PUTTING HEART IN CPR

MASTER THESIS

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Special Thanks:
Ingeborg van der Eijk, Jos Oberdorf, Tessa Dekkers, Pat Collins, Sandra Collins, Tadhg O' Mahony, Session Participants, Firefighters at Cork City Fire Station, Darragh Nagle, Joyce van Dijk, Magdalena Ludwiczak, Yufe Wong, Selina Touriche, Omar Azzalini, Roel Redert, Pieter Jan Stappers, Aadjan van der Helm

Text Styles:

Section Heading

Sub Heading

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Reading guide:
Grey pages summarize each chapter of the report. References and methodologies are summarized in the side panel. The appendix and this report can be freely downloaded on TU Delft repository.

Report Structure

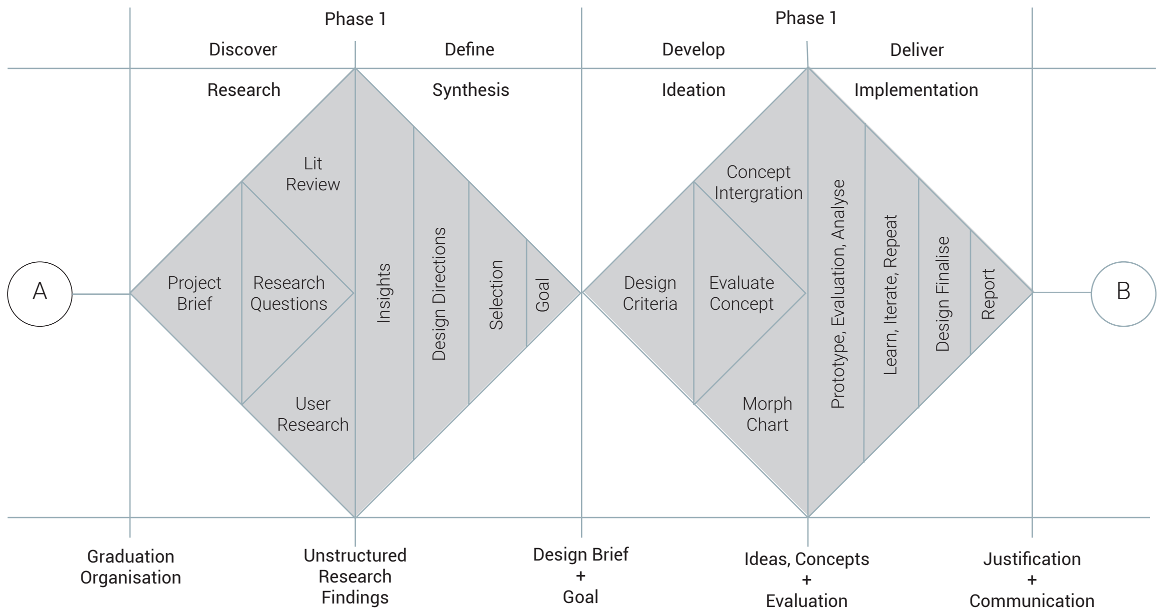

Figure 1: Visual of double diamond method

Executive Summary

The focus of this report is two-fold: the first phase explores the current limitation of CPR Training and develops design solutions to address these. The second phase explores one of the chosen ideas (Livis Ora) in detail. The structure is based on the double diamond method (Figure 1).

Phase 1:
Currently, 88% of cardiac arrests are witnessed but only 30% of victims will receive bystander CPR. Survival rates of cardiac arrests are low and more victims have the possibility of living if they receive CPR within the first few minutes of cardiac arrest. Outside of a hospital setting , ambulance services cannot make it to victims in time to provide quick cardiac intervention and the responsibility of providing CPR falls on the witnesses of the event. Educating laypersons provides the opportunity to close the gap between desired and actual bystander intervention.

The focus of this project is to explore CPR learning opportunities and develop a solution which will increase CPR skill acquisition and knowledge retention. This increased competency in peoples' ability to perform CPR enables them to feel confident to intervene in an emergency situation.

From analysis, evidence suggests that CPR skills deteriorate within 3 months of training and in order for people to feel the responsibly to perform bystander CPR they must have obtained a high level of skill acquisition. Feedback aids provide opportunity to practice and obtain objective information on many vital aspects of CPR such as compressions and rescue breaths. This feedback increases skill acquisition and knowledge retention. However, feedback aids are scarcely used in current Dutch CPR training courses for laypersons.

