to be usable in a real live context
- They must provide a possibility for objective observation assessment (no arbitrary assessment)

Towards the testing environment and the target group, we added some extra requirements:

- The scenario must be easy to implement without the need of a full theatre infrastructure
- It must be usable for learners without any background in the field
- It must be usable for learners in different types of learning paths
- The language skills needed are limited
- The scenario is safe for learners in a testing environment

Based on this requirements, together with experts in the field we listed a series of possible scenarios:

- Inspection of a ladder
- Use of a ladder
- Recognition of safety signs
- Focussing a profile spot
- Recognising safety signs

- Venue check
- Storage of chemicals
- Use of chemicals
- Recognising chemical signs
- Choosing PPE (personal protection equipment)
- Connecting trusses
- Connecting spotlights
- Find electrical errors
- Replace light bulb
- Fire reaction
- Find the … (based on safety signs)
- Go get … (recognition of tools
- Find errors in rig
- Make a risk assessment

After the evaluation of a first initial description of these scenarios, we selected two scenarios that fit all criteria to test and represent two types of learning:

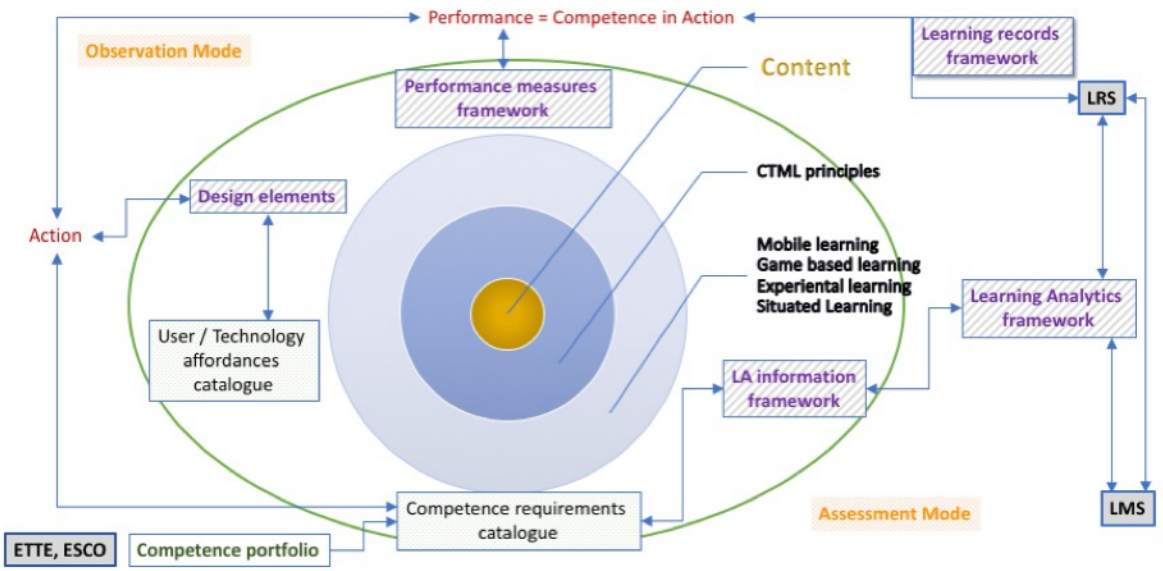
- Training of factual knowledge, by recognising safety signs (from ETTE) in a real live environment
- Training of procedural competence, by connecting trusses with conical connectors in a simulated environment

10.2 The theoretical framework

The theoretical framework consists of a technical and methodical framework for Learning Analytics in Augmented Reality based learning applications. The technical and methodical framework supports the project's progress for prototype development in AR, including current technology (devices), developer tools, design principles, research results useful and other research currently running, including LA and AR in professional education and training. This contains furthermore a framework for tracking learner behaviour (xAPI).

The innovation elements are thereby the generic framework in a conceptual form, as well as functional prototypes in software (e.g., node editor for training processes, training recorder for recording training sequences, generic tools for the creation of AR/VR environments), for developing further AR based training applications. Both, framework and prototypes are focussing on learner behaviour and are designed to support competence and qualification profiles, developed in previous projects like ECVAET, ETTE, TeBeVAT, following the ESCO guidelines. A further innovation is, that the conceptual approach for the training applications follows a competence-based structure, in comparison to a course-based structure in traditional learning environments. Finally, the framework incorporates elements for assessment to have both, training and assessment integrated in one application.

Expected impact is first, that the generic framework will fulfill the requirements for developing AR based training applications and will be used in further developments of such tools, not just for the present LAAR project but also for future projects in practice.



(LAAR conceptual framework)

ELEMENTS OF THE FRAMEWORK:

SYSTEMS:
- ETTE, ESCO; Competence descriptions
- LRS Learning Record Store
- LMS Learning Management System

REQUIREMENTS:
- Competence portfolio; Source: ETTE, ESCO
- Competence requirements catalogue; Source: Competence Portfolio
- User / Technology affordances catalogue; Source: Scientific Reports

ACTION:
a learning / training activity supported by AR applications

PERFORMANCE:
ACTION observed,
investigating Competence in ACTION

SUB-FRAMEWORKS:

- Design principles/elements framework
Source: Learning Theories/Research, Actions

- Performance measures framework
Source: Competence requirements + Actions

- Learning records framework
Source: Competence in Action

- Learning Analytics framework
Source: LA Theory/Research, LRS

- LA information framework
Source: LA framework, Requirements cat.

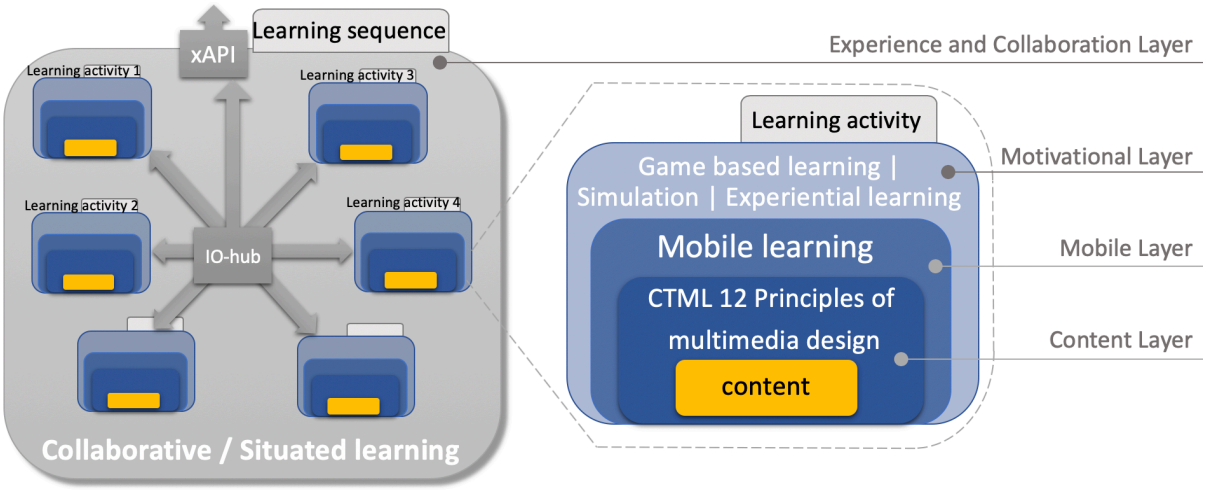
TWO MODES:

Observation Mode: during learning activity
Assessment Mode: in connection with learning activity (accompanying, subsequently)

10.3 The design framework

The design framework is the inner core of the conceptual framework and connects theoretical and empirical foundations with the form and function of concrete AR applications (apps). Therefore, a systematic literature review was performed to identify and group the learning theories that have been used in empirical studies on AR for teaching and learning. In a second step, the main system features of the apps in each theory group were identified, grouped to design elements, and arranged in a logical and hierarchical structure (i.e., the layers in the final framework). As a result, design

elements were identified that can be traced back to both abstract learning theories and concrete system features.



(The design framework)

The first layer addresses the preparation of the learning content used in an AR application (app) and contains elements derived from Mayer's CTML. The second layer introduces mobile aspects of the learning design to break the boundaries of a single location and to enable, for example, the integration of location awareness. Since motivation and engagement are fundamental components of a learning process and AR has the potential to support these aspects of learning, the design framework incorporates elements in the third layer that include motivational aspects of AR learning design. Finally, a primary added value of implementing AR learning is that learning can be an isolated individual task or a collaborative activity. Therefore, the framework includes in the fourth layer the design of a single learning activity and multiple activities composed in a learning sequence. This layer also contains elements derived from situated learning theory (i.e. learning at specific places) and collaborative learning.

Future trends for AR in teaching and learning focus on measuring and evaluating learning in personalized student learning experiences, which requires collecting information about the learner's behaviour, activities, and results and exchanging this information with external systems. Both the internal and external process management and the communication between learning activities and with learning management systems can then be supported by the implementation of an input-output hub (IO-hub).

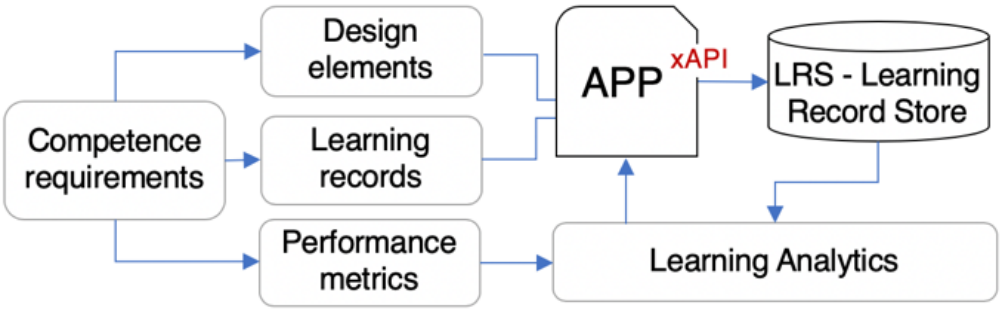
10.4 The implementation

We developed several collaborative AR-based prototypes for smartphones, tablets and the Microsoft Hololens and filled it with content from an existing competence requirement catalogue, developed in collaboration with training experts from industry.

We collaborated with domain experts from the event technology industry in all stages of the development and evaluation process. The app followed a predefined storyline and considered the training requirements derived from a catalogue covering competence requirements, which should be

implemented in the training session. Furthermore, the design of the app was based on design elements for AR learning app design suggested by Sommerauer and Müller (2018).

The following figure shows the conceptual setup. For logging the user data, we implemented so-called experience-statements recorded on a learning record store (LRS), applying the xAPI. For this purpose, we used LearningLocker® and shaped the xAPI statements to log a user's data to fit the requirements of the performance measurement catalogue.



(Conceptual setup for app development)

Aspects derived from the competence requirements catalogue determine the applied design elements for the app design and the learning records implemented in the app and define the investigated performance metrics, e.g. task performance. The app in practice sends user data to the LRS to provide it for further processing, i.e. for learning analytics and to prepare a feedback for users (e.g. on a dashboard).

10.5 Learning the safety signs

For the training of factual knowledge, we chose a scenario for recognising safety signs (from ETTE) in a real live environment. Understanding the meaning of safety signs, and learning where they can appear in a real live environment is part of the factual knowledge needed for safe behaviour.

Safety signs are explicit knowledge, one must be able to recognise them and explain the meaning in the specific context.

10.5.1 Analysing the conventional learning method

Traditionally, the learner would be thought the different symbols or read them from a book. The learner would memorise them and get a kind of test or examination at the end.

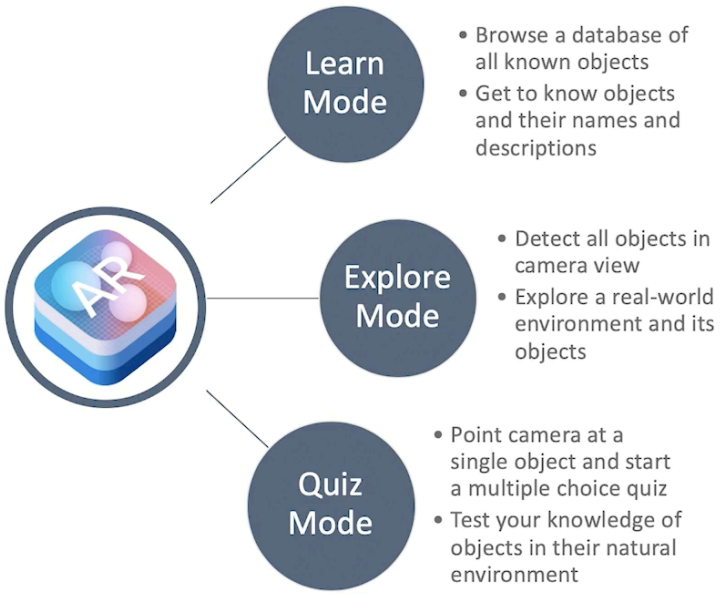
The limitations in this methodology are that it is focussed on short term remembering (learning for the exam). There is limited consolidation (permanent storage in the memory) of the knowledge. Moreover, the knowledge is disconnected from the real live environment.

