QAED

The future of AED training for laypeople.

Master Thesis by Anna Mira Gębala
in collaboration with Laerdal Medical

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GLOSSARY

AED	-	Automated External Defibrillator
AHA	-	American Heart Association
BLS	-	Basic life support
CPR	-	Cardiopulmonary resuscitation
EMS	-	Emergency Medical Services
ERC	-	European Resuscitation Council
OHCA	-	Out-of-hospital cardiac arrest
SCA	-	Sudden Cardiac Arrest

EXECUTIVE SUMMARY

Ability to provide the first aid is one of the most powerful skills which can save someone's life. The survival rate of out of hospital cardiac arrest in Europe is only 9%, even though AED (automated external defibrillators) can be accessed in public places to treat it successfully in most of the cases. First aid training is recognised as the most efficient way to provide skills, knowledge and confidence to use AED devices. Laerdal Medical is the company which provides a wide range of training equipment and is specialised in advanced CPR mannequins. As the next step, they research and work on the new tools for AED training.

The extensive research was conducted to understand participants, instructor and company perspective towards the future of the AED training. With the help of St John Ambulance in the United Kingdom, the field trip was organised to investigate their current methods and needs of first aid training institution, but also better understand the users by observing courses and interviewing multiple instructors. The research showed that the aim of the courses is to make students effective and not necessarily perfect. Besides, gaining the confidence to act is as important as gaining skills and knowledge. In that process, the huge part plays the practice with the device and the positive and constructive feedback from the instructor. As a result, the project focused on empowering instructors to train and support students without unnecessary limitations. One of the challenges is assessing the performance of multiple students at the same time and also providing constant feedback without losing track of other students. Laerdal's QCPR (Quality CPR) technology addresses this problem efficiently, however there is no solution which can be applied while students practise the AED use.

The concept of future AED training was created. It consists of two elements: the physical QAED Trainer and QAED Classroom app and can be integrated with the Laerdal's QCPR products. The AED training device does not only provide the conditions for practice but also collects participants performance. The QAED Classroom app analyses the data and provides an instructor with the reliable information which student should be addressed and suggestion what feedback to provide. When an exercise is finished the detailed information about students performance is created. Besides, if the instructor will decide to share the visual feedback with the class, the special interface can be projected on a TV or projector. The concept aims to provide a simple and accessible overview of the student's performance so the instructor will be less stressed to control everyone but also provide more time to give feedback.

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1. INTRODUCTION

This chapter discusses the aim of the project and general background information. First, the problem statement, initial assignment and approach will be discussed. Next, the client and research partner will be introduced. This chapter also includes essential information about cardiac arrest and the reasons behind the need for AED training improvement.

Problem statement

Cardiovascular disease is a leading cause of global mortality, accounting for almost 17 million deaths annually or 30% of all global mortality. It is estimated that about 40-50% of all cardiovascular deaths are sudden cardiac deaths (Mehra, 2007). In Europe, 350 000–700 000 individuals a year are affected by SCA, and it remains as one of the primary causes of mortality despite advanced technology and diagnosis (Travers, A. H. 2015)(Berdowski, J et al., 2010).

In the context of out-of-hospital cardiac arrest victim's chance of survival depends on the bystander intervention. Unfortunately, the survival rates are low. It is only 9% in Europe and 6% in North America (38). One of the most critical steps which has to be provided in sudden cardiac arrest is early electrical defibrillation. It includes the use of publicly accessible Automated External Defibrillator (AED), which helps the heart to restore the normal rhythm. Although AEDs can be correctly operated without prior experience, even minimal training improves performance, timeliness, and efficacy (Cheng et al., 2018). Moreover, there are barriers to action, such as concern about hurting the victim within trained and untrained respondents (Newman et al., 2016). As a result, they may reduce the chance of successful defibrillation and victims survival. Studies show that each minute of delay to use an automated external defibrillator (AED) reduces the probability of survival by 3–4% with CPR and 10–12% without (Gavin et al., 2015).

Therefore, one of the critical determinants of survival in cardiac arrests is an efficient education. Together with CPR (cardiopulmonary resuscitation), AED training is a part of the first aid curriculum for laypeople. However, according to the American Heart Association, current educational offerings in the form of standardized online and face-to-face courses are insufficient. There is a need to improve public knowledge and confidence in the use of AED (Lofgren et al., 2009) (Dahan et al., 2016) but also reduce the decay of skills over time (Cheng et al., 2018). Thus, the conditions for AED training and how trainees acquire AED skills and knowledge and maintain them should be improved.

Initial assignment

The project aims to develop a product solution in the context of future AED training which will contribute positively to laypeople's ability to use AED in an emergency. Therefore, the concept design will tackle the training efficiency and knowledge translation from training to actual performance in resuscitation.

Project approach

The project follows the double diamond model. It divides the design process into four distinct phases: Discover, Define, Develop and Deliver. The phases have a diverging or converging objective, to enable the designer to explore the issue widely and then to narrow down the scope of action.

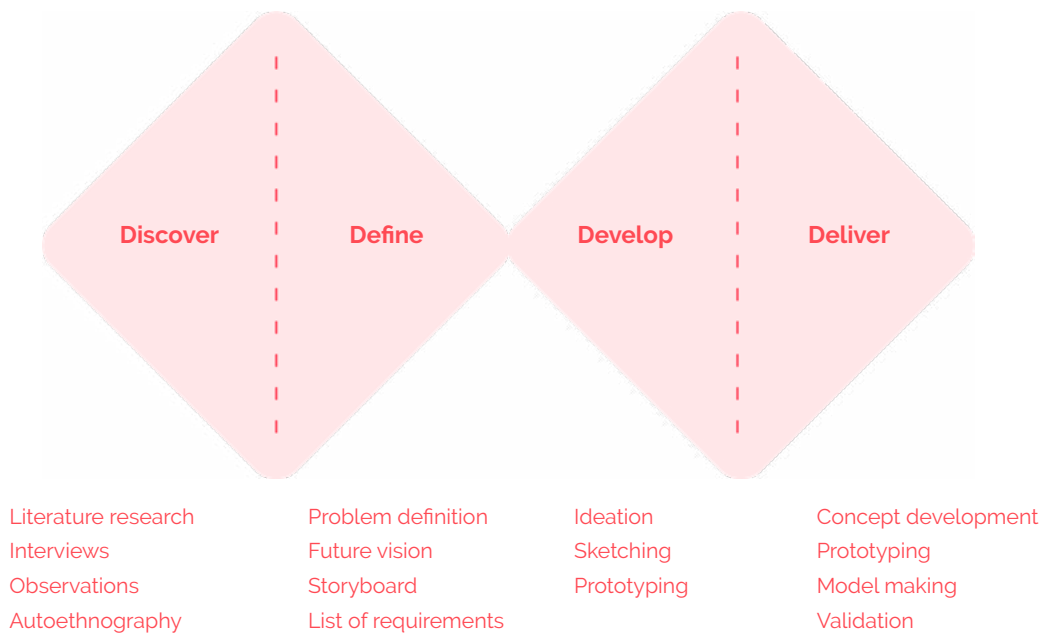| Discover	Define	Develop	Deliver
Literature research	Problem definition	Ideation	Concept development
Interviews	Future vision	Sketching	Prototyping
Observations	Storyboard	Prototyping	Model making
Autoethnography	List of requirements		Validation

Figure 1: Visualization of the project approach

Figure 2: Laerdal Medical Headquarter in Stavanger, Norway

Client

Laerdal Medical is one of the world's leading providers of healthcare training solution for laypeople and clinicians. One of the branches of the company is simulation and training for resuscitation. It offers a wide range of mannequins for CPR training and feedback devices. Besides, Laerdal has introduced QCPR (Quality CPR) solutions for the community market, which is an advanced platform for CPR training. It also meets the standard for the AHA's 2019 feedback requirement ("Little Anne QCPR," n.d.). However, there is currently no responding AED training solution which would meet those standards. Moreover, the devices cannot work with the QCPR to provide complete resuscitation training. Currently, Laerdal provides two types of AED units for laypeople: AED Trainer 2 which simulates the Philips HeartStart® FR2 and AED Trainer 3 which is a replica of the Philips Heartstart FR3 AED ("AED Trainer 2" n.d.) ("AED Trainer 3" n.d.).

Figure 3: Little Anne   Figure 4: AED Trainer 3 and AED Trainer 4

Research partner

St John Ambulance is the first aid charity which provides the first aid training programs. It has over 260 venues nationwide, and every year, it trains more than 400,000 people how to save a life. Moreover, in order to improve the health, it organises campaigns, emergency response program, and community project ("St. John Ambulance" n.d.). The history of the organisations reaches the 11th century. It is the moment when the first Knights of St John set up a hospital in Jerusalem to provide free medical care to sick pilgrims. The charity provides first aid and first aid training for over 140 years "St. John Ambulance" n.d.).

St John Ambulance is was the main research partner for this project. The branch in the United Kingdom has a close relation with Laerdal and agreed to also participate in this project.

HEADQUARTERS

London (Prince of Wales's) District

St John
Ambulance

PLEASE RING
AND WAIT

Figure 5: St John Ambulance centre London, where one of the observations studies took place.
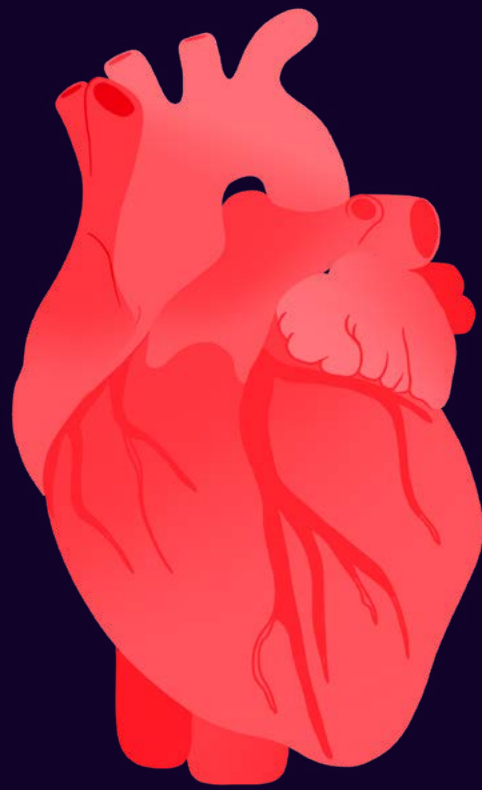
1.1. CARDIAC ARREST & FIRST AID

Out-of-hospital cardiac arrest

Sudden cardiac arrest is caused by the heart's electrical system malfunctions and results in a disturbed pumping action. As a result, blood stops flowing to the brain and other vital organs. Without immediate assistance, it is frequently fatal within minutes (American Heart Association, 2019). Out-of-hospital cardiac arrest (OHCA) is a term used to describe the cardiac arrest which occurs outside of a hospital setting.

Who?

The most commonly reported causes for OHCAs are age, cardiac arrhythmia, coronary artery disease, and cardiomyopathies. Non-cardiac OHCA can be caused by trauma, drug overdose, asphyxia, and drowning (Raffee et al., 2017).

Figure 5: Cardiac arrest context

How to recognise?

There are two main indicators of sudden cardiac arrest. It is a sudden loss of responsiveness and abnormal breathing. Specifically, every person who suddenly colapses and loses consciousness with no response to physical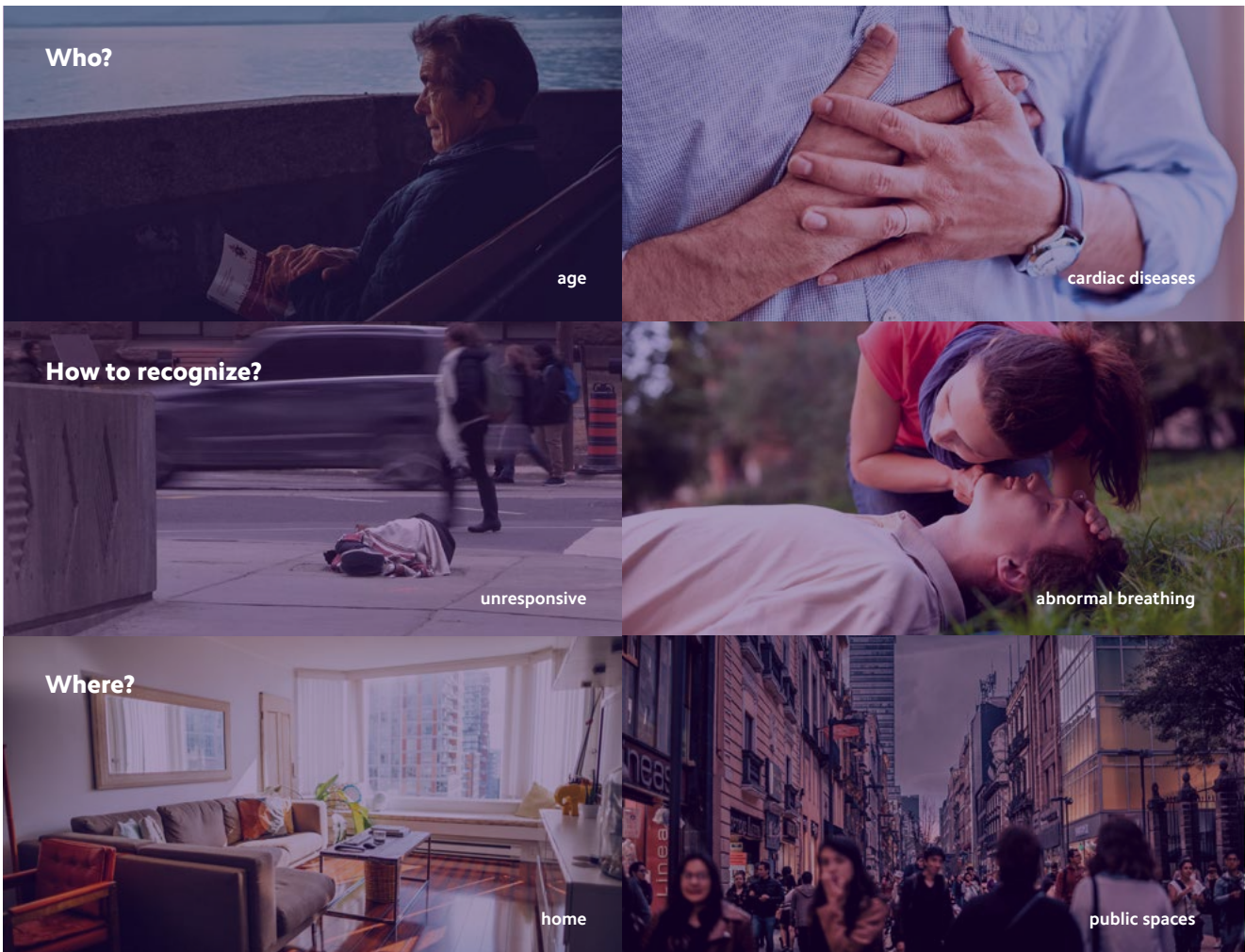 and verbal stimulants and no normal breathing should be assumed as cardiac arrest by bystanders and received the correct first aid.

Where?

Cardiac arrest is a sudden and unexpected event which may happen anytime and at any location. According to the study of out-of-hospital cardiac arrest, the most common location of it is home (65.5%). Remaining OHCA occurs in healthcare facilities (11.7%), in public places (9.5%), on streets (6.9%), at workplaces (3.2%) and others (3.2%). Among public places, it occurs at railway stations, at sports facilities, in public buildings, at schools and airports (Murakami, Y.,2014).

First aid in OHCA

First aid is defined as the immediate assistance provided to a sick or injured person until professional help arrives. Its objective is to "preserve life, alleviate suffering, prevent further illness or injury and promote recovery". (ARC, n.d.) In more than 60 per cent of the countries in Europe, there is a law which requires a citizen to act in case of an emergency. ("International first aid and resuscitation guidelines", 2016)

The term "Chain of Survival" summarises the best approach to the treatment of persons in sudden cardiac arrest. According to the ERC guidelines, the chain of survival consists of early recognition and call for help, early bystander CPR, early defibrillation and early advanced life support and standardised post-resuscitation care (Greif, R., 2018). Early defibrillation is defined as defibrillation, which takes place 3-5 minutes of collapse. It is important as it can produce survival rates as high as 50–70% in cardiac arrest (Greif, R. 2018). Defibrillation is the use of a high-energy electric shock to stop the chaotic rhythm of a heart and allows the normal, organised, electrical rhythm to re-start. It will result in the return of pumping action of the heart and blood circulation (RC, 2017).

Figure 6: Chain of Survival
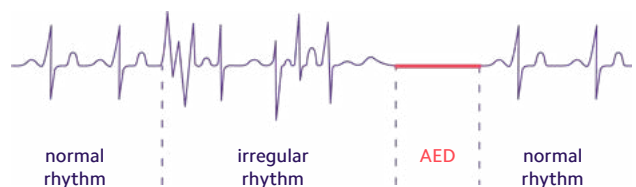
Figure 7: Visualization of the heart rythm and defibryllation in cardiac arrest

Figure 8: AED device in a public place

AED

Definition

An automated external defibrillator (AED) is "a medical device that automatically analyzes the heart rhythm in victims of cardiac arrest, and delivers an electrical shock to the heart to restore its normal rhythm" ("Center for Devices and Radiological Health", n.d.). It is lightweight, battery-operated and portable. It is designed for minimally trained or untrained non-medical personnel and guides the users with audible and/or visual prompts.

AED system

An AED system consists of an AED device, battery, adhesive pads (electrodes)("Center for Devices and Radiological Health", n.d.). Through these pads, the AED can both monitor the heart's electrical rhythm and deliver a shock when it is needed.

electrodes

AED

battery

Figure 9: Main components of the AED system

Philips
HeartStart OnSite

Philips
HeartStart FRx

Zoll
AED Plus

Zoll
AED 3

HeartSine
Connected Samaritan PAD

Physio-Control
CR Plus

Physio-Control
CR2

Defibtech
Lifeline View

Cardiac Science
Powerheart G3 Plus

Cardiac Science
Powerheart G3 Plus

Mindray
Beneheart D1

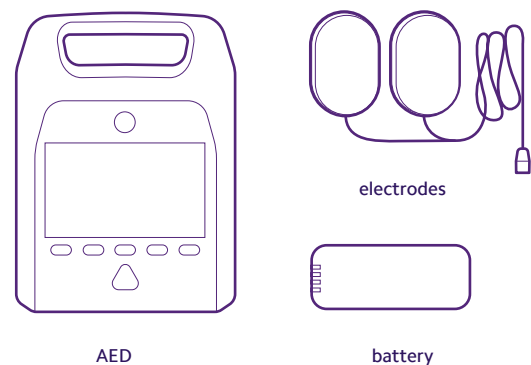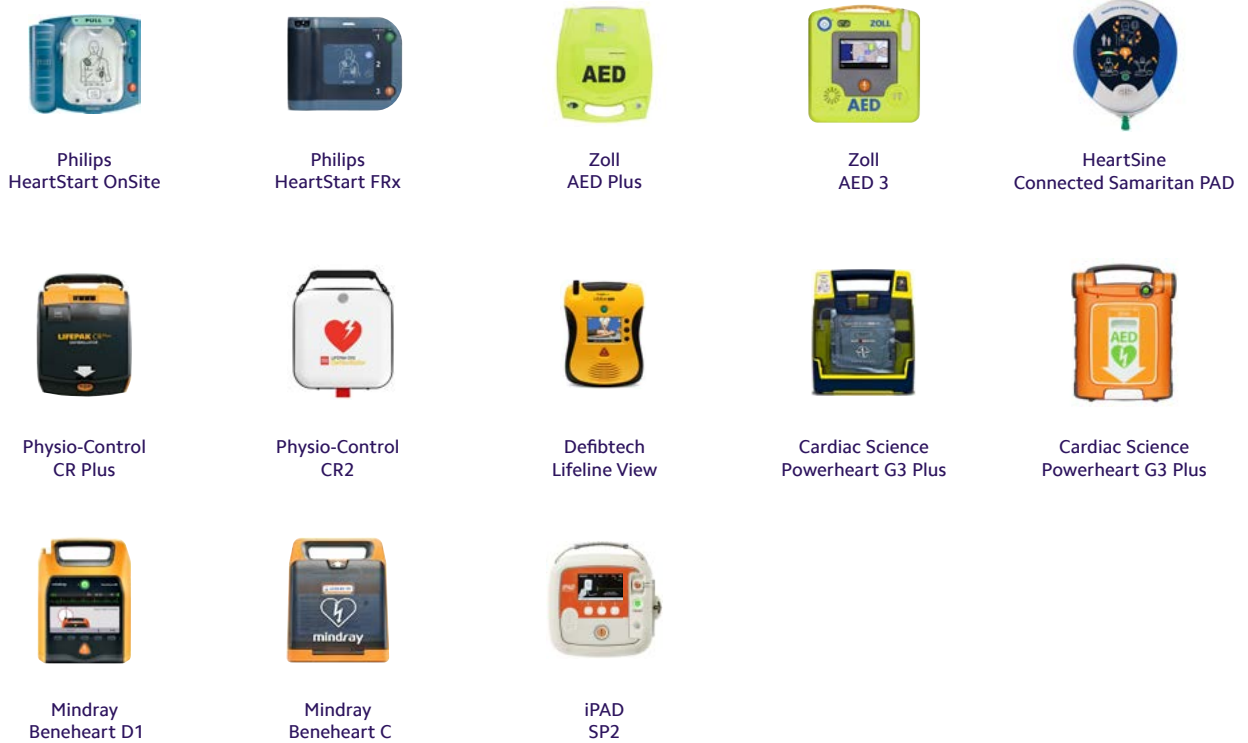**Mindray**
Beneheart C

iPAD
SP2

AED devices

With the development of technology and the growing market of defibrillators, AED devices become more affordable and accessible. There are 20,000 public AEDs in the Netherlands the number is still growing(Dutch News, 2017). There are many AED models available on the market. They have similar functions, but features that affect the ease and speed of use vary.

In general AED devices are divided into two types based on the operation use:
fully automated (when it detects a shockable rhythm, it will deliver a shock without further action from the first aid provider) and semi-automated (it requires pressing a button by first aid provider to deliver a shock).

Location:

AED is intended for use by the general public. They are placed in public places that have a high density of citizens, such as airports, railway stations, bus terminals, sports facilities, shopping malls and offices. AEDs are also purchased by local councils, voluntary aid societies, private companies and single-site organizations. For instance, pubs and golf courses. Public Access Defibrillation (PAD) programs are created to encourage deployment and use of automatic external defibrillators in high-use public areas.

The use of AED

"With the introduction of early defibrillation in the chain of survival, laypeople are being asked to undertake a procedure that previously was primarily performed by healthcare professionals" (AHA, 2018). However, with the current technology and interface design, AED devices are safe and effective when used by laypeople with minimal or no training (AHA, 2018). Although, there are small differences between models, there are universal steps of AED operation.

0. Before

After checking the scene and ensuring that the person needs help, the bystander should alert emergency service by calling 112 for help and dispatch someone to bring AED. When the bystander is alone, he/she cannot leave the victim. As the next step, the first aid provider sho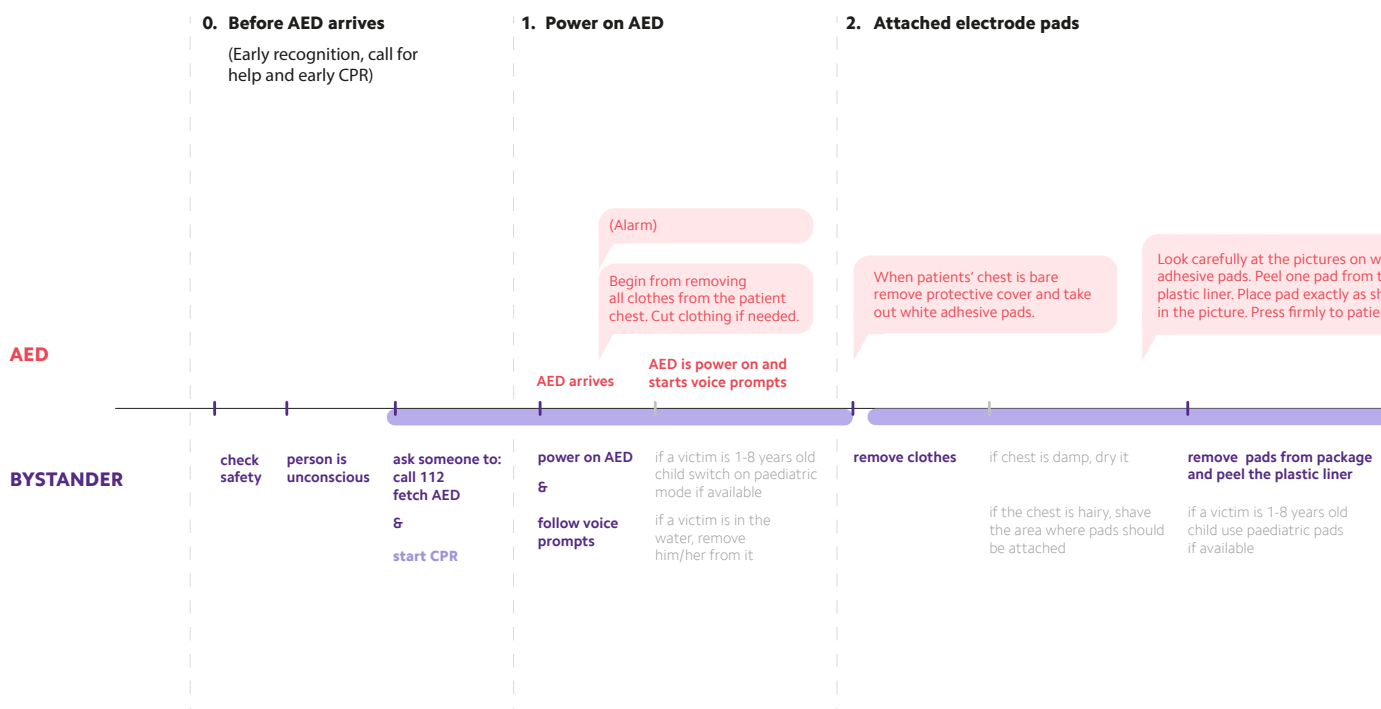uld start CPR and continue until AED arrives. When AED Arrives, and more rescuers are present, CPR should be continued with minimal interruption of chest compressions while an AED is being brought on-site and applied, but defibrillation should not be delayed any longer.

