



QAED

The future of AED training for laypeople.

/ Process report

by Anna Mira Gębala
in collaboration with Laerdal Medical

Master Thesis

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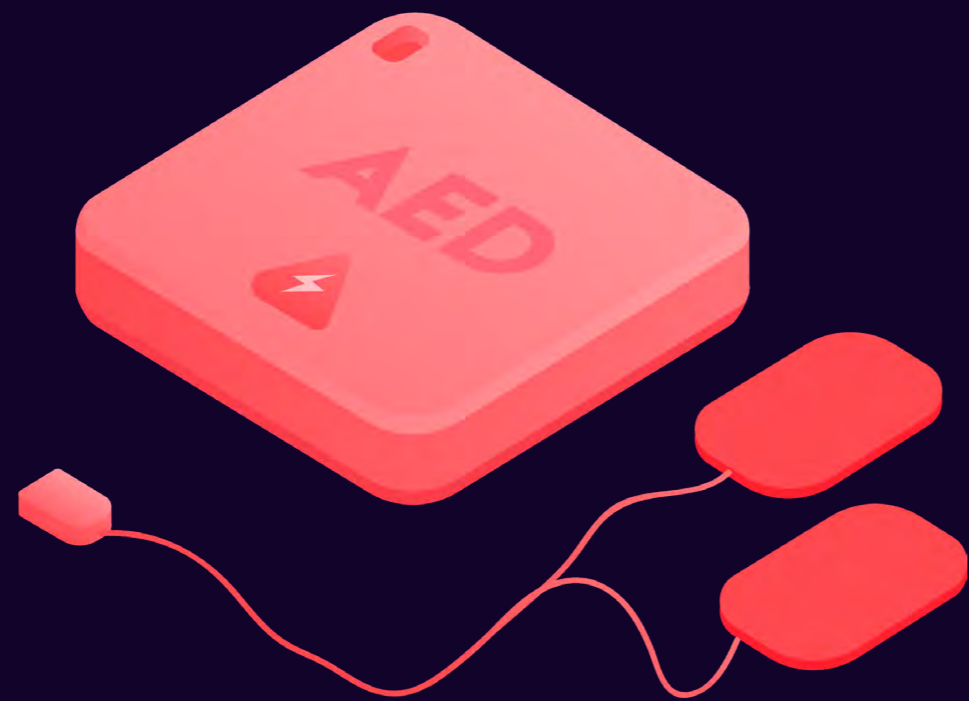
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ANALYSIS



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.

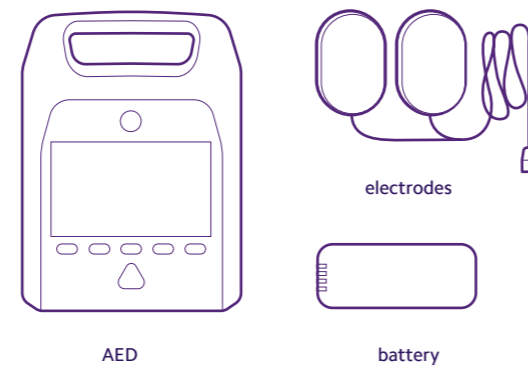
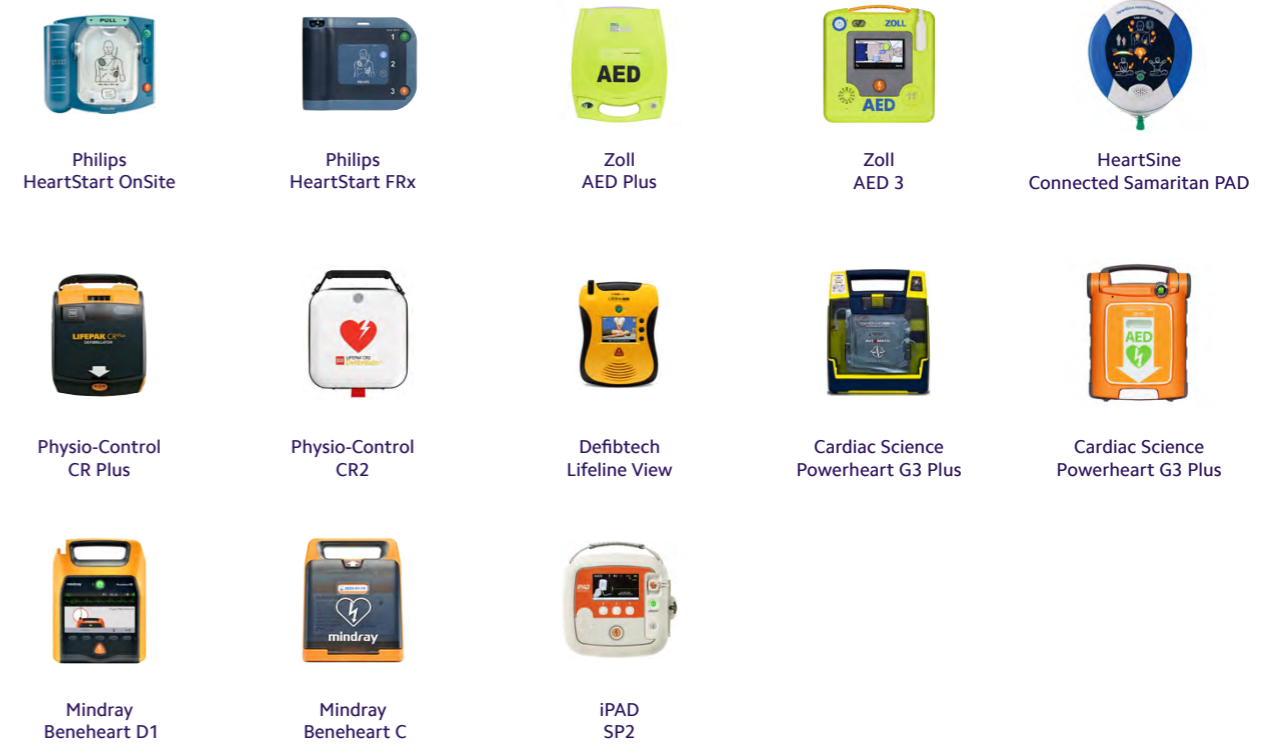


Figure 9: Main components of the AED system

Figure 10: Examples of the most common AED devices on the market



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.

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.

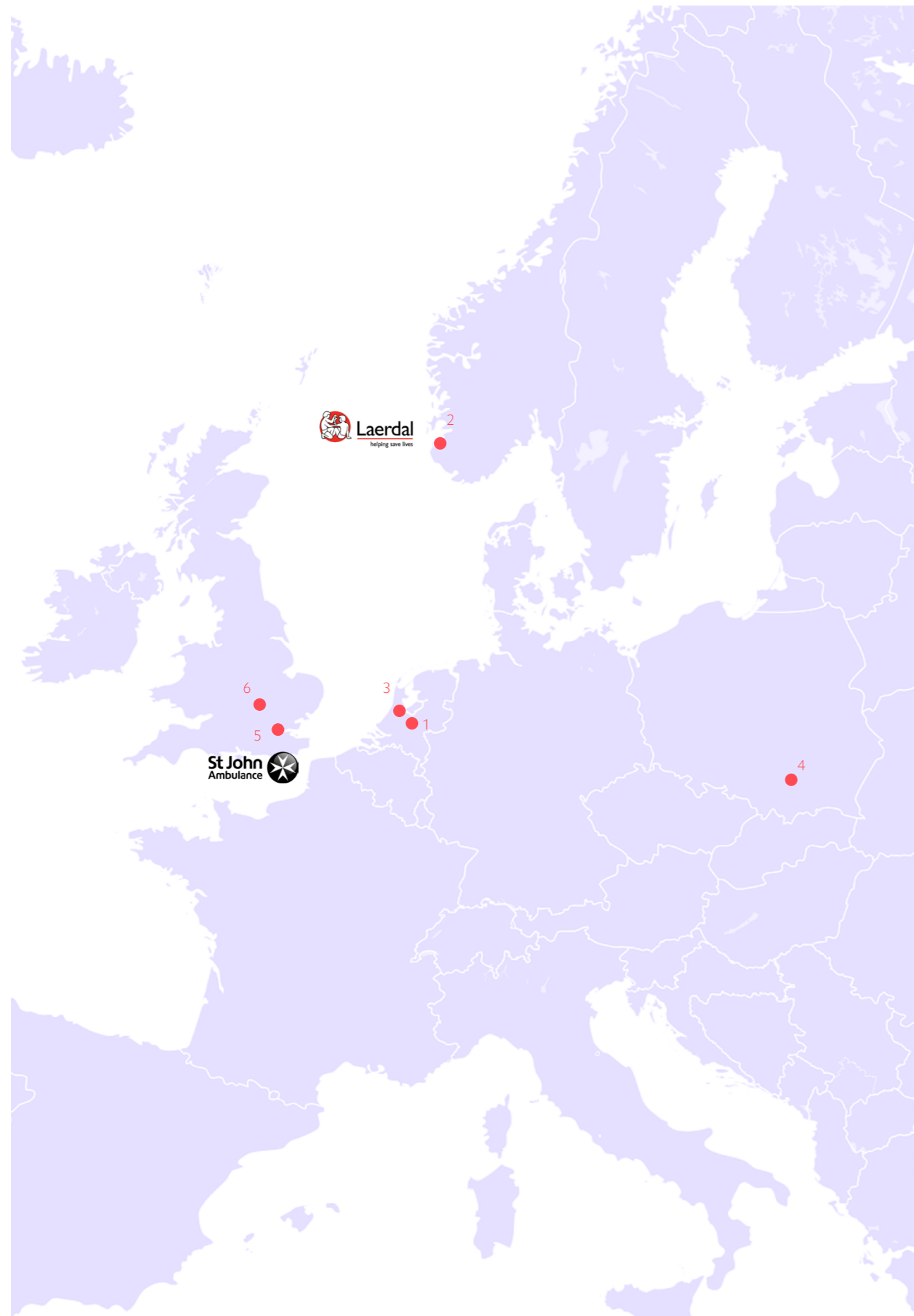


Figure 12: Research locations

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 first 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 Quallsafe instructors, Bradford, the United Kingdom (6)

Quallsafe 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.