To improve this, repetition is needed in different situations in a real live environment. This creates references to the normal use and context. Ideally the repetition includes also motivating elements, to avoid that the activity becomes boring.

10.5.2 The i-Phone/i-Pad app "Explore-App" and "Who Am I?"

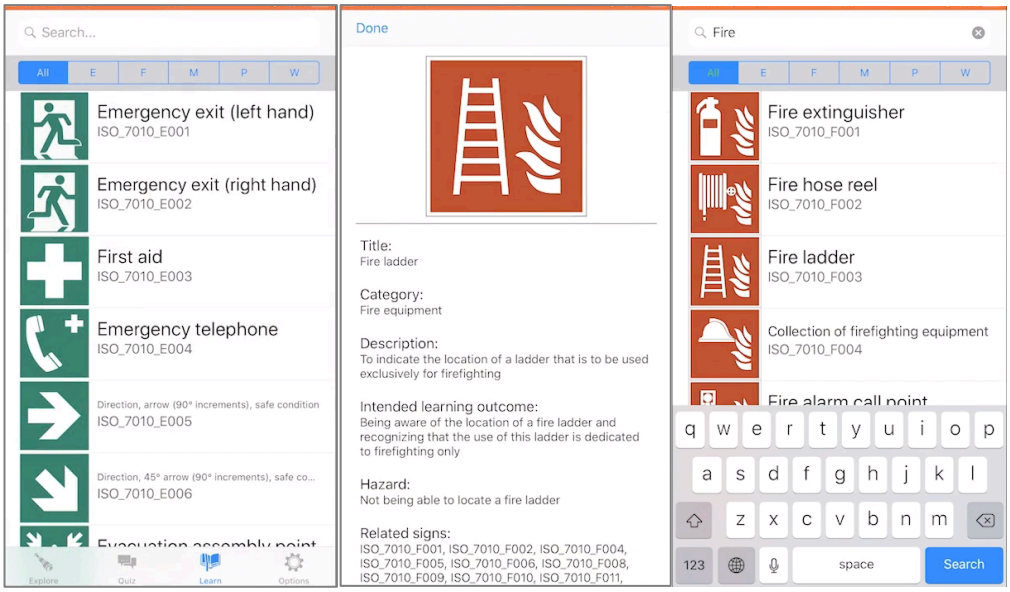
The LAAR project developed an application to learn about objects in a real environment, e.g. the different safety signs. The app was developed in multiple iterations (first version: Explore-App, final

version: Who Am I – app), is multilingual and includes three different modes: a training mode, an exploration mode and a quiz mode.



(The features of the “Who Am I” app)

In **training mode**, the user can browse to a catalogue of safety signs to learn. Alternatively, the signs can be searched based on keywords. For each sign, a detailed description is available based on the ISO descriptions and the developed learning outcomes. This mode is similar to the conventional learning method.

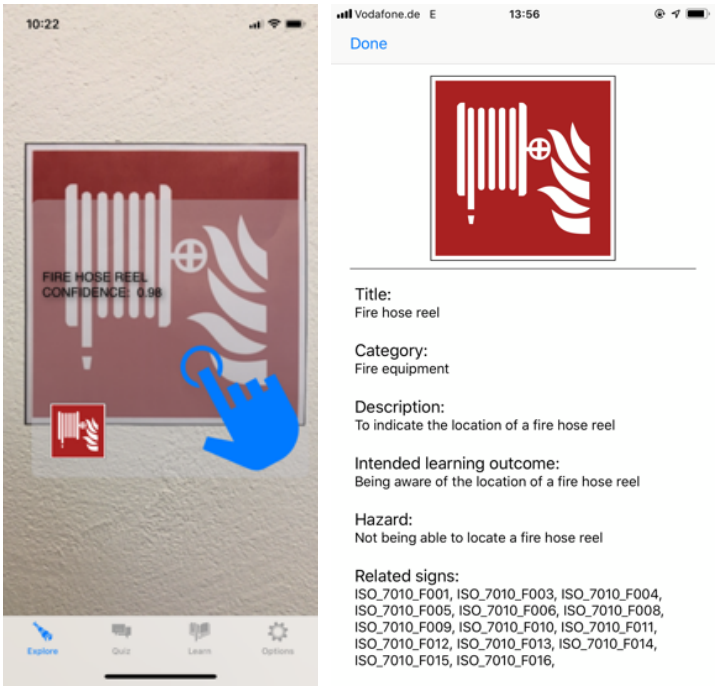


(The “Who Am I” app in learn mode using database search and keyword search)

The **exploration and quiz mode** incorporate AR and machine learning technologies to recognize objects in the environment. The app combines machine learning techniques for image recognition with machine translation to identify objects that are in the focus of the mobile phone camera in real time and superimposes information like the object’s name onto the object in various languages. This helps learners to visually recognize objects in their natural environment and learn about their names

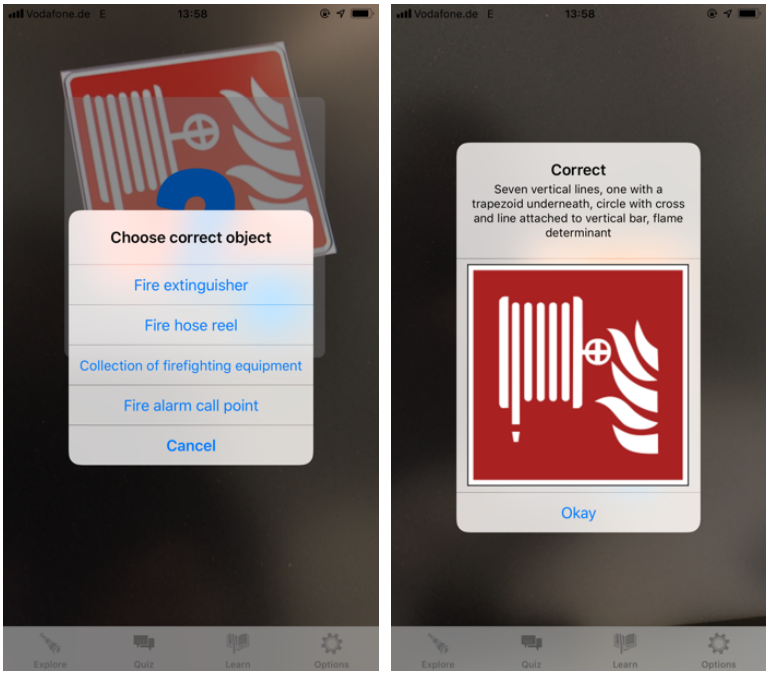
and descriptions. The fact that the application does not need markers to identify objects makes it usable in every environment. The learner focuses on a particular safety sign using the device's camera (e.g., smartphone, tablet, any head-mounted device).

In the **exploration mode** the app shows the most likely label for the sign and superposes extra information about it when clicking on the image.

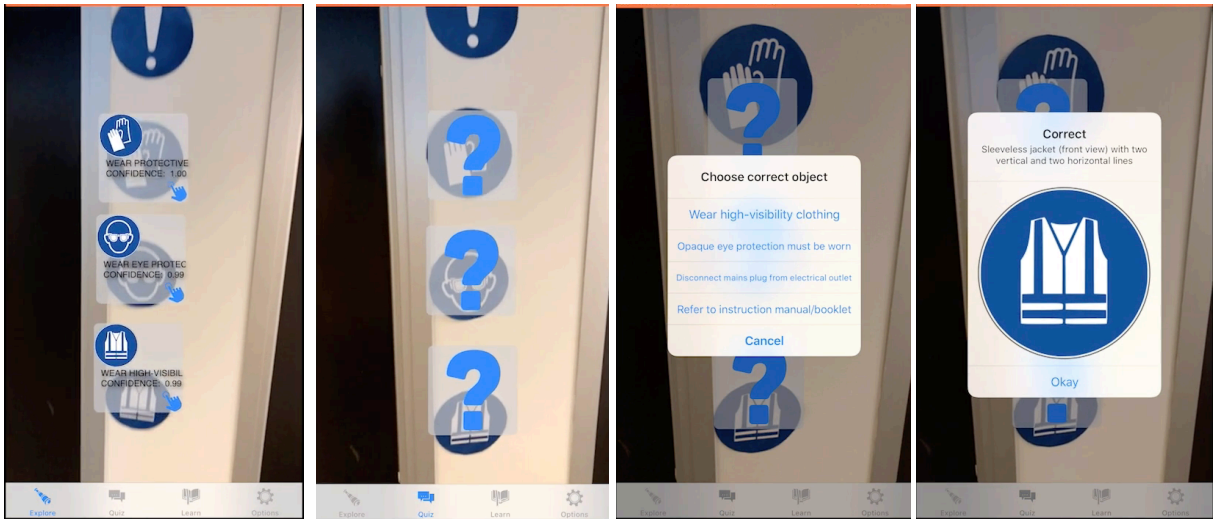


(The "Who Am I" app in explore mode)

The **quiz mode**, which is implemented to support learning at any time and at any place, presents a selection of labels for an identified safety sign, and the user chooses the one that is correct. The app gives feedback for correct and incorrect answers.



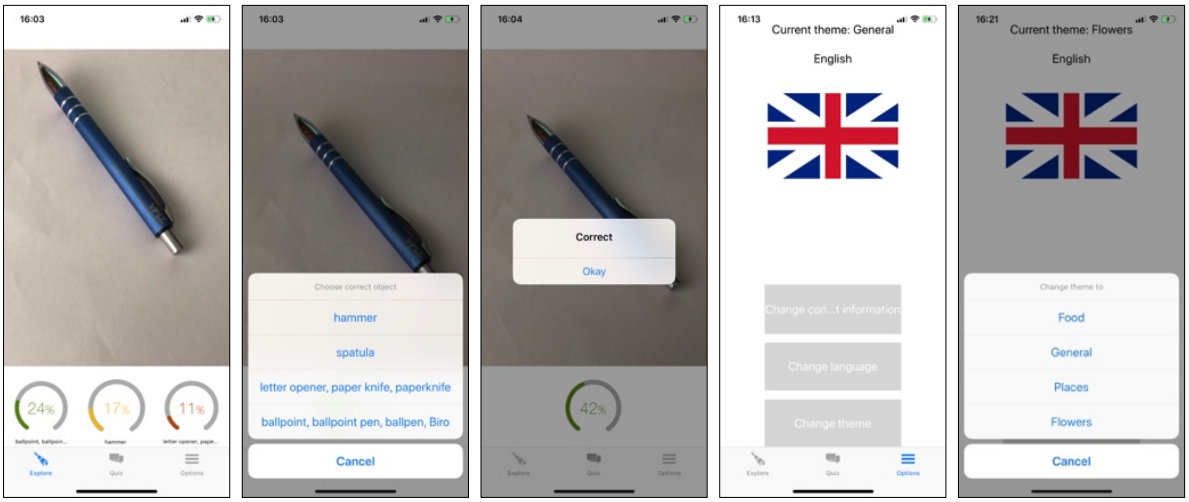
(The "Who Am I" app in quiz mode)



(The “Who Am I” app in explore mode and quiz mode)

The “Explore App” / “Who Am I” app follows the idea of implementing object recognition and its application in both school and professional education (VET). The applied design principles follow Billinghurst et al. (2015) (i.e., real physical objects/virtual elements displayed and linked with an interaction metaphor) and the design framework, as presented earlier.

The “Explore-App” also supports the task of learning names related to physical objects used in an every-day environment (e.g., at home, at the office) or in other professional domains. The examples below show the use in an office/home environment and a professional florist environment.



(The “explore app” in explore mode, quiz mode and selection of language and theme)

(The “explore app” in a field test using the flowers theme)

10.6 Two ways to train the egg

For training of procedural knowledge (competence), we chose a scenario for connecting trusses. Trusses are the modular aluminium structures used at concerts and events. They are used to hang sets, light, sound and video equipment. There are different ways to connect trusses. In the chosen scenario we use conical connectors (eggs) that fit into the truss ends.

This is an activity that is often performed on a low level. It is a very basic action, taking only a couple of minutes for an experienced practitioner. But on the other hand, the procedure includes a set of activities, checks and choices that have to be performed in the right order. Additional difficulty is that there are more than one “right orders”.