1. Power on the AED

The first step in operating an AED is to switch it on. It will initiate voice prompts, which guide the operator through with the next steps. Depending on the device, it could be done by pressing a power button or lifting the monitor cover or screen to the "up" position.

2. Attach electrode pads

Self-adhesive electrode pads should be opened and attached directly to the skin of the victim's chest. The pads and cables can be preconnected to the AED

0. Before AED arrives	1. Power on AED	2. Attached electrode pads
(Early recognition, call for help and early CPR)		

AED

(Alarm)

Begin from removing all clothes from the patient chest. Cut clothing if needed.

When patients' chest is bare remove protective cover and take out white adhesive pads.

Look carefully at the pictures on w adhesive pads. Peel one pad from t plastic liner. Place pad exactly as sh in the picture. Press firmly to patie

AED arrives

AED is power on and starts voice prompts

BYSTANDER

| check safety | person is unconscious | ask someone to: call 112 fetch AED & start CPR | power on AED & follow voice prompts | if a victim is 1-8 years old child switch on paediatric mode if available | remove clothes | if chest is damp, dry it | remove pads from package and peel the plastic liner |

if a victim is in the water, remove him/her from it

if the chest is hairy, shave the area where pads should be attached

if a victim is 1-8 years old child use paediatric pads if available

LEGEND

text - AED status
text - AED voice prompt
text - main step
text - additional step when the given condition is present

or may require a connection between the cable and AED or between the cable and electrode pads. One electrode pad should be placed on the upper-right sternal border and the second one lateral to the left nipple. The correct position of the electrode pads is often illustrated on the pads or another part of the AED.

3. Analyze the rhythm
Bystander should ensure that nobody is touching the victim while the AED is analyzing the rhythm.

4.A. Shock advised
Bystander should ensure that nobody is touching the victim and deliver a shock. The shock button should be pushed as directed. When AED is fully-automated, it will deliver it automatically. If signs of circulation do not return should resume CPR. After 60 seconds, most devices will prompt a check for signs of circulation and inform if next shock is advised or not.

4.B. Shock not advised
If shock is not indicated, AED should always be left attached, and bystander should initiate CPR.

5. Care After Successful Defibrillation
When signs of circulation and breathing return, the patient should be placed in a recovery position, and the AED should stay attached. Bystander should continue to monitor the victim. Many AEDs monitor rhythm continuously and advise the operator if fibrillation recurs. It is important to check breathing and signs of circulation frequently.
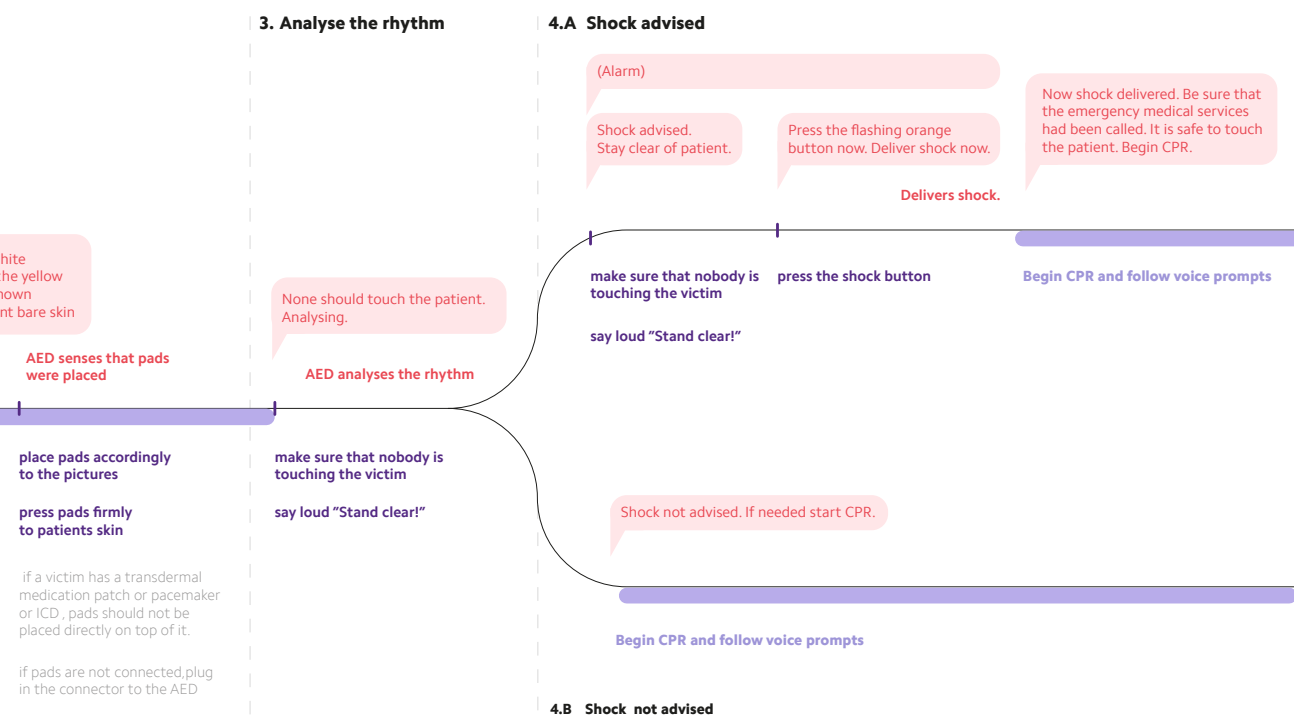

3. Analyse the rhythm

4.A Shock advised

(Alarm)

Shock advised. Stay clear of patient.

Press the flashing orange button now. Deliver shock now.

Now shock delivered. Be sure that the emergency medical services had been called. It is safe to touch the patient. Begin CPR.

Delivers shock.

make sure that nobody is touching the victim

press the shock button

Begin CPR and follow voice prompts

None should touch the patient. Analysing.

AED analyses the rhythm

say loud "Stand clear!"

hite he yellow own t bare skin

AED senses that pads were placed

place pads accordingly to the pictures

press pads firmly to patients skin

make sure that nobody is touching the victim

say loud "Stand clear!"

Shock not advised. If needed start CPR.

if a victim has a transdermal medication patch or pacemaker or ICD , pads should not be placed directly on top of it.

if pads are not connected,plug in the connector to the AED

Begin CPR and follow voice prompts

4.B Shock not advised

Figure 11: Main steps of the bystander first aid in OHCA with the use of AED

Successful defibrillation

Based on the literature study the most relevant factors which affect the chances of delivering a successful defibrillation were recognised.

Time
The most crucial factor for the successful defibrillation is the time from SCA to the first shock. For that reason, shock from an AED must be provided with the minimum of delay. Survival rates decrease approximately 7% to 10% with every minute that defibrillation is delayed (Larsen et al., 1993). Delays can be caused by the user, device design, or location of AED. The usage of AED includes also providing CPR between shots. It is recommended to minimize the interruption in chest compression as much as it is possible.

Education
Although AEDs can be correctly operated without prior experience, even minimal training improves performance, timeliness, and efficacy, which is crucial in sudden cardiac arrest (Cheng et al., 2018). Moreover, there are studies which highlight the need to improve public knowledge and confidence in the use of AED (Lofgren et al., 2009) (Dahan et al., 2016). Positioning the pads correctly or following the correct safety procedures are recognised as the common mistakes within untrained subject which can affect the successful intervention (Mattei et al., 2002). In addition, bystanders who used AED in a cardiac arrest, found the first aid course essential for feeling comfortable with using the AED (Hansen et al., 2017).

Teamwork
In many sudden cardiac arrest cases, bystanders describe the resuscitation attempt as a team effort. When there is more than one responder task can be distributed. For example, CPR can be provided continuously, while AED is brought and power on and pads are placed. Good teamwork helps bystanders taking action, delegating tasks, not interrupting each other, and staying calm (Hansen et al., 2017).

Negative emotions
Emotional factors which stop or delay initiating first aid include panic, a fear of litigation, causing harm, or not performing it correctly for both trained and untrained bystanders (Hansen et al., 2017). When bystander overcome initial hesitation to act, the reason for declining to use AED is fear of legal liability or removing a stranger's shirt can be present (Taniguchi et al., 2013).

AED design
AED user interface and features can significantly influences the ability of untrained caregivers to appropriately place pads and quickly deliver a shock (Andre et al., 2004) Also, number of steps to deliver shock can affect it efficiency, for example the need to plug the electrodes into the AED (Mancini et al., 2009). Further research is recommended to making devices user-friendly and robust to untrained layperson (Mattei et al., 2002).

Conclusion

Cardiac arrest can happen to anyone at any time and remains a leading cause of death in Europe and the United States. Nevertheless, the combination of immediate CPR and use of AED can provide the survival rate as high as 50–70%. As the AED devices became easily accessible, the general awareness of defibrillator and their benefits has increased. However, they can be operated without prior training, education is a crucial factor which helps to increase the chances of successful defibrillation and minimise delays. Victims brain has 4-6 minutes from the cardiac arrest before the irreversibly damaged will occur. AED training improves the speed with which the electric shock is delivered. Besides, it has also a positive influence on other vital elements. It boosts bystander confidence and comfort, which can affect the willingness to provide first aid and use AED. Moreover, it provides knowledge about AED interface and how to use it in combination with CPR. Nowadays, AED is considered an integral component of training in basic life support(X).

2. ANALYSIS

In the chapter, the context of AED training and training equipment is analysed. This was done by defining the purpose of the AED training - learning objective and how it is conducted currently. To understand which stakeholders are involved at on which levels, stakeholder analysis was done. In the user analysis, both participants and instructors where research to have a comprehensive understanding of their role, needs and aims. Further, the AED train equipment was analysed. Finally, the conclusion of the analysis resulted in a list of challenges which will be used for the problem definition in the next chapter.

Figure 12: Research locations
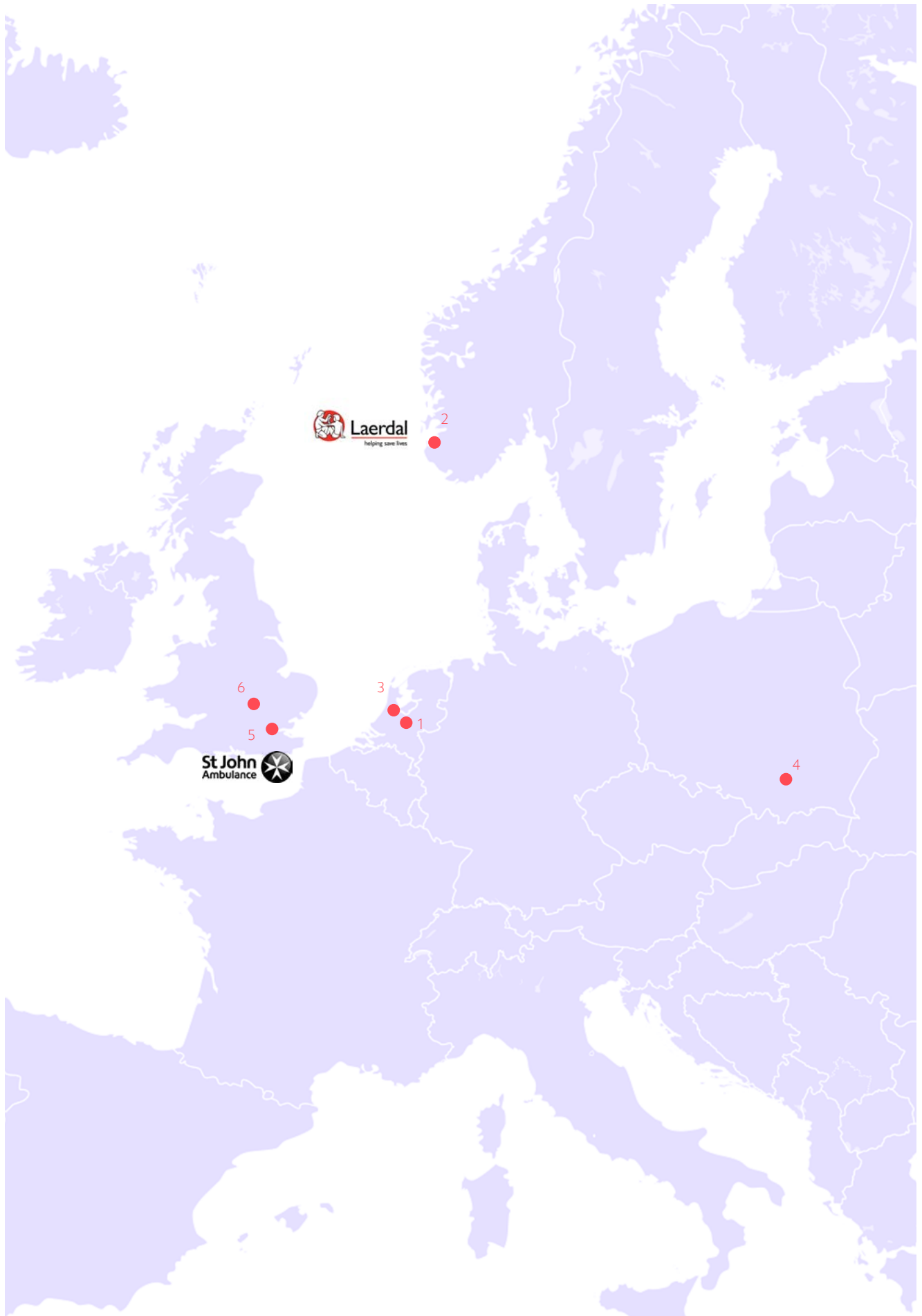
Methods

As part of the research, multiple methods were used, including interviews, observation and autoethnography to gather relevant information from multiple stakeholders and understand different perspectives. Also, research was conducted in multiple locations including Poland, the Netherlands, Norway and the United Kingdom.

Literature and desktop research (1)
The literature review and desktop research were done to gain a holistic perspective about the legal, user and market requirements of AED training and equipment. It also gave an understanding of the current conditions of training by including different fields such as psychology, sociology, medical science. The main documents which were used are European Resuscitation Council Guidelines for Resuscitation 2015 Section 2. Adult basic life support and automated external defibrillation, and AHA scientific statement Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest from 2018.

Company visit, Stavanger, Norway (2)
Trip to the Laerdal Medical headquartered in Stavanger was made just before the start of the project. The aim was to define the final assignment and to recognise the client perspective. During those three days, the company had presented their current work, manufacturing facility and their future vision of firs aid training. Besides, the testing of their products, including AED trainers and mannequins, was done.

Autoethnography, Amsterdam, the Netherlands and Krakow, Poland (3, 4)
In order to understand the context of AED training, the autoethnography method was used by participating in two certificated first aid courses. The first course was Basic Life Support with additional AED training, and the second course was Basic First Aid for Adults. They were provided in different locations by different providers, but they were both aligned with European Resuscitation Guidelines. Also, there were differences in the curriculum, but both of them included AED training and provided insights for the research topic.

Observation study, London, the United Kingdom (5)
Two different courses were observed at St John Ambulance. The first was the AED course, and the

second one was the first aid course. These observation studies gave insight into methods used for teaching, course dynamics and the interaction between instructor, participants and the equipment.

Interview with St John Ambulance instructors, London, the United Kingdom (5)
During two days of the visit, five semistructured interviews were conducted with certified instructors from St John Ambulance. Participants were selected based on the availability and experience in providing diverse courses which include AED training. Interview questions were prepared with the aim to understand instructors perspective on the course, teaching methods, and evaluate AED training devices. Besides, instructors needs and aims were defined.

Interview with Qualsafe instructors, Bradford, the United Kingdom (6)
Qualsafe is one of the most significant first aid training providers in the UK. Their extensive portfolio includes First Aid qualifications, Health and Safety qualifications, Fire Safety qualifications, Food Safety qualifications, Manual Handling qualifications, Prehospital Care qualifications. A short, semistructured interview was conducted with two employees. Interview questions were the same as the questions used for the interviews with St John Ambulance.

Interview with Projekt AED, Krakow, Poland (4)
At the beginning of the project, office of Projekt AED in Kraków, Poland was visited. It is a company which distributes AED devices and provides AED training for the clients. A semistructured interview was conducted with a person who is the project coordinator and a certified first aid instructor. The aim was to understand the market of AED devices used in emergency and its connection with first aid training.

Interview with participants (1)
Short, semistructured interviews were conducted with seven participants. Participants were selected based on their knowledge about AED and experience with first AED training. The purpose of the interviews was to understand the perspective of potential bystanders before and after exposure to the training.

2.1 AED TRAINING

Learning objective of an AED course

European Resuscitation Council describes the aims of layperson BLS training as providing knowledge and skills for performing CPR and use AED, but also increases the willingness of bystanders to perform those actions in cases of OHCA"(Chatterjee, Corral, 2017) Learners who participated in the course are expected to demonstrate in a simulated cardiac arrest that they can place an automated external defibrillator (AED) and deliver a shock within 180 seconds (Gavin et al., 2015). Moreover, AED skills include correct placement of pads, check and verbal warning before all analyses and safe shock delivery. ERC recommends to incorporated non-technical skills (e.g., communication skills, team leadership, and team member roles) into life support courses (ERC,2015). Whereas, AHA guidelines put the primary focus of the training on overcoming laypeople barriers to initiate first aid, with less emphasis on optimising the way it is performed(AHA, 2015).

Most of the assessment guidelines from AED courses focus on the cognitive skills and performance of participants during training. However, the willingness to use AED in an emergency and confidence in skills, are critical points of AED training. They should be addressed in the curriculum, and there should be a visible improvement. Whereas, they are difficult to asses as they assume the performance in the scenarios of emergency which cannot be fully created in the course. Besides, the ethical questions arise if the willingness to use AED and the confidence in skill can be asses as part of the grading. Nevertheless, the evaluation of those aspects is essential to define the quality of the training and should be further investigated.

Interviews with instructors provided additional insights into the essential skills which have to be gain during a course by participants. They were divided into three main categories: emotional, cognitive and technical skills. Emotional aspect was described as a primary objective of the course. It includes getting rid of fears, empowering participants to act and helping them gain confidence. Cognitive skills are essential to help participants understand the purpose of AED, how does it work but also the conditions of cardiac arrest. They learn that time is the crucial factor in the victim's survival and speed of their actions is crucial. Moreover, the information that AED is safe to use is provided and steps to secure the use of it. Technical skills include steps in operation of AED such as pads placement, turning the device on and following voice prompts. Although it is AED course, there is a strong focus on the cardiopulmonary resuscitation and combination of CPR with the AED.

According to ERC and AHA guidelines, Laerdal has created a detailed description of the learning objective for AED laypeople training. It was used as a based for the presented learning objective.

Main Learning objective
Learner express willingness to use AED in an emergency situation and demonstrates proficiency in using an AED according to ERC and AHA guidelines during an individual examination.

High priority skills were selected and marked by a red colour. For the purpose of the project, they were used as a key point of the training.

Detailed description of the learning objective

1. Attitude (not affect the evaluation outcome)
1.1Express the willingness to use AED in the emergency if there is no ethical objection.
1.2 Demonstrates the confidence in his/her skills to operate an AED.

2. Cognitive skills
2.1 Remembers that AEDs are safe to use by anyone.
2.2 Identifies and describes Universal AED sign.
2.3 Remembers to apply pads on bare skin, avoiding an excess of chest hair or water, medical patches and pacemakers.
2.4 Remembers to not defibrillate if patient is lying on water.

3. Decision-making
3.1 Delivers the shock if advised to.
3.2 Adjusts the AED function when rescuing a child or infant.
3.3 Performs only CPR if AED is not available or is alone.
3.4 Switches roles every two minutes to allow recovery of rescuer.
3.5 Decides to stop CPR if victim starts to move or

react or someone with more advanced training arrives.

4. Technical Skills
4.1 Power on AED (press a correct button or open the lid)
4.2 Follows instructions given by AED prompts
4.2.1 Demonstrates the ability to not let anyone touch the patient when the AED tells so by loudly stating 'stay clear'.
4.3 Places pads on the patient's bare chest according to the graphics on pad label.
4.3.1 Plugs in the pads' connector if necessary.
4.4 Minimises delays:
4.4.1 For switching on the AED when available.
4.4.2 For compressions hands-off time pre-shock and post-shock.
4.4.3 When receiving instructions given by AED prompts

5. Teamwork and communication
5.1 Asks witness to get an AED and alert emergency service by calling 112
5.2 Assigns role for compressing, ventilating and AED when being more than one rescuer.

Stakeholder analysis

To gain insight into AED training, a stakeholder analysis was done. It gives an overview of all the involved stakeholders, their role in the process.

Regulators:
Their role is to define the steps in the first aid but also the skills needed to receive certificates. They also choose who (occupation) and how often needs to attend the training. Often the legislation is the primary motivation to attend it. Regulators do not set down how the training will be provided. Training institutions can define their teaching approach and methods. However, they conduct researches and publish recommendations about the most promising training methods and approaches.

Governments
Voluntary training does not result in a sufficient amount of the population to ensure full protection in emergencies. The most effective way to increased first aid education is by making training mandatory in certain circumstances (ERC, 2015). Based on the Global survey data on first aid from IFRC, 37 per cent of the countries have a law that makes first aid training compulsory for workers and professional drivers, respectively. Nonetheless, only 16 per cent of the countries have a law that makes first aid training compulsory at school or for retirement home's personnel (IFRC, 2016).

International Liaison Committee On Resuscitation (ILCOR)
It is a liaison between major resuscitation organisations worldwide. One of the objectives of ILCOR is to produce statements on specific issues related to resuscitation. Those documents reflect international consensus and disseminate information on training and education in resuscitation (ILCOR, n.d.).

European Resuscitation Council (ERC)
The ERC provides the standard for resuscitation and training in Europe and beyond. The European Resuscitation Council Guidelines for Resuscitation 2015 are current guidelines used in Europe. It also includes specific instructions on how resuscitation should be practised (ERC, 2015).

American Heart Association (AHA)
AHA is the oldest and largest voluntary organisation dedicated to fighting heart disease and stroke in the US, The American Heart Association, publishes medical guidelines and scientific statements on various cardiovascular diseases. For example, Guidelines for CPR & ECC Resuscitation Education Science Statement (AHA, n.d.).

Education organisations
First aid training is provided through community organisations or commercial providers. Depending on the type of training, participants may or may not receive a certificate.

European Resuscitation Council
A network of National Resuscitation Councils aside from publishing guidelines, also provide resuscitation training for lay rescuers and health professionals. The ERC defines the standard for delivery of high-quality training and certifies providers (ERC, n.d.).

The International Federation of Red Cross and Red Crescent Societies (IFRC)
IFRC is the world's largest volunteer-based humanitarian network. It is also a major first aid educator and provider in the world. Almost all 190 Red Cross Red Crescent National Societies have first aid as their core activity (IFRC, 2016).

American Heart Association (AHA)
AHA has a network of authorised Training Centers and Instructors around the United States. It offers training in a variety of formats: in-person classroom training, eLearning, and blended courses. It is educating more than 22 million people globally in CPR each year (AHA, n.d.).

St John Ambulance
John is an organisation delivering first aid, healthcare and support services around the world. It is located in multiple countries including England, the United States, Uganda, Jamaica, Wale and Canada. St John programmes are community-based and volunteer-led. It has trained over 2.3 million people in First Aid and other health issues (AJA, n.d.).

Producers of AED training devices

Most of the producers of the AED training devices are also producers of AED. For example, Zoll, Defibtech and iPad. The training equipment is a supportive product to the dedicated AED device and mimics it in the appearance and operation. There are only a few companies which produce generic AED training devices. They aim in the lower price market and eases of transport.

Laerdal Medical

Laerdal produces training equipment. It includes a wide range of products for CPR and two models of AED. The company does not provide training but conducts research on it and cooperate closely with both regulators and training provides. That work results in new teaching solutions and teaching equipment. Those products become tools and are supported by guides. However, instructors make the final decision how they will use them.

Instructors

An instructor is a person who holds a credential to teach in a specific resuscitation training program (AHA). In other words, it is a person who undertaken specific training in medical education and the principles of adult learning. Also, that person is responsible for delivering the educational principles of the courses. Instructors are trained in both teaching and assessment. Moreover, an instructor should show qualities of leadership and team working but also be articulate, supportive, and motivated (ERC, 2015).

Participants

Participants of the AED course are 'lay people.' It could be employees of companies, corporations, or public facilities which require the first-aid certificate. Especially the professions with a duty of care for others (e.g., school teachers, care workers, security personnel). Also, institutions which implement PAD programs provide CPR & AED training for the employes. Another group of participants is family members and friends whose loved one is at high risk for sudden cardiac death (ERC, 2015). Additional learners may come from personal interests.

Main insights

Regulators define a number of participants during a course and the skills they need to acquire. Training institutions decide about the teaching approach, time frames of the course and equipment used during training. However, instructors can decide which methods they will use and how they will deliver the material. They might be able to choose equipment and materials from a provided range or got it assigned and be limited by it. For example, the number of mannequins and AED devices per group of students.

In terms of the AED training devices, there is no regulation or guidelines. Participants have to demonstrate specific skills, but how they will be taught them is not defined. Although there are some recommendations for the mannequins appearance and functions, there are no direct suggestions for AED training equipment. Also, there are no guidelines about AED interface, and as a result, there are no guidelines for training devices. The lack of regulations about AED training provides freedom for the training institutions how and if they will use the equipment but also for the producers, what is the appearance and functions of the AED training device.

Types of training

Instructor-led
The most popular method of training for BLS & AED is instructor-led course (AHA, n.d.). The recommended ratio of instructors to candidates is 1:6. The set up includes at least one manikin and one AED for each group of six candidates (SJA, n.d.).