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' activities 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 initial skills. Participants in a group of two were asked to perform first aid and use a

mannequin and AED. The instructor could observe and assess 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 were 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.

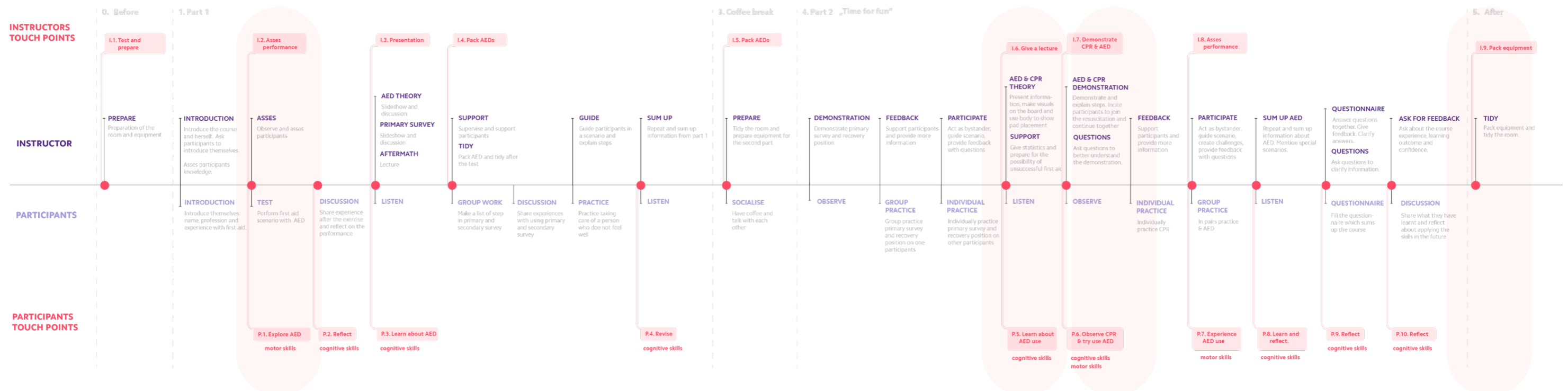


Figure 14: Timeline of the observed AED training at St John Ambulance



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 variety 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. Quallsafe 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 through 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. 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.

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 update 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 Q CPR and group feedback beneficial, and others are worried about the stress, which scores put on the participants, so they do not use it.

As an instructor, their role is teaching, assessing and facilitating. Based on their judgment, 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 for 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 assess 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
- Assess participants performance
- Provide accurate and constructive feedback

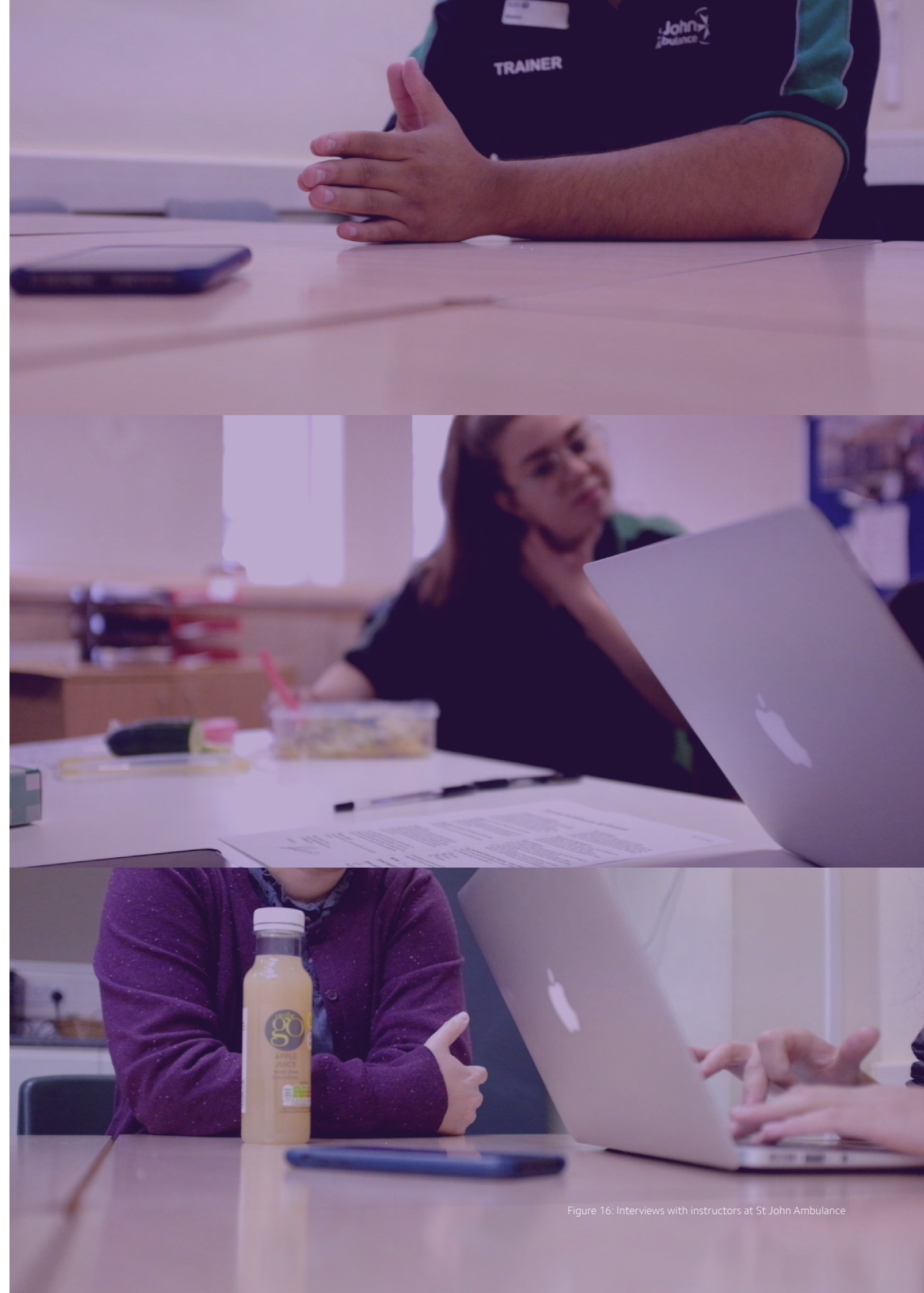
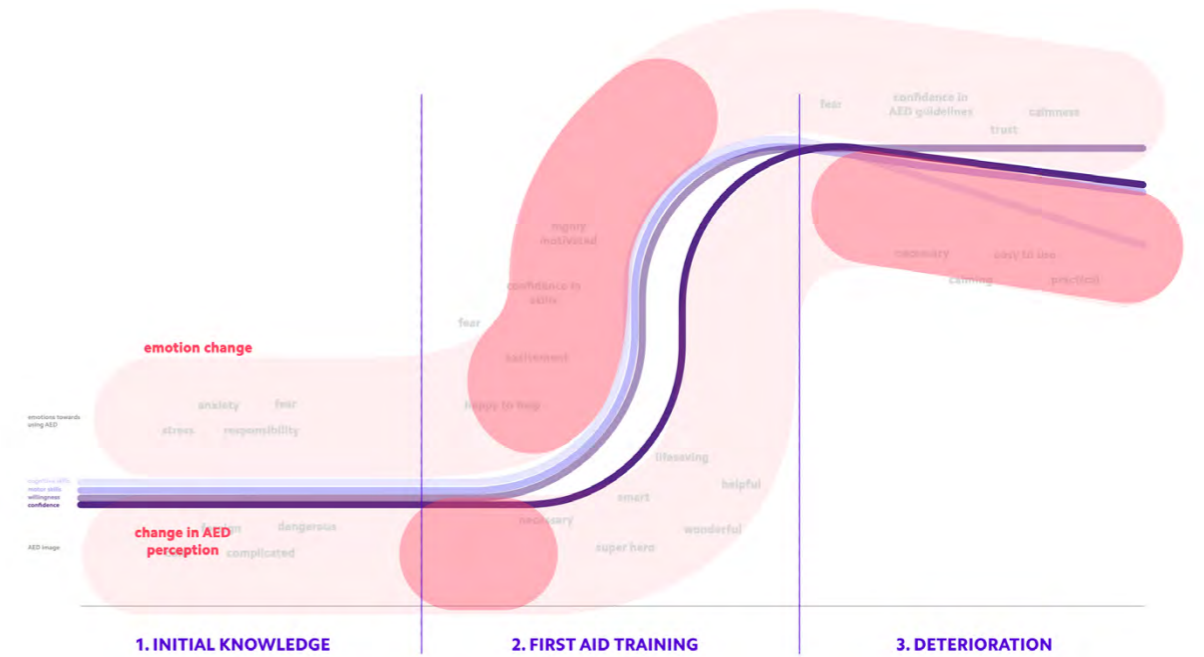


Figure 16: Interviews with instructors at St John Ambulance



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.

There are two significant changes in participants. There is the shift in perception of AED from dangerous demanding device to helpful, super hero. 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

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 improve 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.