Research with learners shows that keeping their knowledge up to date and practicing skills between training sessions was impossible. Learners want to practice more to gain muscle memory of CPR and understand if they are continuing to perform skills correctly. It is clear that a design solution should focus on creating practice opportunities outside of a training course.

These insights from analysis lead to the creation of a design goal. The design goal is to create a convenient and personal training aid which provides feedback on the learners' actual performance to assist in the mastering of vital CPR steps. This practice device would eliminate the need to attend a practical lesson in order to learn or perform CPR.

In conclusion, the real value of the design lies in its ability to provide comprehensive feedback, self-instruction with hands -on practice and cost effective regular training sessions. Currently, these aspects are either non-existent or poorly executed in the current training system with scientific evidence showing the need for change in traditional training. An adaptable training aid with integrated feedback technology, therefore, provides the ability to enhance CPR skills and confidence of those who are likely to utilise their skills. This concept was further developed in Phase 2 of the report.

Phase 2:
The concept will now be referred to as LivisOra. The integration of this device can be considered an alternative to attending a CPR training course.

The main aspect of the device is the ability to practice within the home environment. The aid creates a training which gives emphasis to hands-on practice to obtain psychomotor skills. This practice has real -time feedback which is informative and has clearly defined targets to achieve competency of skills. It allows the user to know when they are performing a step incorrectly and lets them know how to enhance their performance. It also gives the learners the ability to reflect on their performance and motivate continued learning to achieve objectives.

The final design is compact, portable and optimised for individual training. It contains sensors which connect to the design App in order to give audio and visual feedback for the learner to understand their CPR performance. With Livis Ora, it is possible for learner to gain confidence in the CPR ability when they practice regularly in the comfortable environment of their own home. The designed solution far outweighs any possible competitors in terms of functionality and also suitability for the future of CPR guidelines and legislation.

It is expected that an ambulance should reach the location of where it is needed in less than 20 minutes. However, it has been shown that if proper CPR medical attention can be administered by a bystander within 6 minutes, then it will increase survival rates by 15%. This is a total of 52,500 real human lives that can be saved each year within Europe. Ora is a concept which has the potential to contribute positively to people's ability to perform CPR and allows them to feel confident to help those in need. With this confidence, those most likely to witness a cardiac event will perform CPR without hesitation. These are the critical moments which can mean life or death for the victim.

Table of Contents:

CH 1: HOW TO SAVE A LIFE?

Understanding context, CPR quality, learning CPR and current solutions

This chapter will introduce the context and goal of the project. The main limitations with regards how people learn CPR are uncovered along with the current advancements in CPR guidelines and learning technologies. To communicate findings a benchmarking methodology was used and this was concluded with a research direction.

Introduction:

Cardiac arrest is when the heart is not correctly pumping blood around the body and if not treated is fatal. CPR or Cardiopulmonary resuscitation is a means of keeping someone alive during a cardiac arrest. CPR requires a rescuer to press on the victim's chest repeatedly and blow air into their lungs. The rescuer is manually taking on the role of the heart and respiratory system for a temporary period to keep the person alive long enough for further advanced medical attention. This is a situation where literally every second could mean life or death for the victim.

The use of CPR is not new, it actually dates back to 1740.Yet even today many people in non-medical professions don't know how to perform it. 70% of people claim they feel helpless to act in an emergency situation because they either do not know how to administer CPR or their training has significantly lapsed (Graham, McCoy & Schultz, 2015). What makes this statistic even more alarming is the fact that 88% of cardiac arrest occur in the victim's home (Cummins, Ornato, Thies & Pepe, 1991).

Within Europe, 275,000 persons will experience cardiac arrest per year and only 29,000 will survive (Atwood, Eisenberg, Herlitz & Rea, 2005). An additional 15% could survive if efforts were made to increase early recognition and intervention of CPR (See figure 2) (Slot, 2010). The main limitation is that Emergency Medical Services (EMS) rely on bystanders to keep the victim alive with early CPR intervention until they can arrive at the emergency. These bystanders, the non-medical professionals, have stated with an overwhelming majority that they feel helpless to act.