Self-directed training
If instructor-led training is not available, self-directed training may be considered for lay providers to learn AED skills (AHA, n.d.). Self-directed learning can overcome many of the barriers that keep individuals from attending the training (Mancini et al., 2009). This method doesn't require an instructor, includes flexibility in time and space, and has a lower cost compared to other methods (AHA, n.d.). Participants can train anywhere, on any device, start immediately, without waiting for a place in the course and go through it with their own pace. Currently, there are two types of self-training: computer-based learning and video learning.

Computer-based learning
Interactive computer learning uses a micro-simulation web-based interactive program. The course takes approximately 30 to 60 minutes to complete and provides a certificate (Proaed, n.d.). This method is also used to equip more people with basic knowledge about first aid for free. For instance, the interactive video Lifesaver created by the Resuscitation Council UK. It is an online course which can be access by everyone for free("Lifesaver", n.d.)

Video learning
This method is mostly used to raise awareness about AED by first aid. Short demo videos (briefing) are accessible for everyone on Youtube or Vimeo. Only one video-based eLearning platforms which provide certified courses was found. A course like this lasts three hours and ends with a multiple-choice test ("CPR Training Video "2014).

Blended courses
Combination of self-instruction and instructor-led teaching with hands-on training can be considered as an alternative to traditional instructor-led courses for lay providers(AHA, n.d.). It can use video, computer-supported feedback, and shorten instructor coaching. The online part usually must be completed prior to attending the in-class part and must be taken on a PC or tablet with a high speed Internet connection.
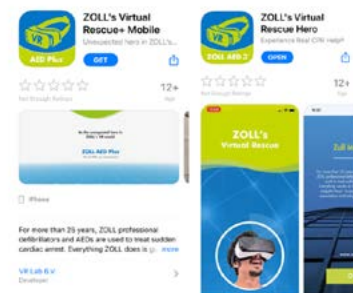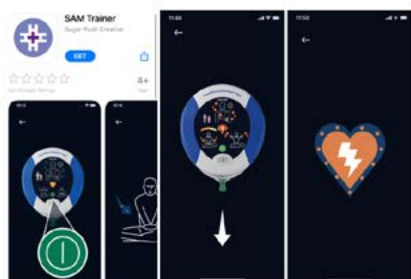
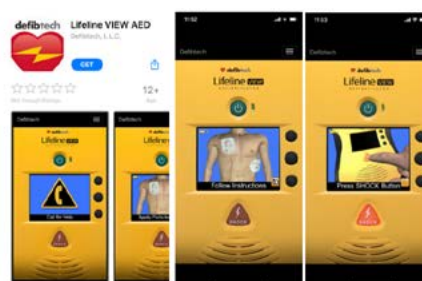ZOLL AED 3™
VR Hero app
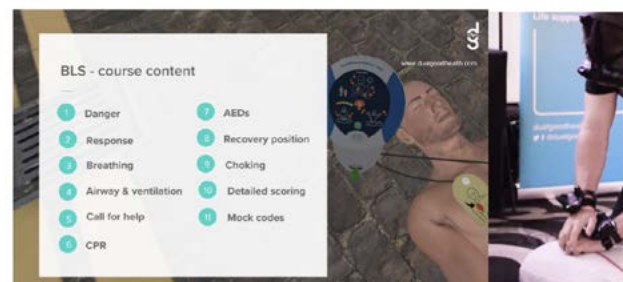
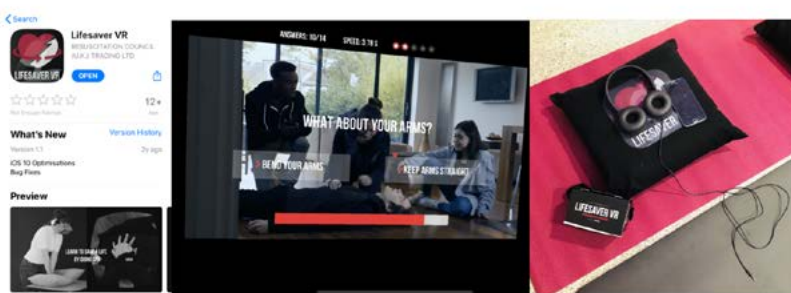BLS VR Training
by Dualgoodhealth

AED Trainer
by Medgadget

TabletAED
by Doczero

SAM Trainer
by Stryker

Lifeline View AED
by Defibtech

Lifesaver VR
Resuscitation Council U.K.

How to use a defibrillator (AED)
St John Ambulance

Figure 13: Different types of training

Types of training

Based on the scope of material and type of the certificate, there are a few standard types of the courses: Firs Aid, BLS & AED and CPR & AED. They differ not only in the amount of material which is taught, but also time frames and the number of students. As a result, AED training has a different form in each of them. Depending on the training institutions, it could be the only introduction to the AED with a lecture, practice without equipment or extended practice with AED training device.

First Aid course

First aid course teaches how to provide immediate assistance to a sick or injured person until emergency service arrives. The curriculum covers not only physical injuries or illnesses but also other initial care, including psychosocial support. Typically it also covers information about CPR and AEDs (RC, n.d.).

BLS & AED

Basic Life Support teaches a set of procedures for preventing the condition of lifeless (non-breathing) casualties. It consists of skill demonstrations, hands-on practice, and lectures. The current format of BLS and AED course by the European Resuscitation Council (ERC, n.d.) lasts 'approximately half a day'.

CPR & AED

As the aim is to train as many people as possible, the concept of shorter, more accessible and affordable courses was introduced. American Heart Association proved that 2h class is sufficient to acquire and retain CPR and AED skills when a brief re-evaluation is performed after six months. AHA Heartsaver AED & CPR course is a classroom-based course which lasts 2.5 h. (AHA, n.d.) This type of short course is also often offered by AED vendors. It is part of the service to help implement the devices after their purchase.

Refreshing courses

Many training centres also provide refreshing courses. The objective is to refresh the heart physiology, cardiac rhythms, principles of defibrillation, operation of AED and practice in the application of AED on in special situations and maintenance. It lasts three hours and also includes written and practical assessment to obtain the certificate. (SJA,n.d.)

The current model of 1 to 2 days of resuscitation training every couple of years provides short-term learning and fail in the long term. Education guidelines indicate that shorter learning sessions (1-2h) every few months (3-6) may improve learning outcomes. Frequent practice of psychomotor skills such as the use of an AED provides the best opportunity for skills maintenance (AHA, 2018).

Comparison of First Aid training and AED training at St John Ambulance

First Aid Training

duration:	8h
number of participants:	22
number of instructors:	2
equipment:	1 mannequin peer 3 people, no AED training units, low price equipment (printed mock-ups of the pads)
aim of the AED part:	increase AED awareness
AED usage:	short practice, one scenario, no voice prompts, high pace (intensive programme)

AED Training

duration:	2h
number of participants:	6
number of instructors:	1
equipment:	1 mannequin peer 2 people, at least 1 AED training device peer 2 people
aim of the AED part:	master the skills of AED use
AED usage:	complex exercise with multiple steps, multiple scenarios, use more than one type of AED, medium pace

Timeline of the AED training

Based on the AED course, which was observed at St John Ambulance, the timeline was created. Even though the main objective of the course is AED, it also covers the basics of the first aid and extensive CPR practice. The timeline outline instructor's and participants' actives but also the main touch-points with AED.

The AED course lasted for two hours and was divided into two parts with a short break in between. The first part of it was focused on the theory and second on the practice. The most critical touch-points for were selected and described further.

I. 2 Asses performance / P.1 Explore AED
The courses started with the introduction and assessment of initials skills. Participants in a group of two were asked to perform first aid and use a

mannequin and AED. The instructor could observe and asses their knowledge and skills and decide on the course characteristics. Such as the amount of theory, speed of stages and extent of the practice.

I.7 Demonstrate CPR & AED skills / P.6 Observe CPR & try to use AED
Firstly, the instructor demonstrated CPR and explain the steps. Next, the participants were asked to accompany the instructor based on the instructions. Participants could see how to use AED correctly, but they ware also engaged in the scenario by helping with small tasks.

I.8 Asses performance / P.7 experience AED use
While participants were providing CPR, the instructor acted as a third bystander and brought AED to the scene. One person continued CPR while the second
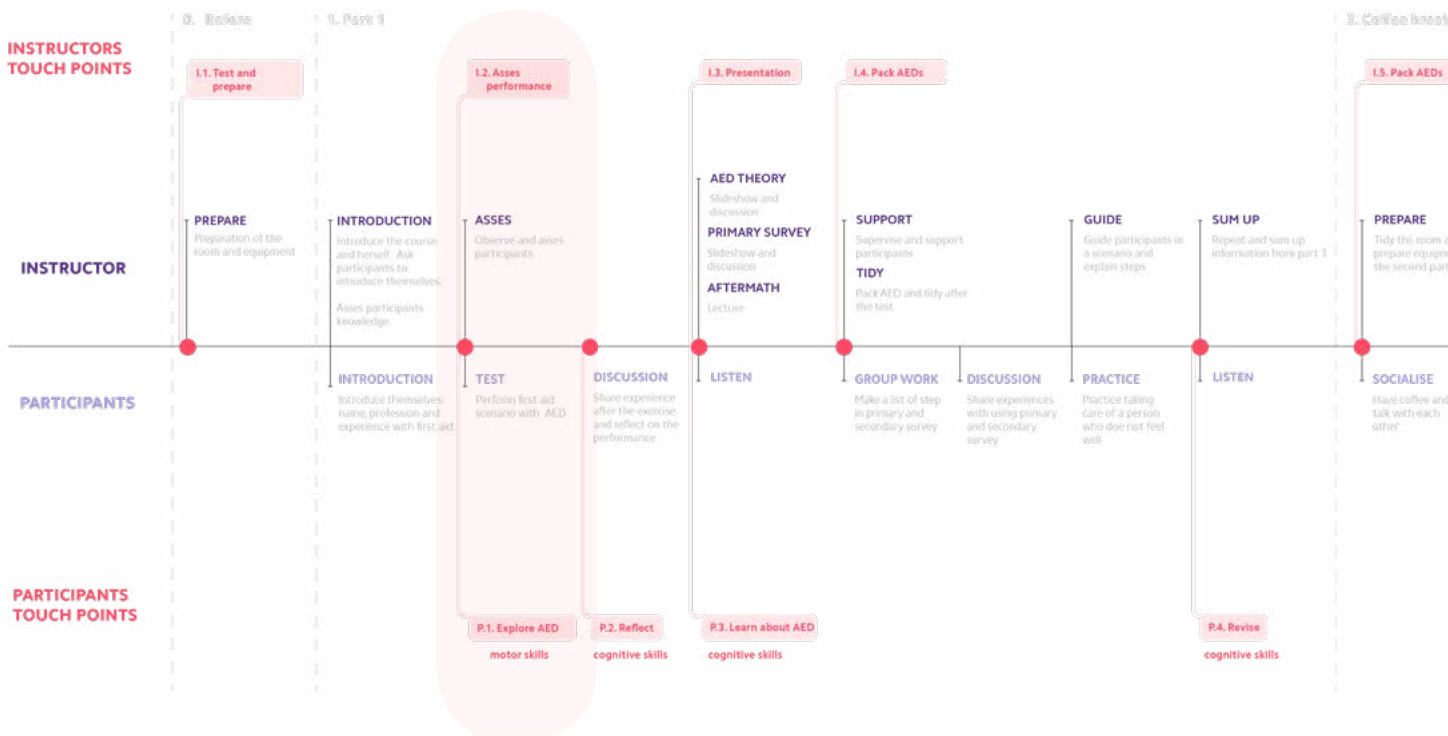
pretended to cut clothes, turned on AED and follow voice prompts. Instructors were assessing participants performance and providing feedback.

P.10 Reflect
Group discussion which was facilitated by an instructor. Participants were drawing the conclusion of the training and reflect on their willingness and confidence. At that time, the instructor addressed emotional challenges and assured them of their abilities.
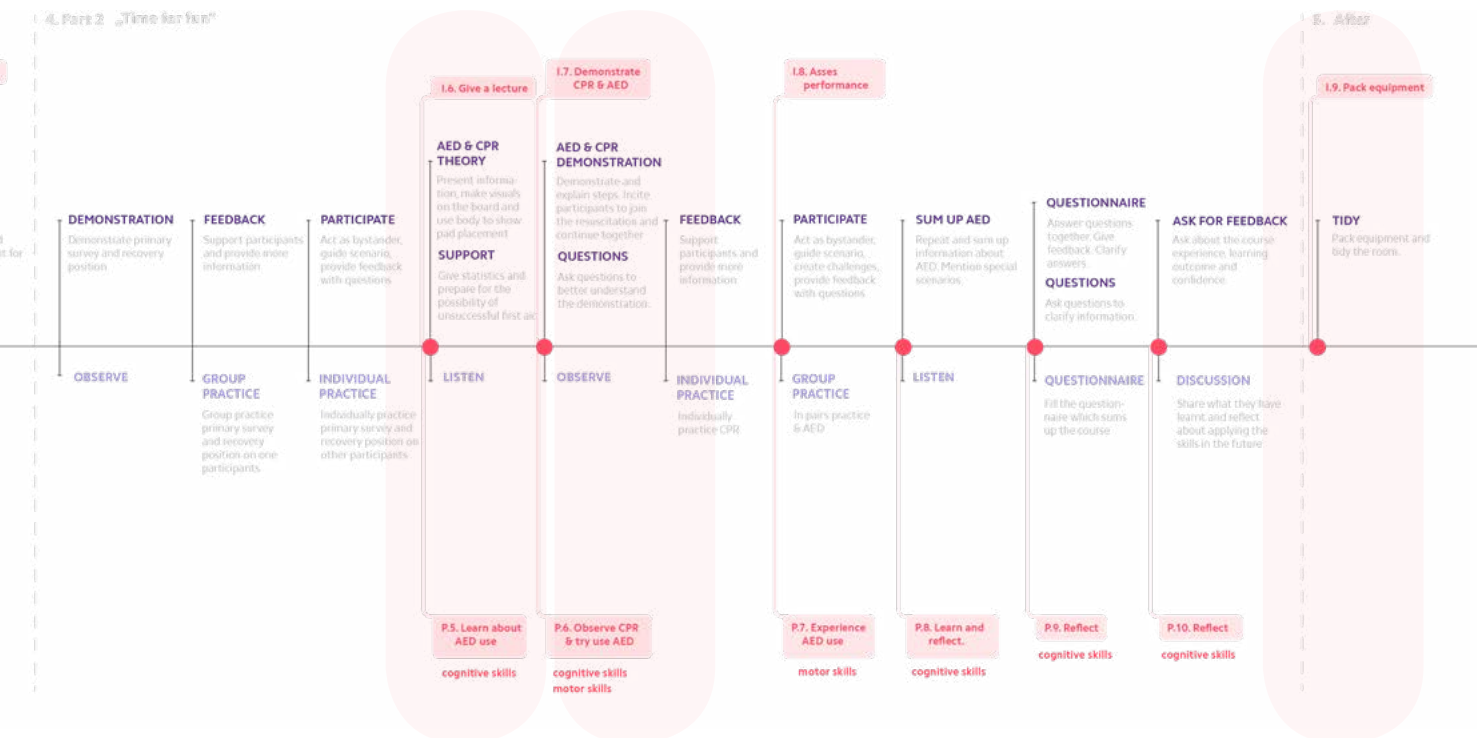

Figure 14: Timeline of the observed AED training at St John Ambulance

Figure 15: Observation research at St John Ambulance

Key elements of the AED training

Based on the literature study, observations and interviews with instructors, the main elements of the AED training were recognised. It was crucial to understand how participants gain skills and knowledge, and what are the key factors of the training.

Variety of teaching methods
Teaching methods vary between trainings. There are no fixed guidelines, and there are multiple approaches toward teaching. Moreover, instructors use verity of methods because different people learn differently. Most common methods are explanation (lecture, presentation or audio), demonstration, imitation (following instructor) and practice. Besides, questioning, assessment sheets and peer assessment could be observed at some courses. Qualsafe uses Peyton's Four-Step Approach. It is a model for teaching a procedure and often CPR. The four steps are demonstration, deconstruction, comprehension and execution. Some instructors create their methods. They include dancing, games, sabotaging scenarios, simple comparisons.

The practise is a key
Overall, the practice was described by instructors as the most crucial part of the course. The longer participants practice the more confidence they will gain. Also, going throw multiple scenarios is beneficial to understand the process better and is the only way to gain skills such as communication and teamwork.

Addressing emotional weight
There is no certain method to address the emotional weight of providing the first aid. Instructors use conversation and practice. They try to talk to the students and explain to them that often things may not go successfully, and it will be not their fault. Also, listening and address their concerns is a common procedure, for example, the AED final decision to deliver a shock.

Ongoing assessment
Assessing learner competence is a critical part of resuscitation training. Instructors must make complex decisions about their learners' competence. Poor-quality assessments can result in not identifying participants who struggle and not providing them

with feedback (X). Depending on the number of students, the difficulty and time of assessing varies. CPR is a repetitive task. It could be stretched in time so an instructor can take a look at each participant one by one. However, AED use is more complex in number of steps and assessment of all skills. It requires constant observation. It was observed that instructor was taking a glance at each team for a few seconds trying to divide attention equally. Also, in order to see participants' performance, an instructor had to change position always. The aim was to have a correct field of view for every participant. Class management which includes positioning of the mannequins in the class, can help the instructor with this problem to some extent.

Peer assessment
To improve the assessment, St John Ambulance uses assessment form. It encourages peer assessment, and instructors describe it as quite effective. That method allows the instructor to be more a facilitator than a teacher, what puts less stress on their work.

Positive feedback
Feedback is provided during exercising. It should be positive to encourage participants. For example, by saying "fabulous" or by showing thumbs up. Feedback must also be constructive. When negative feedback is needed, it is also essential to address it based on the participants' sensitivity and mixed it with the positive. The literature warns of the methods which demand perfection and decreases responder confidence. Participants worry about their skill performance, and it might affect their self-assessment (X).

Friendly atmosphere
Without additional elements which address course atmosphere, it could be stressful and unpleasant for participants. Instructors try to keep it positive and engaging, for example, by jokes or funny activities. Also, group work enables participants to socialise and create a bond with each other. It resulted in providing peer feedback and supporting each other in a friendly atmosphere.

Instructors

Interviews were conducted with 8 instructors, and they were the base for creating an overview of the user. Being a first aid instructor is their primary occupation. They all are certified instructors and have to updates their credentials every three years. They teach a wide range of training. For instance, the first aid at work, paediatric first aid, AED course, sport first aid.

Instructors know the importance of the first aid training and are passionate about teaching it. They are also proud of their job and the institutions they work for.

Although they receive recommendations and teaching materials from the training institutions, they are the one who makes the decisions on how to provide the training. As a result, they have the greatest influence on the participants' skills after the course. Based on their knowledge and beliefs, they create a training scenario. The differences are visible in the proportions of the theory to practice during a course. Also, their preferences are the factor which affects the decision which equipment is used during training when the choice is possible. For example, some instructors find QCPR and group feedback beneficial, and others are worried about the stress, which scores puts on the participants, so they do not use it.

As an instructor, their role is teaching, assessing and facilitating. Based on their judges, participants will or will not receive the certificate of completing the course. Consequently, during a course instructor is often multitasking. For example, she or he supervises participants and at the same time, give feedback and organise the equipment for the next exercise. Time constraints of the course, amount of material to teach and a number of students puts stress on instructors and becomes challenge.

The instructor has to interact with the participants constantly. It requires excellent soft skills such as communication and empathy. It was observed that the more positive instructors were, the more engaged were participants. It is also especially visible when the feedback is provided. One situation was observed when direct negative feedback causes disengagement fo the student in the exercise in the Red Cross training.

Needs:
Reliable tools which will support the education process
Participants engagement
Be respected and admire
Understand and asses the group to adjust the teaching methods and course dynamics
Simple and easy way to operate AED devices

Aims:
Address all participants
Make participants willing to use AED in emergency
Make participants able to use AED:
Transfer the knowledge about AED use
Teach participants skills required to use AED
Asses participants performance
Provide accurate and constructive feedback

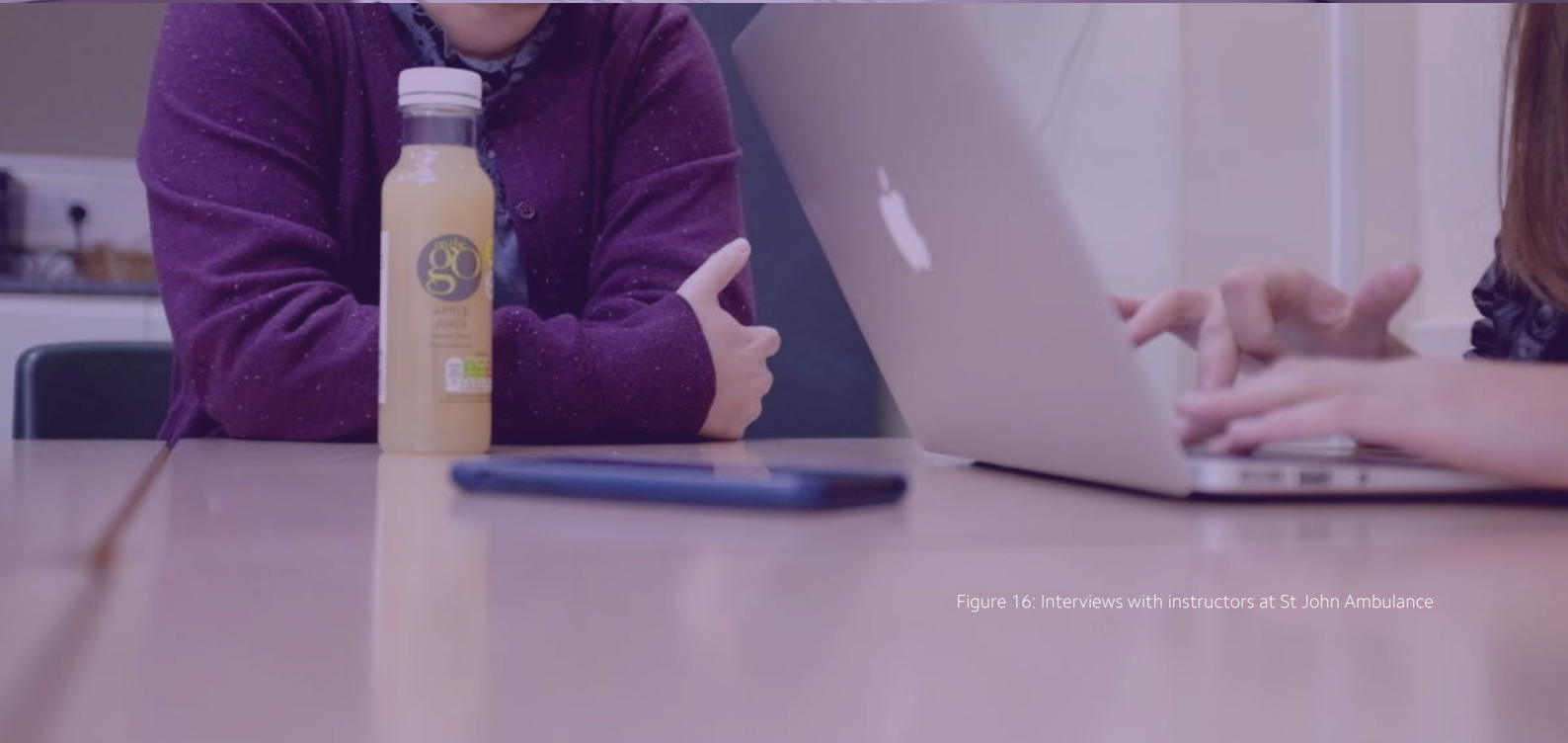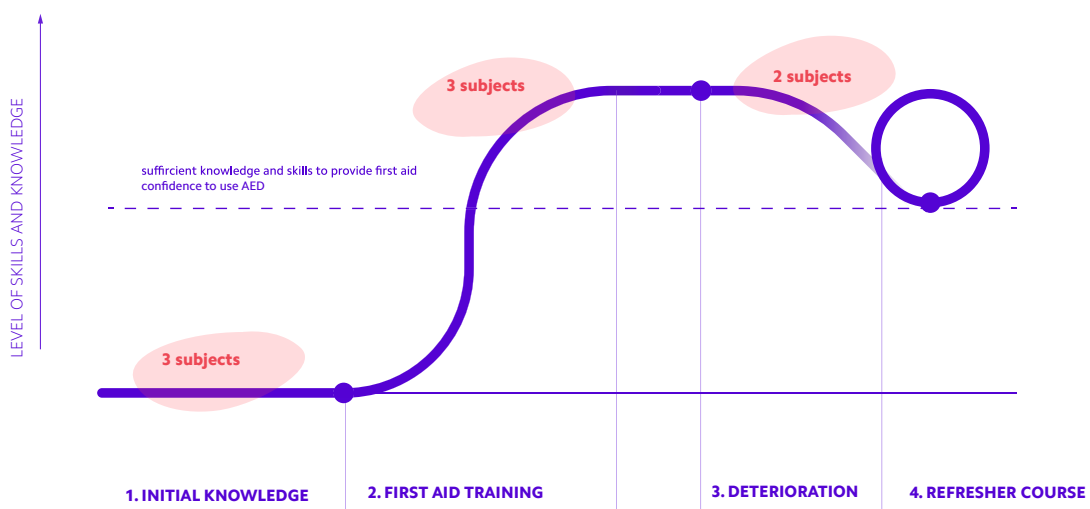Figure 16: Interviews with instructors at St John Ambulance

Figure 17: Interviews with potential participants

Participants

To understand the impact of the AED training on participants skills, eight interviews were conducted with the potential bystanders. Subjects were divided into three groups: people without the training, people during training, people who participated in training more than 6 months ago.