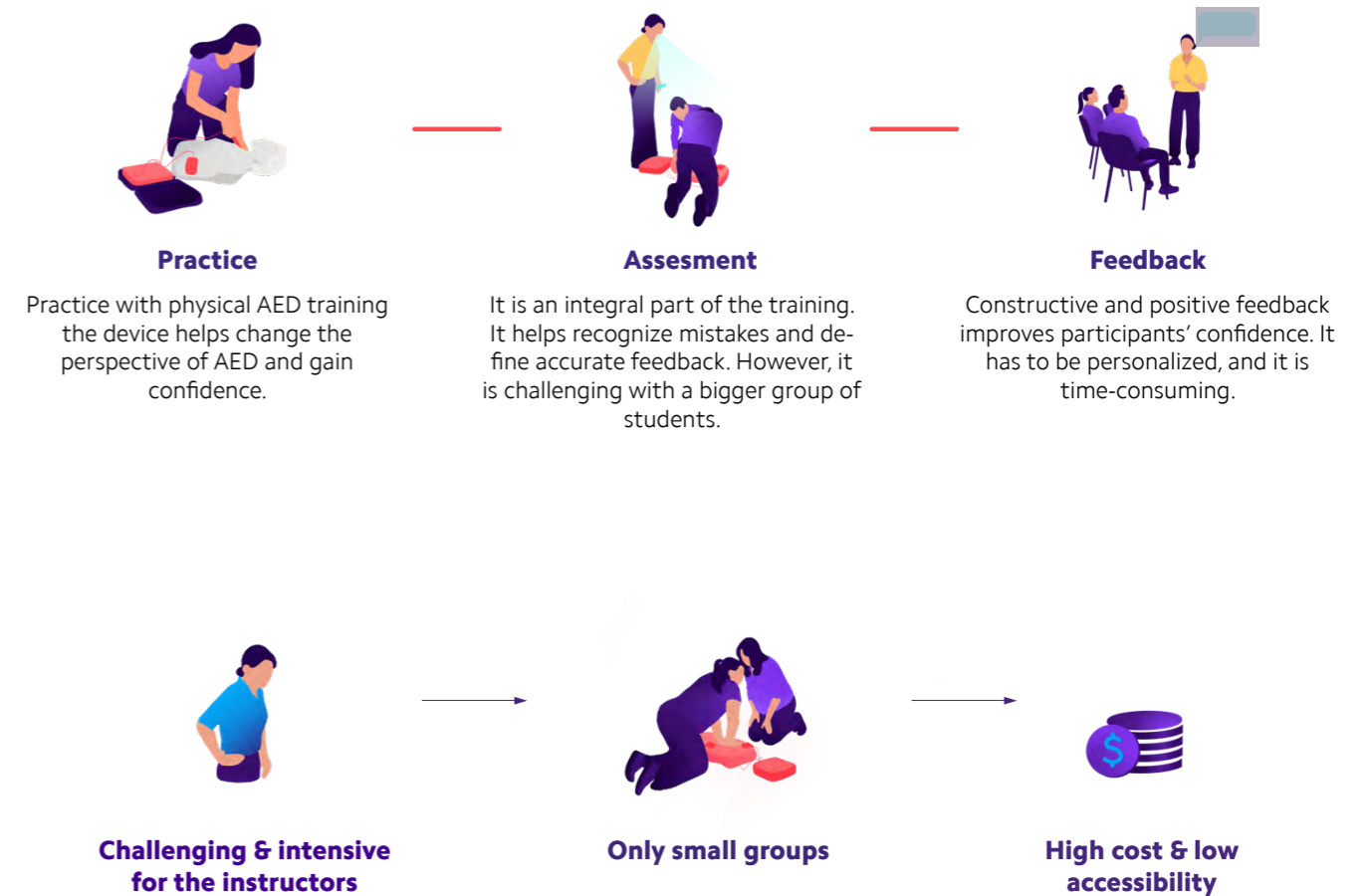
Instructor limitations

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 assess participants if they would practice with AED.

Combine CPR & AED

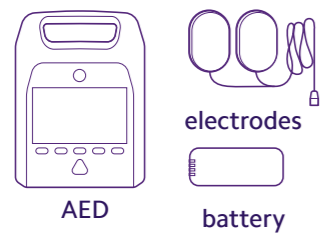
The use of AED is strongly related to the cardiopulmonary resuscitation. CPR has to be provided with AED usage without delays. The assessment has to be done of skills related to both the AED but also to the CPR. As a result, the concept has to provide a solution which can integrate mannequin and AED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



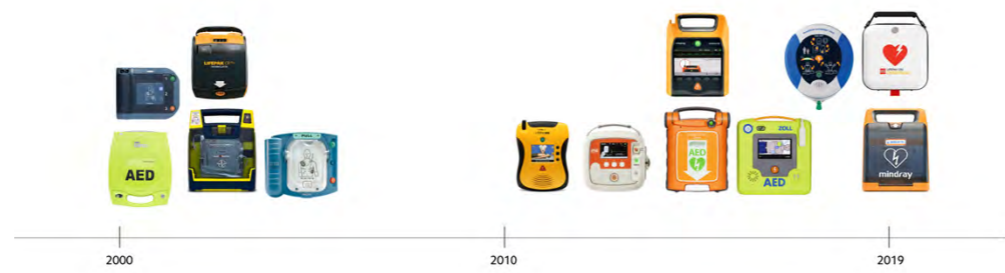
Medical AED appearance

AED devices used in an emergency were analyzed from interaction and aesthetic perspective to design the generic training device.