The current advancements in learning technology and improved CPR infrastructure provide opportunities to improve the effectiveness and quality of bystander CPR. The focus of this project will be to explore these opportunities with regards bystander CPR and develop a solution which will increase CPR skill acquisition and knowledge retention. This project is supported by Livis who currently offer training courses for bystanders to learn CPR. This project aims to develop competency in people's ability to perform CPR and enables people to feel confident in an emergency situation, especially those who are most likely to be called upon to use CPR knowledge.

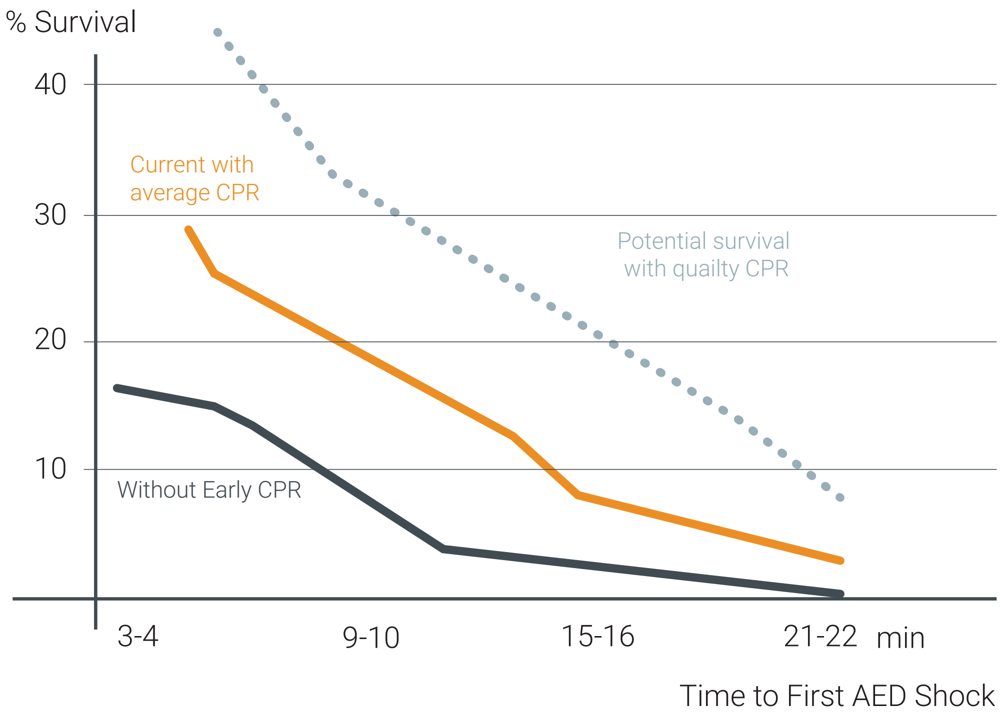

Figure 2: Graph showing the Survival rates related to CPR delivery

1. Atwood, C., Eisenberg, M., Herlitz, J., & Rea, T. (2005). Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. Resuscitation, 67(1), 75-80. doi: 10.1016/j.resuscitation.2005.03.021

2. Cummins, R., Ornato, J., Thies, W., & Pepe, P. (1991). Improving survival from sudden cardiac arrest: the "chain of survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation, 83(5), 1832-1847. doi: 10.1161/01.cir.83.5.1832

3. Graham, R., McCoy, M., & Schultz, A. (2015). Strategies to improve cardiac arrest survival (2nd ed., p. 2, Understanding the Public Health Burden of Cardiac Arrest: The Need for National Surveillance.). Washington (DC): National Academies Press (US).

4. Slot, M. (2010). Als elke seconde telt De brandweer als First Responder.. [ebook] p.15. Available at: https://extranet.infopuntveiligheid.nl/Infopuntdocumenten/Slot%2011%20brandweer%20als%20first%20responder%20met%20AED.pdf [Accessed 18 Feb. 2018].

Terminology:

<u>Cardio Pulmonary Resuscitation (CPR):</u> a medical procedure involving repeated cycles of compression of the chest and artificial respiration, performed to maintain blood circulation and oxygenation in a person who has suffered cardiac arrest.

<u>Basic Life Support (BLS)</u>: is a level of medical care which is used for victims of life-threatening illnesses or injuries until they can be given full medical care at a hospital. It can be provided by trained medical personnel and by qualified bystanders.

<u>Sudden Cardiac Arrest (SCA)</u>: occurs when the heart's ventricles (chambers) suddenly stop contracting effectively. This causes the heart to stop completely or assume an abnormal chaotic rhythm. Blood is then not pumped effectively throughout the body. This is life threatening and requires urgent medical attention.