The research gave insights into the initial stage of the users who can participate in the AED training, users who experience training and the ones who can judge deteriorations of skills and approach towards AED. Findings were arranged into three categories and presented on the graph to indicate the linear change.

LEVEL OF SKILLS AND KNOWLEDGE

3 subjects

2 subjects

suffircient knowledge and skills to provide first aid
confidence to use AED

3 subjects

1. INITIAL KNOWLEDGE   2. FIRST AID TRAINING   3. DETERIORATION   4. REFRESHER COURSE

AED image
There is a significant shift in the perception of AED devices between groups.

The first group described AED only with negative adjectives such as dangerous, complicated and cold. The reason is assimilating AED device with medical defibrillator used by EMS or in the hospitals. As a reason, they thought that it is a complicated device which requires medical knowledge to be operated. Besides, they believed that they would have to decide if the shock is recommended and deliver it. The shock was described as high and combine with the responsibility to deliver it. They found the device dangerous.

The second group which is still during a first aid course but after the part about AED had a very positive image of AED, and there were excited about it. The most often used word was lifesaving and necessary. Fact and statistics about survival were used to underline how important it is for victims survival, also from the awareness of how AED, it was described as smart and helpful. Overall the potential of the device and its admiration is high: "superhero" and "wonderful".

The third group saw AED more analytically compared to the first group. It also had a positive image, but there was a more significant focus on operation "easy to use" and "practical".

Emotions towards using AED
Fear was present in all groups. It comes from the stressful and emotional aspect of the emergency. However, the second group said that their knowledge and skills would help them to stay calm, and the third group mentioned that being guided by AED will help them calm down.

Participants without trying were not aware of how AED work, and it resulted in anxiety abuot hurting the victim with AED. Also, they find the use of AED as a challenge which comes with much responsibility. It results in stress about consequences.

The second group was excited about the possibility to be able to use AED in the emergency. They believed that they could only improve the victim's state, and felt happy that they could help.

The third group was more reserved about the emotional aspect of the possibility to use AED, but they described the device as a source of all positive emotions. Willingness to use AED is low in the first group. Participants said that they would not use it or they would avoid the possibility to do it. The only possibility that they mentioned that they could do it was when some would guide them.

Willingness to use AED in emergency
With the participation in the first aid training, willingness reached a high level and maintained at the same level with time.

Willingness to use AED is low in the first group. Participants said that they would not use it or they would avoid the possibility to do it. The only possibility that they mentioned that they could do it was when some would guide them.

Confidence is the factor which affects the willingness to use AED emotions towards using it in an emergency. Two types of confidence were defined: confidence in their own skills and knowledge and confidence in AED that it will guide a user. Participants described that their confidence in skills comes from knowledge (cognitive skills) bust mostly from practising (motor skills).

The figure shows a graph with three phases along the horizontal axis:

1. INITIAL KNOWLEDGE | **2. FIRST AID TRAINING** | **3. DETERIORATION**

Labels within the figure include: emotion change, change in AED perception, emotions towards using AED, AED image, anxiety, fear, stress, responsibility, dangerous, complicated, highly motivated, confidence in skills, excitement, happy to help, lifesaving, smart, necessary, helpful, wonderful, super hero, confidence in AED guidelines, fear, calmness, trust, necessary, easy to use, calming, practical.

There are two significant changes in participants. There is the shift in perception of AED from dangerous demanding device to helpful, superhero. Following the emotions towards using it are changing. Stress and anxiety are replaced by confidence and even excitement.

Needs:
A safe and friendly learning environment
Guidance in the education process.
Simple and clear instructions.
Assurance that the exercise is performed correctly.
Assurance of AED safety
Understand how AED works
Tools to be able to experience the use of AED
Experience the use of AED in the scenario
Positive feedback
Understanding

Aims:
Be able to use AED
Achieve the mastery of skills
Gain confidence in using AED
Remember the information presented in the course.
Receive a certificate

The concept of learning

Learning is a relatively permanent change in a person's knowledge or behaviour due to experience. Resuscitation knowledge includes competence (cognitive skills and practical skills) and confidence (self-esteem and willingness to perform). Cognitive skills include understanding what AED is and what are the conditions to use it. Practical skills are obtained through exercise, by repeated activities and by use of physical tools (e.g., training manikins, AED trainer). Confidence and willingness to act in an emergency can be influenced by motivations, feedback, and confirmation (79).

Theory of experiential learning is used by the American Heart Association and Swedish Resuscitation Council's to describe resuscitation training (AHA,80). Experiential learning programs rely on Kolb's learning cycle to create holistic educational experiences (A. Y. Kolb & Kolb, 2005). These programs address the affective, perceptual, behavioural, and cognitive dimensions of learning. Kolb's Learning cycle consists of four stages: acting, experiencing, reflecting and thinking.

Acting (Active experimentation)
The learner is trying out what has been learned in practice. Placing the knowledge in a relevant context can be a relevant factor to decrease knowledge detention.

Experiencing (Concrete experience)
A task includes active involvement, having and experience, not only observation.

Reflecting (Reflective observation)
Reflecting on the experience includes thinking critically about what has been done and experienced or what happened in a particular situation.

Thinking (Abstract conceptualisation)
It is the process of learning from the experience. It consists of linking the experience to theories, concepts, or hypotheses. It also involves interpreting events and understanding the relationships between them.

Irrespective of the entry into the cycle, a good learning process is something that makes the learner complete the entire cycle before exiting (79). During this project, Kolb's learning cycle was considered as a perfect analogy for AED training.
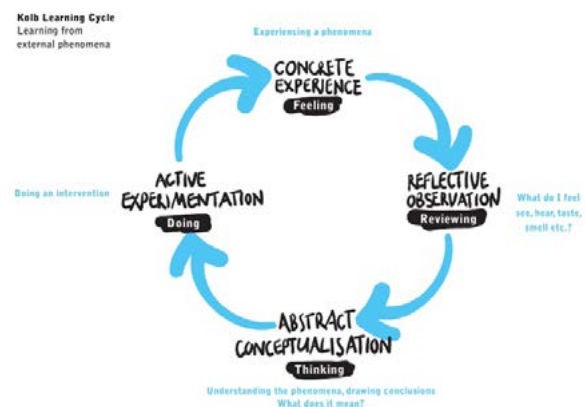
AHA & ERC recommendations for a First Aid Training

To recognise fundamental teaching approaches in resuscitation training for laypeople, two documents were analysed. The European Resuscitation Council Guidelines for Resuscitation 2015 Section 10. Education and implementation of resuscitation and AHA scientific statement Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest from 2018.

Simple

It is recommended that the curriculum for basic life support and AED training should be kept as simple as possible (ERC2). The reason is to avoid cognitive overload, maintain engagement, and not create perceived complexity which can prevent bystanders from acting (AHA).

Feedback

Constructive and corrective feedback, as well as debriefing on performance, will encourage the behaviour change. Also, it should be delivered in small portions so the learners can understand and implement it (ERC2).

Data collection and feedback

Collect data on the performance and use it as feedback can encourage performance improvement. Quantitative data provided during resuscitation education should come from instructors, CPR devices, and simulators. Setting a performance standard, such as time, accuracy, and best practices, could be used to measure performance to motivate learners. It could be available in real-time, but mostly during debriefings (AHA, 2018).

Aside from the user level, it can be used in the system level by comparing, reporting, and sharing data to various stakeholders (AHA, 2018). For example, systems that measure resuscitation training and performance data can be used for comparisons between instructors, training institutions, teaching approaches, and equipment. It could be used to recognise and implement improvements by instructors, training institutions, guidelines providers, equipment developers, and researches.

Team

Team training methods include information sharing, demonstration, or practice-based learning with feedback. A demonstration is useful for modelling desired behaviours, but practice-based learning is critical for students to learn how to integrate teamwork skills into their work (AHA, 2018).

Gamified learning

To improve laypeople's willingness to act and their performance, new methods and digital platforms can be applied. Gamified learning has a recognised potential to improve learner engagement and skill retention. In addition, game attributes can affect the behaviour or attitude of a learning-related task. It also has the potential for reaching larger populations as it enhances the teaching environment for various types of learners.

Use of smart devices

The prevalence of smartphones and tablet devices has created an opportunity for the introduction of new teaching methods through the use of mobile applications. Interactive education apps can engage with the user and create an immersive and interactive means of educating the user (ERC2).

Conclusion

Learning objective

An AED is designed to be easily operated without prior training. The literature recommends training based on the positive effect on the level of skills and performance of laypeople. However, interviews with potential bystanders showed a significant difference in willingness to use the device between people with and without training. Moreover, instructors also stress the need for the training based on the positive change in approach towards AED. Thus, the emotional aspect is the primary objective of the course. It includes an increase in the willingness to use AED in an emergency but also provide participants with confidence. Nevertheless, the training provides certificates which put the emphasis on the cognitive and technical skills. It is also crucial to equip participants with those skills as they can increase the efficiency of delivering the shock. Also, cognitive and technical skills can minimise the possibility of making a mistake, such as incorrect pad placement.

Willingness and confidence

Based on the interview with participants of the first aid course, essential processes were defined, which occurs during a training and have a positive effect on the learning outcome. Firstly, participants have to change the perception of the AED device. Often the initial image of AED is negative what affected the willingness to use it. The shift is from dangerous and complicated to safe, helpful, trustworthy, easy and smart. The second process is the change the feelings towards using AED. Participants have to gain the willingness to deliver shock and confidence that the device can only help the victim.

Training essentials

Research shows that practice with AED is the key activity to change the participant's perception of the device (AED image) and use of it (emotions towards using it), learn necessary skills. It also and provide the context for accurate assessment and feedback, which were also described as highly influential. Assessment is

an integral part of the training. Correctly done, helps to recognise the mistakes and define the accurate feedback. Participants need confirmation from the instructor even when they perform the exercise correctly. Thus, the feedback has to be constructive and positive to improves performance but also participants confidence.

Instructor-led training

The literature suggests that video or internet training can result in sufficient performance and longer retention of skills compared to traditional instructor-led training (19). However, the research indicates that practice and feedback are the key activities to gain the confidence and willingness to use AED in an emergency. As a result, the project focused on instructor-led training which includes all those elements. Besides, this type of training is the context of current Laerdal's products. It requires the training equipment which includes Little Anne QCPR and AED solution.

Number of participants

Some training institutions do not provide the AED training devices to participants during the first aid courses due to the budget limitation. For example, the first aid courses at St John Ambulance provides only printed mockups of pads. The reason is the high number of participants at that course (22) and as a result, the high number of devices which would be needed. It results in insufficient practice. Also, the high proportion of participants to the equipment is a reason that many activities are done in groups. In some scenarios, participants have to take turns what decreases the time of practice.

Instructor limitations

Assessing students performance in AED use is challenging. The first reason is the complex scenario with multiple steps which requires almost constant observation to catch all mistakes. The second reason is the need to divide attention equally between all participants. For example, providing necessary feedback

to one participant leave the other ones without assessment. Moreover, the big groups puts stress on instructors and assessment could be insufficient. For this reason, St John Ambulance has a limit of 6 participants for AED training. It put constraints on the number of participants who are trained and increases the cost of the training. Currently, AED practice at First Aid course is just about "awareness of AED". With current equipment and resources, it is impossible to see and correctly asses participants if they would practice with AED.

Combine CPR & AED
The use of AED is strongly related to the cardiopulmonary resuscitation. CPR has to be provided with AED usage without delays. The assessment has to be done of skills related to both the AED but also to the CPR. As a result, the concept has to provide a solution which can integrate mannequin and AED device.

AED training have to:

Change perception of AED

AED is safe, helpful, trustworthy, easy to use and smart

Change Feelings towards using AED

Gain willingness and confidence

Equip with skills and knowledge

Provide participants with skills to achieve proficiency in using AED

It could be achieved by:

Practice

Practice with AED device helps change perception of AED and gain confidence

Assessment

Assessment is integral part of the training. It helps recognise the mistakes and define the accurate feedback.

Feedback

Constructive and positive feedback improves participants confidence

The challenges are:

Number of Participants

Limited access to the equipment Group work is necessary

Instructor limitations

Limited possibility to asses and provide feedback to each participant
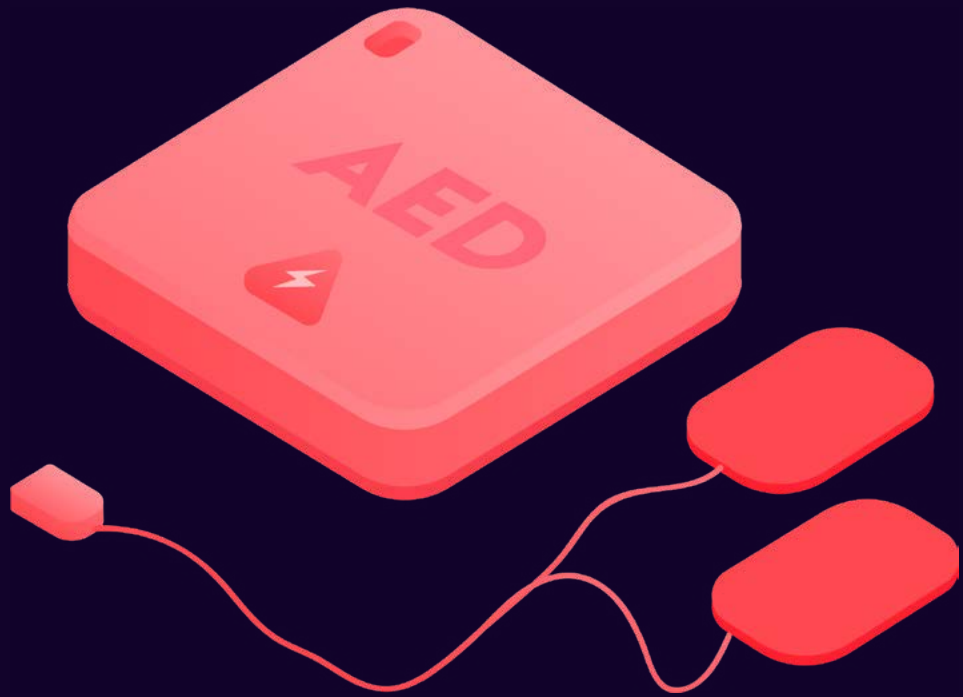
2.3. PRODUCT ANALYSIS

AED training devices

There is no official AED training unit definition. Literature and guidelines provide the descriptions of training and learning objective but do not indicate the equipment specification. For the purpose of the project, a definition was created based on the manufactures descriptions.

The AED Training unit is a "non-shocking" simulated AED. It is used for teaching correct AED procedure to first responders.

There is a various fidelity of the training equipment. The most common unit has the same general external features as a rescue AED. It simulates each rescue stage and creates simulated cardiac rescue scenarios, both shockable and non-shockable. The device comes with adhesive reusable training electrodes and often remote control (64). The AED training device can represent semi-automatic and fully automatic AED or have settings to mimic both of them.

Types of AED training units

Generic model
It has a unified appearance and supports the most common functionalities of AED rescue models.

Supported model
It is a replica training version of an existing AED device. Those AEDs also provide training of the maintenance of the AED rescue device, for example, battery installation.

The purpose is to teach learners how to use the specific device rather than provide the best and most effective teaching experience of early defibrillation. The design of training equipment mimics the design of the AED devices.

Basic AED model
The most basis AED replica simulate the only presence of the AED, buttons, and pads. It is a one-time unit made of the carton with a printed interface, lace, and single-use stick-on pads. User can mimic pressing the buttons and attaching electrodes. There is no voice prompts or feedback. It is the most affordable option.

Laerdal products

QCPR is a Quality CPR system

It provides real-time CPR feedback, intelligent scoring and guidelines and gaming elements with QCPR race competition. It consists of the mannequin, QCPR kit and a feedback device. QCPR kit can be integrated with the mannequin (Little Anne QCPR), or it could be added to the older mannequins (QCPR upgrade kit). QCPR sensor measure compression rate and depth, but also ventilation rate and amount. The feedback can be provided by a mobile device with the use of one of the app: QCPR Classroom, QCPR Instructor, QCPR Learner or by a Skill Guide device.

AED system

Laerdal has two AED systems. They both consist of the mannequin and Laerdal's AED device (Trainer 2 or Trainer 3). The aim of the product is to asses the correct pad placement and allow the audio sequence (voice prompts) to continue. The first system, Little Anne AED Training System consist of two capacitive sensors under a skin, PCB and a battery. The second system uses the metal stripe, which is placed on the mannequin instead of the sensors. Unfortunately, metal stipe is not a realistic solution. It indicates participants where to place pads. The AED devices have two types of training pads: regular ones and Link Technology pads which allows two-way communication between AED and capacitive sensors inside the mannequin. For the purpose of the study, Little Anne AED Training System with Link Technology pads will be analysed as the most advanced products from the company portfolio.

Little Anne AED mannequin

Training AED
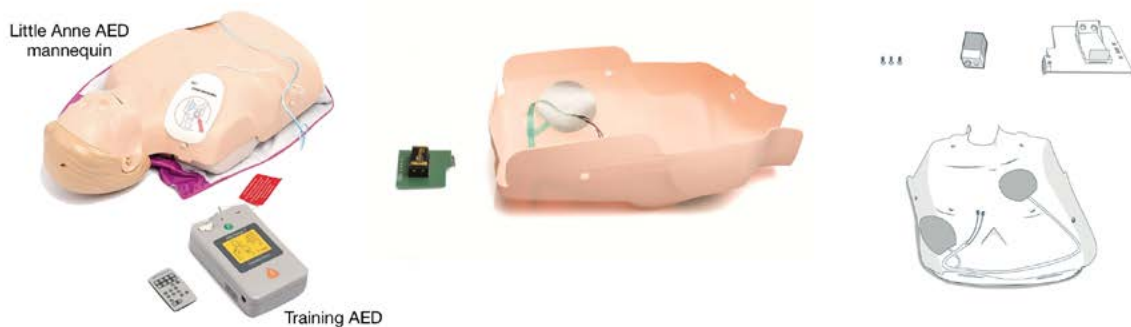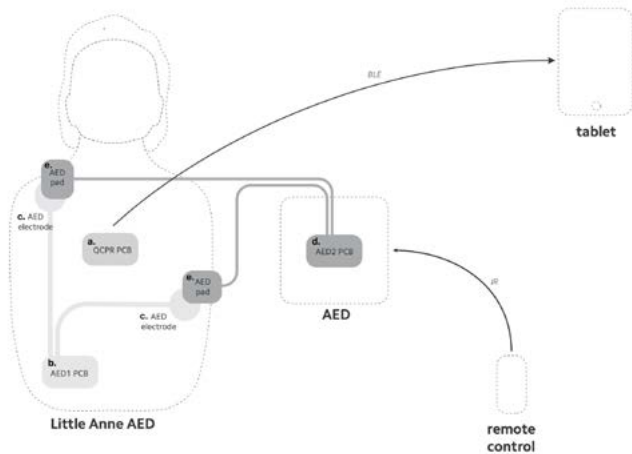
List of components:
- Little Anne AED (mannequin):
a. QCPR PCB with BLE module and battery
b. AED1 PCB with battery
c. AED electrodes (connected with a capacitive sensor)
- AED:
d. AED2 PCB with battery
e. AED pads (connected with a capacitive sensor)
- Mobile device e.g tablet (QCPR Classroom app)
- AED remote control

Assesment of the correct pad placement
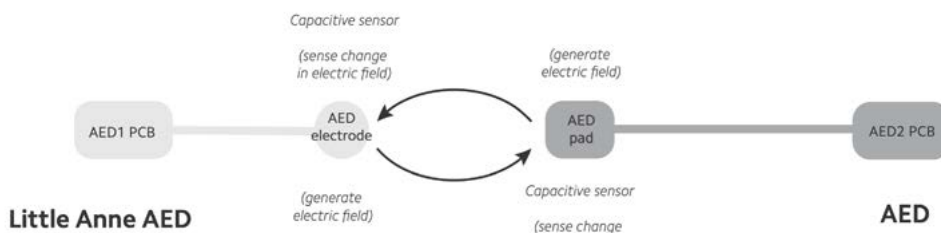
Advantages:
- Provides feedback for assessment of correct pad placement.
- Capacitive sensor can precisely detect that pads are attached to the mannequin (low probability of error with a distance)

Disadvantages:
- QCPR system cannot be used during AED training. The use of AED negatively affects the results of CPR. QCPR system does not recognise the use of AED and identify it as an incorrect performance.
- There is no communication between AED and feedback device, which results in a lack of data about the participant's performance. As the data is not recorded, there is no feedback and guidlines.
- Capacitive sensor requires too high precision for placing pads. As a result, error can occur which will not happen in a real scenario. It puts the pressure on the participants to be perfect, instead of building the confidence when the pads are placed correctly. Solving the accuracy problem will require to increase the size on the pad which cannot be done.

Conclusion:
To provide feedback about the CPR and AED use, the current system has to be improved. Firstly, it has to enable the use of QCPR and AED at the same time. Secondly, it is important to provide the connection between the AED with the mobile device to collect and analyse data about participants performance. Also, the sensor used for the assessment of correct pad placement has to create a realistic scenario. To do it, it has to allow to detect pads on the bigger surface than the capacitive sensor.

Market analysis

In the market analysis, multiple AED training devices were evaluated based on their functionality. The research includes currently available models. There are examples of almost all of the generic models and only a few supporting models (replica training version).

Supporting models (replica training version)

Laerdal
Trainer 2

Laerdal
Trainer 2

Zoll
AED Plus Trainer

Zoll
AED 3 Trainer

Cardiac Science
Powerheart G3 Plus Trainer

Mindray
Beneheart D1 Trainer

iPAD
SP1 Trainer

Defibtech
Lifeline View Trainer

Generic models

Prestan
Professional AED Trainer Plus

Prestan
AED Trainer Ultra

Multiple (XTF / WNL)
Trainer

Multiple (XTF / WNL)
Practi-trainer

Meditech
The Defi 1T AED Trainer

Multiple (XTF / WNL)
Mini AED Trainer

There is a significantly higher number of supporting models (replica training version) available on the market. The main reason is that every AED device has its training version and the market of AED devices is big compared to the training equipment.

51.
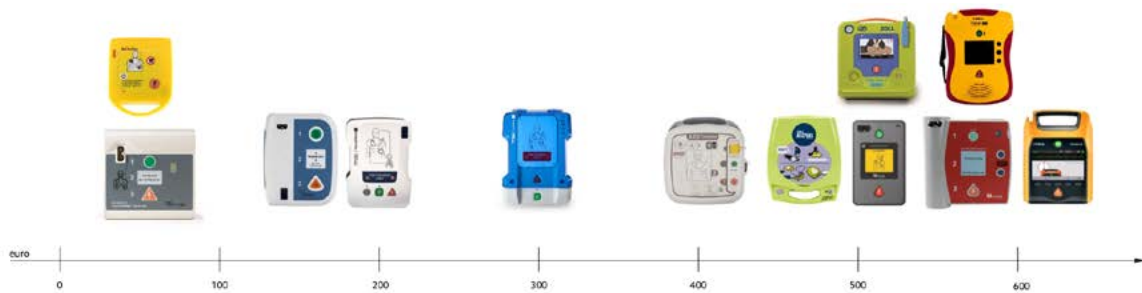
Price range

There is a visible difference in the price between generic and supporting models. The price range of the generic devices is between 50-300 euro. However, the supporting models cost between 400-750 euro. The cause of this clear division is the brand positioning and high quality of the supporting models, which also represent the medical AED devices. Generic devices are associated with lower price and quality. However, Prestan is the only brand which is trying to break the pattern and provide good-quality and more affordable equipment.

Interface

There are three types of interface in the training devices to guide participants on how to use it correctly. The most simple and standard is audio. Voice prompts the primary communication method used in medical AED devices, and as a result, it is present in every training AED. However, in a loud environment, commends can be not clear. To solve the problem, visual instructions can be added. There are two types of combination of an audio and visual interface. AED can have illustrations on the top side which are combined with LED lamps. They light up to indicate which step should be taken next. This method is relatively cheap, but it can affect the size of the device to provide enough space for clear images. The size requirement is the reason why this method is not used in generic models which are significantly smaller. Some of the most recent devices use displays. This type of interface is used mostly for supporting models and copy the solution used in the corresponding AED device. There is only one generic model on the market form Meditech which has a display.

Power source

Most of the training AED devices use strand type batteries. User can decide if they are reusable or not, and which brand will use. It gives easy access to them and a wide choice of options. Nonetheless, it can have a negative environmental impact when single-use batteries are used. Especially that 2 to 8 batteries are needed only for one device, and at least three devices are used for one training. There are 4 models which have designated battery and a charger. The weak point of many devices is a lack of battery status. Precaution to always have a device which battery can last the whole course, can lead to unnecessary battery change and overcharging.

Pads

Pads are an integral part of each AED training device. They are reusable with an adhesive layer on the bottom. Producers recommend to replace them when they stop to stir correctly. Every brand has its own model, but most of them have the same characteristics. Two rectangular pads with an illustration about the recommended placement are connected with a cable and a connector, in the end, to plug it into AED. Only Zoll products have a special type of pads which are attached to the chest as one piece and have CPR sensor in the middle. Presten and XTF/WNL have modular pads which allow replacing only pads which reduce the cost of maintenance.

Power source

Every AED training device has a remote control as an accessory. It used to change the setting of AED, such as volume and language. Besides, there is also a possibility to change the scenario or alter it. Some product requires confirmation on the remote that the pads are placed correctly to allow the scenario to go further. One remote can be used for multiple devices as long as they are the same model. IR technology allows that to communicate but also requires correct pointing on the sensor on the chosen AED.

Instructors recommendations

Complains
The high price of pads which is the main maintain cost
Low quality of pads which increases the need for replacement
Problems with remote connectivity due to the number of devices and characteristics of IR technology which is used for the communication

Suggestions for improvements:
Durable pads
Easy and reliable control with the remote especially when there are more devices
Lightweight and small
Reliable and robust device
Simple and intuitive
Possibility to easily and fast check the battery status
Easy to reset settings before the training
Additional elements such as metal stripes are problematic for instructors
Paediatric mode
Future proof design (future possibility of software and hardware update)
Limit the number of scenarios from 10 to 2-3
Show two types of pads (regular and Roll pads)
Not fully adhesive pads surface to help detach them from the mannequin

Best sellers
According to the Qualsafe and Projeket AED data, the most often sold devices are the generic ones. Universal AED Practi Trainer and the Mini AED Trainer from XTF/WNL are their best sellers. The most significant factor is the low price of the devices and pads but also the small size which help is transport.