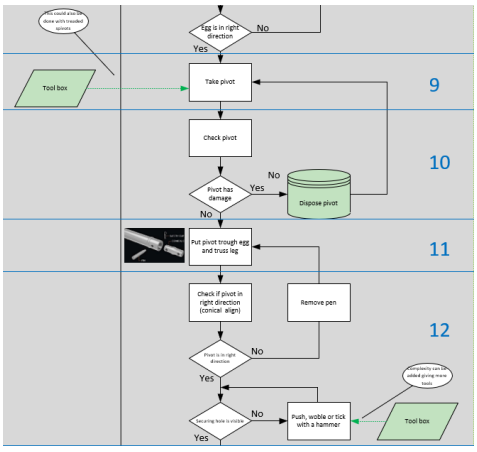
10.6.1 Analysing the procedure

In a first step, we analysed the procedure, listing every action and choice to be made, including loopbacks if for example a part does not have the required quality or a part doesn’t fit perfectly.

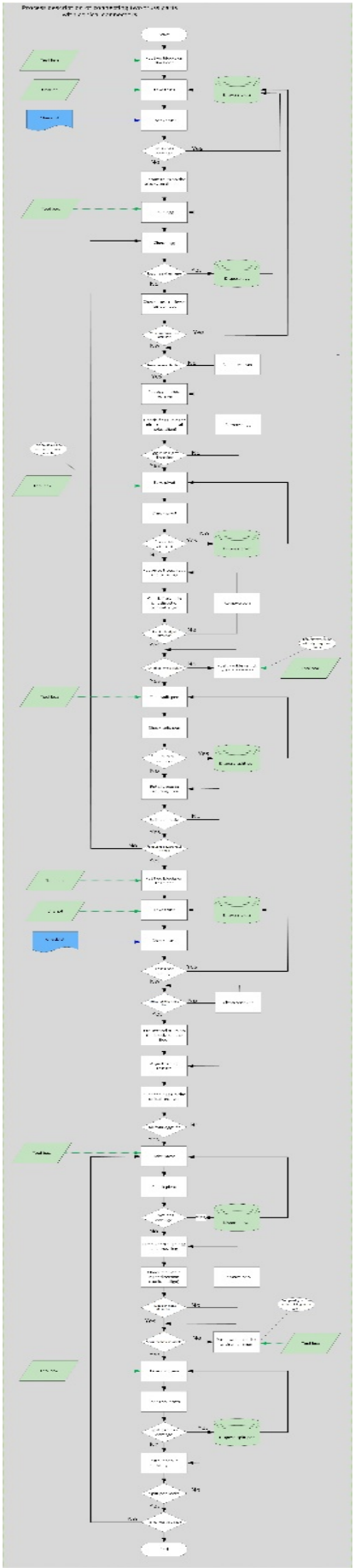
In the procedure typical common elements reoccur:

- Choosing parts or equipment
- Checking parts
    - If no loop back (replace)
    - If yes, continue
- Action putting parts in the right place
- Check mounting is done properly
    - If no loop back (redo)
    - If yes, continue

All these elements were put in a “flow chart like“ map that supported the development of the app. The map also indicated the complexity of choices and decisions to be made even on this low level. This becomes even more significant if we realise that one wrong choice can end up in a lethal accident.



(Flow chart connecting a truss)



10.6.2 Analysing the conventional learning method

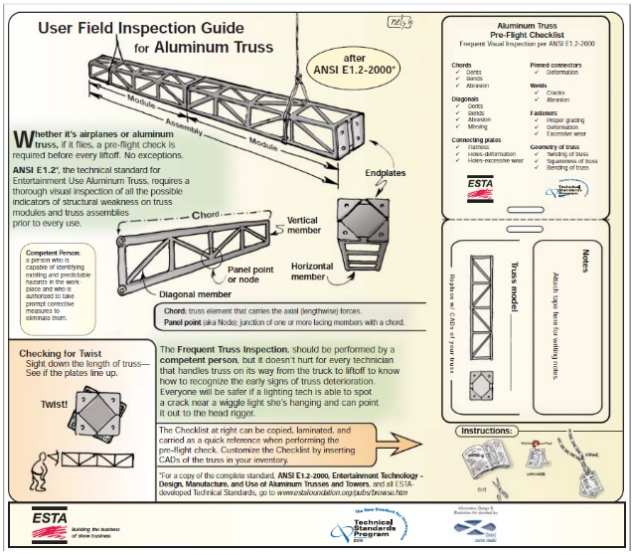
Next, we analysed the conventional methods used in different types of training situations. As this is a basic competence, it is trained as well on the floor, through self-instruction, by peer learning and in a traditional school context.

10.6.2.1 Trainer method

In a trainer or “Master - Apprentice” approach, the trainer shows step by step how the action is to be executed. The trainer will point out all the tricky elements, the choices to make and the checks to be done. The learner copies each step separately. After this is done, the trainer would repeat whole sequence at once for the learner to repeat. In a next step the learner will perform independently, but the trainer will keep overview and double the checks to be sure no risks occur. Bit by bit the learner gains independency until the trainer decides checks are no longer needed. This type of training is often based on experience.

10.6.2.2 Instruction sheets

Several organisations (like USITT) and manufacturers have developed instruction sheets that show all details to be considered when performing the truss connections. These are typical examples of self-training material. The learner bases his training on the instructions, but there is no check or feedback on his learning.



(Instruction sheet trusses, ESTA – USITT)

10.6.2.3 Peer method (for practicing)

Once the learner has acquired basic understanding of the competence, peer learning/checking can be used. The learner performs the actions and checks and a peer verifies the actions. To improve the quality of this peer verification, the peer uses a checklist. The checklist is developed so that it only needs objective observation and no judgement is involved.

An example of such a checklist is the one below:

- Wears the proper PPE (safety shoes, gloves, hard hat)
- Handles trusses with care (they are fragile)
- Lifts and carries ergonomically
- Puts trusses on blocks
- Checks trusses visually for damage
- Chooses the right connectors and pivots
- Checks the connector for damage
- Checks the connector and the receiver for dirt
- Slides connector in, in the right direction
- Checks spigot for damage
- Fits the spigot in the connection
- Secures the spigots with R springs
- Checks the R springs are fixed
- Lines the trusses up
- Checks the second receiver for dirt

- Checks the truss connection fits
- Fits the spigots on the second part
- Wiggles the truss to fit the spigots
- Chooses the right type of hammer (if needed)
- Uses a minimum of force
- Secures the spigots with R springs
- Checks the R springs are fixed

All the statements are written in a way that they can be observed, without interpretation. At the end of the activity, the learner gets feedback based on the statements observed. The statements can be traced back to larger competences, of which they are part. By doing so, the learner can prove the mastering of these competences in different situations.

10.6.2.4 School method

In a traditional school environment, the learner will learn first the theory, the background, the calculations, … behind the activity. Then the procedure is explained and the learner has the opportunity to try this out in protected environment. The problem is often that there is limited time to practice. In the best case, practical work experience is added to create more training time.

10.6.2.5 Disadvantages of the existing methods

Most methods are very time consuming for the teacher/trainer. Often there is a lack of visual material to give insight (you can't see the inside of the connection). While training, there are no time limits, while in reality there are. On top of this, the trainer will unconsciously correct learner or influence the situation. Therefore, the learner cannot learn from mistakes. There is no tracking of the quality.

An improved method should include visual information, no correction during the training (learning from mistakes). It should take advantages of the existing methods in account like the fact that a learner verifying the result learns from his/her peers mistakes.

10.6.3 The phone app "Follow Me"

The phone app for learning the connection of trusses is based on the peer assessment method. There are two interconnected apps, one for the learner, one for the peer. The learner gets instructions, the peer verifies the results and steers the progress.

The truss connection application was developed using the Unity3D game engine[1] accompanied by the built-in Vuforia Augmented Reality and HLAPI (The Multiplayer High Level API) frameworks. In order to quickly adapt the prototypes to the project needs, a node editor tool for generating final applications was implemented. This allows the developer to create, edit, and connect nodes - each node represents one task that the trainee has to perform (e.g. "Take, check and mount egg on corner 1") which is further subdivided into subtasks (e.g. "Has taken an egg", "Chose an egg with right size", etc).

To simulate a realistic workplace environment, we built a 6m x 4.5m black-box room to simulate a setting similar to a theatre, re-enacting the scenery of a stage background with reduced lighting. The black box was equipped with a SD square heavy steel truss element which was fixed on the floor, a table with tools and components required for truss connection and electric power supply with a busbar. The truss had a square profile and thus four corners.

[1] Helgason D., Francis N., Ante J.: Unity3D. In: Copenhagen: Unity Technologies. (2004)

The setup of the training session followed industrial training instructions for connecting a truss and covered the identification of the items and tools used in the activity and the preparation of a truss element to prepare the connection of a further truss element. First, a so-called egg with a conical drilled hole needs to be put correctly into the hole of the longitudinal member at the first edge. Then, a pin needs to be mounted in the correct direction to fix the egg. For this activity, a hammer is used to ensure a strong connection. The final action is to secure the pin with a spigot. All four corners of the truss need to be prepared this way.

In our simulation, we designed the app following a learning process based on Peyton's four learning steps: demonstration, deconstruction, comprehension, and execution. Trainees need to start the app and point the camera of their device towards the truss. At the first corner, the app superimposes a 3D model of the egg to demonstrate how to install the egg into the hole and the trainee is requested to follow the instruction. To get to the next step, the trainee needs to push a button and the app shows with 3D animations how to correctly put the pin into the holes of the truss. Once the trainee is ready for the next task, the app displays a 3D animation demonstrating how the spigot should be placed correctly. During the session, the trainer is invited to give verbal feedback and to intervene, if corrections are necessary. At the end of each step and the activities on the first corner, the trainer is requested by the system to send feedback based on a predefined checklist and starts the training on the second corner. The information provided by the trainer's checklist is stored at the LRS and contain aspects for evaluating a trainee's task performance linked to the checklist item descriptions.

At the second corner, the app provides a single 3D animation combining all three steps of the activity in one animation. Again, the trainee is invited to replicate the given visual instructions and the trainer checks afterwards, whether the tasks were fulfilled correctly. Again, the trainer is allowed to give verbal instructions and also to reject the evaluation; in this case, the trainee needs to start again with the activities for the current corner.

For the remaining two corners of the truss, the trainee receives the instructions to assemble the corner on his/her own. Since we want to measure the task performance in these two steps, the app requires pressing a button after successfully assembling corner three and four. Thus, the trainees' task performance, i.e. time to completion, can be measured. The training session itself ends with feedback given by the trainer and the app shows the participant's performance analysis via a dashboard, based on the analysis of the recorded user's data from the LRS.