AED components



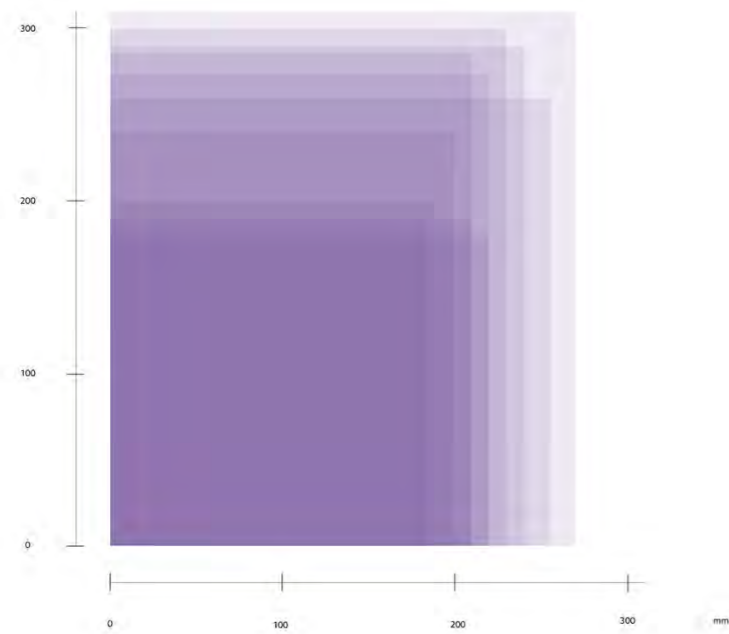
analyzed devices



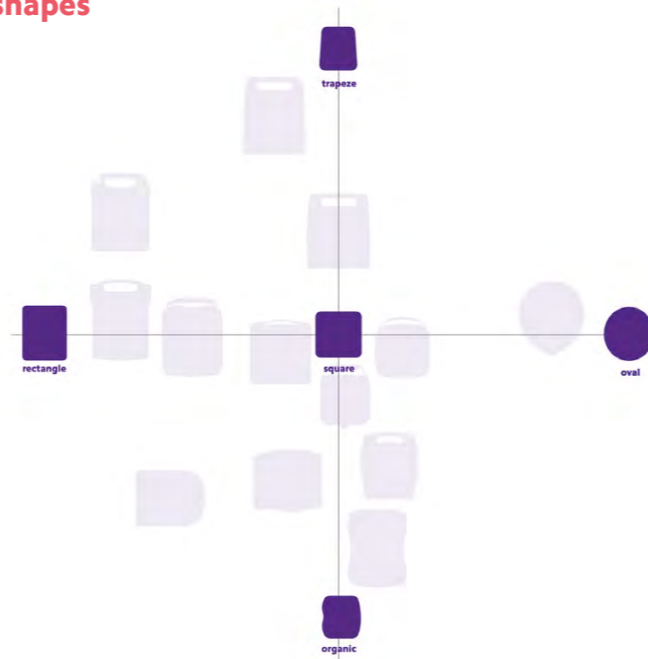
color palette



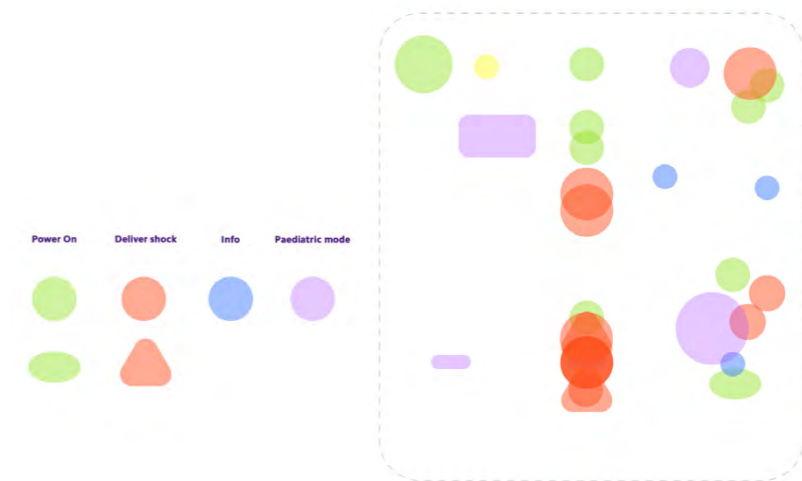
dimensions



shapes



key buttons arrangement

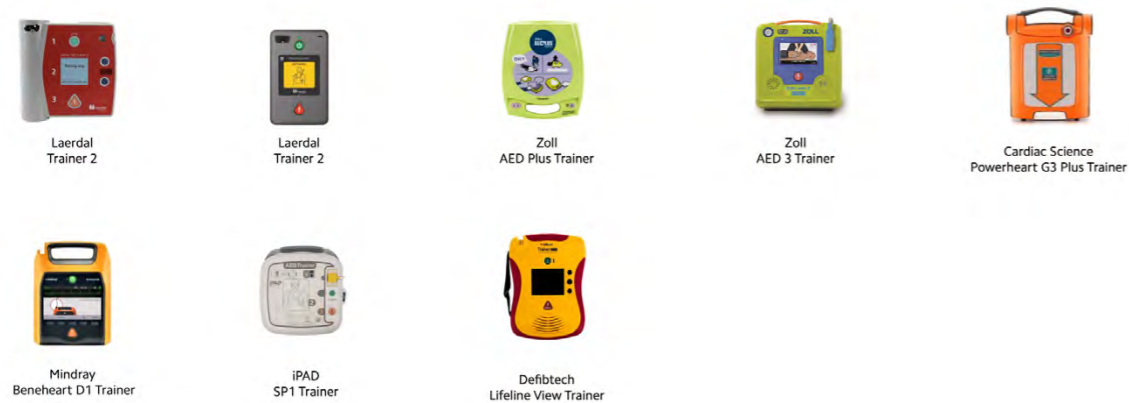




Training AED market analysis

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)

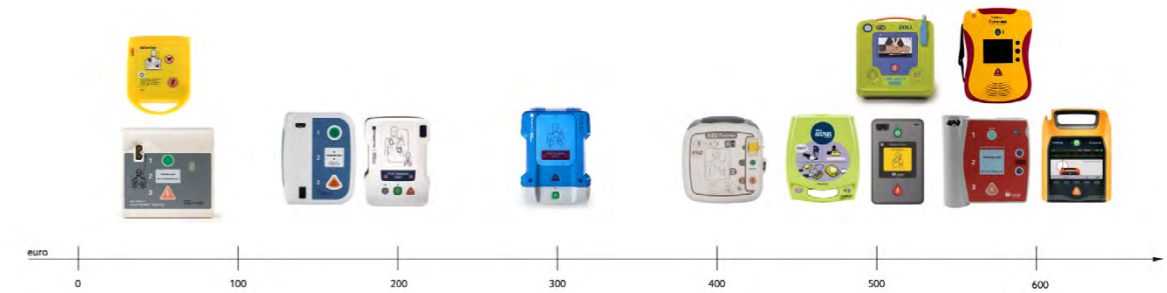


Generic models



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.

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, commands 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.

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 IR 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.

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.

Simplified AED

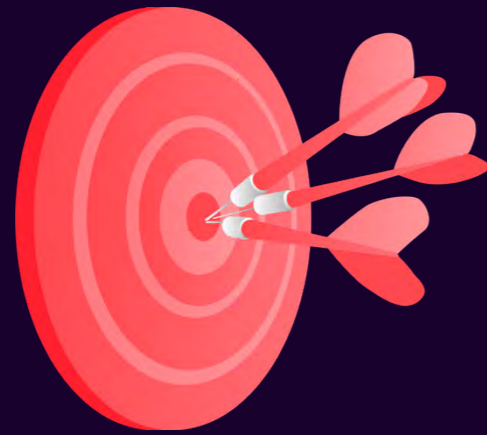
Training devices has strong focus on mimic AED devices. There is no additional education functions and the device is oversimplified (e.g. number of buttons).

Maintenance

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

Paediatric mode

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



Problem definition



**Problem 1
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
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
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

Design directions

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.

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.

DESIGN

Ideation



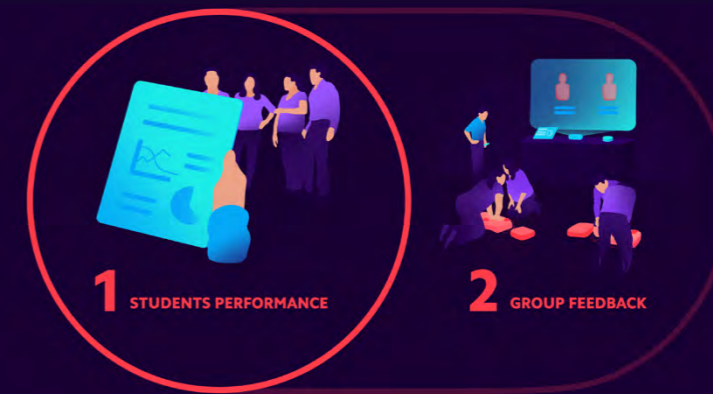
How Might We method was used for the ideation proces. Questions were divided into categories:| change of AED perception, changing feelings toward AED, assessment, feedback, reflection, practice and maintenance. Ideas were drawn on the posits. Further, they were clustered, and most promising ideas were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

Vision



QAED creates a system that seamlessly supports the instructor to provide a high-quality assessment and constructive feedback for participants.

Selected concept



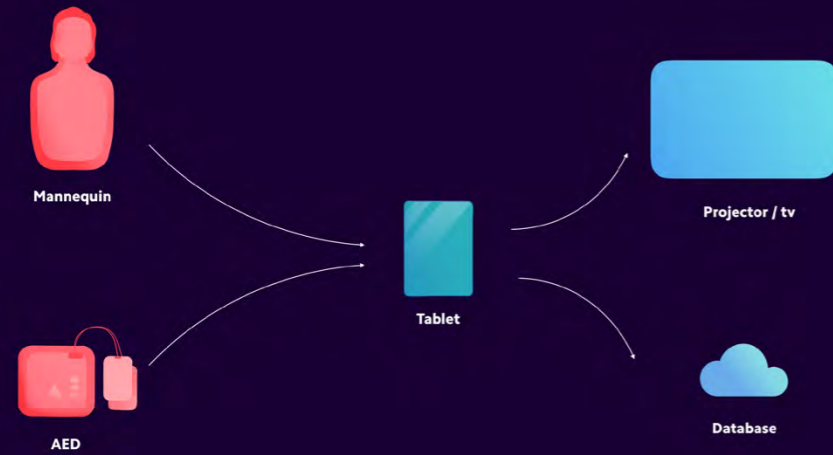
What?

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.



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).

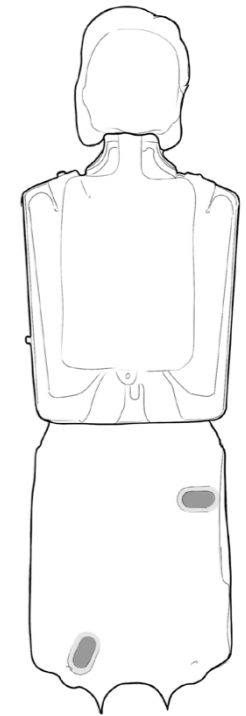
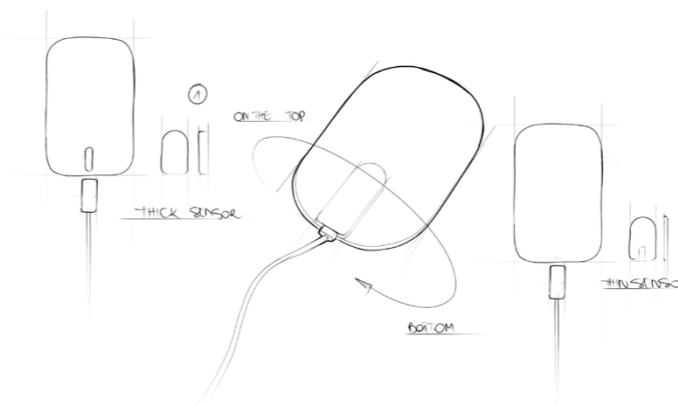
Delays can occur:

- 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)