Multiple (XTF / WNL)
Trainer

Multiple (XTF / WNL)
Mini AED Trainer

Instructors' favourites
Unlike the trends in sells, the instructors preferred the supporting models. They explained that they are more intuitive and reliable. Also, the quality of the device and voice prompts are significant advantages.

Philips, HeartStart FR2, Trainer 2 by Leardal

"It is intuitive and user friendly"
"It is robust, easy and it is the one I have learn first"
"When training battery is put out and it is and operation tool. I enables to practice battery failure and it is easy to change scenario"

ZOLL AED Plus Trainer 2

"I like to show Zoll, to show different types of pads"
" It is interesting, pads are different"
"It is really easy, it has remote, pictures, voice prompts"

iPad by CU Medical System

"It is simple, intuitive, no additional functions and has paediatric mode. It doesn't scare with medical sounds and looks a bit bulky and toy'ish. Together it makes it feel friendly."

Conclusion

However, all AED training devices mimic medical AED, there is a visible diversity of the products. There is no guiltiness for the design of them. Also, the main focus of the products is to imitate AED, and there is no development into training.

Quality and price of the pads were the main complaints of the instructors. As pads have to be replaced every few courses, their qualities affect the cost of the maintenance. Also, instructors shared their problems with controlling training equipment with the remote controls. The high number of buttons and complexity make the use not intuitive. Moreover, frequently they mentioned the struggle to change the settings on a specific device as the IF signal was affecting the other device.

In order to integrate AED solution with QCPR there must be a communication between devices and a system which will analyse and combine the data. In the current system, the use of AED affects the scoring system in QCPR. Also, the current solutions for the assessment of pad placement have to be improved. The capacitive sensor is too precise, and the metal stripe is not realistic.

Lack of guidelines

Lack of standardises AED design results in a lack of guidance in training units. Also, education guidelines don't provide description of equipment functionalities.

Simplified AED

Training devices has strong focus on mimic AED devices. There is no additional education functions and the device is oversimplified (e.g. number of buttons).

Paediatric mode

Some AEDs requires pressing a button in a paediatric mode what is not addressed in a training devices.

Complex control

There is a slow response to decrease the complexity of the remote but it still requires correct IR connection.Controlling multiple devices becomes a challenge.

Maintenance

Current system of pad and buttery replacement cause high maintenance, problems for instructors and in unsustainable.

3. DEFINITION

In the chapter, the findings from the research were concluded. Main problems were defined, and the direction of the project was chosen. Based on it, the goal was defined to equip the AED training instructor with a high quality of assessment and provide constructive feedback to participants. Further, detailed list of requirements was created. For the scope of the project, it was summarised in demands and whises.
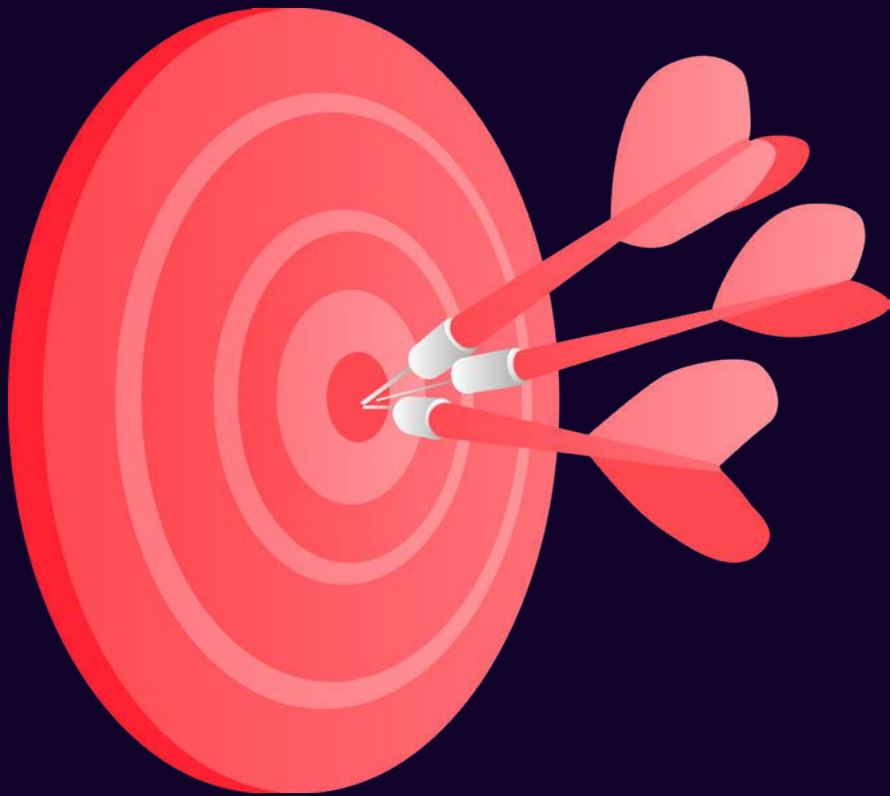
3.1. DESIGN SCOPE AND GOAL

Problem definition

Problem 1

What is the problem?
Lack of AED devices - Unable to experience AED

Who has the problem?
Participants
First Aid Course in St John Ambulance

What are the relevant context factors?
High number of participants at the course requires high number of devices
Training institutions has to maintain the same conditions for all courses what requires the simultaneous porches on the new equipment and big cost

What are the goals?
Provide an opportunity for every participant to exercise with AED and be asses on the skills

What are the side effects to be avoided?
High cost of the purchase
High noise of multiple devices in one room
Lack of control of multiple devices by one instructor

Which actions are admissible?
Lack of control of multiple devices by one instructor

Problem 2

What is the problem?
Skills assessments

Who has the problem?
Instructor
Every course with more than 2 groups of participants.

What are the relevant context factors?
Multiple users performing the exercise at the same time
Limited attention of an instructor
Complex exercise with multiple steps (Not repetitive steps)

What are the goals?
Provide a correct assessment of multiple participants

What are the side effects to be avoided?
Distractions of an instructor
Participants stress of being asses

Which actions are admissible?
Pad placement could be observed through longer time

Problem 3

What is the problem?
Receive limited feedback

Who has the problem?
Participant
Every course with more than 2 groups of participants

What are the relevant context factors?
Multiple users performing the exercise at the same time
Limited time to provide feedback

What are the goals?
Provide a positive, accurate and constructive feedback

What are the side effects to be avoided?
Distractions of a participants
Question an instructor competence

Which actions are admissible?
-

Design directions

Based on the problem definitions, two main design directions were created.

I. Experience AED

Based on Problem 1. Lack of AED devices - Unable to experience AED

This direction focuses on the courses such as first aid where AED training devices are not used due to the high cost of the devices. The approach is to explore the solutions for affordable teaching equipment which will allow participants to practice.

II. Support instructors

Based on Problem 2. Skills assessments and Problem 3. Receive limited feedback

The second directions aim to improve the current scenario of AED training by eliminating the unnecessary challenges of the instructors. It includes the one caused by the teaching equipment but also by the complexity of the training. A solution should include the improvement of training device but also allow the connection with QCPR.

I. Experience AED

Every participant can learn how to use AED by practice with physical

an affordable AED training unit

II. Support instructors

Equip instructors with tools to support a teaching process.

a system witch integrates QCPR and AED traing

Support instructors

Equip instructors with tools to support
a teaching process and their experience.

Improve participants skills
and confidence.

Chosen direction - II. Support instructors

The instructor is a key factor in AED training. It is the source of the assessment and the feedback, which is crucial for participants learning objective. However, teaching is emotionally and mentally demanding and frequently stressful activity. Also, AED training is a complex process and is challenged by a number of participants and time frame. It puts additional stress on an instructor to address all participants and provide equal feedback and assessment. Current equipment does not support instructors work and even course distractions such as not intuitive remote or incorrect assessment of the pads placement.

Factors of the direction selection

Design
More design opportunities - push boundaries of current training equipment
Explore new functionalities of AED

Business
It is their first generic AED produced by Laerdal
The CPR technology is advanced, and there is not corresponding AED equipment
Laerdal has the potential to be the first company to provide high-quality AED training equipment which can also include the CPR performance

Users
Increase the quality of the training for participants
Support instructors

First Aid Education
Gathered data about the quality of teaching methods for further research and development of new products

Design Goal

Equip the AED training instructor with a high quality of assessment and provide constructive feedback to participants.
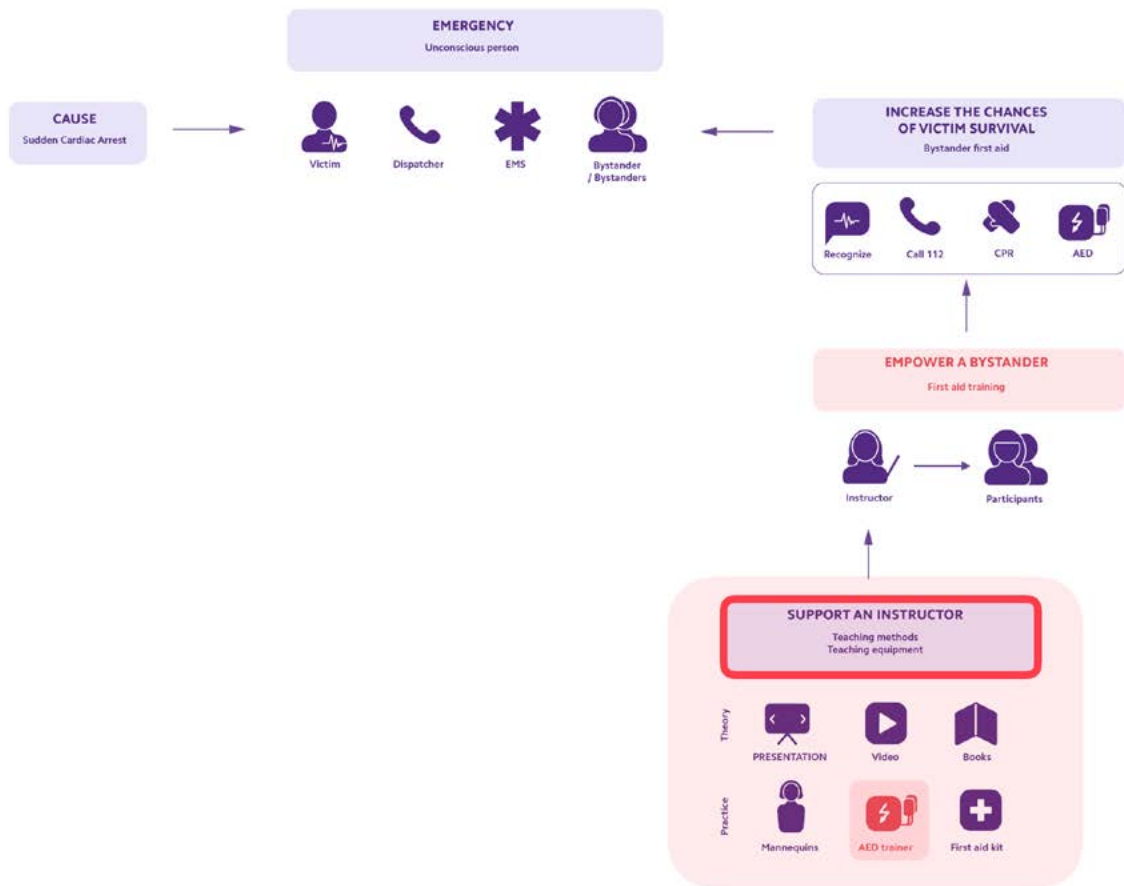
List of requirements

PERFORMANCE

The product has main functions which are necessary to practice how to use AED: voice prompts, buttons and adhesive pads.

The product must give the participant the feeling that the use of a training device is equal in the operation principle with the use of an AED device (Semi-realistic simulation of AED use).

The product has to provide the instructor with information about the participants performance.

The product has to provide the instructor with information what feedback can be provided to each student/group of students (each AED operator).

The product has to work together with QCPR system (mannequins and QCPR Instructor app, QCPR Learner app, and QCPR Classroom app).

The feedback suggestions must address all participants. One device (remote or app) has to control all AEDs connected to the system.

The product has enhance an engaging and constructive learning environment.

The product has to adapt to the teaching methods and participants (increase and decrease the number of functions).

The instructor shall be able to select and customize training scenarios for AED courses.

ENVIRONMENT

The voice prompts should have limited volume not to harm the hearing

Sound quality has to allow to understand voice prompts easily

MAINTENANCE

An instructor should be able to:
set up the device for a training
change/charge the batteries
assemble the pads
replace the adhesive part of the pads

SIZE AND WEIGHT

The product should be slightly smaller than small AED to improve transportation and storage.

The product should be big enough to give a feeling of similarity to the AED.

AESTHETICS, APPEARANCE AND FINISH

The shape of the product must remind AED.

The appearance of the device must make it easy to distinguish that it is a training device.

The device should look professional not to question the quality of the course.

MATERIALS

Easy to clean and disinfect.

Lightweight but give the feeling of AED.

Not easily damaged and scratch by the impact.

Adhesive pads should be able to be used multiple times.

ERGONOMICS

Must be convenient to grip.

Visuals (illustrations and icons) used during the operation of AED must be easily readable from a distance of 0,5m.

STORAGE

All different parts of the product have to be able to be stored together

SOCIETAL AND POLITICAL IMPLICATIONS

Instructor and participants trust the accuracy of the measurements and feedback.

Demands

The product has main functions which are necessary to practice how to use AED: voice prompts, buttons and adhesive pads.

The product must give the participant the feeling that the use of a training device is equal in the operation principle with the use of an AED device (Semi-realistic simulation of AED use).

The feedback suggestions must address all participants. The product has to provide the instructor with information about the participants performance.

The product has to provide the instructor with information what feedback can be provided to each student/group of students (each AED operator).

The control of the AED devices must be intuitive.

One device (remote or app) has to control all AEDs connected to the system.

Requires the minimal amount of attention from the instructor to operate the system.

An instructor should be able to change/charge the batteries

An instructor should be able to replace the adhesive part of the pads and assemble them.

Whishes

The product has to adapt to the teaching methods and participants (scale down and up the functions).
Increase the level of participants engagement
Enhance peer feedback.
Avoide the feedback's negative side effects.
The product has functions which can enable the advance practice: paediatric mode, replaceable battery.
A tool used by an instructor to control the AED devices do not abstract movement (mobile)
The device should look professional no to affect the perception of the quality of the course
Do not increase the number of products in the system.
Instructors and participants acceptability
Do not increase the maintenance time.
Cost.
Easy to substitute in case of regulations change.
Minimize waste.
Do not create additional delays during the training.
Avoid the instructor's soft skills dependence.
Speed of use.

4. DESIGN

In the chapter, the vision of the future of AED training with a storyboard was created. Based on it, ideation was done, and it was concluded with three concepts. Further, they were evaluated with St John Ambulance instructors during a second trip to the UK. Based on their feedback and Harris Profile method, the final concept was selected and explored. Multiples sketches and mockups were made to define the AED device and app. The final design was presented to instructors and assessed. Also, the interface for students was tested with potential participants of the course. Most of the findings were implemented to the concept, and remaining ones are included in the Recommendations for implementation.

4.1. DEVELOPMENT

Future vision

The future vision of instructor-led AED training is focused around the scenario-based practice. The number of participants increases from 6 due to the implementation of the assessment technology. The cost of the training decreases and more people could be trained. Participants gather in the classroom with an instructor and go through exercises with AED in groups of 2-3. It mimics the cardiac arrest scenario, which usually requires more than one bystander to fetch AED and continue CPR. It also provides conditions to gain teamwork and communications skills.

The system consist of Little Anne QCPR mannequins but also physical AED training devices. AED training equipment has similar physical characteristics of medical AED. For example, the physical body, buttons, pads. It provides a similar experience to the use of AED in an emergency. For instance, the sensation of pressing a button, attaching pads. It helps participants gain confidence that they can use not only a training device but also the medical AED. Both mannequins and AED devices collect data about participants performance and send it to the mobile device. The data is analysed and presented in an accessible way to an instructor in an app.

Connected equipment creates a system which supports the instructor in having an overview of the course. An instructor becomes a facilitator who is in the control of equipment but also participants performance. App also makes suggestions for the feedback which the instructor can provide to participants. In the system, there is also a screen which is used for presenting information to participants (presentation), creating a more immersive experience, for example by displaying for the possible environment, but also to share feedback.
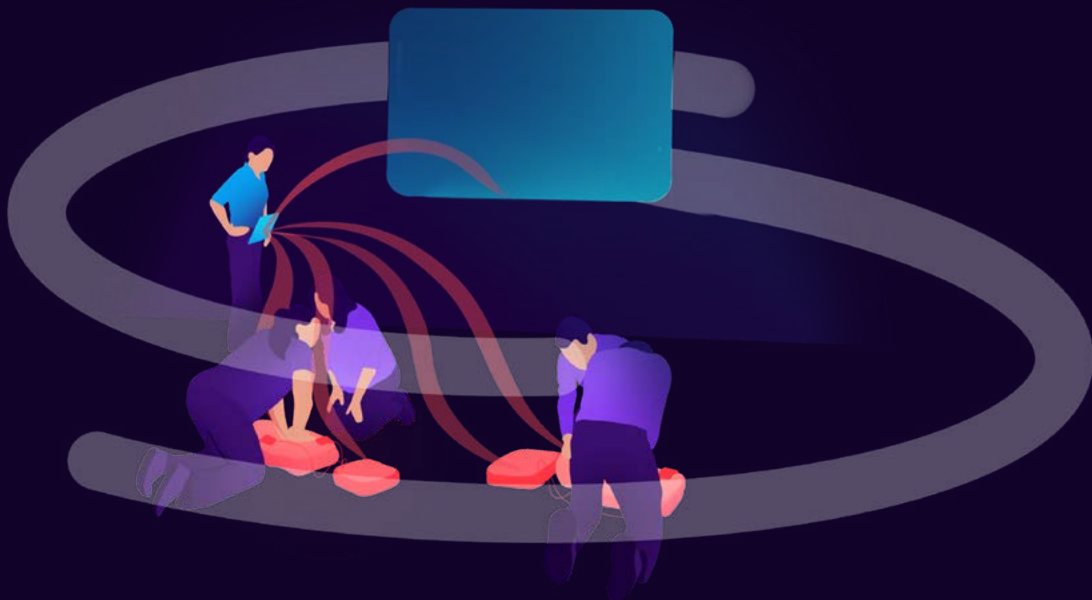
Storyboard

Storyboard method was used as a visual representation of the envisioned scenario. It aims to help understand the implementation of the system in the AED training context. The scenario focuses on three activities: explore, practise and test. It is important that after every learning activity, there is a reflection phase.

1. Participants sign up for a course. They are asked to take a test. It will define their initial knowledge about First aid and AED but also estimate skills based on experience and participation in previous courses. The test will also evaluate the participant learning preferences such as feeling, watching, thinking and doing from the Kolb's earning cycle. They can also receive detailed information on the course to know what to expect to minimise the stress about the course. Also, education materials such as books can be provided in a digital form.

2. Before the course instructor receives information about the group of students who will participate in the course. Based on it, instructs can decide which methods will fit best the group and also the initial level of throning such as basic, medium and advanced.

3. The instructor is preparing the equipment and tools for training. By losing to the system, all education materials will be available — for instance, presentations, videos, app. An instructor can also check the battery level of mannequins and AEDs.

4. When participants enter the class, they are asked to confirm their presence in the instructor's app.

5. Instructor welcomes participants.

6. Ice breaker activity takes place at the beginning of the course. It enhances the informal, positive atmosphere but also to creates a connection between participants. They will feel more comfortable with providing feedback to each other and less hesitated to ask questions.

7. As the second activity, participants are asked to provide the first aid. They can explore the AED and have their first experience with it. It can help them connect further information with the scenario of providing first aid. In addition, during this activity, the smart system measures participants performance from which the final progress will be calculated. It will be used to refine the course scenario — for instance, the level of the course and proportion of the theory to practice and reflection.

8. Participants can analyse their performance, what they have discovered but also receive the feedback from the instructor.

9. After receiving general information about the first aid and mastering the CPR skills, participants start the practice with AED in teams. While participants practice, mannequins and AED training devices collets data about their performance. Instructors can see the results of all the teams and provide the feedback accordingly.

10. After practice instructor provides more extensive feedback based on the app evaluation. Most significant

mistakes can be addressed. Also, the instructor can see what progress participants made from the exploration phase.

11. As the last learning activity participants will take a test/quiz. It helps to asses their knowledge but also clarify all information presented at the course.

12. The course is finalised with the reflection. The instructor asks participants about their willingness and confidence to provide first aid and use AED in an emergency. If there are some concerns, the additional conversation can be used to empower participants.
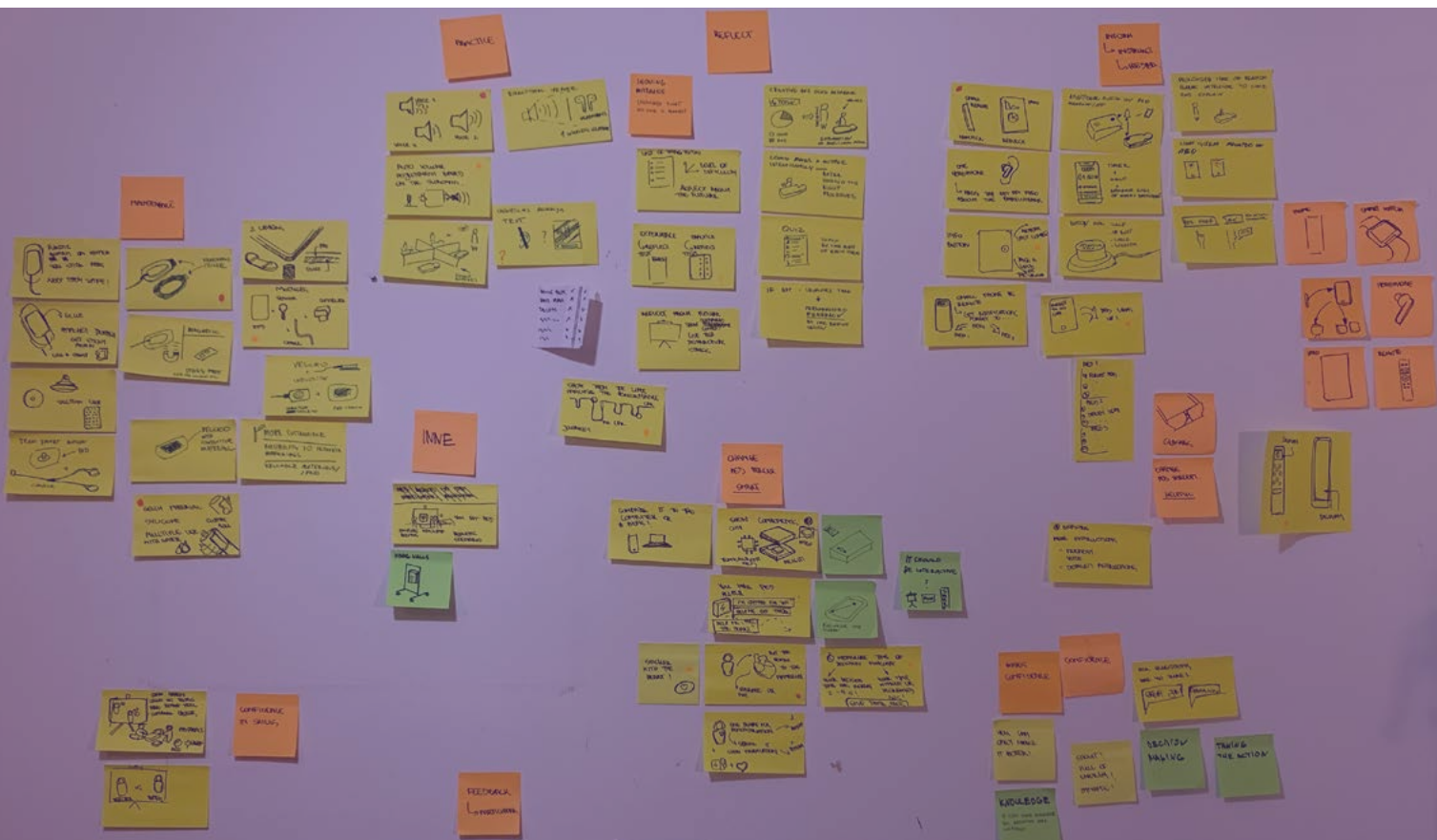
Ideation

How Might We method was used for the ideation proces. Questions were divided into categories:| change of AED perception, changing feelings toward AED, assessment, feedback, reflection, practice and maintenance. Ideas were drawn on the posits. Further, they were clustered, and most promising ideas were chosen to proceed as the concepts.

Concepts

Three concepts were created. During the initial exploration, concepts were generated without being constrained by the list of requirements.

1 STUDENTS PERFORMANCE

Concept 1. Students performance

Why?
Limited possibility to asses multiple participants at the same time
and provide constructive feedback due to the complexity of the task and the number of participants.

What?
Guidelines for the instructor to support the assessment and feedback process.
(Smart AED connected to the system and an interface for the instructors' screen device).