<u>Out-Of-Hospital cardiac arrest (OHCA)</u>: a stopping of heart mechanical activity that occurs outside of the hospital setting and is confirmed by the absence of signs of circulation.

<u>Emergency Medical Services (EMS)</u>: are a type of emergency service dedicated to providing out-of-hospital acute medical care, transport to definitive care, and other medical transport to patients with illnesses and injuries which prevent the patient from transporting themselves.

<u>Automated external defibrillator (AED)</u>: is a portable electronic device that automatically diagnoses the life-threatening cardiac arrhythmias of ventricular fibrillation (an aspect of many SCA) and is able to treat them through defibrillation, the application of electricity which stops the arrhythmia, allowing the heart to re-establish an effective rhythm.

<u>European Resuscitation Council (ERC)</u>: is the European Interdisciplinary Council for Resuscitation Medicine and Emergency Medical Care. The objective is "To preserve human life by making high quality resuscitation available to all". The ERC is the network of National Resuscitation Councils in Europe and is responsible for resuscitation research and for all guidelines related to CPR training.

Situation Assessment:

The reality is that 30% of victims have CPR initiated before the arrival of emergency services (Axelsson, Herlitz & Fridlund, 2000). When you consider that about 76% of cardiac arrests are witnessed there is great room to improve this number from the current 30%.

How do you improve this system? The system is heavily reliant on the co-operation of medical professionals and the general public. According to the ERC to improve survival chances the focus must be to improve 3 disciplines: (1) medical science (guidelines), (2) educational efficiency and (3) local implementation (Søreide et al., 2013). This project focuses on the educational efficiency aspect of these disciplines. Educational efficiency is experiencing the least amount of innovation in recent years with more funding going towards developing guidelines (research grants) and local implementation (increasing AED locations).

Previously, increasing the number of people receiving CPR training has been regarded as a measure of success for the ERC. However, recent guidelines (2015) have now viewed this as limited due to a positive link established between the quality of CPR performed and patient outcome (Isbye, Rasmussen, Lippert, Rudolph & Ringsted, 2006). In particular, the quality of vital CPR aspects such as cardiac arrest recognition, chest compressions and rescue breaths can greatly improve chances of survival. The limited view of just training people in CPR is under scrutiny and is recognised as unsatisfactory. Therefore, there is desire to explore advancement in CPR training to improve the quality of CPR skills obtained.

A number of studies have shown that the practice of CPR skills is often sub-optimal, with regards compression and ventilation practice (Søreide et al., 2013). This leads to errors in compression depth, prolonged interruptions in chest compression and hyperventilation occurring frequently (Yeung et al., 2009). All of these mistakes make CPR less effective at keeping the victim alive. Around 20% of people feel insecure in their ability to perform CPR three months after training (Isbye, et al 2006). Over time this insecurity results in a lack of skill retention. 3 years after training, 10% of participants were able to perform resuscitation attempts to a sufficient quality which would actually benefit a victim (Isbye, et al 2006). This is why the ERC recommends renewing training every 2 years. When participants want to renew their skills they must attend the same training course as their first practical session which has already been proved to be sub optimal for increasing CPR quality (Monsieurs et al., 2015). This then becomes a toxic cycle of poor training, insecurity and lack of retention.

This analysis of the training situation and difficulties laypersons experience has led to the formulation of some research questions:

1. What is quality CPR?

2. How to improve Learning and skill acquisition?

3. How to improve Competence and confidence in CPR?

4. What are the current solutions within CPR training?

The remaining aspects of this chapter discuss the findings to these research aspects.

Quality CPR

A minimally acceptable performance of CPR in a real situation would be similar to not performing CPR at all, in terms of survival benefits. However, it has been reported that those who attend training courses have difficulty acquiring necessary knowledge and skills and then forget them rapidly (Handley & Handley, 1998).