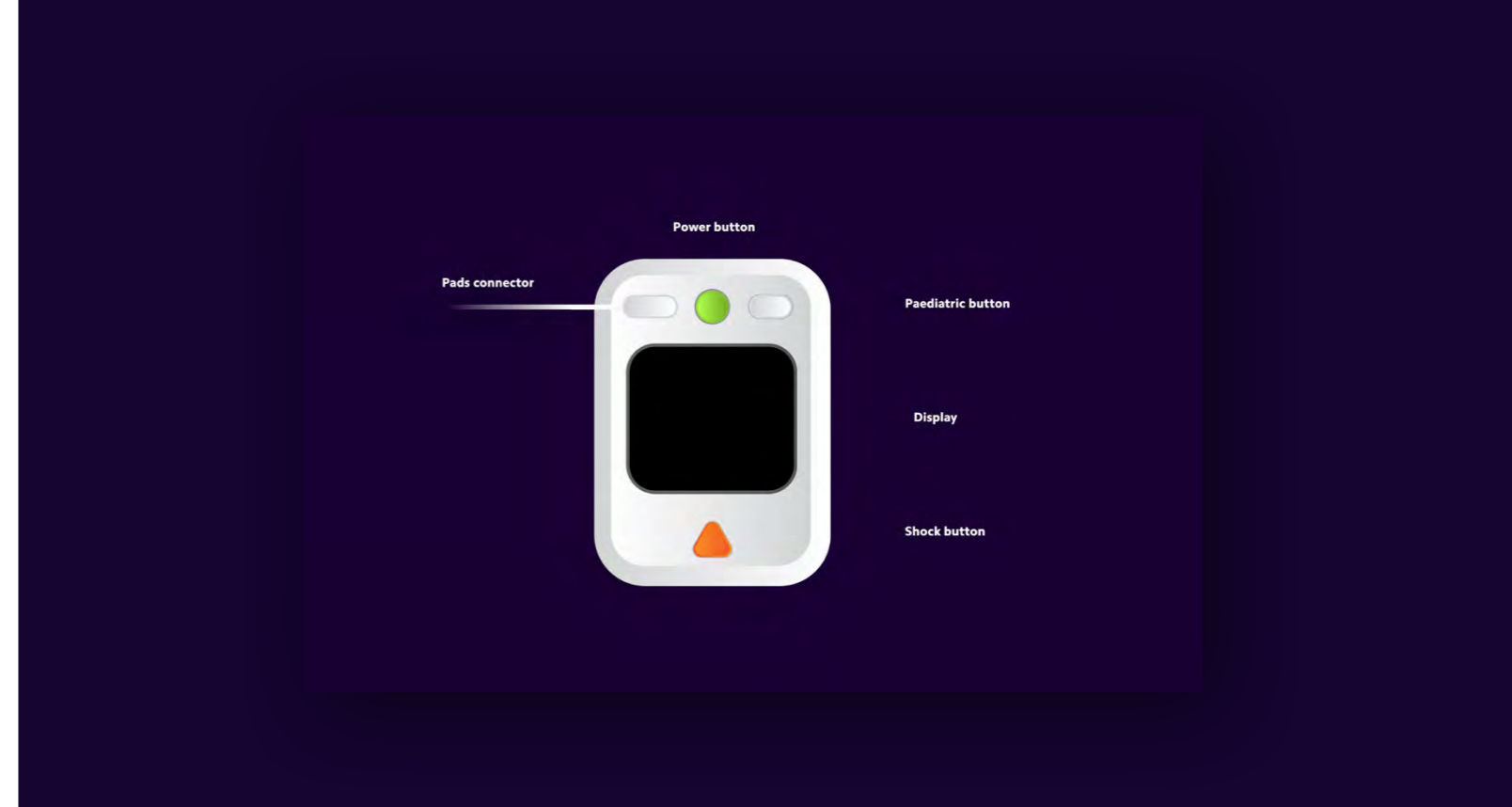
Detect the presence of the AED (AED ID)
The mannequin will detect the presence and ID of AED when pads will be placed correctly on the mannequin. Assessment of correct pad placement
The mannequin will detect the correct placement of the pads by the use of the NFC tag under the skin of the mannequin and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



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 about 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.



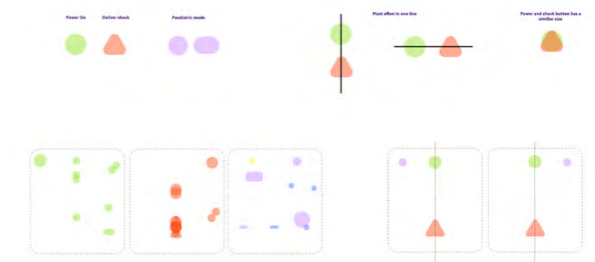
Training device

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.

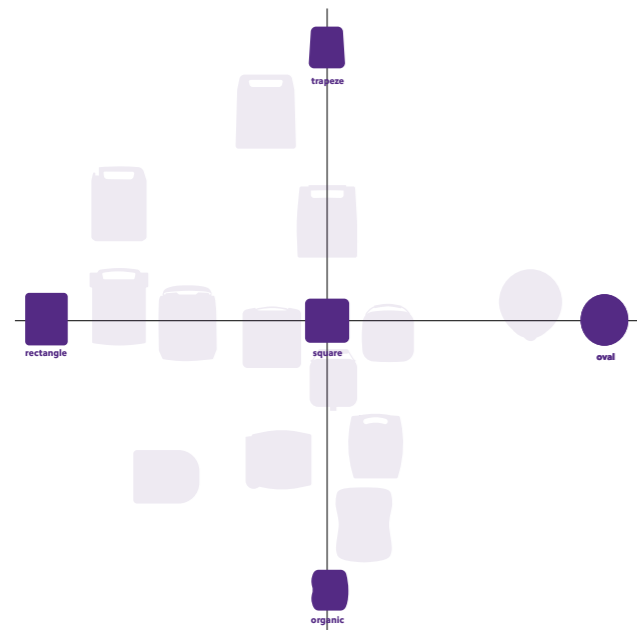


Analysis

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.

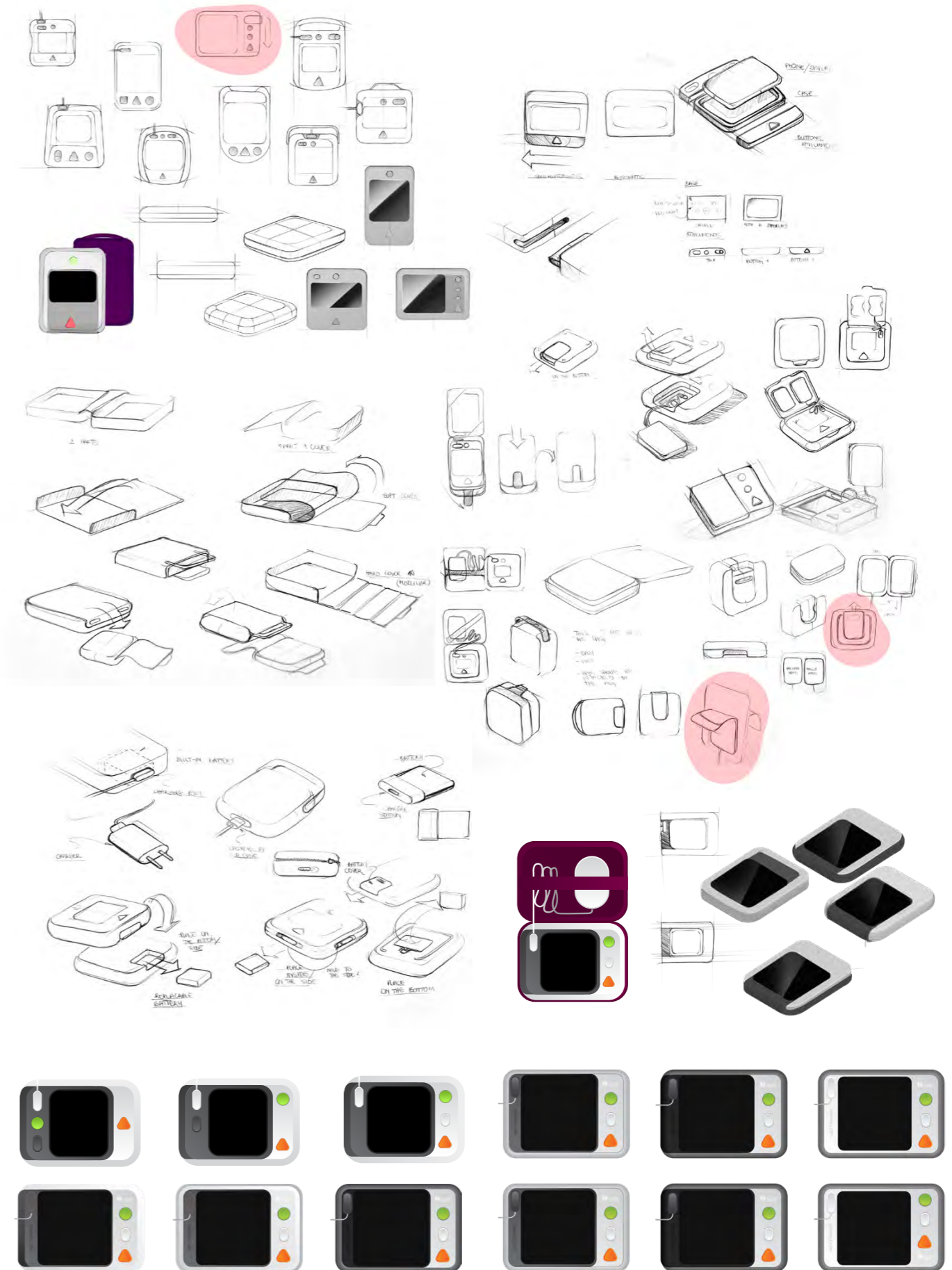
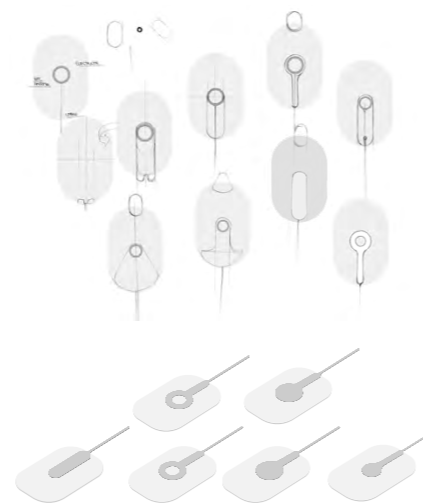
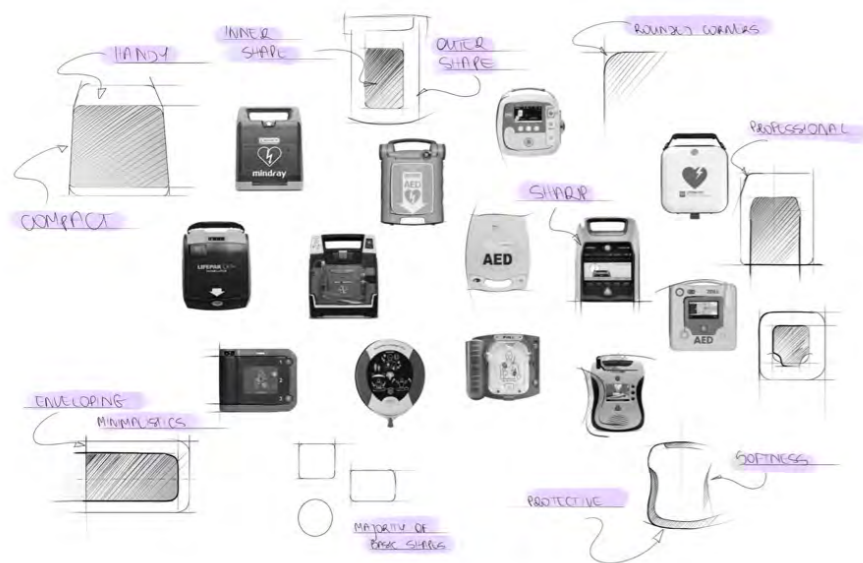