How?
Collect and analyse participants performance and translate the results
to guidelines for an instructor. Instructions will include information about the most problematic tasks and point the students who could require more attention.
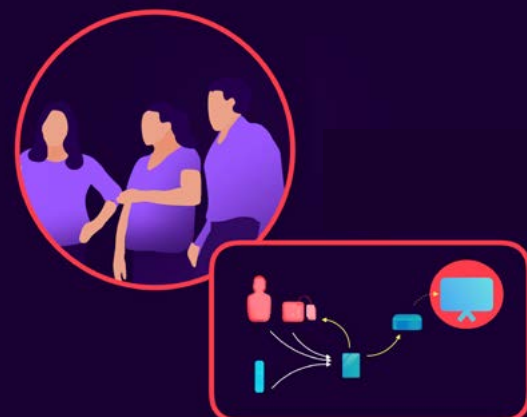
2 GROUP FEEDBACK

Concept 2. Group feedback

Why?
Limited possibility to asses multiple participants at the same time
and provide constructive feedback due to the complexity of the task and number of participants.

What?
Guidelines for the students to assess each other and encourage reflection.
(Smart AED connected to the system and an interface for the projector)

How?
Collect and analyse participants performance to translate into results. The simplified version will be presented on display after a participant complete the exercise.
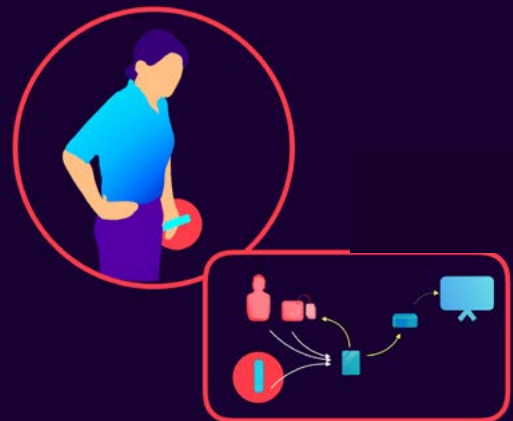
Concept 3. Be in control

Why?
Importance of a practice in multiple scenarios and difficulty to control multiple devices.

What?
Simplify and intuitive solution which enables to control multiple AEDs and the presentation.

How?
Connect all AED to the one system which could be controlled with one device.

Concept evaluation

Concept 1. Students performance

Benefits:
- The system can pick up the small things which were missed by the instructor
Opportunity to use the data to support the development of the trainers and collect more accurate statistics about the effectiveness
Benefits of the results for the reflection activity after practice

Possible side effects:
The app can cause distraction. Feedback should be provided afterwards.

"I would say feedback should be created afterwards. My priority in the classroom is towards students, to really watch every step they are making. It could be a distraction if you look at the screen."

Recommendations:
- Be careful with detailing feedback

Concept 2. Group feedback

Benefits
Participants can support each other
Gives the instructor more time and possibility to go more in-depth with the feedback when he/she is assured that everyone got basic information about their performance from the system
Providing feedback per group not per person put less pressure on individuals

Possible side effects:
Some groups are too competitive
For a group with a strong hierarchy, for instance, a boss with employees, some participants might not feel comfortable with the full exposure of their performance

S" It would be nice if there will be the option just to see one group see so the instructor can spend a couple of minutes with each group so to get the group discussing how they think it went and then instructor visit each group to give the feedback."

Recommendations:
Must be an option not to show the feedback
Even and equal feedback
Avoid showing the percentage to the students like QCPR. It is too detailed, and they focus too much on achieving 100%. Unless they reach it, they are not happy with their performance even though it was sufficient. It may affect the confidence negatively
Traffic light system

Concept 3. Be in control

Benefits
Remote can control all devices at the same time
Switching between controls the devices and letting them define the best scenario for each group based on their progress

"I'm actually will be ok with the remote which will control all of them at the same time."

"I like the idea that you can switch, that heave the control on it and then have the iterations that you can adapt to the individual needs more."

Recommendations:
- Decrees the role of the remote by giving more control to AED

Instructors were asked to select the strongest concepts. Every instructor said that there is a strong connection between concepts and they are all relevant for their work. Two instructors selected the combination of Concept 1 and Concept 2.

"I think if you can combine 1 and 2 that would be pretty amazing for me. So the instructor gets a bit more feedback and can have a word with individuals if needed, but the groups get some feedback. There could be some feedback for the instructor and some basic to the individuals. To me, it would be amazing if you can combine 1 and 2."

Two other instructors selected the combination of Concept 2 and 3.

"Being in control of the devices is a massive problem."

"Group feedback is less stressful than the individual one, but being in control is much easier to manage from the instructor point of view, and I think that having an option to be in control and do group feedback. I like that combination of two and three."

As a second method for the concept evaluation, a Harris Profile method was used. Concepts were divided into two categories. First compared the concepts about the feedback. Second, the group had three methods of providing control over AED devices. Each group had a separate list of requirements.

FEEDBACK: Instructor feedback app vs Group feedback app
1. The feedback suggestions must address all participants.
2. The product has to provide the instructor with information who needs the feedback.
3. The product has to provide the instructor with information what feedback can be provided to
4. Instructors soft skills dependence
5. Amount of attention required from the instructor
6. Don't create additional delays
7. Enhance the peer feedback
8. Increase the level of participants engagement
9. Lack of the feedback's negative side effects

CONTROL: Remote control vs app on the tablet vs app on the phone
1. Intuitive
2. Speed of use
3. Amount of attention required from the instructor
4. Don't obstruct movement (mobile)
5. Amount of products in the system
6. Acceptability
7. Maintenance
8. Cost
9. Easy to substitute
10. Reduce waste

Phone and App

	- -	-	+	++
Intuitive		■		
Speed of use		■		
Amount of attention required from the instructor		■		
Don't abstract movement (mobile)		■		
Amount of products in the system	■			
Acceptability		■		
Maintenance			■	
Cost	■			
Easy to substitute			■	
Reduce waste	■			

Instructor feedback app

	- -	-	+	++
Address all participants		■		
Provide the instructor with information who needs the feedback.				■
Provide the instructor with information what feedback can be provided to				■
Instructors soft skills dependence		■		
Amount of attention required from the instructor		■		
Time consumption		■		
Enhance the peer feedback		■		
Increase the level of participants engagement			■	
Lack of the feedback's negative side effects			■	

App on the tablet

	- -	-	+	++
Intuitive		■		
Speed of use	■			
Amount of attention required from the instructor		■		
Don't abstract movement (mobile)	■			
Amount of products in the system				■
Acceptability		■		
Maintenance				■
Cost				■
Easy to substitute				■
Reduce waste				■

Peer feedback app

	- -	-	+	++
Address all participants			■	
Provide the instructor with information who needs the feedback.		■		
Provide the instructor with information what feedback can be provided to		■		
Instructors soft skills dependence			■	
Amount of attention required from the instructor			■	
Time consumption			■	
Enhance the peer feedback			■	
Increase the level of participants engagement				■
Lack of the feedback's negative side effects		■		

Remote control

	- -	-	+	++
Intuitive				■
Speed of use				■
Amount of attention required from the instructor			■	
Don't abstract movement (mobile)			■	
Amount of products in the system	■			
Acceptability				■
Maintenance		■		
Cost		■		
Easy to substitute	■			
Reduce waste		■		

Concept selection

For the first category, the concept with per feedback app turned out to be slightly stronger compared to the Instructor feedback app based on the order of requirements. However, the difference is not unambiguous. Moreover, the experience and individual approach of instructors is a significant factor which affects participants performance and emotions. Taking into account that it is a first attempt to provide feedback on AED training, the use of instructors assets would support the concept.

For the second category, the concept of Remote control was the best concept with App on the tablet being the second best. It is the most intuitive and fast way of controlling the devices. Nevertheless, it will require much improvement compared to the current remotes to be reliable. Taking into account the company preferences and the cost of development of physical device compared to the digital product app was recognised as the most feasible choice.

Based on the session with instructors and evaluation with Harris Profile final concept was selected. It is concept nr 1. Students Performance which provides an instructor with an overview of participants performance and suggestions for the feedback. The decision was also made to integrate partially Concept 2. Group Feedback as an extension of the instructor app. Due to the time constraints of the project, it is limited to one example of the information which could be presented after the participant will finish the exercise. However, the Concept 3 was recognized as needed, it has less effect of training outcome.

What?

New AED training device and digital tools to support it.

How?

Equip the AED training instructor with a high quality of assessment and provide constructive feedback to participants to improve their confidence.

1 STUDENTS PERFORMANCE

2 GROUP FEEDBACK

4.2. DETAILING
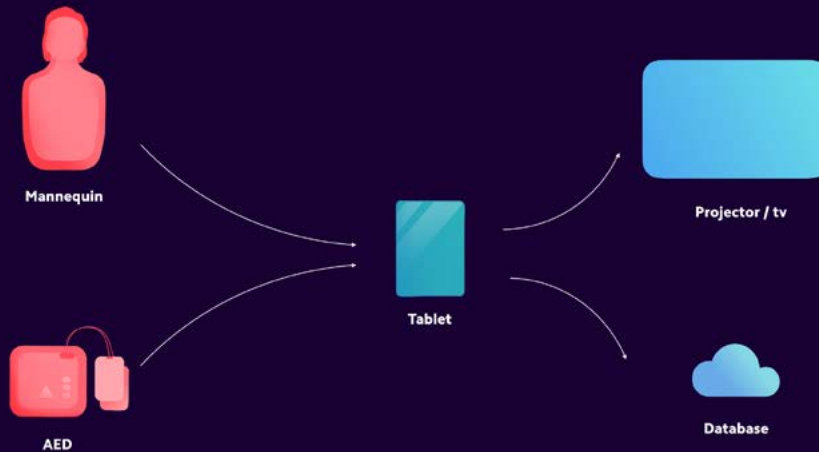
System architecture

In order to integrate the QCPR with AED, the system has to recognise the presence of the AED (beginning of the interaction with AED) and the ID of the AED device. This information is used to calculate the CPR score, which is not affected by the correct operation of AED, but also recognises the delays in CPR which are the reason of incorrect operation of AED (teamwork, not following the voice prompts).

Qualities to measure:

Pad placement:
Pads have to be placed in the correct location: victims upper right and lower left. The assessment of correct pads placement is done based on the area, not a single point. The surface should have 30-45 mm in each direction from the centre of the correct position.

Reversing of the pads is not recommended with the AEDs produced between 1990-2005. They could have monophasic pads which are not interchangeable with regards to placement. However, the newer devices have biphasic pads which are interchangeable. This information could be address at the course but due to the low chances of interaction with the older device and extensive material of the first aid course, it is not necessary to include it as the requirement. Overall, correct pad position with the possibility to reverse pads is the only quality which has to me asses bu the system.

Delays in CPR:
Delays in CPR indicate both the skill to continue CPR when AED arrives and is being attached but also to follow the voice prompts (provide/continue CPR or stay clear).

Delays can occur:
Before AED arrives
When AED arrives
When pads are being attached
When AED recommends to provide/continue CPR

Design implications for the system design:

Requirements:
Provide feedback for assessment of correct pads placement (correct, incorrect)
Data from AEDs should be collected by a mobile device, analysed and presented in the form of feedback for each pair of devices (BLE connection with the mobile device)
The system can recognise the delays in CPR after pads are attached (following voice prompts). To do it, the AED needs to have an ID number which can be read by the mannequin in order to combine the CPR and AED data.
Participants are not required to do any additional steps which are not a part of the CPR&AED training
No changes in the QCPR PCB
Do not increase the size of the pads
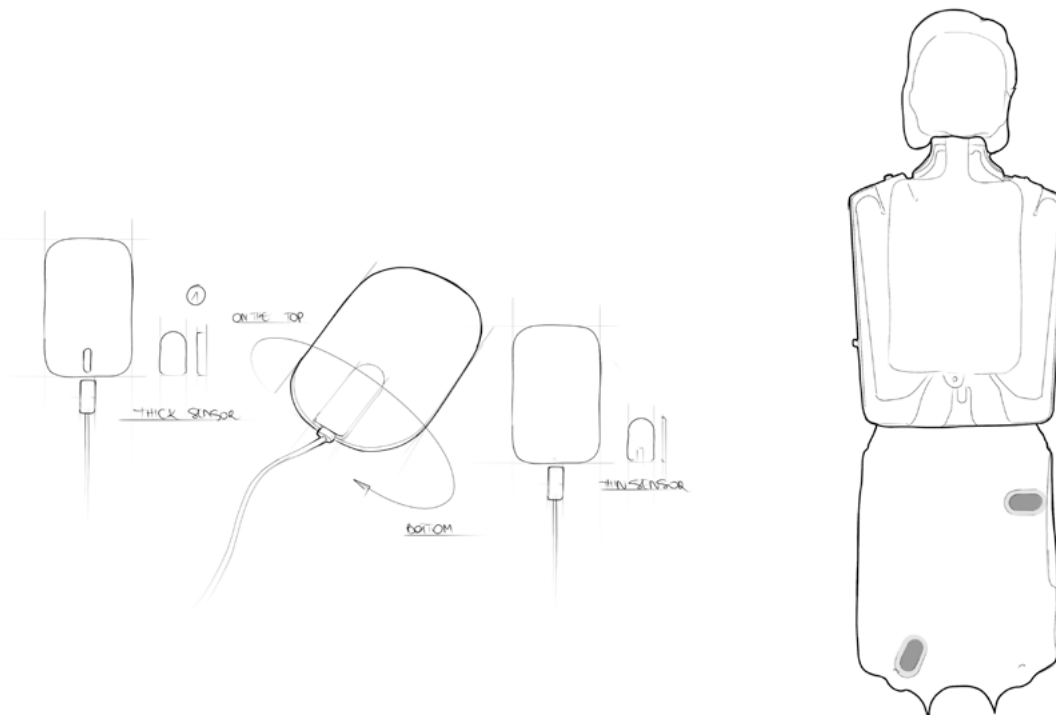
Wishes:
Live feedback for the instructor and participants
QCPR system recognise the presence of AED and does not mark it as incorrect delay in CPR. Enable the use of AED with QCPR to provide the completed training scenario and assessment system
Assessment of correct pad placement has a margin of mistake between 30-45 mm in each direction.
Minimal number of additional activities to set up the equipment for instructor and participants
Low cost of AED pads

Technology
The NFC is precise and secure method of pairing the AED with the mannequin. However, it requires small distance between a tag and a reader. As a result this technology can only be integrated at the sage of attaching pads. This late recognition of AED in the scenario can affect the QCPR score and doesn't allow to integrate the systems in a complete way. Two concept were created to minimise the disadvantages

and achieve the most reliable feedback.

NFC tag is placed under the skin and the NFC reader is it the pads (the NFC reader antenna is placed in the pads and the PCB is in the AED)

Detect the presence of the AED (AED ID)
The mannequin will detect the presence and ID of AED when pads will be placed correctly on the mannequin.
      -      Assessment of correct pad placement
The mannequin will detect the correct placement of the pads by the use of the NFC tag under the skin of the mannequin and NFC reader integrated into the pad

The system can also work with the reverse position of the components. However, due to the disadvantages for the pairing the tag with the AED when pads are replaced only this concept was selected.

Professional

Robust

Trustful

Smart

Moodboard

A mood board was created during the detailing phase. The theme of the mood board was represented with four keywords: professional, robust, trustful and smart. They were chosen based on the interviews with both participants and instructors. As the AED collects data about the participants' performance and takes control over the training, its appearance should communicate smartness which is included in the device. At the same, time it should create a feeling of being solid and robust. Participants must be comfortable with using the devices in a rush to deliver the shock as soon as it is possible, rather than being too conscious abut the device. A combination of two materials, plastic and rubber will create the desired look and additionally create a trustful looking device. AED should also have professional appearance not to decrease the perception of the quality of the training.

Power button

Pads connector

Paediatric button

Display

Shock button

Training device

Product architecture
To start with ideation a product architecture has been developed to make sure that the following components are the integral parts of the product.
1. Main body of AED
2. Pads
3. Charging system
4. Case

In order to provide all functionalities necessary to practice all skills required to operate AED, the design of the body started with defining the interface. On the top side of the training AED, three buttons are placed: power on/off, shock and paediatric mode. Also, the display is placed on this side to help participants understand what steps they should take when the environment is too loud to hear it. It is necessary as the system evaluates the performance of participants all factors which can bias the score should be eliminated.
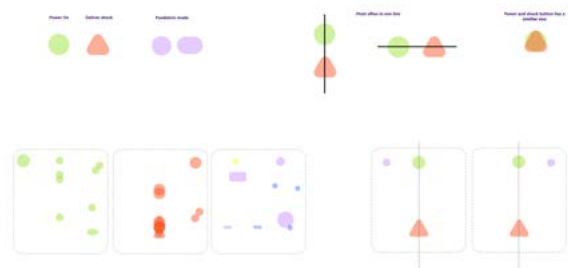
Analysis
Training AED must be similarly operated to the medical AED what put restrictions on the interface of the device. Analysis of the medical AED devices was made to define the trends in positioning the buttons which were used for the training device. Aligning power on/off and with shock button was the most common arrangement.

Power button

Shock button

Paediatric button

selected buttons
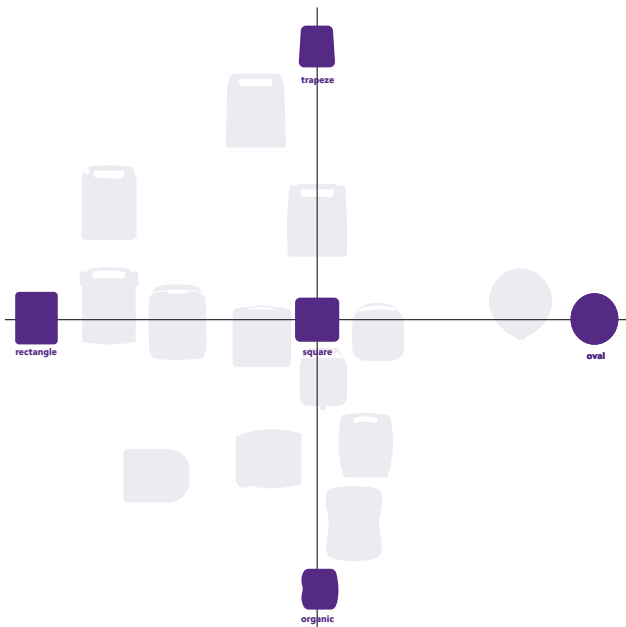
Multiple sketches ideations were done to explore different elements of AED architecture. Multiple options were considered for AED, for example, modular construction, lid on the top or handle on the top of the device. For the final AED rectangular shape was chosen in a horizontal position. The simple form will minimize the number of parts which can break but also makes the device smaller what helps in transporting.

Among the possible options for the pads storage, back of the AED was chosen as the most favourable place. It makes the device more compact but also will secure the cable. It was observed that AED often throws from the case. When the pads were stored in the case they and remain connected to the device, it may cause destroying the connector or cable.
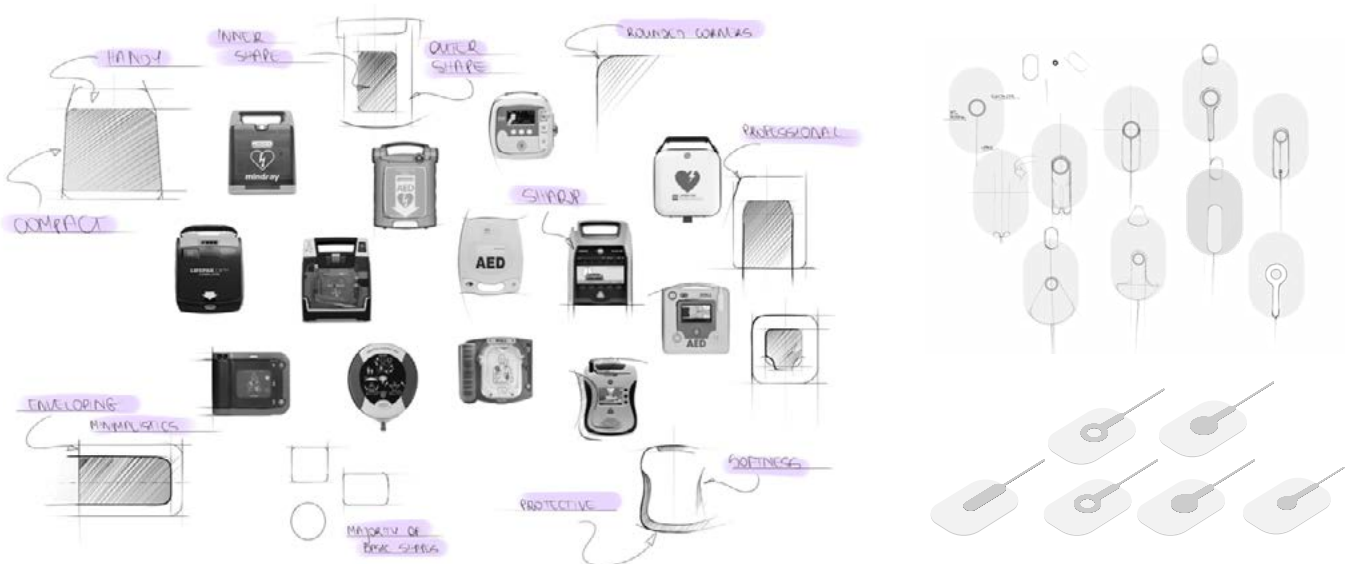
For each sketch, the physical mockup was made. Foam and 3D printing were used to prototype and test ideas about the form. Also, some models were adjusted to fit the phone. It helped to test the presence of the screen on the device but also try different options for the interface.

The second reason for making a physical model was an exploration of dimensions in relation to medical AED. The aim was to decrease the size of the training AED device, but maintain the feeling of the similarity to the real device. Moreover, the analyse of the sizes of medical devices, and training one was done.
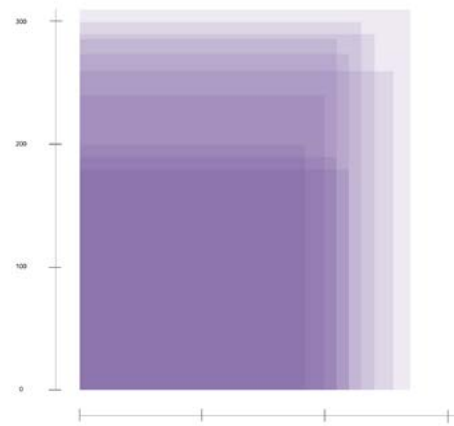
medical AED devices
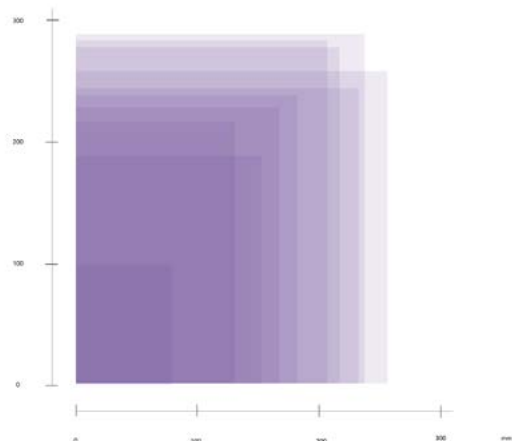
traning AED devices
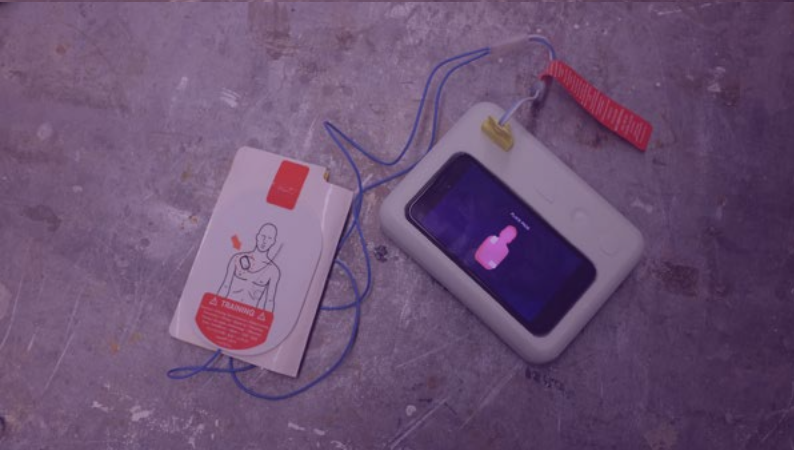
App

This is the concept of the app, which should be used after the participants will master the CPR skills and AED use could be added to the first aid as the next step.

The logic and architectures were inspired by AED training observation and interviews with instructors. Firstly, AED training device is used with different training methods such as demonstration, repeating instructors steps and practice. The app should provide a broad spectrum of tools and let the instructor decide which suits his/her approach and a specific group of participants. Secondly, the CPR feedback is still present. However, it was assumed that participants have already gained this skill, it is a crucial ability which can be still improved. Also, there is an importance of receiving information on how CPR is affected by the use of AED. For example, with delays or group work.

The layout of app was created based on the layout of the current QCPR Classroom app by Laerdal. The concept is an extension of this app, and in the future, they should be combined into one software. Based on the instructor's feedback about Laerdal's apps, the strong suggestion was made to avoid the use of percentage when the results are shown to the participants. One of the instructors suggested the use of the traffic light scale and it was explored with different colour scales.