To measure a participant's overall performance, we focused on three aspects:

- Number of correctly and incorrectly fulfilled tasks
- Completion time for corners 3 and 4
- Time taken for the whole training scenario (Corners 1-4)

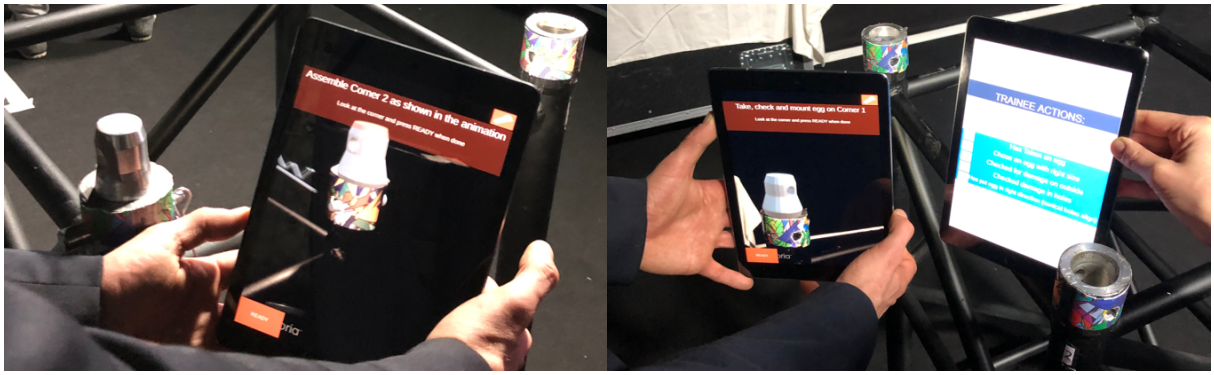
The training covered the following activities:

- In step 1 and 2, prepare a truss following the instructions;
- Correctly identify damaged parts;
- Follow the advices of the assessor;
- Fulfill the tasks in step 3 and 4 on your own;
- Complete a questionnaire afterwards;

Competence reference		Checklist item description
10 Fit up and rig performance equipment	10.02 Inspect the technical performance equipment visually for damage	Checked for damage on outside
		Checked damage in holes
		Checked pivot for damage
		Checked if pivot fits
		Checked if split pen closes properly
	10.03 Choose the right mounting accessories	Has taken an egg
		Chose an egg with right size
		Took the right pivot
		Chose correct split pen
	10.04 Choose the right mounting methods	Wobbled or hammered (if needed)
	10.05 Mount and rig technical performance equipment according to instructions and/or plans	Has put egg in right direction (conical holes align)
		Placed the pivot in right direction (conical hole)
	10.08 Secure technical performance equipment and accessories	Put split pen in hole of pivot
	10.10 Take action if something goes wrong	Disposed damaged pivot (if needed)

(Checklist items related to competences)

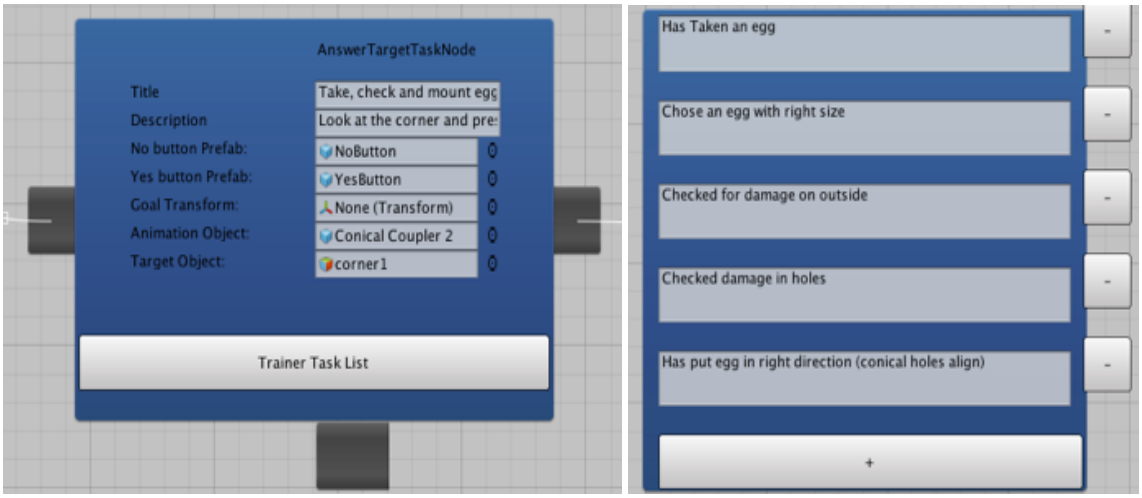
Then the trainer handed over an iPad where the training app was already started and connected with the trainer's app. The app provided a unique session code for each training session which was used as a session identifier and to link sessions and questionnaires. Participants were allowed to ask any questions and the trainer was instructed to support the activities in step 1 and 2 (preparing corner 1 and 2 of the truss). The following figure shows a participant in action.



(Collaborative AR in the field study)

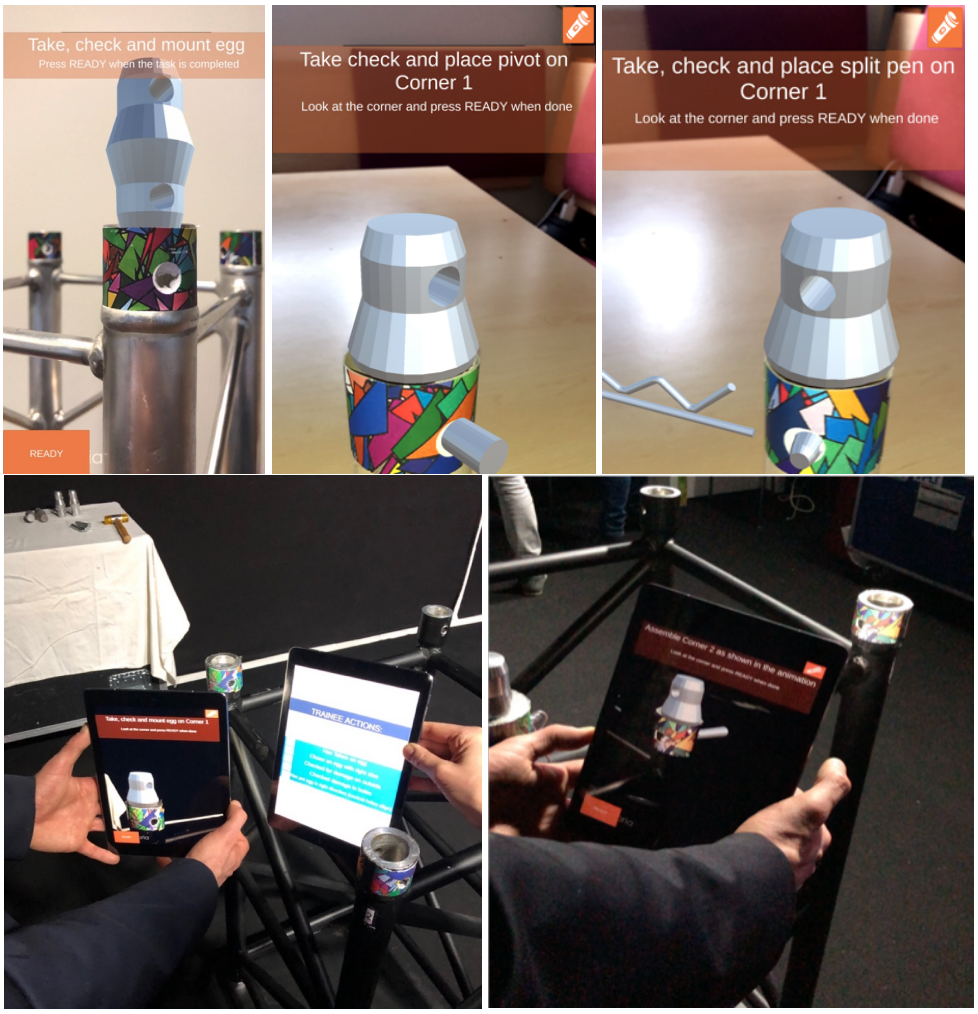
The learning activity enriched with AR and implemented in the "Follow Me! app", was developed with the elements from the design framework in mind. The setup of the training session followed the training instructions for connecting a truss and covered the identification of the items and tools used. A node editor (see next page) was implemented for the app development to follow the requirements of a modularized, process-oriented training sequence.

The key activity is to prepare a truss element for connection with another truss element. The training app has a trainer mode and a trainee mode. Both modes are connected via a multiplayer server environment to interact in a virtual room. The app running in trainee mode asks the user to point the camera to one of the four corners of the truss. The first corner is marked with a trigger image to start a 3D animation that shows step-by-step the requested activities; the user has to confirm completion for each step. The procedure for preparing the second corner is identical, but the app illustrated all steps combined in an 3D animation. For both corners, the animation is superimposed on the particular corner of the truss.



(Node editor to define training steps for the truss app)

For the third and fourth corners, the user is requested to prepare everything "on his/her own," so the user has to recall the steps, activities, and required components and tools from memory. At all steps, the app logs the learner's and the trainer's activity. The following figure shows screenshots from the app in trainee mode and from the experiment in both modes.



(Screenshots from the Follow Me! app in trainee- and trainer-mode, pictures show both modes during a field experiment)

The training session is guided by a trainer who uses the AR training app in trainer mode. The app in trainer mode fulfill two core tasks: supporting the trainer in, first, leading the trainee's activity and in assisting with (to a low degree) and discussing the activities with the trainee, and second, in observing and evaluating the trainee's performance according to a prepared checklist.

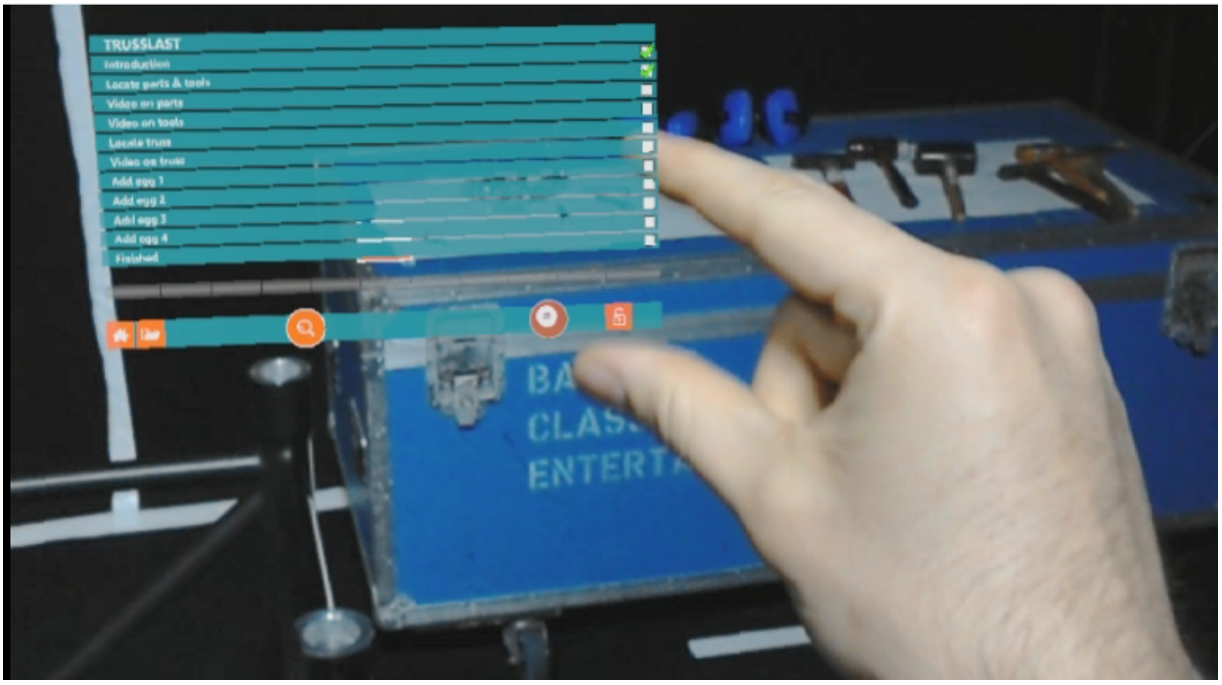
10.6.4 The Hololens app

A second application to train connecting trusses was developed for the Hololens. The application leads the user through the process, but gives more freedom to choose which type of information the user wants to see or use.

Before going through the training for the connections, the user needs to be trained to use the interface of the Hololens. This training is mainly to learn how to control the menu's that are controlled by different movements and gestures of the hands. The gestures are recognised as mouse clicks, zooming, etc. This process takes about 15 min.

(Users in a field test)

The information stream is controlled by the user, but the choices are depending on the objects in the space. In other words, the menu options change depending on what one is looking at.