selected buttons



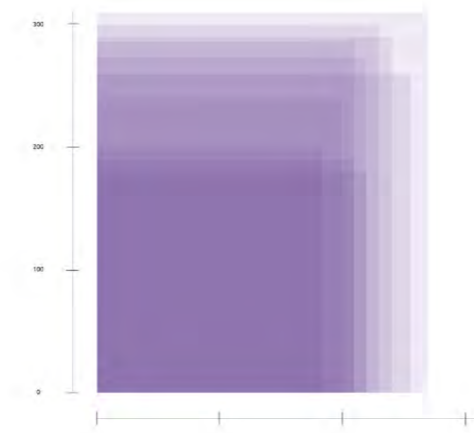
Multiple sketches ideations were done to explore different elements of AED architecture. Multiple options were considered for AED, for example, modular construction, lid on the top or handle on the top of the device. For the final AED rectangular shape was chosen in a horizontal position. The simple 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.

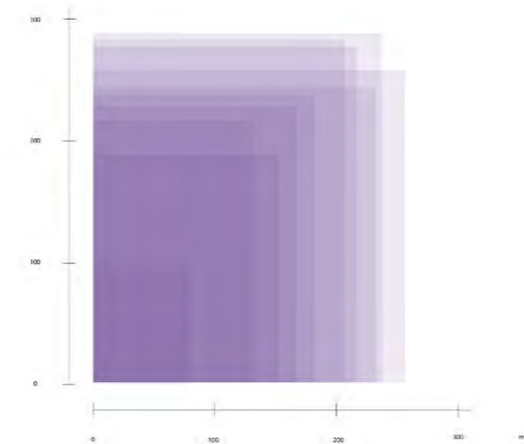


For each sketch, the physical mockup was made. Foam and 3D printing were used to prototype and test ideas about the form. Also, some models were adjusted to fit the phone. It helped to test the presence of the screen on the device but also try different options for the interface.

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



training AED devices



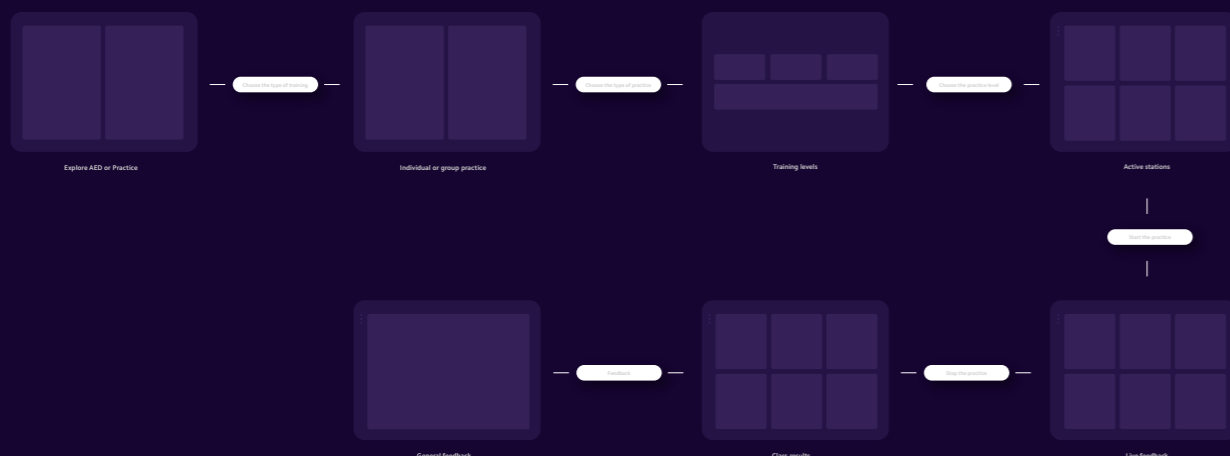
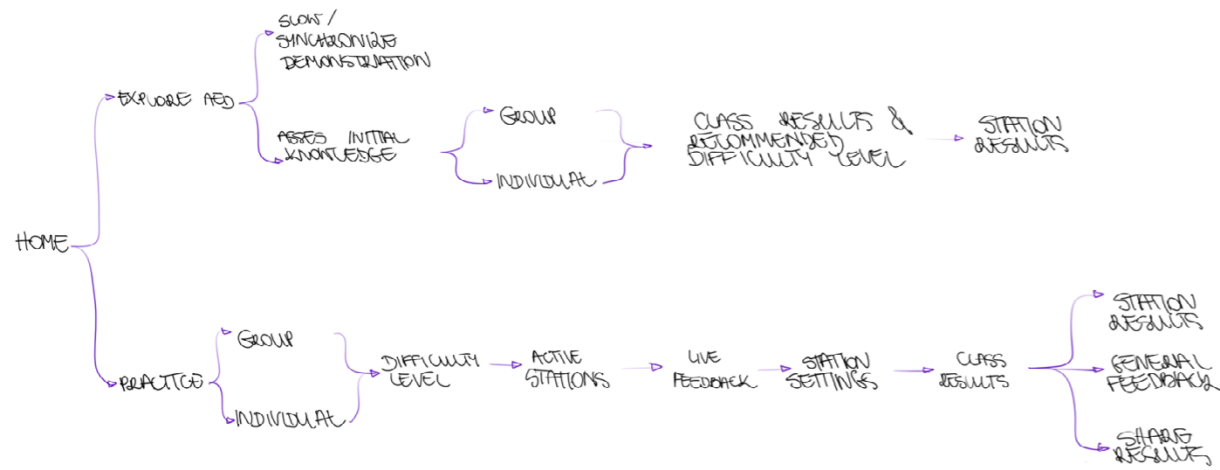
App

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.

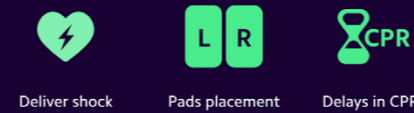
The logic and architectures were inspired by AED training observation and interviews with instructors. Firstly, AED training device is used with different training methods such as demonstration, repeating instructors steps and practice. The app should provide a broad spectrum of tools and let the instructor 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.

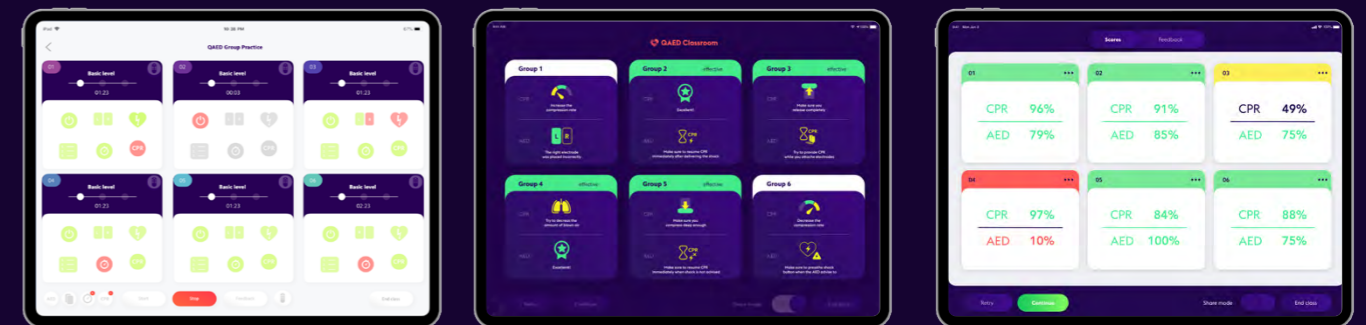
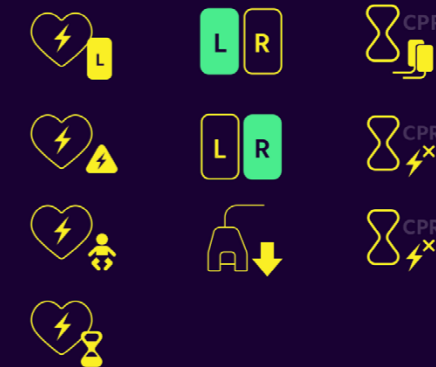
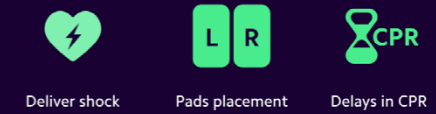
The layout of app was created based on the layout of the current Q CPR Classroom app by Laerdal. The concept is an extension of this app, and in the future, they should be combined into one software. Based