QCPR   QCPR CLASROOM app   QCPR RACE

QAED   QAED CLASROOM app   QCPR GROUP FEEDBACK
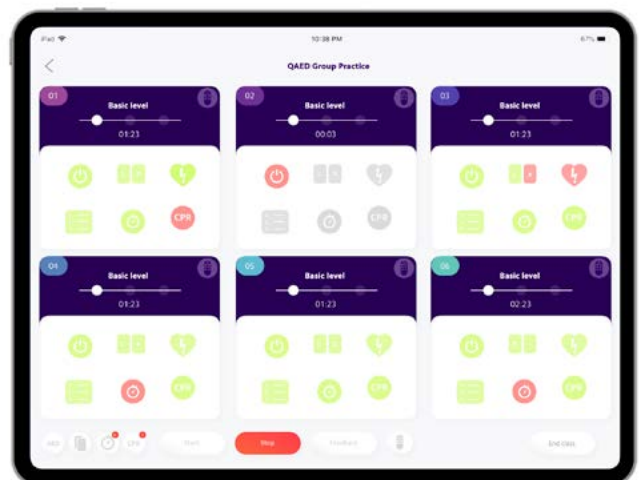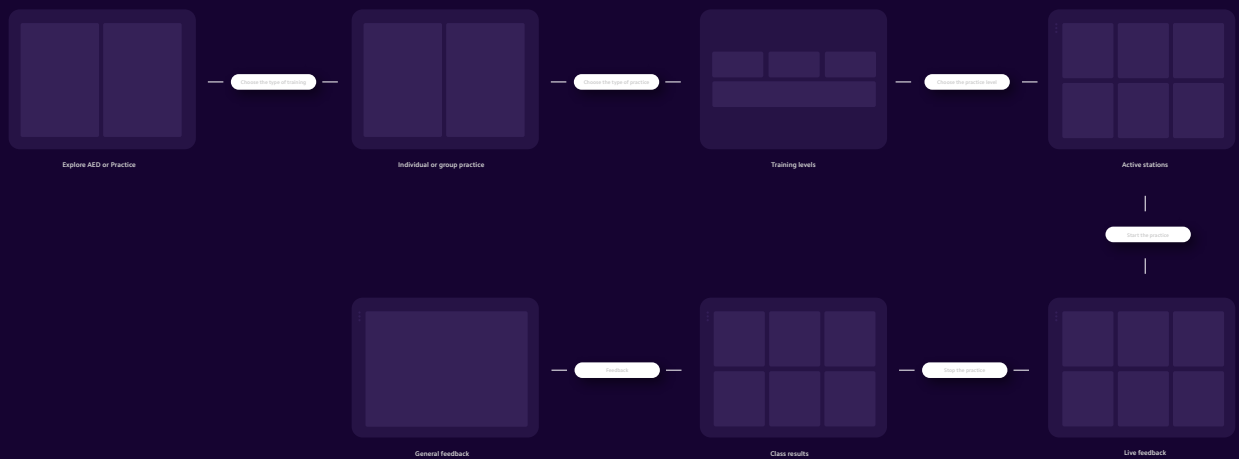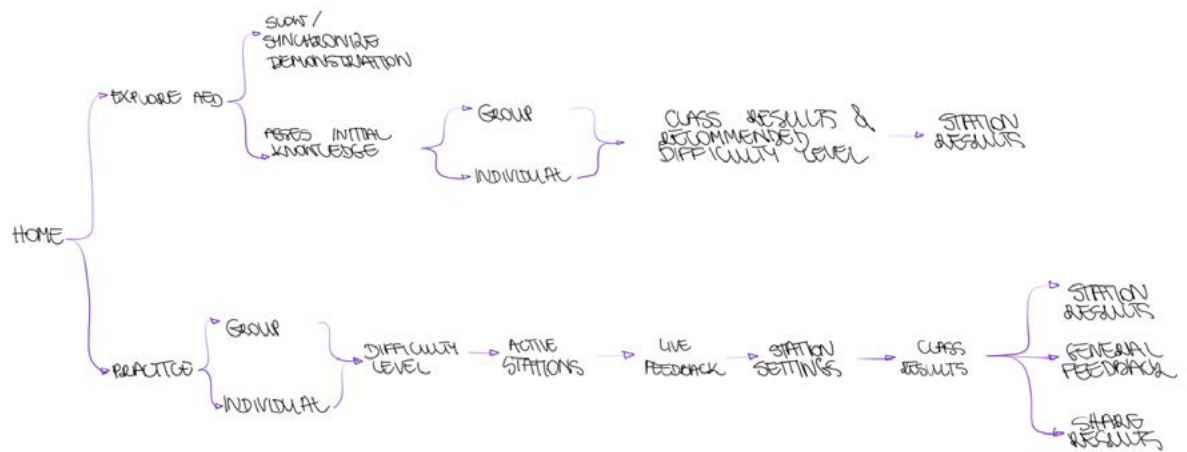
4.3. FINAL DESIGN

System

The NFC is precise and secure method of pairing the AED with the mannequin. However, it requires small distance between a tag and a reader. As a result this technology can only be integrated at the sage of attaching pads. This late recognition of AED in the scenario can affect the QCPR score and doesn't allow to integrate the systems in a complete way. Two concept were created to minimise the disadvantages and achieve the most reliable feedback.

NFC tag is placed under the skin and the NFC reader is it the pads (the NFC reader antenna is placed in the pads and the PCB is in the AED)

Detect the presence of the AED (AED ID)
The mannequin will detect the presence and ID of AED when pads will be placed correctly on the mannequin.

Assessment of correct pad placement
The mannequin will detect the correct placement of the pads by the use of the NFC tag under the skin of the mannequin and NFC reader integrated into the pad

The system can also work with the reverse position of the components. However, due to the disadvantages for the pairing the tag with the AED when pads are replaced only this concept was selected.

List of components:

- Little Anne AED:
a. QCPR PCB with BLE module and battery
b. NFC tag

- AED:
c. AED2 PCB with BLE module, battery
d. NFC reader
e. NFC antenna integrated with pads

- Mobile device, e.g. tablet (QCPR Classroom app)

NFC tag

AED pad

NFC antenna

AED2 PCB

NFC reader

AED

Little Anne AED
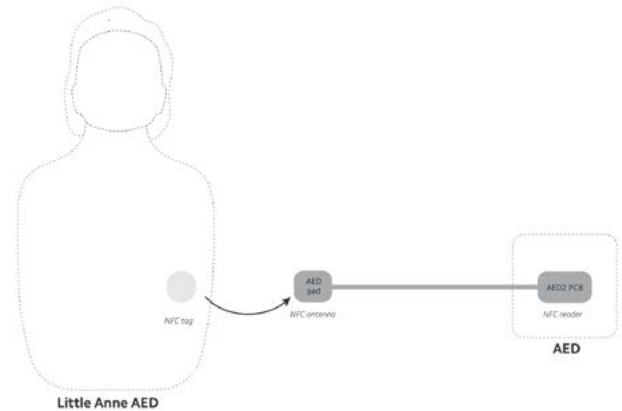
The first use (e.g. guided by the instructor or exploration)

course timeline

0. BEFORE THE COURSE
1. ONLY CPR (no AED)
2. AED IS BROUGHT TO THE STATION (AED is near the mannequin)
3. AED IS UNPACKED (AED is near the mannequin)
4. AED IS TURNED ON (AED is near the mannequin)
5. PADS ARE PLACED ON THE MANNEQUIN (AED is connected with the mannequin by pads)

DETECT PADS

MANNEQUIN IS PAIRED WITH AED

COLLECT CORRECT CPR DATA

The second use (practice)

course timeline

0. BEFORE THE COURSE
1. ONLY CPR (no AED)
2. AED IS BROUGHT TO THE STATION (AED is near the mannequin)
3. AED IS UNPACKED (AED is near the mannequin)
4. AED IS TURNED ON (AED is near the mannequin)
5. PADS ARE PLACED ON THE MANNEQUIN (AED is connected with the mannequin by pads)

MANNEQUIN IS PAIRED WITH AED

DETECT PADS

COLLECT CORRECT CPR DATA

The concept requires the first use with the selected devices to pair them. When AED pads are attached, reader under the skin recognise the NFC tag and pair devices together. However, the recognition takes place late in the scenario. The first results don't integrate the CPR performance before the pads are attached. With the second use devises are already paired and the data can be combined to calculate the correct CPR performance. Nevertheless, the system has one requirement, which is to use the same device with the same mannequin. If devices are changed, it should be communicated with the system (reset the pairs), and participants will receive only partial feedback.

QAED Trainer

The concept of an generic AED trainer was created integrates the research findings and personal approach towards design and aesthetics. QAED stands for the Quality Automated External Defibrillator, which indicates the connection with the QCPR family of products from Laerdal. The final design of QAED Trainer includes the design of the training unit and electrodes.

Dimenssions

The size of the device was an important aspect of the design. The training unit has to be big enough to be similar to AED so participants will have a similar experience, but also small to support storage and transportation. The final dimensions were defined based on the comparison of AED Trainer 3 and generic AED trainers. It resulted in a size which oscillated around the mean value of this comparison and was empirically tested positively.
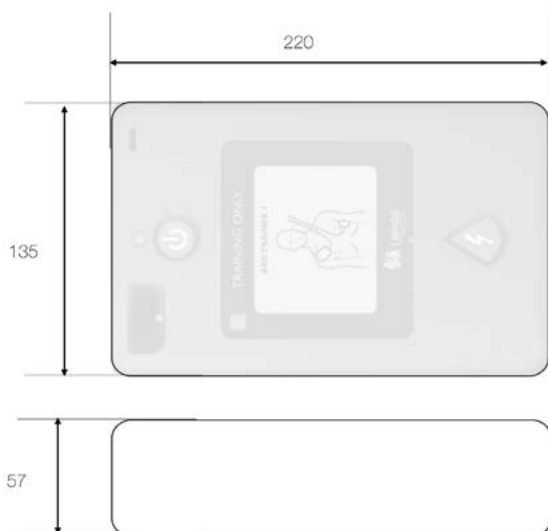
AED Trainer 3 by Laerdal

QAED Trainer

electrodes connector

electrodes

speaker

display
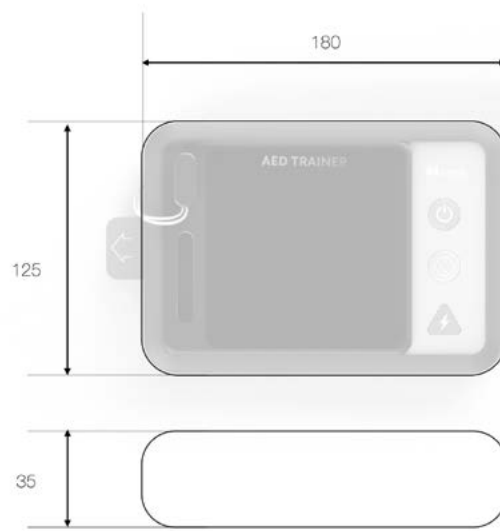
AED buttons and it is arrangement

On the top of the device, three main buttons are located: power on/off, paediatric mode and shock button. It provides conditions for basic practice (automated and semi-automated AED) but also more advanced practice (AED use for children). They are group together and arranged in the order of use. It is complied with the analyse of the AED devices and AED training devices. Also, this research was used to define the shape and colour of buttons and suggestions for the icons to represent the function.

Display

The display is located on the top of the device to present the visual information which will support understanding of the voice prompts in the loud environment. This method was chosen as it allows to display multiple communicates without increasing the size of the device compared to the static illustrations. Also, they are provided one at a time, which makes it easier to read, and this method is already used in newer AED devices and provides valid training experience. Besides, the use of display enables to change, and updates communicate according to the countries where it is used and changes in the first aid guidelines without the need to change the physical device.

battery

battery status indicator

charging port

Charging and battery status

The device is designed to use a designated rechargeable battery. It can be charged by a USB-C, which is a new standard port. This solution removes the need to carry multiple disposable batteries which is inconvenient for instructors. Although the initial cost is higher, rechargeable batteries have a much lower total cost of ownership and environmental impact. When the battery reaches the maximum number of charging cycles, Laerdal should provide the possibility to replace it.

The indication of the battery status provides instructors with estimated information how long the device can be operated and if there is a need to charge it. That knowledge is comforting for instructors as they can be confident that the device will not run out of power unexpectedly in the middle of the training. It is placed on the side, so when multiple devices are stuck on another, their status can be chacked easily.

Electrodes storage

Electrodes are stored on the bottom of the device. Although it decreases the size of the unit, it provides a more compact solution. The electrodes are protected, and the cable is rolled up and coved what can increase their lifespan. The orange sticker with an arrow indicates the location of electrodes and how to access threm.

main body

silicone case

Silicone case

QAED TRainer consists of the main body where are all components, and the interaction takes place and a silicone cover. It protects the device in a dynamic environment of the AED training, where devices are being dropped often. Silicone cases are successfully used in many electronic devices to amortise falls and prevent scratches. The main aim of this component is to decrease the lifespan of the device. However, it also provides the possibility to personalise the device with the colour of the case.

Fabric pouch

Aside from the silicone case, a textile pouch is needed to store and transport the device. It also needs to protect the screen of the device. A rough suggestion was made how it can look like although the design of it should be further explored. The necessary elements are the handle and the easy access to the right side of the device when they are stuck on another. It will give the possibility to check the battery status and charge it without taking each device from the case.

QAED Clasroom app

To support the use of QAED Trainer, the instructor's app was designed. It is used to control the devices (remote control) but also to show and evaluate students performance.

Colour scale

During a training the performance scale has two levels. Green for correct and yellow for a mistake which needs to be adressed.

The scele proposed to show the results of the performnace after the training was increased to the three levels. The red colour was added for the situation when shock will not be deliverd what is the main objective of a training. It is the most crucial mistake which has to be alwyas adresed.

CPR icons

For the CPR perfromance, the Laerdal's icons from QCPR Classroom app were used. The user group is already familiar with them and they should be consised through all Leardal's products.

AED training icons

A new set of icons was created to show the participants performance for the AED use. Three most important skills were chosen to be addressed: delivering a shock, pad placement and delays in CPR. Aside from the colour scale of correct and incorrect performance, they try to covey the information about the reason for the mistake. It could be used to provide constructive feedback on how to improve performance.

Performance scale during a practice

Performance scale after a practice

Laerdal's CPR icons

Compression depth   Ventilation   Compression rate

Concept of AED icons

Deliver shock   Pads placement   Delays in CPR

Selection of the type of training and the difficulty level of it.
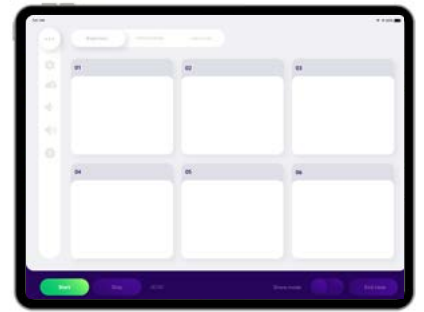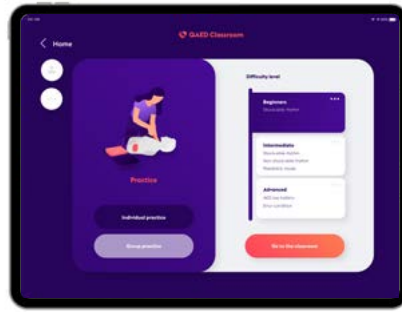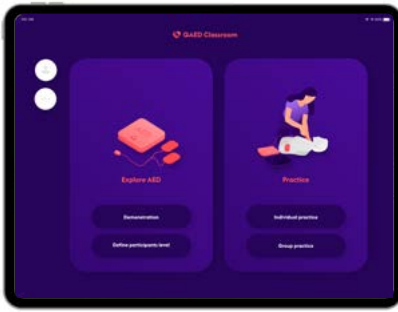
Evaluation of participants performance during the practice
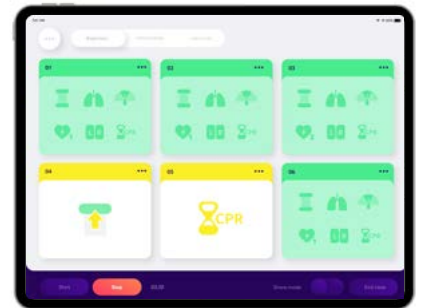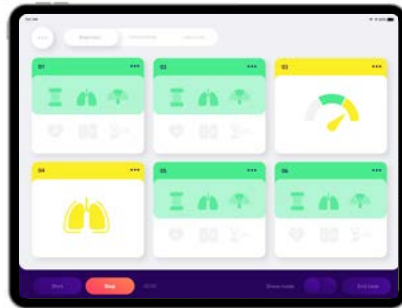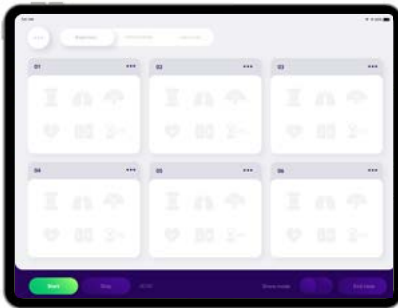
Evaluation of participants performance after the practice

Examples of the interface with the bigger number of groups.
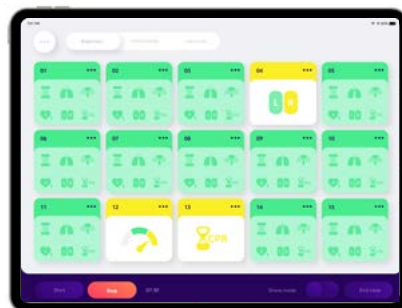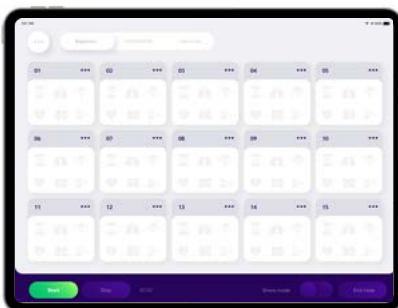
Sharing feedback with participants

A proposal for the feedback which can be shared with participants on a TV or projector after the practice was designed. It is an additional interface to the QAED Classroom app. It is optional to share this information with the class on a and instructor should have the final decision. Depending on the class level and dynamics, it can have positive or negative results.

During practice, there is no content on the TV/projector not to distract the participants. When the exercise is finished, each group receive information if their performance was effective or not. Also, there is more detailed information for CPR and AED provided by an icon and text description. The icons are equal with the one used for the instructor. However, the scale of the final performance has only two levels (correct, incorrect). The main objective of the feedback was not to discourage the participants while informing them what they can improve. The dark colour was used for the background to distinguish between instructor mode and share mode easily but also to improve the visibility of the information on project/TV with a more significant contrast.

Version 1

Version 2

A QAED Trainer shows the number of the group after the practice to read the correct feedback
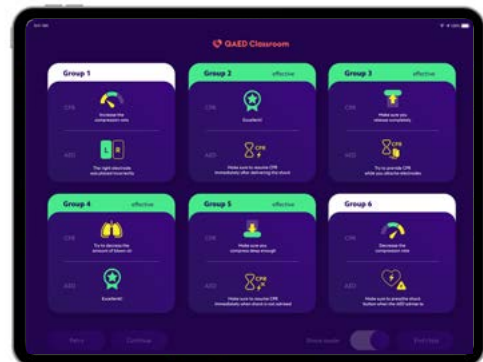
Final version
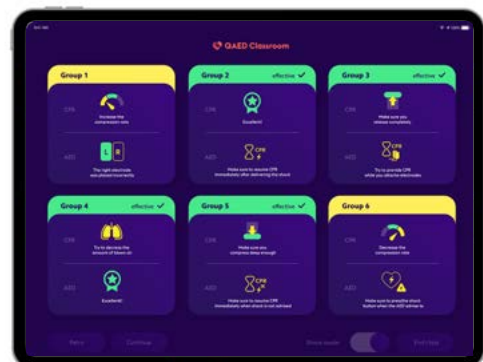
Evaluation of the concept with instructors

In order to understand if the concept could work in the context of AED training and how it could be improved, it was evaluated with both instructors and potential participants of the AED course. Two separates test were done for two users groups to evaluate the AED design, interface of instructors' app and interface for participants. The test provided insights into the recommendations for the further development of the concept.

Method:

The design of the AED training device and interface of the app were tested with three instructors from St John Ambulance. Semi-structured interviews have been conducted through Skype call. In the interviews, the researcher showed the presentation with training AED visuals and interface to the instructors and asked qualitative and quantitive questions. The number of the subject was too small to draw the conclusion based on the quantitative measurements. However, the purpose of those questions was to gather insights from explanations of the choices about the possible improvements. The qualitative questions were about the subjectively perceived ergonomic and hedonic qualities of the design. The questionnaire was created based on the simplified AttrakDiff scales created by Hassenzahl, Burmester, & Koller (n.d.)

Results / QAED training unit:

The interviewed instructors reacted very positively to the AED training unit. They were very enthusiastic about the concept and expressed the willingness to use the QAED training device at their course. Also, all instructors agreed that there is a future potential for that concept. The main advantages were simplicity, small size, rechargeable battery and battery status.

QAED trainer appearance was described as representative for the generic training devices. One instructor brought a concern about the colours which are less bright than AED devices. Nevertheless, based on the market research, the colour selection is aline with the greyscale colour palette used for the generic devices.

When asked about the familiarity of the training unit appearance to the AED used in an emergency, two instructors evaluated the appearance as highly familiar. One instructor disagreed with that statement by giving the low score. The reasons were the more simple and compact appearance compared to the AEDs. However, those differences were described as advantages for the training purpose. Also, the instructor said that participants will still understand the similarity between those two types of devices.

Regarding the interface of the unit, instructors were asked about the design of the buttons. The arrangement of the buttons on the device was assessed as correct and representative for the AED devices. The functions of the power and shock buttons were easily recognised due to the shape, colour and icons. However, the child icon, which represents the paediatric mode, was unclear to the instructors and should be improved. It was suggested that also the contrast on that button was low and made it more challenging to read the icon.

In addition, subjects were asked about the use of display on the device to show visual cues which will support the voice prompts. It was evaluated as a positive feature. All instructors stated that it would help to understand the voice prompts in the loud environment of the training. Also, it was pointed out that it is a similar solution to the one used in live models.

As a next feature, the instructors were asked about the pads, and the place was they are stored in the device. Overall, the feature of recognising the correct and incorrect position of pads was evaluated as positive and beneficial for training. Nevertheless, some concerns were rise about the price of the pads and if maintained, will add more work to instructors. The position of the pads on the bottom of the unit was evaluated as nice and compact. It was also mentioned that it could facilitate the safety of the pads and cable. No disadvantages were recognised. However, instructors said that the interaction with the physical device is needed to evaluate it thoroughly. Also, the

topic of the pre-connected pads was raised. The discussion gave insights about having them connected and not, but no conclusion can be in favour of any solution. This activity is usually not part of the training, and it is mentioned only during the presentation or demonstration. One instructor raised some concerns about the safety of exposed cable when it is pre-connected.

Then the group of qualitative questions was asked about the ergonomic and hedonic qualities was asked. QAED trainer appearance was evaluated as in between traditional and innovative, and it was assessed as an advantage. The appearance represents AED so it can be used at every course, but it looks refreshed and is adjusted for training. Overall QAED trainer appearance was evaluated as professional, and all instructors said the QAED trainer appears as a high-quality device. It was described as neat, compact and robust thanks to the additional case. Moreover, instructors described QAED trainer as attractive for the AED training device.

Evaluated button   Improved button

Conclusion:

- Overall, the design of the QAED training device was assessed positively and according to the instructors has a potential for further development.
- The main improvement which has to be done based on the test is the icon and the contrast on the paediatric button
- Further tests with a physical device are needed to evaluate the usability and the experience of the concept.

Results / QAED Classroom app:

Overall, the instructors appreciated the information and the visuals of the interface. Firstly, they agreed that the chosen three qualities of the AED training are the most important to asses from their perspective. Regardless of the design, the proposed icons for the QAED performance qualities were described as coherent with the one used currently for the QCPR. In general, they were evaluated positively, and no recommendations were given for the improvement of their appearance. Also, one of the instructors stated that icons are the most efficient communication tool during the training for live feedback. The instructor expressed concerns that adding the text with the description or feedback suggestions would take instructors' attention form the students. Also, she said that one information at a time was easy and fast to read.

The second important issue was the colour scale of icons for the live feedback and the final score. For the live feedback, all instructors agreed that 2 level scale with green and yellow suites best the training scenario. It was assessed as simple and effective for having an overview of the class performance. For the final score, instructors were divided about the need of the 3 level scale (green, yellow, red). The first instruct said that QCPR Instructor app has 3 level scale so it should have been the same to maintain the consistency. The second instructor stated that performance should be evaluated only as effective and not effective what would result in a 2 level scale. However, the third

instructor saw a significant advantage of having the strong information that someone did not deliver a shock with the use of third colour. Also, in terms of the final score, instructors gave the positive and negative effects of the use of numbers. However, the conclusion was that the instructor should be trained if and how to use the scores in communication with students

In general, the interface was evaluated as simple and clear. However, one instructor pointed out that he is colour blind, and he struggles with reading between green and yellow icons. Furthermore, the interface was rated as plain, which was interpreted as a positive adjective which expresses a clear and consistent design, and there are no missing elements. Also, instructors assess the interface as a professional. Integration of information about CPR and AED plus the appearance of the icons were the main reasons for the high score in this category. Finally, the interface was rated as attractive. Instructors said that it is clear, consist and nice to look at.

The last topic which was raised was the possibility to share the performance date with students. Instructors stated that sharing data about the class performance with students on the TV/screen should be optional. However, that screen was not evaluated by instructors in details; they all agreed that participants should not see the red colour because it will have a negative effect on their confidence.

Conclusion:

- The proposed appearance of the interface was evaluated positively. It was described as simple, plain, clear, professional and attractive.
- The improvement which has to be done is to adjust icons to the cold blind people by differentiating both the shape and colour
- The colour scale used in QAED Classroom app should have consisted with the one used in other Laerdal apps, so one system should be created.
- The red colour and numbers are not recommended to be used in the interface which is shown to the students
- Further tests with a working prototype are needed to evaluate the usability and the experience of the concept and define the colour scale

Discussion:

There were some aspects during the test that have influenced the outcome of it. Firstly, the test about QAED Trainer was conducted based on the visuals without the possibility to try the physical the device. Some of the respondents commented on the difficulty to answer some questions without having the object. Also, QAED Classroom app was evaluated based on the examples of the interface without the possibility to interact with it.