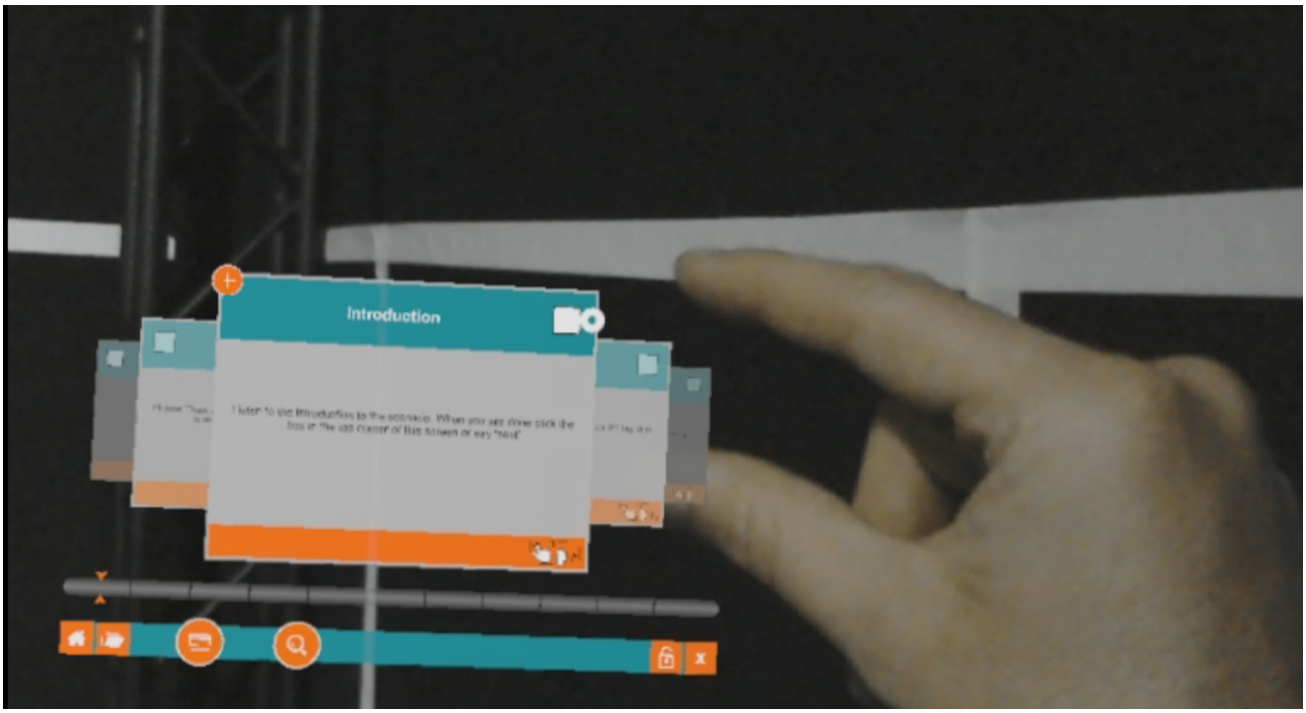


(Menu in Hololens application)

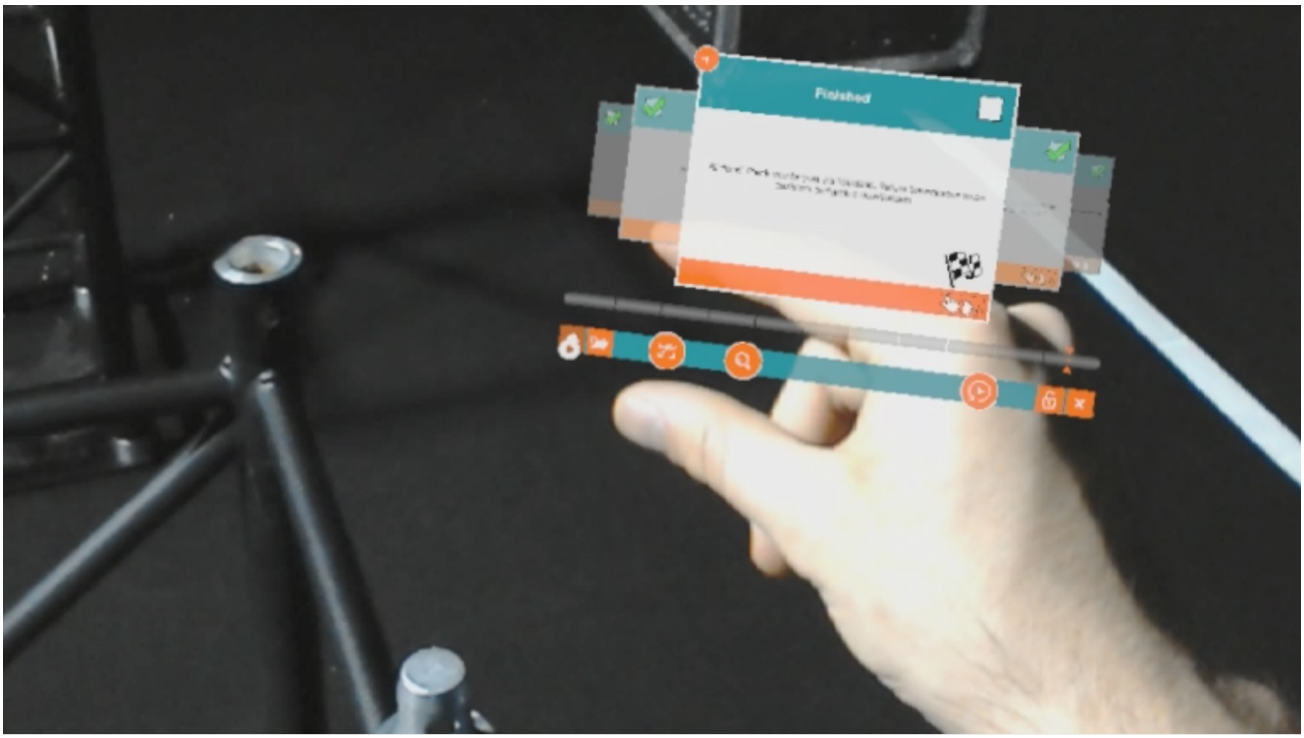
The user can choose between different types of information about the actions or tools to be used, based on the learner's preference. The information is superposed on the image the learner sees of the environment, through the Hololens.

10.6.4.1 Text

Text information is the most basic form of information. This can be as well menu choices, instructions, extra information about a tool or feedback.



(Text information in Hololens application)

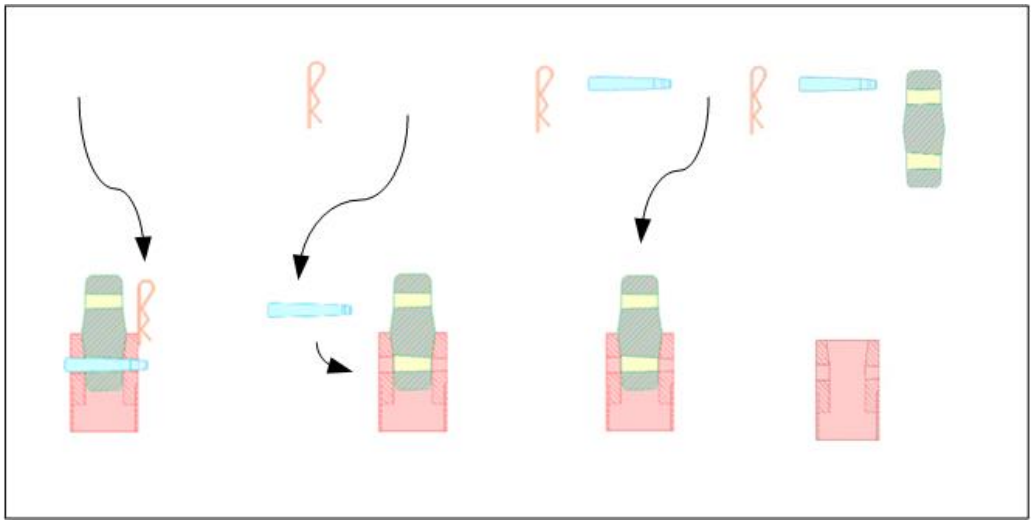


(Text information in Hololens application)

10.6.4.2 Animation

Another type of information is animation. The advantage of this type of information is that it is language independent. The learner just sees how the action has to be performed, without written or oral instruction.

The figure below reflects the animation about the connection of a truss with a conical coupler (egg).



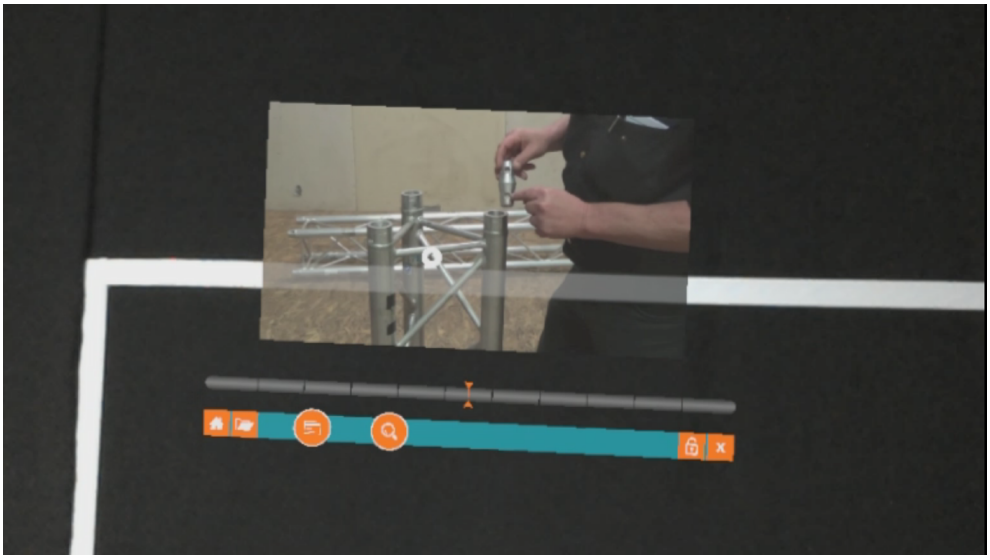
(Animation about mounting conical connectors)

10.6.4.3 Instruction video

Pre-recorded video is another option. The example is a screenshot of a video explaining what has to be checked on the different parts chosen. The image is combined with oral instruction.

(Screenshot instruction video on checking parts)

Integrated in the Hololens, the video is seen as a part of the total image, the user keeps in contact with the real-world environment and can relate the video content with the reality.



(Instruction video seen from the screen of the Hololens)

The Hololens allows the user to use both hands while watching the video. In this way he can copy the actions shown in the real world.

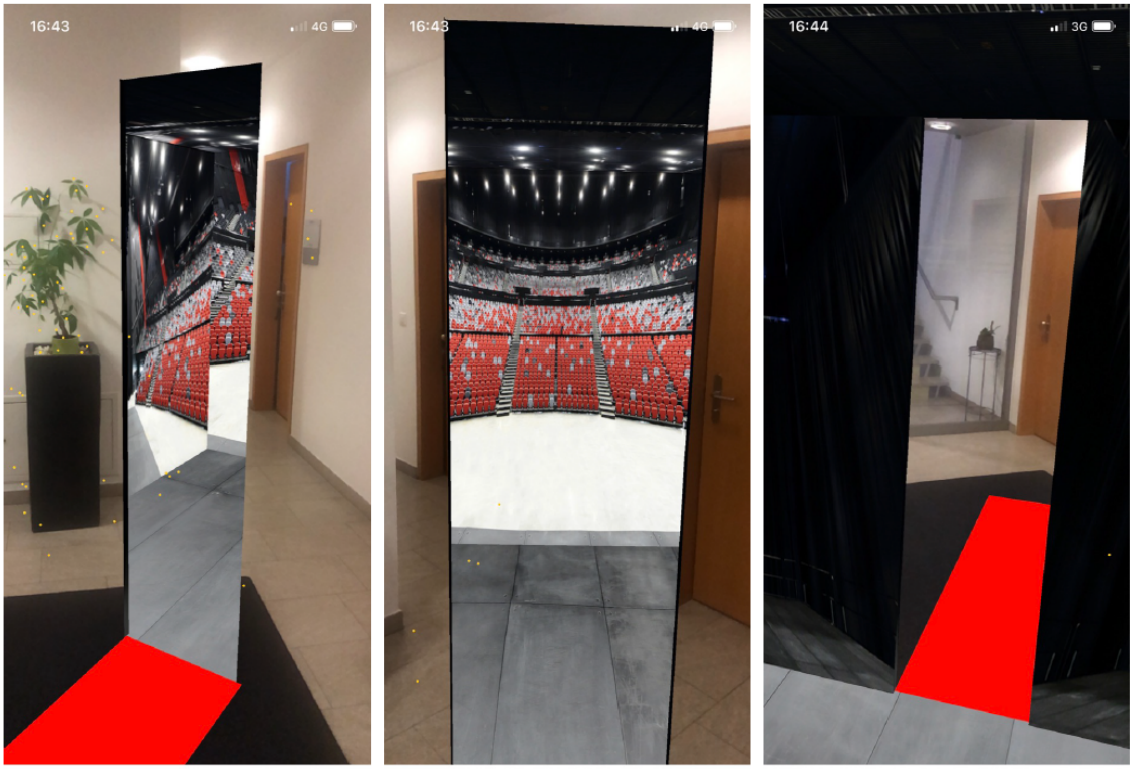
10.6.5 Virtual learning environment

VLEs provide a safe environment to test scenarios that would be too difficult or dangerous to perform in real life. Industry applications integrated elements that allow people to learn skills like how to operate a laboratory device without ever having seen one. In other simulations of an AR/VR environment, users are standing on the roof of the Empire State Building to train how to behave when working in heights. Such lessons also provide the opportunity to “move in time”, e.g., students may witness historical events with their own eyes as well as experience historical places, architecture, clothes and people behaviour. In a practical sense, simulations in VLEs can train people how to use acquired knowledge when getting faced with particular problems (e.g., firefighting).