The performance of rescue breaths and chest compression involves 50 separate psychomotor skills (Ward, Johnson, Mulligan, Ward & Jones, 1997) and the full CPR sequence has eight steps in total. The remembering of this complex sequence can be difficult for the average lay person. When learning CPR, the learner must not only understand the CPR sequence but must perform CPR correctly. The full

5. Axelsson, Å., Herlitz, J., & Fridlund, B. (2000). How bystanders perceive their cardiopulmonary resuscitation intervention; a qualitative study. Resuscitation, 47(1), 71-81. doi: 10.1016/s0300-9572(00)00209-4

6. Søreide, E., Morrison, L., Hillman, K., Monsieurs, K., Sunde, K., & Zideman, D. et al. (2013). The formula for survival in resuscitation. Resuscitation, 84(11), 1487-1493. doi: 10.1016/j.resuscitation.2013.07.020

7. Isbye, D., Rasmussen, L., Lippert, F., Rudolph, S., & Ringsted, C. (2006). Laypersons may learn basic life support in 24min using a personal resuscitation manikin. Resuscitation, 69(3), 435-442. doi: 10.1016/j.resuscitation.2005.10.027

8. Yeung, J., Meeks, R., Edelson, D., Gao, F., Soar, J., & Perkins, G. (2009). The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. Resuscitation, 80(7), 743-751. doi: 10.1016/j.resuscitation.2009.04.012

9. Monsieurs, K., Nolan, J., Bossaert, L., Greif, R., Maconochie, I., & Nikolaou, N. et al. (2015). European Resuscitation Council Guidelines for Resuscitation 2015.

description of the sequence of steps can be found in the Appendix D.

The main component of CPR which should be performed to help pump oxygenated blood through the body is the chest compressions together with ventilations. These components are the most difficult to grasp for CPR learners and therefore, it will be the focus of this project to increase skill acquisition of these aspects.

Below are the parameters which contribute to achieving these skills according to ERC guidelines:

Compressions:
1. Compression depth: A range of approximately 5cm but no more than 6cm for an averaged sized adult.
2. Compression Rate: chest compressions should be performed at a rate of 100 -120 per minute.
3. Compression wall recoil: Avoid leaning on chest after each chest compression to improve effectiveness.

Ventilation:
4. Rescue Breaths: volumes of air delivered should be approximately 500-600 ml delivered for a duration of 1s to see a visible rise in chest and avoid forceful breaths.
5. Ventilation Rate: maximum two breaths and should not exceed 10s interruption in compressions.
6. Compression -Ventilation Ratio: 30:2 was recommended for a single CPR provider attempting resuscitation in an adult.

The ability to respond quickly and effectively in an OHCA directly contributes to the chances of survival for the victim. A number of studies have shown the quality of intervention is often inadequate with regards compressions and ventilation. The project solution will focus on increasing the effectiveness of these aspects. The other CPR aspects (detailed in Appendix D) such as cardiac arrest recognition and assessment of scene are considered secondary. The designed solution can include these secondary aspects but the primary concern if to help improve the skill acquisition and retention of compressions and ventilations.