Evaluated icons
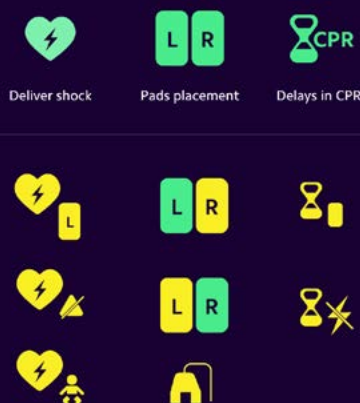
Improved icons
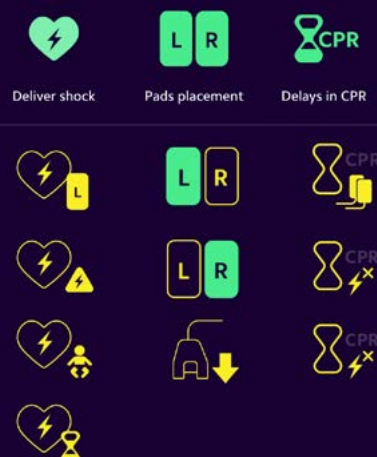
Evaluation of the concept with potential participants

Since the concept of the app provides the possibility to share the course results with participants, it was relevant for the project to evaluate that interface with potential participants of the AED course.

Method:

The online questionnaire was used to test how do the participants experience the use of visual feedback. Firstly, participants received the description of the context and scenario. They were asked to asses their performance and confidence as a Group 2 for two examples of the feedback (effective and noneffective). The second part of the questionnaire was about the subjectively perceived ergonomic and hedonic qualities of the design. It was created based on the simplified version of the AttrakDiff scales created by Hassenzahl, Burmester, & Koller (n.d.)

Results:

In total, 44 responses were collected. Slightly more than half of the participants were males with 60 per cent, and the remaining 40 per cent were females. Most of the subjects were in the age group 20-30 years olf (81 per cent). Also, only 41 per cent of responders stated that they had experience with AED training.

Scenario 1.

Firstly, participants were asked to evaluate their performance and the confidence to provide first aid based on the interface which represented noneffective performance. The majority of participants rated their performance as 3 (43%) what showed that they interpreted it as noneffective but not poor. It indicates that the interface presented the information correctly, and performance was not perceived as extremely negative what could be discouraging. In terms of confidence, it was rated slightly lower than than the performance with the mean value 2.8. However, the most common value was 2 (43 %). It showed the difference between performance results and emotional perception of them. In both questions, there was a small percentage of answers which indicated a positive interpretation of performance. For the first question, it was 7 per cent and for the second one 16 per cent. It can indicate the need for more clear information on negative performance. There is also a possibility that the positive answer about the confidence could be affected by the previous experience with first aid training.

Scenario 2.

Participants were asked the same questions but the in thi scenario their performance was effective. The majority of participants ranked their perfomance as positive with the mean value 5.5. Despite green colour, and written text "effective" and "excelent", 9 per cent of participant described their performance as negative. It showed that the interface could stronger communicate the good performance. The confidence assesment were close to the interpretation of the perfromace with the mean value 5.4. However, almost 16 per cent felt that they are not confident to provide first aid.

simplified AttrakDiff scales

Complicated (1) - Simple (7)	
Confusing (1) - Clear (7)	
Overwhelming (1) - Plain (7)	
Discouraging (1) - Motivating (7)	
Unprofessional (1) - Professional (7)	
Unattractive (1) - Attractive (7)	
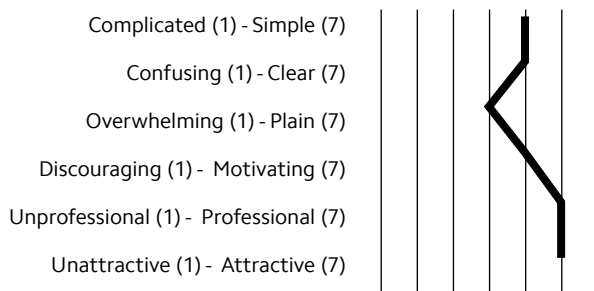
The outcome of the AttrakDiff scales presented a clear outcome. Most of the responses were positive with one neutral. There is a visible decrease in results for perceiving ergonomics and more positive towards hedonic qualities.

Conclusion:

In general, the understanding of the feedback based on the interface was correct. However, there were some cases in which participants rated it opposite to the presented information. The interface should clearly communicate effective and not effective performance which was not fully achieved based on the test. Also, the methods to increase the confidence of the participants with visual elements could be improved as the perception of it is not equal to the perception of the performance. The results of a second part of the test, which was measuring perceived ergonomics and hedonic qualities it could be concluded as positive. However, in the dynamic environment of the training and limited time to see the interface, it should be simpler and more clear. Also, participation in training is an intensive activity, and the presented information should not be overwhelming.

Discussion:

Unfortunately, due to the used method of the online survey, the interface was presented in a small size what could affect the readability and perception of it, and as a result of the evaluation of simplicity, clearance, and being plain. Nonetheless, it is intended to be used on the TV or projector the size will be significantly bigger but also the distance to the screen will increase. Also, the majority of the participants without first aid experience what could affect the understanding of the text and icons. The interface will be implemented in the second half of the AED course so participants will be acquainted with the vocabulary and the qualities which were assessed. Moreover, participants tested the interface individually, and the presence of other students could alter the confidence when the information is presented to the whole classroom. Besides, the instructor can explain the feedback and help to interpret it. Besides, the verbal comments of an instructor like "great job" or "do not worry can" could change the perception of it. Further test with the trained participants, instructor and in the context

QAED Trainer with improvements

Training unit

Based on the instructor's evaluation and company feedback, small changes to the design has been made accordingly to the time. Further improvements are discussed in the next chapter Recommendations for further development.

Additional button was added on the side of the device. It will be used to activate the LED in a battery status indicator but also to turn on the device to access the settings such as language.

The second change which was made was the button for the paediatric mode. The contrast was increased, and the icon was improved. However, further tests are needed it see if it improves the understanding of its function.

NFC tag

The concept of the sticker with the NFC tag was visualised. Two tags are needed to sense the correct position of the electrodes on the mannequin. They are passive, so they do not require any power source and as a result, no maintenance. They can be used only with the QCPR Laerdal's manneqins. The tags should be placed on the bottom of the ribs in the correct pad position. Each tag has an individual number on the top. It is needed to pair the tags with the mannequins in the app.

Pads

The design of the pads was not in the scope of the project. However, to integrate them into the system and communicates with the NFC tags, they need an additional component: the antenna. It is a small flat coil. Visuals present current Laerdal's pads with the additional component, but further exploration is recommended. Also, an additional element of QAED system was needed to store pads in the QAED Trainer body. The simple, flat, plastic part was designed so the pads can be stick to it.

QAED Classroom app with improvements

Colour scale

In order to unify the system in the project, two level scale was suggested for all elements of the feedback. It simplies the evaluation system and there is not difrence in the information shown to the instructor and participants.

Icons

To make the interface more inclusive and improve its readability by the colour blinded people, changes were made in icons. In the previous version, the main characteristic which was used to recognise mistake was a change of colour. In the improved icons, the second characteristic was added, which is a change in shape. When a mistake occurs, the solid icons change into an outline. Nevertheless, this improvement makes icons less coherent with CPR ones.
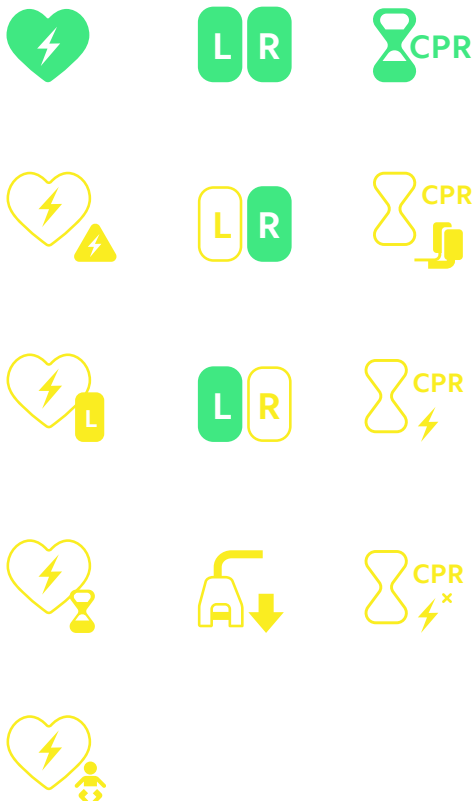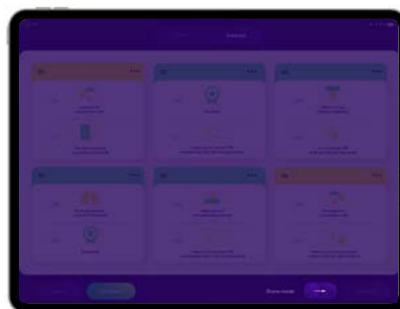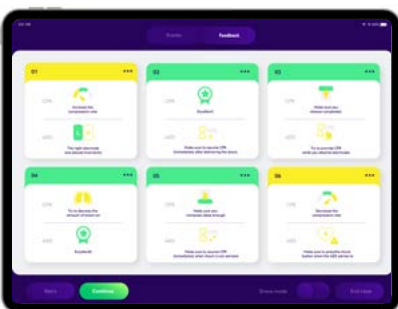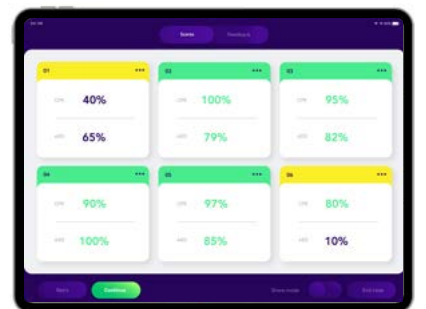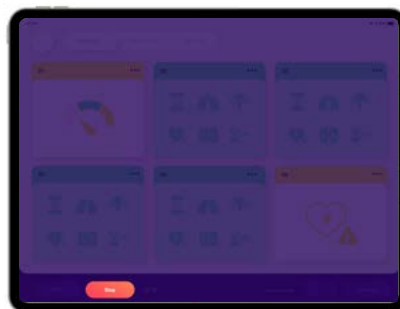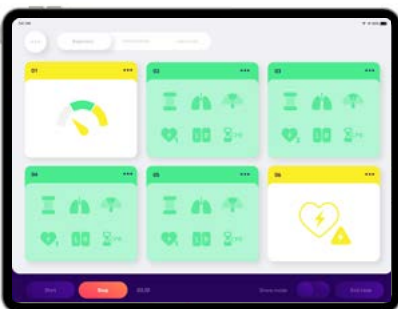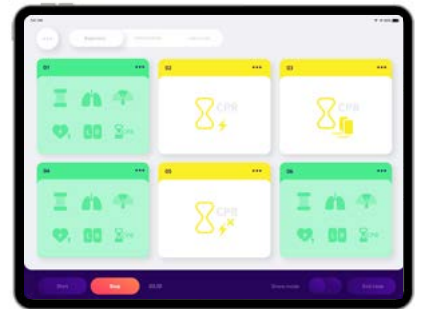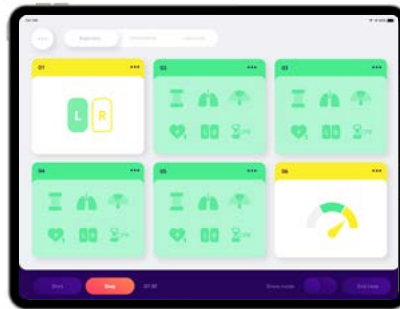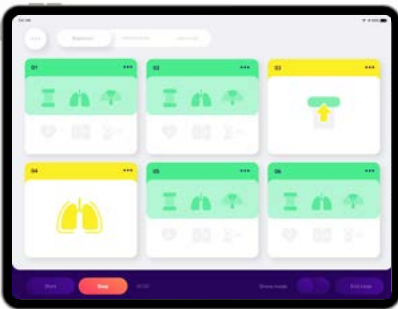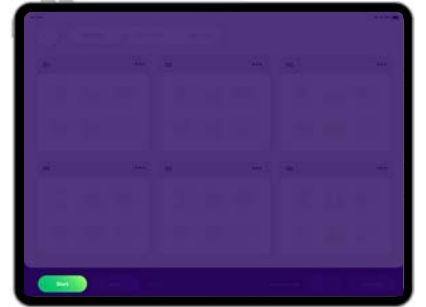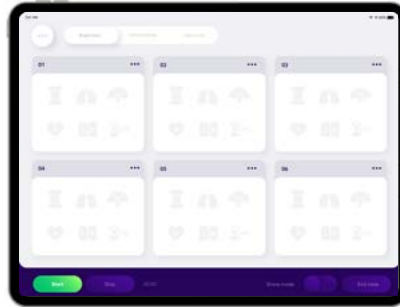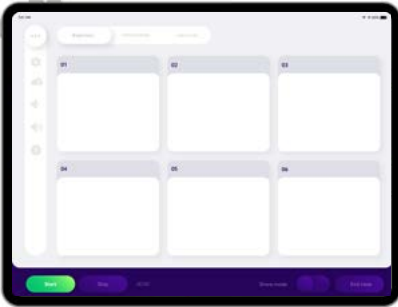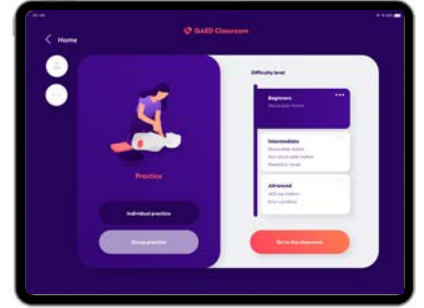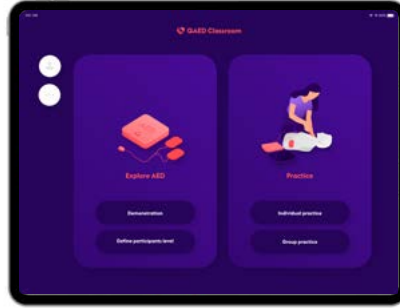
4.4. DISCUSSION

Recommendations for further development

QAED trainer

Dimensions
The AED trainer dimensions should be tested if they provide the experience which does not affect the confidence of using AED in an emergency. They need to trust that they can transfer the skills gained during the training to the real situation. On the other hand, the smaller device will improve storage and transportation. What was mentioned by instructors is the possibility to store 4 AED training devices with 4 CPR mannequins in one pouch so they can be transported together.

Display
Compare the use of the display to the static illustrations to help define the visual ques based on the performance at the course, maintenance and market.

AED display interface
If the decision will be made about the implementation of the display in the training device, the interface has to be designed. Based on it, the type of display should be defined to meet the requirements of visual elements.

Pads placement
Test the accuracy of the NFC sensors and what should be logic of performance evaluation system. Firstly, it should be define if the contact with the sensor should be above certain time. Secondly, if plugging the connector to the AED has to be done before or after attaching the pads and communicated as a mistake.

Design of the pads
The design and the material selection of the pads should be improved based on the user feedback about the maintenance cost and the negative sustainability effect. The modular design will be recommended however it should be investigated how components are divided, for example, if there is an additional connector in the cables or the electrodes also should be modular (sensor and adhesive pad).

Connector
It is recommended to improve the electrodes connector. Firstly, it should be easier to unplug it based on different finger sizes. Secondly, if the situation will

occur that the connector will stay plugged in and put into the fabric pouch, it should create the flat surface and not stay above the body shape. It is crucial when the multiple devices will be put on each other.

Fabric pouch
The concept defines the need for the fabric pouch, although the final design was not made. A few implications for the design were made, such as easy access to the charging port and battery status without taking the device out of the pouch and a handle on the side.

Sustainability
There is a visible change in the legislation of electronic devices and their environmental impact. It should be investigated how does or might it affect AED training devices. Their durability and reparability will have to become to crucial factor during the design process.

AED Guidelines
Try to investigate further the legislation and guidelines towards AED devices, AED training and AED training devices. There is a visible gap which causes a significant diversity of the products and context. With the expected increase of the AED market, those problems could be addressed soon, and Laerdal together with research partners can participate in the process of change.

QAED Classroom app

Data and feedback
The sensitivity of the technology should be compared with the instructor's needs and conditions of the training. There is a significant concern that the app can take away the attention of instructors from the participants performance. Also, it should be defined what is recognised as a delay in delivering a shock and in providing CPR which should be communicated by the system.

Colour scale
One colour scale for feedback through all Laerdal's digital products should be defined to maintain consistency. It will make it more intuitive to the users who are familiar with other apps and limit the time to adapt to the new digital product.

Icons
The designed icons for the AED training are more complex than the one used currently for CPR. It should be tested how detailed information instructors need for AED training and if the icons range can be simplified. Also, the appearance of them should be improved to increase the understanding of presented information.

Multiple screens
Provide the possibility for instructors to share the feedback on TV projector but at the same time be able to maintain instructor interface on the tablet. Instructor expressed the willingness to go to each group and give detailed feedback while others discuss the shared feedback. Besides for that purpose, the layout of individual group performance should be created.

Different devices
Test how the interface which is shown to the participants should change when it is presented on a tablet, TV screen or projector. The contrast and layout can change based on the type of the device. Also, it was mentioned at the interviews that some apps work only on a certain type of the tablet what affected the use of it negatively.

Remote control
Instructors were excited about the possibility to control AED devices which are recognised as a challenge. This concept should be further investigated how it could be combined with the app and at the same time, not limit the access to the information about participants performance.

Sharing feedback with participants
Based on the research, it was defined that it is important to test the feedback with potential participants but also with instructors. They make the final decision if the presented information will be beneficial to the classroom and will not affect their feelings negatively. It could be explored if instructors should have more options about the amount of presented information to avoid the situation when the feedback will not be used.

Participants interface
Based on the questionnaire, it was concluded that the interface could be more clear and less overwhelming. Also, the feedback should be easy to understand by participants so they can interpret it correctly. Although further tests are recommended, some changes can be made based on the evaluation.

Acknowledgments

References

1-on-1 video training, available 24/7. (n.d.). Retrieved from https://www.proaed.co.uk/learn/training-videos

A guide to Automated External Defibrillators (AEDs). (2013). A guide to Automated External Defibrillators (AEDs).

About ILCOR. (n.d.). Retrieved from https://www.ilcor.org/about-ilcor/about-ilcor/

About Us. (n.d.). Retrieved from https://www.heart.org/en/about-us

AED Trainer 2. (n.d.). Retrieved from https://www.laerdal.com/us/products/skills-proficiency/defibrillation-cardiology/aed-trainer-2/

AED Trainer 3. (n.d.). Retrieved from https://www.laerdal.com/us/products/skills-proficiency/defibrillation-cardiology/aed-trainer-3/

AED/CPR/First Aid Certification Training. (n.d.). Retrieved from https://fc-safety.com/product/aed-cpr-first-aid-certification/

Andre, A. (2004). Automated external defibrillator use by untrained bystanders:*1Can the public-use model work? Prehospital Emergency Care, 8(3), 284–291. doi: 10.1016/j.prehos.2004.02.004

Berdowski, J., Berg, R. A., Tijssen, J. G., & Koster, R. W. (2010). Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. Resuscitation, 81(11), 1479–1487. doi: 10.1016/j.resuscitation.2010.08.006

Brooks, B., Chan, S., Lander, P., Adamson, R., Hodgetts, G. A., & Deakin, C. D. (2015). Public knowledge and confidence in the use of public access defibrillation. Heart, 101(12), 967–971. doi: 10.1136/heartjnl-2015-307624

Brukner, P., & Khan, K. (2019). Brukner & Khans Clinical sports medicine. Sydney, NSW: McGraw-Hill Education (Australia).

Brukner, P., & Khan, K. (2019). Brukner & Khans Clinical sports medicine. Sydney, NSW: McGraw-Hill Education (Australia).

Center for Devices and Radiological Health. (n.d.). Automated External Defibrillators (AEDs). Retrieved from https://www.fda.gov/medical-devices/cardiovascular-devices/automated-external-defibrillators-aeds

Cheng, A., Nadkarni, V. M., Mancini, M. B., Hunt, E. A., Sinz, E. H., Merchant, R. M., … Bhanji, F. (2018). Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation, 138(6). doi: 10.1161/cir.0000000000000583

Contact Info: Hong Kong St. John Ambulance. (n.d.). Retrieved from https://www.stjohn.org.hk/en/contact-info

CPR Facts and Stats. (n.d.). Retrieved from https://cpr.heart.org/en/resources/cpr-facts-and-stats

Deakin, C. D., Nolan, J. P., Sunde, K., & Koster, R. W. (2010). European Resuscitation Council Guidelines for Resuscitation 2010 Section 3. Electrical therapies: Automated external defibrillators, defibrillation, cardioversion and pacing. Resuscitation, 81(10), 1293–1304. doi: 10.1016/j.resuscitation.2010.08.008

ERC Guidelines 2015 have arrived, download them now! (n.d.). Retrieved from https://cprguidelines.eu/

Greif, R. (2018). European Resuscitation Council Guidelines for Resuscitation 2015: Section 10. Education and implementation of resuscitation. European Resuscitation Council, 288–301. Retrieved from https://ercguidelines.elsevierresource.com/european-resuscitation-council-guidelines-resuscitation-2015-section-10-education-and-implementation

Hansen, C. M. (2017). Lay Bystanders' Perspectives on What Facilitates Cardiopulmonary Resuscitation and Use of Automated External Defibrillators in Real Cardiac Arrests. Journal of the American Heart Association, 6. Retrieved from https://doi.org/10.1161/JAHA.116.004572

Heart foundation urges crowdfunding to buy 5,000 more defibrillators. (2017, October 7). Dutch News.nl. Retrieved from https://www.dutchnews.nl/news/2019/10/heart-foundation-urges-crowdfunding-to-buy-5000-more-defibrillators/

History of the American Heart Association. (n.d.). Retrieved from https://www.heart.org/en/about-us/history-of-the-american-heart-association

PDF. (2015, May). Geneva.
International first aid and resuscitation guidelines 2016. (2016). International first aid and resuscitation guidelines 2016. Geneva.

Larsen, M. P., Eisenberg, M. S., Cummins, R. O., & Hallstrom, A. P. (1993). Predicting survival from out-of-hospital cardiac arrest: A graphic model. Annals of Emergency Medicine, 22(11), 1652–1658. doi: 10.1016/s0196-0644(05)81302-2

Little Anne QCPR - creating quality lifesavers. (n.d.). Retrieved from https://www.laerdal.com/us/products/simulation-training/resuscitation-training/little-anne-qcpr/

Løfgren, B., & Krarup, N. (2008). AED voice prompts—Significant differences between four commonly used AEDS. Resuscitation, 77. doi: 10.1016/j.resuscitation.2008.03.163

Mancini, M. E., Cazzell, M., Kardong-Edgren, S., & Cason, C. L. (2009). Improving Workplace Safety Training Using a Self-Directed CPR-AED Learning Program. AAOHN Journal, 57(4), 159–167. doi: 10.3928/08910162-20090401-02

Mancini, M. E., Cazzell, M., Kardong-Edgren, S., & Cason, C. L. (2009). Improving Workplace Safety Training Using a Self-Directed CPR-AED Learning Program. AAOHN Journal, 57(4), 159–167. doi: 10.3928/08910162-20090401-02

Markenson, D., & Ferguson, J. D. (2010). Part 17: First Aid: 2010 American Heart Association and American Red Cross Guidelines for First Aid. Circulation , 122. doi: 10.1161/CIRCULATIONAHA.110.971150

Mattei, L. C., Mckay, U., Lepper, M. W., & Soar, J. (2002). Do nurses and physiotherapists require training to use an automated external defibrillator? Resuscitation, 53(3), 277–280. doi: 10.1016/s0300-9572(02)00023-0

Mattei, L. C., Mckay, U., Lepper, M. W., & Soar, J. (2002). Do nurses and physiotherapists require training to use an automated external defibrillator? Resuscitation, 53(3), 277–280. doi: 10.1016/s0300-9572(02)00023-0

Murakami, Y. (2014). Outcomes of Out‐of‐Hospital Cardiac Arrest by Public Location in the Public‐Access Defibrillation Era. Ournal of the American Heart Association, 3. Retrieved from https://doi.org/10.1161/JAHA.113.000533

Newman, M. (2018). Abstract 20370: Baseline Consumer Study of Public Awareness About Sudden Cardiac Arrest. Circulation, 2016(134). Retrieved from https://www.ahajournals.org/doi/10.1161/circ.134.suppl_1.20370

Part 4: The Automated External Defibrillator. (2018). Circulation, 102. Retrieved from https://www.ahajournals.org/doi/10.1161/circ.102.suppl_1.I-60

Perkins, G. D. (2015). European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation, 81–99. Retrieved from https://ercguidelines.elsevierresource.com/european-resuscitation-council-guidelines-resuscitation-2015-section-2-adult-basic-life-support-and/fulltext

Powerheart® G5 AED Training Device User's Guide. (2014). Powerheart® G5 AED Training Device User's Guide.

Shurlock, B. (2007). Pioneers in Cardiology: Frank Pantridge, CBE, MC, MD, FRCP, FACC. Circulation, European Perspectives in Cardiology European Perspectives in Card. Retrieved from http://ahajournals.org/

Taniguchi, T., Omi, W., & Inaba, H. (2008). Attitudes toward automated external defibrillator use in Japan. Resuscitation, 79(2), 288–291. doi: 10.1016/j.resuscitation.2008.05.011

Travers, A. H. (2015). Part 3: Adult Basic Life Support and Automated External Defibrillation. Circulation, 2015(132). Retrieved from https://doi.org/10.1161/CIR.0000000000000272

What is First Aid?: Understand First Aid. (n.d.). Retrieved from https://www.redcross.org/take-a-class/first-aid/performing-first-aid/what-is-first-aid

What We Do - First Aid in the Community & More. (n.d.). Retrieved from https://www.sja.org.uk/what-we-do/

Yeung, J., Okamoto, D., Soar, J., & Perkins, G. D. (2011). AED training and its impact on skill acquisition, retention and performance – A systematic review of alternative training methods. Resuscitation, 82(6), 657–664. doi: 10.1016/j.resuscitation.2011.02.035

Yeung, J., Okamoto, D., Soar, J., & Perkins, G. D. (2011). AED training and its impact on skill acquisition, retention and performance – A systematic review of alternative training methods. Resuscitation, 82(6), 657–664. doi: 10.1016/j.resuscitation.2011.02.035