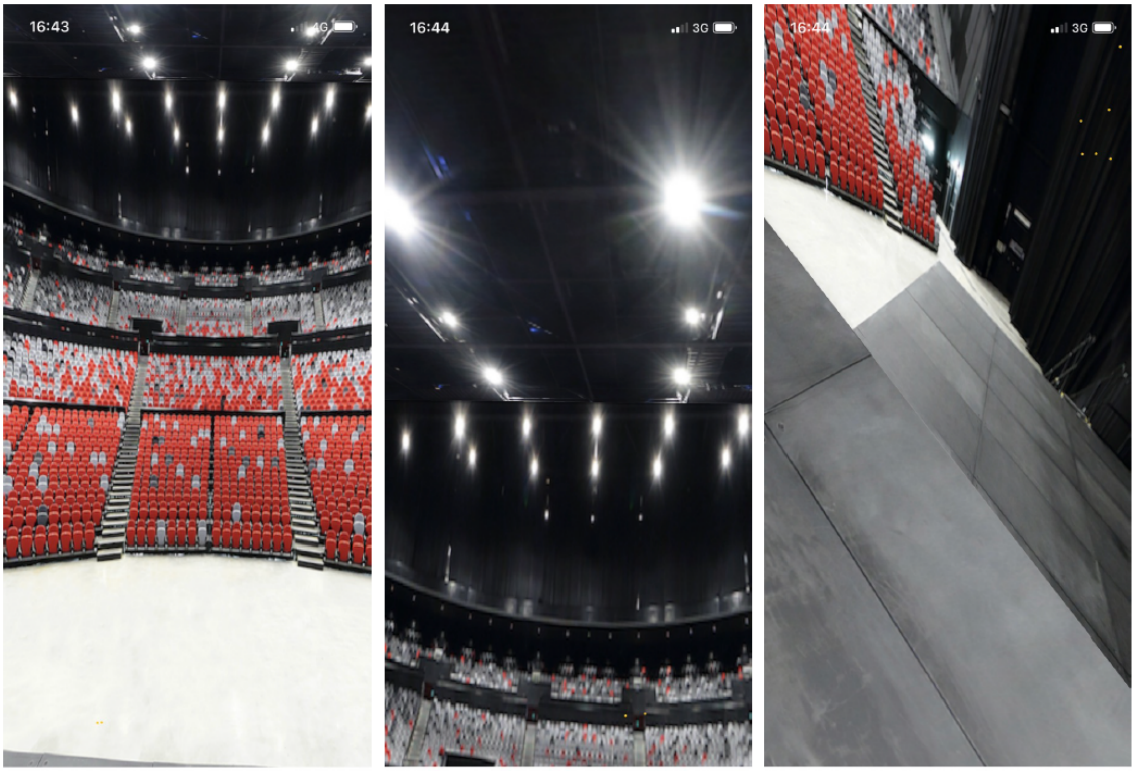
In the LAAR project, a VLE is constructed using full immersive AR to train people how to behave at a particular stage setup. Inside such VLEs, various training scenarios can be integrated (e.g., chasing the constructed error situations in an VLEs, identify the numbers of safety signs, etc.). Additionally, the above apps and additional multimedia-based training content could also be integrated to create a larger consistent learning experience.

The LAAR project’s VLE was developed as “Portal-app” for a smartphone or tablet. The learner enters the environment through a “virtual” door. Once past the door, the learner can walk through a virtual blackbox, theatre, or event space, which is similar to a real-life theatre situation. Inside the virtual blackbox, different tasks/apps can be performed. The virtual learning environment functions as a container for the developed apps.

An important advantage of the virtual learning environment is that it creates a larger context for tasks the learner has to fulfil, the learner can familiarise with the real-life environment and therefore it reduces fear for the real-life environment. Furthermore, it implements choice and motivational aspects into the learning.



Constructed portal – entrance from outside and inside



Front view – ceiling view – side view

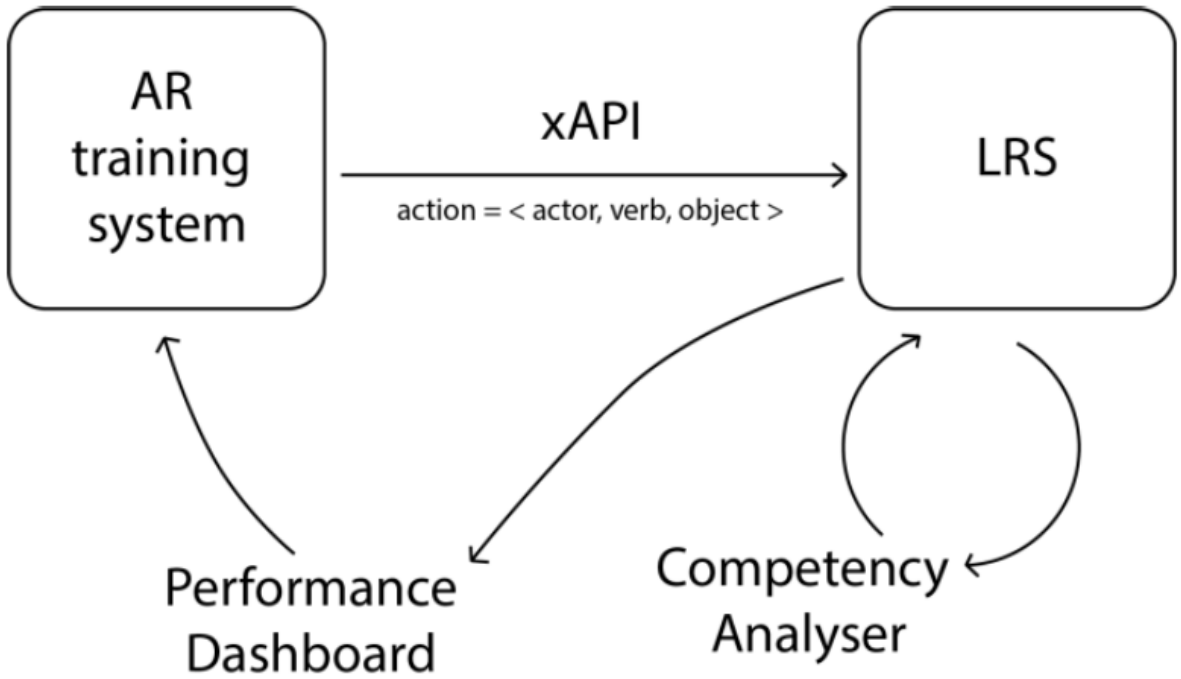
11 Learning Analytics (LA)

Learning analytics (LA) is a multi-disciplinary field which involves aspects from statistics, visualization, information retrieval, artificial intelligence and machine learning. Various tools and methods from other research areas and disciplines are utilized in the analytics part of LA. It is furthermore a domain which interleaves several areas that are related to technology enhanced learning, including educational data mining and academic analytics, and also action research, recommender systems and personalized adaptive learning. LA is further based on human interaction and human related areas like people, networks, culture and communication, which will also show an effect on LA.

The LAAR project integrates these elements into the different applications. The apps interact with the learning wallet or LRS by means of the xAPI statements. Based on the recorded statements, a competence analyser produces information that is fed to the dashboard or can be used to steer the training program.

11.1 What is happening in the background?

The process that takes place "behind the scenes" can be described as follows: When the learner is training with one of the applications, statements of his/her actions are send by the application to the Learning Record Store (LRS), also called learning locker/wallet. The competence analyser uses the content of the LRS and provides understandable information to the dashboard that provides information to the learner about the progress made. The dashboard also informs the training application about the level of the learner in order to adapt the complexity of the training content.



(Picture from Learning Analytics in Augmented Reality, Blueprint for an AR / xAPI Framework)

We describe the function of each component below. For those wanting to go into detail about the exact technical functioning, we refer to Learning Analytics in Augmented Reality, Blueprint for an AR / xAPI Framework, Joshua Secretan, Dr Fridolin Wild, Will Guest.

11.1.1 The xAPI statements

To be able to record the information of the different applications, a standardised language is needed, adapted to the requirements of the competences to be measured and the analysing systems that are used. The Experience API (xAPI) is used in the LAAR project as this standard language.

The xAPI contains 3 types of statements (for general use)

- Tool & Tech specific verbs (Information about user engagement on app level)
    - app started / Launched the software
    - quit / abandoned the app
- Domain-Specific Verbs & Objects (Information about the real-world and digital content engagement)
    - Viewed a video
    - Viewed an tagged object
- Custom Progressions & Patterns (Information about learner achievement
    - Completed the exercise / learning experiences completed
    - Failed the test
    - Passed the test

To be able to record specific actions, we added specific verbs from the ESCO taxonomy to the standard language (in Domain-Specific Verbs & Objects)

ESCO verbs for stage technician essential skills		
adjust	assemble	assess
de-rig	dismantle	distribute
draw	ensure	fit up
focus	follow	handle
hang	install	keep up
light	manage	mark
modify	operate	pack
plot	prepare	prevent
provide	run	set up
technically design	understand	use
work		

(Picture from Learning Analytics in Augmented Reality, Blueprint for an AR / xAPI Framework)

These have a specific meaning in the context of technical theatre (e.g., assembling a set is a different thing than fit-up a set, the first is done in a workshop and included woodworking techniques, the second is done on stage and includes the mounting of prepared parts.

It is important to note that the statements are not a judgement, only an ascertainment of facts.

11.1.2 The developed xAPI statements

During the project we developed a set of xAPI statements needed for the different applications. Where possible, existing statements were used according the guidelines of the consortium. Where needed the statements were developed and registered.

Event (IOS)	Estimated frequency	Verb	URL	Description
On training beginning (after lobby?)	1	initialized	http://adlnet.gov/expapi/verbs/initialized	Begin the formal tracking of learning content, any statements timestamped before a statement with an initialized verb are not formally tracked.
		joined	http://activitystrea.ms/schema/1.0/join	Indicates that the actor has become a member of the object. This specification only defines the meaning of this verb when the object of the Activity has an objectType of group, though implementers need to be prepared to handle other types of objects.
Viewing instruction? Want to see how long they are on each instruction		viewed	http://id.tincanapi.com/verb/viewed	Indicates that the actor has viewed the object.
On trainee submitting for marking	~6	attempted	http://adlnet.gov/expapi/verbs/attempted	Used at the initiation of many "experienced" activities to mark the entry. Attempts without further verbs could be incomplete in some cases.
Trainer click "Yes" on checklist	>40	rejected	http://activitystrea.ms/schema/1.0/reject	Indicates that the actor has rejected the object.
Trainer clicks "No" on checklist	>10	accepted	http://activitystrea.ms/schema/1.0/accept	Indicates that that the actor has accepted the object. For instance, a person accepting an award, or accepting an assignment.
On trainer clicking "retry"	~3	failed	http://adlnet.gov/expapi/verbs/failed	Learner did not perform the activity to a level of pre-determined satisfaction. Used to affirm the lack of success a learner experienced within the learning content in relation to a threshold. If the user performed below the minimum to the level of this threshold, the content is 'failed'. The opposite of 'passed'.
On trainer clicking "continue"	~6	passed	http://adlnet.gov/expapi/verbs/passed	Used to affirm the success a learner experienced within the learning content in relation to a threshold. If the user performed at a minimum to the level of this threshold, the content is 'passed'. The opposite of 'failed'.
On trainer clicking "continue" too (Working on this)	~6	progressed	http://adlnet.gov/expapi/verbs/progressed	A value, typically within a scale of progression, to how much of an activity has been accomplished. This is not to be confused with 'mastered', as the level of success or competency a user gained is not guaranteed by progress.
At the beginning of each new task node	~6	launched	http://adlnet.gov/expapi/verbs/launched	Starts the process of launching the next piece of learning content. There is no expectation if this is done by user or system and no expectation that the learning content is a "SCO". It is highly recommended that the display is used to mirror the behavior. If an activity is launched from another, then launched from may be better. If the activity is launched and then the statement is generated, launched or launched into may be more appropriate.
At end of scenario. (Only once!)	1	completed	http://activitystrea.ms/schema/1.0/complete	Indicates that the actor has completed the object.
		exited	http://adlnet.gov/expapi/verbs/exited	Used to leave an activity attempt with no intention of returning with the learner progress intact. The expectation is learner progress will be cleared. Should appear immediately before a statement with terminated. A statement with EITHER exited OR suspended should be used before one with terminated. Lack of the two implies the same as exited.
Application session terminated without completion	0	abandoned	https://w3id.org/xapi/adl/abandoned	

Events (Other, useful, not used)	Estimated frequency	Verb	URL	Description
Indicate the trainer / trainee relationship?	n/a	mentored	http://id.tincanapi.com/verb/mentored	Indicates that that the actor has mentored the object. For instance, a manager mentoring an employee, or a teacher mentoring a student.
Instead of accept project?	n/a	confirmed	http://activitystrea.ms/schema/1.0/confirm	Indicates that the actor has confirmed an agreement with the object. For instance, a software developer might confirm an issue reported against a product.
...just because...	n/a	experienced	http://activitystrea.ms/schema/1.0/experience	Indicates that the actor has experienced the object in some manner. Note that, depending on the specific object type used for both the actor and object, the meaning of this verb can overlap that of the "consume" and "play" verbs. For instance, a person might "experience" a movie; or "play" the movie; or "consume" the movie. The "experience" verb can be considered a more generic form of other more specific verbs or "consume", "play", "watch", "listen", and "read"
For recording lobbying?	n/a	hosted	http://activitystrea.ms/schema/1.0/host	Indicates that the actor is hosting the object. As in hosting an event, or hosting a service.
Take on a role?		checked-in	http://activitystrea.ms/schema/1.0/check-in	Indicates that the actor has checked-in to the object. For instance, a person checking-in to a place.
Indicate the trainer evaluating answers		evaluated	http://www.tincanapi.co.uk/verbs/evaluated	Verb used for evaluating a previous learning experience. The object of the statement should normally be a StatementRef pointing to an existing statement about the experience being evaluated. The actual evaluation should be provided in the result or either as a score, response or both. See http://tincanapi.co.uk/pages/Tin_Can_Learning_Evaluator.html#Evaluating_and_Reflecting for further details and examples.