Evaluated icons



Improved icons





deliver shock

delays in CPR

pads' position



Smart AED training device for laypeople

System

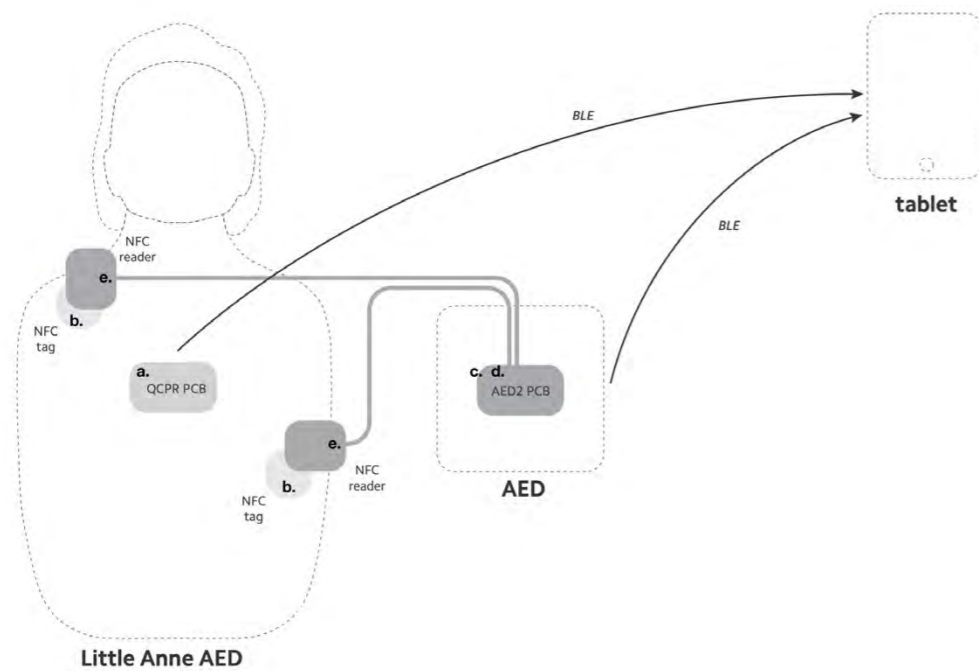
The NFC is precise and secure method of pairing the AED with the mannequin. However, it requires small distance between a tag and a reader. As a result this technology can only be integrated at the stage of attaching pads. This late recognition of AED in the scenario can affect the QCPR score and doesn't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

NFC tag is placed under the skin and the NFC reader is in 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 and NFC reader integrated into the pad

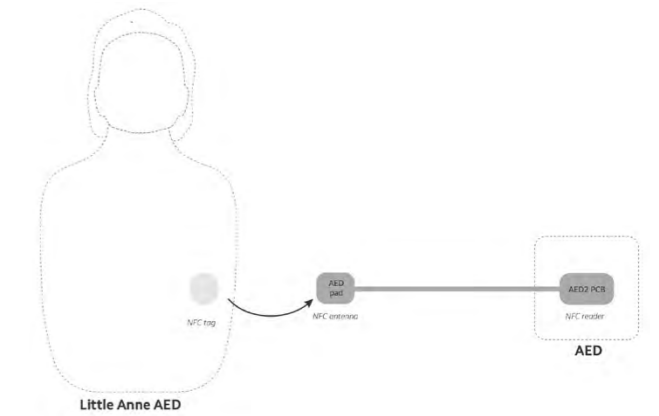
The system can also work with the reverse position of the components. However, due to the disadvantages for the pairing the tag with the AED when pads are replaced only this concept was selected.



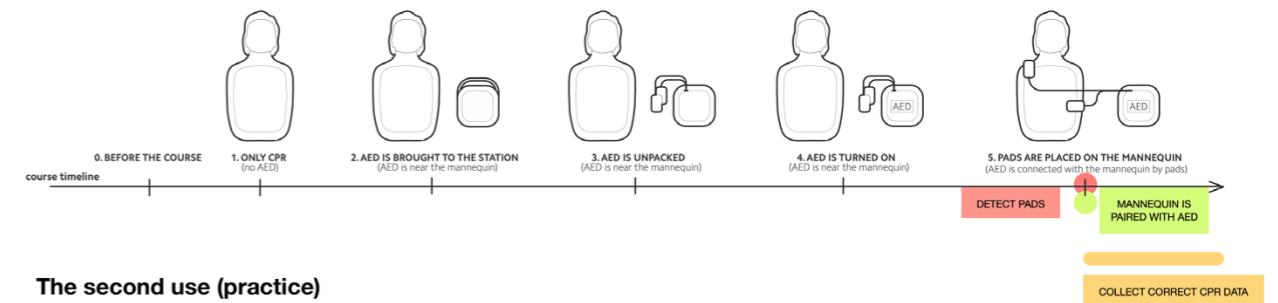
Assesment of the correct pads placement and ID detection of AED device.

List of components:

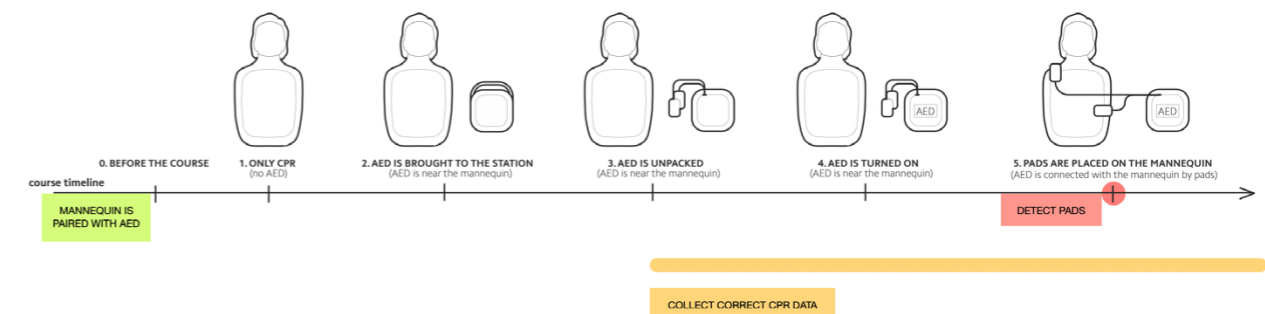
- Little Anne AED:
 - a. QCPR PCB with BLE module and battery
 - b. NFC tag
- AED:
 - c. AED2 PCB with BLE module, battery
 - d. NFC reader
 - e. NFC antenna integrated with pads
- Mobile device, e.g. tablet (QCPR Classroom app)



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



The second use (practice)



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 devices 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.

AED buttons and it is arrangement

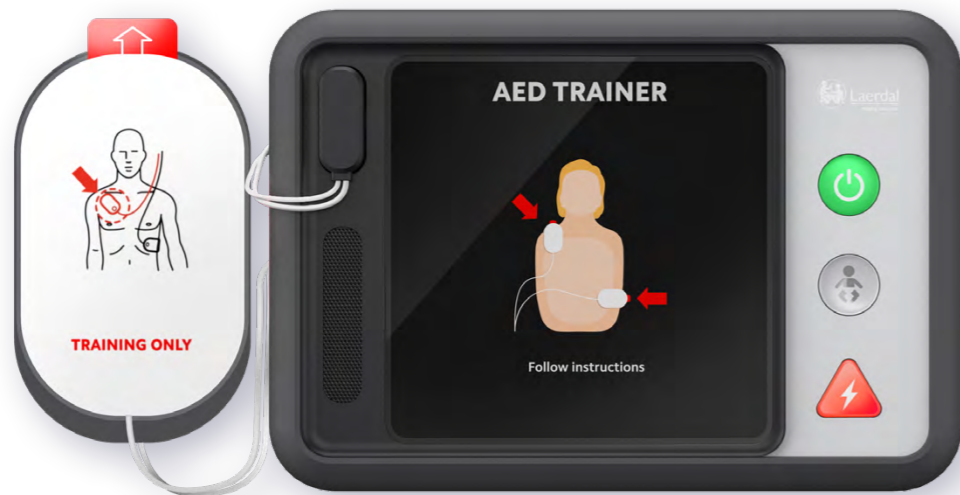
On the top of the device, three main buttons are located: power on/off, paediatric mode and shock button. It provides conditions for basic practice (automated and semi-automated AED) but also more advanced practice (AED use for children). They are group together and arranged in the order of use. It is 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.

Electrodes storage

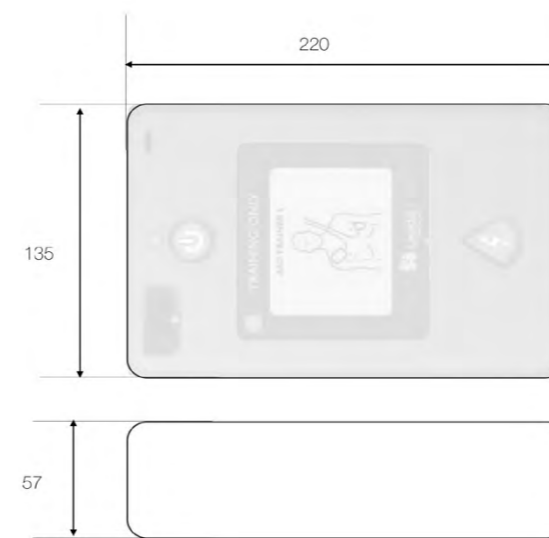
Electrodes are stored on the bottom of the device. Although it decreases the size of the unit, it provides a more compact solution. The electrodes are protected, and the cable is rolled up and covered what can increase their lifespan. The orange sticker with an arrow indicates the location of electrodes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



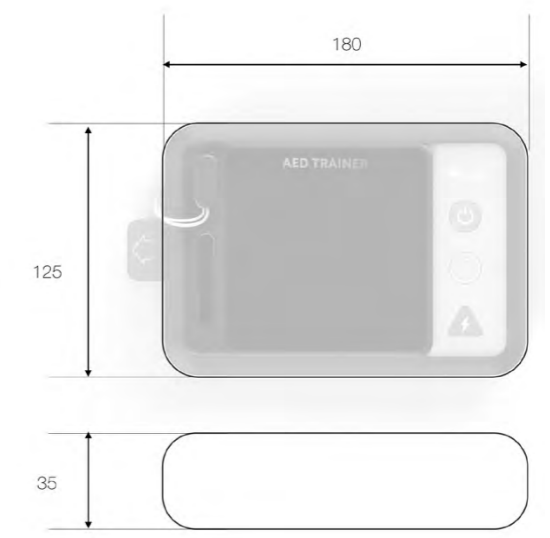


Dimensions

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

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.