Event (Hololear)	Estimated frequency	Verb	URL	Description
On training beginning (after lobby?)	1	initialized	http://adlnet.gov/expapi/verbs/initialized	Begin the formal tracking of learning content, any statements timestamped before a statement with an initialized verb are not formally tracked.
		viewed	http://id.tincanapi.com/verb/viewed	Indicates that the actor has viewed the object.
Trainee user at task node 2		user at	http://activitystrea.ms/schema/1.0/at	Indicates that the actor user located at the object. For instance, a person being at a specific physical location.
		launched		
At end of scenario. (Only once!)	1	completed	http://activitystrea.ms/schema/1.0/complete	Indicates that the actor has completed the object.
Application session terminated without completion	0	abandoned	https://w3id.org/xapi/adl/abandoned	
Trainee consumed video / audio / pdf / object		consumed	http://activitystrea.ms/schema/1.0/consume	Indicates that the actor has consumed the object. The specific meaning is dependent largely on the object's type. For instance, an actor may "consume" an audio object, indicating that the actor has listened to it; or an actor may "consume" a book, indicating that the book has been read. As such, the "consume" verb is a more generic form of other more specific verbs such as "read" and "play".
		created	http://activitystrea.ms/schema/1.0/create	Indicates that the actor created the object.
		read	http://activitystrea.ms/schema/1.0/read	Indicates that the actor read the object. This is typically only applicable for objects representing printed or written content, such as a book, a message or a comment. The "read" verb is a more specific form of the "consume", "experience" and "play" verbs.
		walked	https://brindlewaye.com/xAPITerms/verbs/walked/	Indicates that the actor walked a distance indicated by the activity
		attempted	http://adlnet.gov/expapi/verbs/attempted	Used at the initiation of many "experienced" activities to mark the entry. Attempts without further verbs could be incomplete in some cases.
			http://activitystrea.ms/schema/1.0/li	Indicates that the actor has listened to the object. This is typically only applicable for objects representing audio content, such as music, an audio-book, or a radio broadcast. The "listen" verb is a more specific form of the "consume", "experience" and "play" verbs.

(**verbs** used in xAPI statements)

Actor	Verb	Verb URL	Object	Description
Trainer / Trainee	initialized	http://adlnet.gov/expapi/verbs/initialized	Application	When start learning scenario
Trainee	launched	http://adlnet.gov/expapi/verbs/launched	Learning scenario / Learning node	Record the start of each node
Trainee	viewed	http://id.tincanapi.com/verb/viewed	Content	Record that they've viewed the content
Trainer	evaluated	http://www.tincanapi.co.uk/verbs/evaluated	Trainee attempted statement	The beginning of evaluating
Trainer	rejected	http://activitystrea.ms/schema/1.0/reject	Checklist item	Record when they click through
Trainer	accepted	http://activitystrea.ms/schema/1.0/accept	Checklist item	Record when they click through
Trainee	attempted	http://adlnet.gov/expapi/verbs/attempted	Learning node	Record that they've marked a node complete for testing
Trainee	failed	http://adlnet.gov/expapi/verbs/failed	Learning node	Restart
Trainee	passed	http://adlnet.gov/expapi/verbs/passed	Learning node	Record pass
Trainee	skipped	http://id.tincanapi.com/verb/skipped	Learning node	Not all checklist items ticked but continuing anyway
Trainee	completed	http://activitystrea.ms/schema/1.0/complete	The AR application	
Trainee / Trainer	exited	http://adlnet.gov/expapi/verbs/exited	The AR application	
Trainee / Trainer	abandoned	https://w3id.org/xapi/adl/abandoned	The AR Application	

(xAPI statements for IOS apps)

Actor	Verb	Verb URL	Object	Description
Trainee	initialized	http://adlnet.gov/expapi/verbs/initialized	The AR application (WEKIT)	When start learning scenario
Trainee	start	http://adlnet.gov/expapi/verbs/launched	The ARLEM scenario title	Record the start of each node
Trainee	viewed	http://id.tincanapi.com/verb/viewed	label / audio type	ARLEM label and audio
Trainee	find	http://activitystrea.ms/schema/1.0/find	detect type	
Trainee	listen	http://activitystrea.ms/schema/1.0/listen	audio / sound type	
Trainee	watch	http://activitystrea.ms/schema/1.0/watch	hands type	
Trainee	follow	http://activitystrea.ms/schema/1.0/follow	ghosttrack type	
Trainee	ActionPredicate	http://competenceanalytics.com/ActionPredicate="WILD_CARE_STRING"	Wildcard.	A wildcard for ARLEM actions. Handles any unhandled cases.
Trainee	attempted	http://adlnet.gov/expapi/verbs/attempted	Learning node	Record that they've marked a node complete for testing
Trainee	skipped	http://id.tincanapi.com/verb/skipped	Learning node	Not all checklist items ticked but continuing anyway
Trainee	completed	http://activitystrea.ms/schema/1.0/complete	The AR application (WEKIT)	
Trainee	exited	http://adlnet.gov/expapi/verbs/exited	The AR application (WEKIT)	
Trainee	abandoned	https://w3id.org/xapi/adl/abandoned	The AR application (WEKIT)	

(xAPI statements for Hololens application)

MetaData	Meaning	URL	
sesssionId	initialized	https://w3id.org/xapi/video/extensions/session-id	
language		https://w3id.org/xapi/video/extensions/language	
screensize		https://w3id.org/xapi/video/extensions/screen-size	
Attempt ID		http://id.tincanapi.com/extension/attempt-id	Used to differentiate between attempts within a given registration. This extension is especially useful for games, for example in the Tetris prototype at http://tincanapi.com/prototypes this extension is used as an identifier for each new game of Tetris.

(xAPI Metadata)

11.1.3 The Learning Record Store (LRS)

The Learning Record Store (LRS) acts as the streaming database for xAPI statements. In our case, we deployed the Open Source project LearningLocker.

Connecting two or more learning activities in a learning sequence enables learning to be treated as a process. In most use cases, the definition and management of such processes was handled in the app itself. Future trends for AR in teaching and learning focus on measuring and evaluating learning in personalized student learning experiences, which requires to collect information about learner's behaviour, activities and results and to exchange this information with external systems. Both, the internal and external process management and the communication between learning activities and with learning management systems can then be supported by the implementation of a so-called input-output hub (IO-hub). Such an approach addresses an important issue that needs to be considered to use AR in learning successfully. Data exchange is classified as a main advantage of using mobile AR. Communication between AR apps and external entities allows to collect data in form of activity statements describing the learner's behaviour during the learning sequence. Thus, it addresses current challenges and future trends in AR teaching and learning.

Whenever data is collected and exchanged between entities, using established standards supports the integration of the application into various technology environments. According to the Experience Application Programming Interface (xAPI) specification, which is designed to support the information collection of formal and informal distributed learning activities, a data set describes single activity statements and is stored in a learning record store. In such way, series and different types of experiences can be collected to be analysed later, including data, e.g., from wearables, mobile applications, workplace environments, and geo data.

From a theory perspective, the xAPI specification is influenced by the socio-cultural framework Activity Theory and in close alignment with constructivist learning theory. For applying the xAPI standard in a learning sequence it is recommended to include it early in the design process. Thus, constructivist-aligned strategies are implemented from design through evaluation of the learning activity. Consequently, the data acquisition and data analysis then follow the main aspects of constructivist learning theory.

11.1.4 The competence analyser

The competence analyser takes in account the needs of acceptable assessment. A competence is built out of different skills, that need to be proved in different contexts and at least twice to avoid lucky shots.

The competence analyser brings information of performance together from multiple sources, links it to the sectoral layer and makes it ready to visualise it. It is a logic component and is unique for each knew AR training system, tailored to be able to understand and process the statements.

11.1.5 Measuring performance for Learning analytics

To measure performance in a way that it is use- and meaningful, we can use three types of inputs. The first type are user triggered events. When the user starts or stops the application or part of it, or uses a command, this is recorded and can be used (in combination with other inputs) to determine is the activity has been successful, if it is performed within the time limits, etc.)

Secondly, we can use input from a "third party", someone observing the process and approving (or disapproving) specific statements about performance. The statements have to be built in a way that no appreciation is required, but that objective observation generates the input. In this way bias is minimised.

The third type of input is the technically most challenging. In this type we get input directly from the activities. To generate this input, we need to find measurable actions or results that show successful completion and so indirectly prove competence. The measurable actions can be represented by triggers (an object is placed in the right position, a tag is visible, …) or derived from recorded actions (if the user takes an object out of a box, he/she is able to open the box).

The main issue in this type of measurement is if we really measure what we want to know. And if we can link our measurement to objective behaviour statements, and so to competence. To give a concrete example: a user needs to read an instruction and then perform an action. The action fails. Are we sure the action fails because of lack of competence? Or could a lack of literacy also cause the failure?

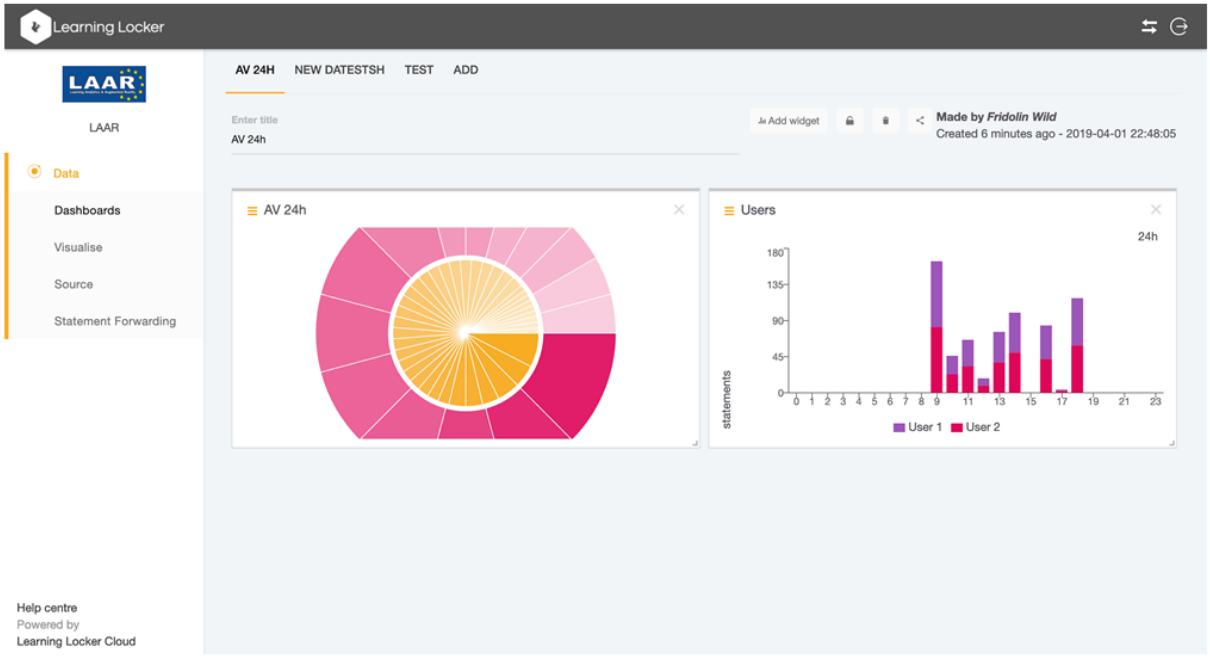
11.2 The dashboard

The dashboard structures the information from the different applications so it becomes meaningful for the user and for the trainer / supervisor. This information could, in a later phase, feed into the learner's portfolio.

An educational dashboard is a display which visualizes the results of educational data mining in a useful way. Educational data mining and visualization techniques allow teachers and students to monitor and reflect on their (online) teaching and learning behaviour patterns. Such information in a dashboard supports students' self-knowledge, self-evaluation, self-motivation, and social awareness. Further, educational dashboards are expected to support the smart learning environment, in the perspective that students receive personalized and automatically- generated information on a real-time base, by use of the log files in the Learning Management System (LMS) or the analysed data from a Learning Record Store (LRS).

The Performance Dashboard (PD) allows the user to view their progress. It visualises the outputs of the competence analyser. This typically is either a component of the AR training app or of the dashboard provided by LRS, LMS or external systems.

The information can be shown in different ways and for different purposes. It can be information about a single learner, a group of learners or a specific activity. The examples below show the different views.



(LearningLocker dashboard)

The learning locker dashboard gives information about the amount of statements, used applications, active users, etc.

(LAAR dashboard trainer view)

This trainer view shows the time a learner needed to complete four consecutive actions. The time is related to the group of learners.

(LAAR dashboard trainee view)

In this trainee view, the user can compare his performance with the group. Depending on the chosen view, the timing is divided per part (in this case connecting a corner), per sub-activity or per competence.

12 Testing one two

12.1 Prototype testing

Within the LAAR project we conducted several field experiments to run and test the build applications in real life situations and simulations. The field experiments demonstrated the possibilities and limitations of AR and LA in this field. Additionally, the applications were presented and discussed in an experts' panel discussion (Multiplier Event), with experts in supported employment, teaching and training experts for professional education, branch experts, HR managers, etc. The field experiments documented in papers and for the scientific community are:

- Field experiment testing "Who Am I" app (flowers theme) with students at the IT University of Copenhagen in Denmark;
- Field experiment testing "Who Am I" app (flowers theme) with students at the Liechtensteinisches Gymnasium in Vaduz, Liechtenstein;
- Field experiment testing "Who Am I" app (safety signs) with refugees at VPLT in Langenhagen, Germany;
- Field experiment testing "Follow Me" app and MS Hololens app with visitors at the fair ProLight&Sound 2019 in Frankfurt, Germany;

The key elements of innovation are the use of AR based training applications for professional / workplace training in multiple iterations, including elements from LA, LS and gamification. The expected impact was that AR based training applications prove itself in practice. Moreover, professional training becomes more attractive, fascinating, transparent and effective with the use of AR and LA, as well as transferable between various branches by modularizing the training units, which was a main conclusion of several qualitative feedbacks.

Therefore, we prepared a questionnaire to receive a participant's feedback based on closed and open questions. The questionnaire included questions addressing a participant's impression of the system's usefulness (perceived usefulness), perceived learning, and motivation. The answers were given according to a five-level Likert scale (strongly disagree, disagree, neutral, agree, totally agree). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance". Perceived learning describes the degree to which a student observes to obtain knowledge in a particular learning situation. Motivation is considered to be intent and engagement as action; both terms are often used interchangeably. Since our study is of exploratory nature, we used the term motivation as a measure for a learner's interest and engagement in a particular learning activity. In that sense, we address a learner's self-perception on this dimension. We formulated the questions according to these definitions:

- Perceived Usefulness: Q1: The App was helpful to fulfill the task.
  Perceived Learning: Q2: With this activity I have learned something.
  Q3: I have learned about truss connection.
  Q4: I can connect trusses correctly and safely.
- Motivation: Q5: The introductory story was motivating.
  Q6: The task was simple and understandable.
  Q7: It was exciting to experiment with the app.
  Q8: The activity was entertaining.

Finally, we also included questions regarding the system usability scale (SUS) to receive feedback on the usability of the whole system (AR application and used devices).

12.2 User experiences

The findings from the evaluation of the training activity with the AR application, especially the findings from the qualitative feedback given by domain experts, contribute to evaluate qualitative aspects and answer questions towards specific aspects addressed by the application of AR in learning activities. Since trainers and trainees benefitted from the motivational, collaborative and realistic training setting and appreciated the aspect that were derived from the design elements (design framework). For example, the interactive, intuitive and safe application, independency, efficiency, and process-orientation were identified as added value of AR in workplace training. The feedback from the experiment session in Frankfurt was mapped on aspects of valuation, sorted by frequency, and assigned to the corresponding layer of the design framework. The following table shows a categorized qualitative feedback from users that were trained with the “Follow Me!” app.

Layer	Aspects	Quotation
Content	Language	Imparts without language barrier what needs to be done. Language and nationalities independent.
	Descriptive	The visual representation is very helpful because it is easy to understand what needs to be done.
	Self-explaining	Trainer may need to correct only minor issues and it is self-explanatory.
	Under-standing	The visual, very clear presentation / instruction makes it easy for everyone to understand how to proceed.
	Complexity	Learning about complex tasks. Ability to combine a series of steps.
	Clarity	Intuitive operation and clearly defined activities.
	Interactivity	Step by step instruction on the object.
	Multimedia	Higher memorability through multisensory learning.
Mobile	Independence	Learning …, time and place independent.
		Can be used for several people on a construction site.
		For trainees and interns as an exercise in the storage.
Motivation / Engagement	Simple	simple handling; simple to learn;
	Quick	You quickly learn how to handle the traverse.
	Entertaining	It's quick and entertaining. Hands-on approach.
	Costs	No need to travel. Cost efficient.
	Safety	Training with no danger.
	Pace	You can train multiple students on their own tempo.
	Fun	Have fun, enjoy the work.
Situated Learning, Collaboration	Collaborative	You learn together and make no mistakes.
	Complex	Learning about complex tasks. Ability to combine a series of steps.
	Realistic	Realistic, simple and descriptive training.

(Categorized qualitative feedback from users trained with the “Follow Me!” app)

Experiences with a different kind of target group:

The applications were tested with a special target group - fugitives and migrants who are looking for an entry into the event industry - as part of the step2mice program in Hanover in October 2018. The target group of 15 people had little or no industry knowledge and experience. The participants were between 20 and 30 years old and come from different countries of origin all with a different skills background. However, due to their age, the target group also had a high affinity to multimedia and mobile devices. The applications are characterized by the fact that they are not text-heavy, but increasingly image-heavy and texts can then be presented in multiple languages. In the course of using the applications, it became apparent that the participants from the target group have a great desire to try out and discover the applications. Especially in comparison to conventional learning methods there are significant advantages.

This first app testing with the target group were under realistic conditions. The app was described by the participants as consistently useful and easy to use. Many of the participants wanted to install the app immediately and directly on their own smartphones.

Motivated by the positive results of the first test, the "Who am I?" App was enhanced by additional functionality (learn-mode), filled with additional content and evaluated again in a field test as part of the step2mice measure.

- First, the app was re-trained so that it is able to recognize safety signs according to DIN EN ISO 7010 (e.g. escape signs, prohibition signs, warning signs, mandatory signs, fire protection signs). This scenario and the specific signs were selected in close consultation with the VPLT experts.
- Furthermore, gamification elements were integrated into the app in order to increase user motivation. In Quiz Mode, users can point their smartphone's camera at objects in their environment and are then asked to select the correct name of a recognized object based on a multiple-choice question.
- Finally, the app was tested with the actual target group - refugees and migrants looking for entry into the MICE industry - as part of the step2mice activity in Hanover in October 2018. This field test was conducted under realistic conditions and confirmed the positive signal from a first test in Denmark. The participants valued the application of the Explore-App as consistently useful and easy to use. Many of the participants asked to install the app for private use on their own smartphones.

13 Strengths and limitations of AR - a SWOT Analysis

In this last chapter we apply a SWOT analysis that reflects the strengths and limitations of the application of AR in workplace trainings, but also demonstrate its opportunities and threats. The analysis emerges from the discussions within the team and with the participants of the pilots over the length of the project.

13.1 AR strengths for workplace trainings

A strength can be viewed as a resource, a unique approach, or capacity that allows an entity to achieve its defined goals (e.g., AR can allow for precise control of stimulus delivery within a realistic training or rehabilitation simulation).

- Enhanced Ecological Validity
- Stimulus Control and Consistency That Supports Repetitive and Hierarchical Delivery
- Real-time Performance Feedback
- Cuing Stimuli to Support “Error-Free Learning”
- Self-Guided Exploration and Independent Practice
- Interface Modification Contingent on User’s Impairments to Support Access to Workplace trainings
- Complete Naturalistic Performance Record
- Safe Testing and Training Environment, which Minimizes Risks due to Errors
- Gaming Factors to Enhance Motivation
- Low-Cost Functional Environments That Can be Duplicated and Distributed
- …

13.2 AR weaknesses for workplace trainings

A weakness is a limitation, fault, or defect in the entity that impedes progress toward defined goals (e.g., the limited field of view and resolution in a head-mounted display can limit usability and perceptual realism).

- UserInterface-Challenge 1: Interaction Methods
- UserInterface-Challenge 1: Wires and Displays
- Immature Engineering Process for AR-based Training Systems
- Platform Compatibility
- Front-End Flexibility
- Back-End Data Extraction, Management, Analysis, Visualization
- Side effects (Cybersickness, Aftereffects, Fokus on Technology)

13.3 AR workplace training Opportunities

An opportunity pertains to internal or external forces in the entity’s operating environment, such as a trend that increases demand for what the entity can provide or allows the entity to provide it more effectively (e.g., tremendous growth in the interactive digital gaming area has driven development of the high-quality, yet low-cost graphics cards needed to make VR/AR deliverable on a basic PC).

- Emerging Advances in AR Technology 1: Processing Power and Graphics/Video Integration
- Emerging Advances in AR Technology 2: AR Devices and Wires
- Emerging Advances in AR Technology 3: Real-Time Data Analysis and Intelligence
- Gaming-Industry Drivers
- AR workplace training applications have widespread intuitive appeal to the public
- Academic and Professional acceptance
- Close-Knit AR workplace training Scientific and Industrial Community

- Integration of AR with Physiological Monitoring, Eye-Tracking, …
- Collaboration in Teletrainings for workplaces

13.4 AR Workplace Training threats

A threat can be any unfavorable situation in the entity's environment that impedes its strategy by presenting a barrier or constraint that limits achievement of goals (e.g., clinical administrators' and financial officers' belief that AR equipment is too expensive to incorporate into mainstream practice).

- Too Few Cost/Benefit Proofs Could Negatively Impact Mainstream AR workplace training Adoption
- Aftereffects Lawsuit Potential
- Ethical Challenges
- The Perception that AR Training tools will eliminate the Need for the Teachers and Trainers
- Limited awareness / Unrealistic Expectations

14 Conclusion

The LAAR project developed a conceptual as well as a practical framework that can be used for future applications. The conceptual framework supports the developers, providing them with the needed basic background on education theory, developing processes and European standards (e.g. ESCO) connecting learning systems and countries. The technical framework includes all the elements needed to support the control, analysis and visualisation of results for different applications. The developed technical framework, including xAPI statements, LRS, virtual learning environment, dashboard, … offers a profound foundation for further development. The developer can focus on creation of content.

The apps developed in the LAAR project can be reused with other content for other fields. Especially the node editor used in the “truss app” has potential to be reused, adapted to, or extended to additional training sequences. The definition of the xAPI-statements designed to log a user’s experience can be reused and extended in any other project and adds to the existing body of knowledge in this field. The “explore app” has several themes that can be extended and applied in various domains. The app can be trained using predefined images from objects.

On the other hand, the LAAR project showed clearly that we are still in the beginning of the development of this technology for educational use in the workplace. The underlaying technologies need to improve to become employable in real life situations. Object recognition, for marked as well as marker-less objects, needs to be improved for limited visibility situations (e.g. backstage environments), specific materials (e.g. aluminium) variations between countries (e.g. safety signs), and longer distances (e.g. spotlights hanging above a stage). Better hardware solutions need to be found so learners can work hands free and without physical limitations. Further study is needed to ensure safety is guaranteed using information devices in a high-risk environment. But the biggest challenge will be to develop methods to recognise and analyse human behaviour in order to assess progress and accomplishment of competence. Until we can reach a high standard of certainty that what is measured is also evidence of competence, human involvement will always be needed.