Pads

The design of the pads was not in the scope of the project. However, to integrate them into the system and communicate 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 stuck to it.

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 mannequins. 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.



QAED Classroom 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.

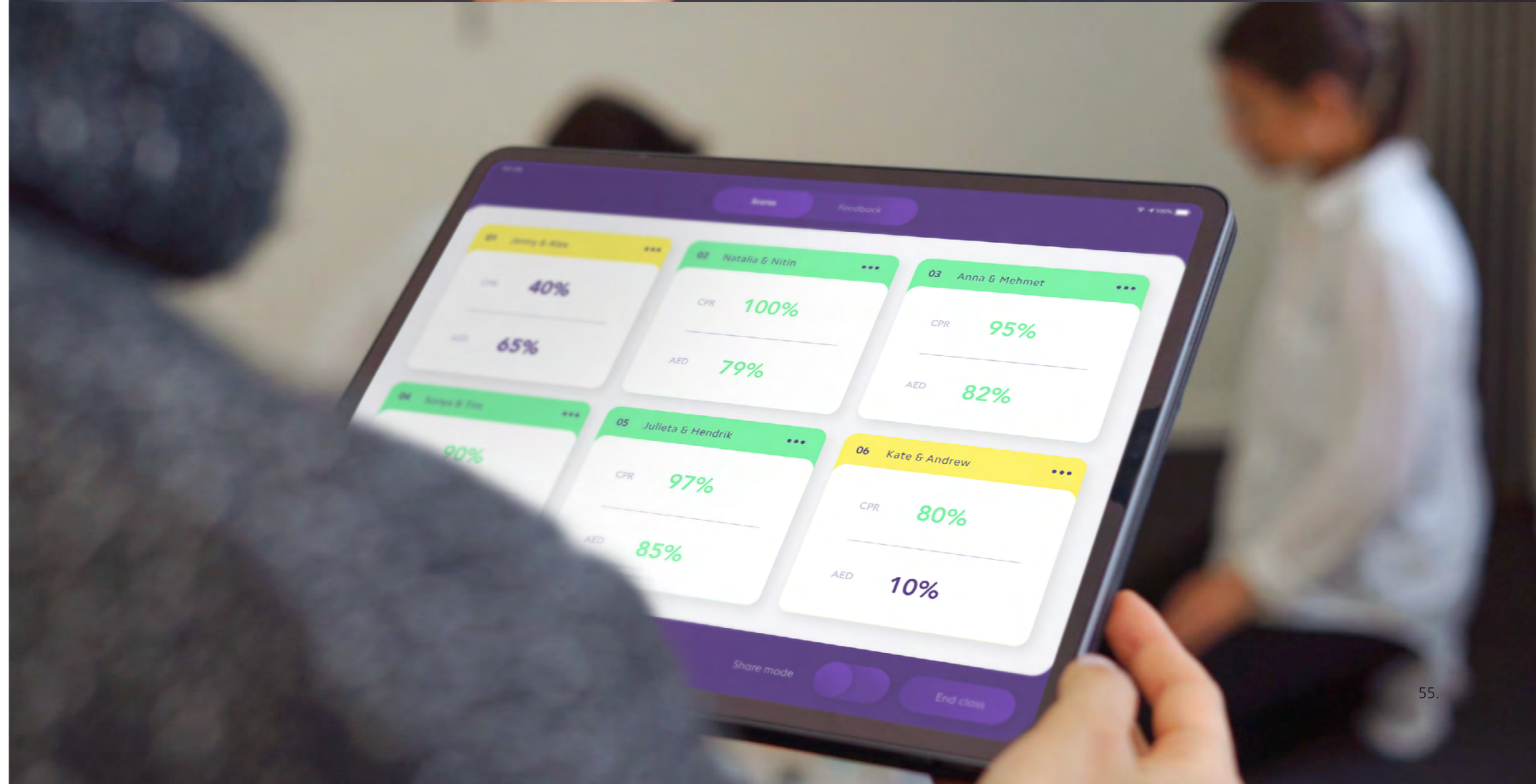
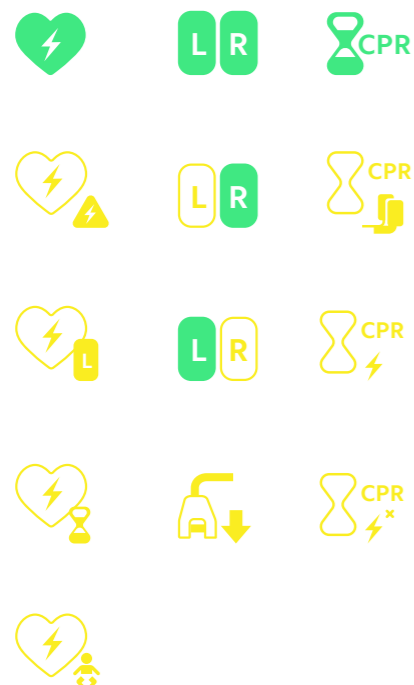
Colour scale

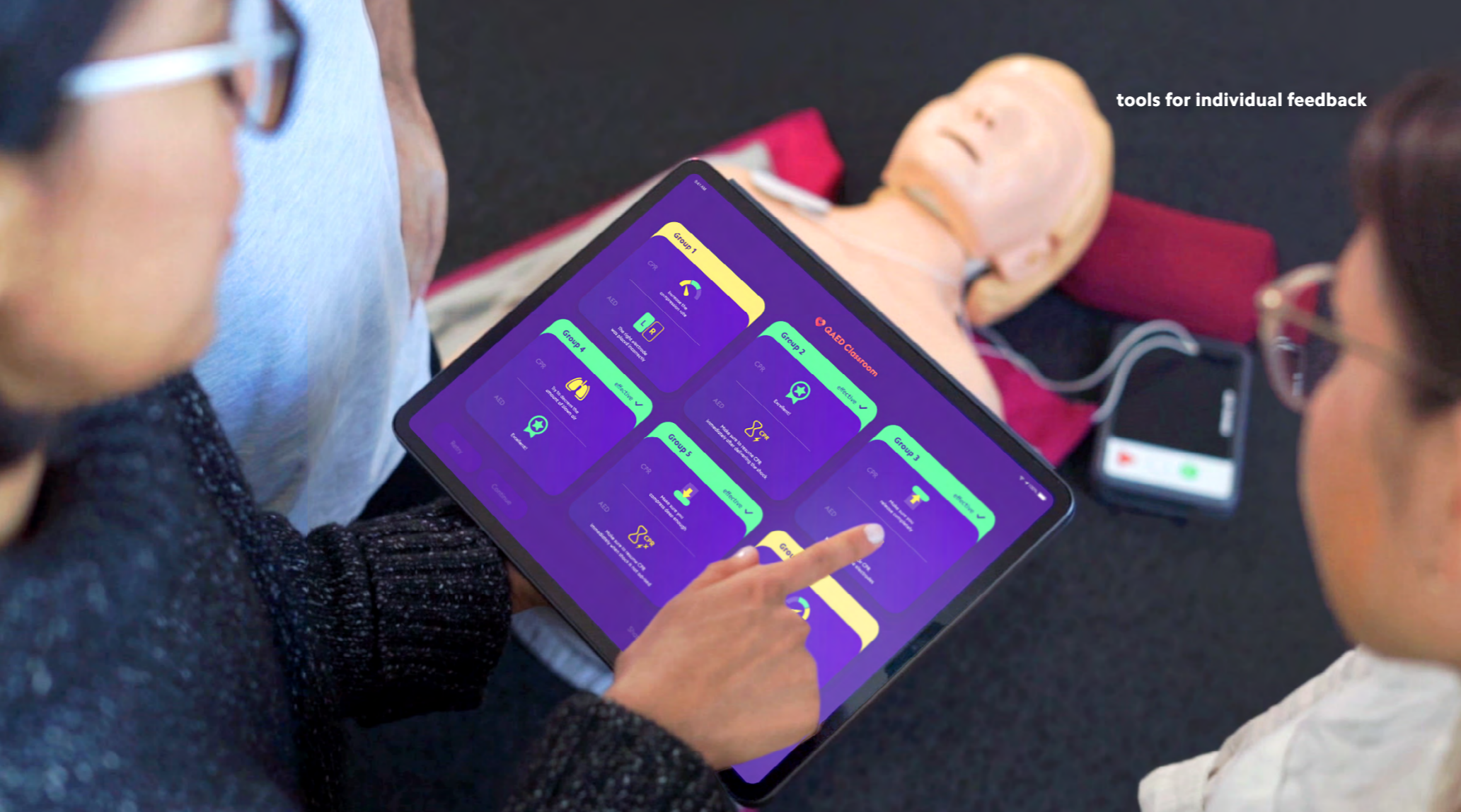
In order to unify the system in the project, two level scale was suggested for all elements of the feedback. It simplifies the evaluation system and there is not difrence in the information shown to the instructor and participants.



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.





tools for individual feedback



class feedback to enhance peer to peer learning

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.