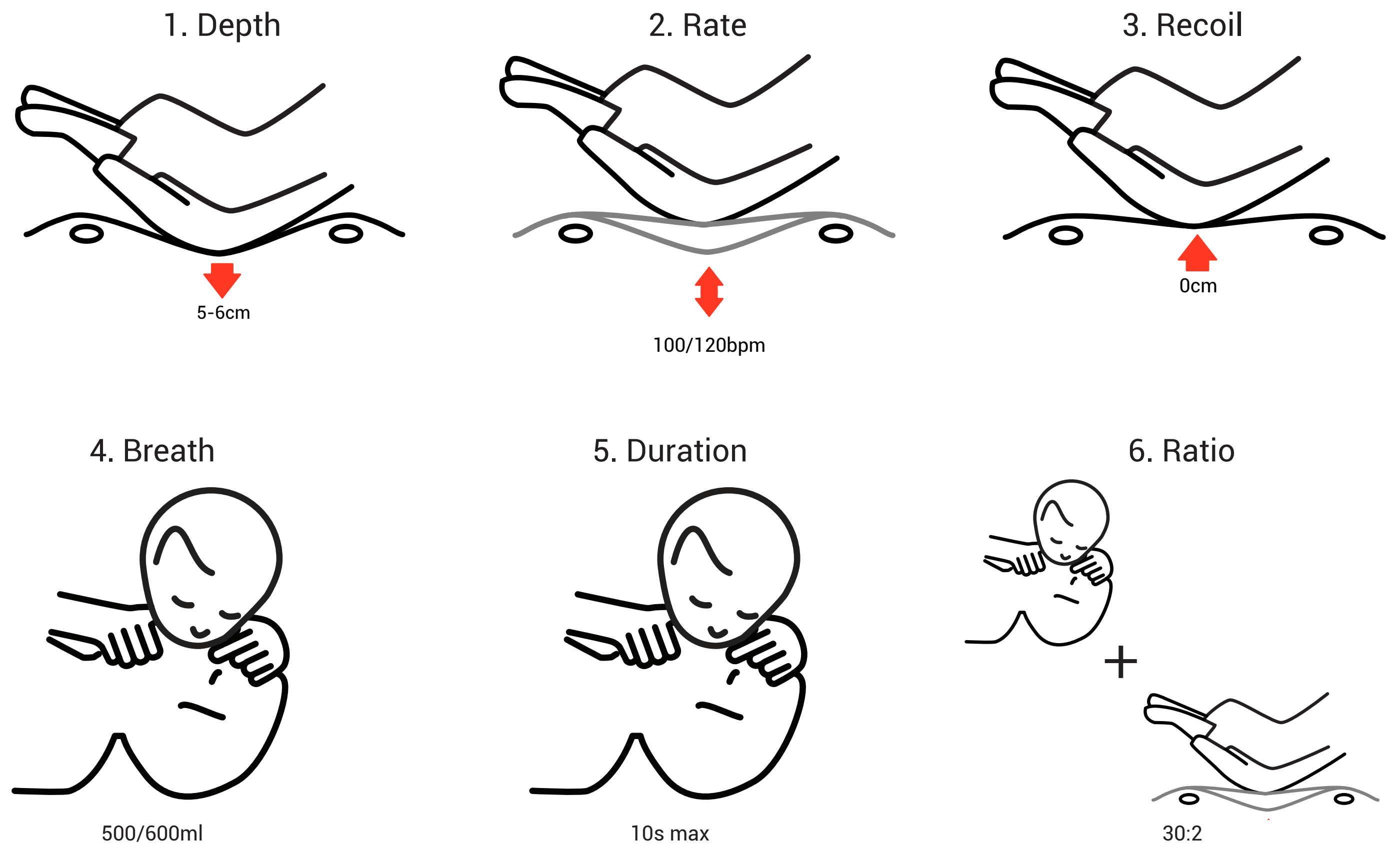

Figure 3: Visual of CPR aspects

10. Handley, J., & Handley, A. (1998). Four-step CPR—improving skill retention. Resuscitation, 36(1), 3-8. doi: 10.1016/s0300-9572(97)00095-69

11. Ward, P., Johnson, L., Mulligan, N., Ward, M., & Jones, D. (1997). Improving cardiopulmonary resuscitation skills retention: effect of two checklists designed to prompt correct performance. Resuscitation, 34(3), 221-225. doi: 10.1016/s0300-9572(96)01069-6

Skill Development:

12. Dreyfus, S. (2004). The Five-Stage Model of Adult Skill Acquisition. Bulletin Of Science, Technology & Society, 24(3), 177-181. doi: 10.1177/ 0270467604264992

Today's CPR training is faced with the challenge of how to achieve more with less. This is because time and money can be limited resources for the lay person learner but trained lay persons are needed as increasing bystander CPR for OHCA will have the greatest impact on survival.

The main challenge for CPR training is how to provide a training solution which can achieve the best learning and practice with a minimal increase in resources. The aim is to achieve efficient learning with clear informative objectives and have a positive impact on the layperson's willingness to perform CPR in an emergency.

The Dreyfus model of skill acquisition is a tool that can be used to help identify and prioritize teaching allowing for a focus on improvement of skills acquired. The model clarifies how students acquire skills through formal instruction and practicing (Dreyfus, 2004).

13. Bhanji, F., Mancini, M., Sinz, E., Rodgers, D., McNeil, M., & Hoadley, T. et al. (2010). Part 16: Education, Implementation, and Teams: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation, 122(18_suppl_3), S920-S933. doi: 10.1161/ circulationaha.110.971135

The model outlines that students pass through five distinct stages: novice, advanced beginner, Competence, proficiency and mastery. The first stage is the novice. This is a person who follows rules without context or sense of responsibility beyond following exact rules. After novice, competence develops when the individual can access particular rules that are relevant to a specific task at hand. This can be called active decision making. Proficiency is shown by individuals who develop intuition in their decision making to formulate plans. The progression from this is mastery, which is faithfulness to rules in an intuitive manner based on tacit knowledge. Summary of the learning stages can be seen in Figure 4.

To reference the 5 stage teaching model, the bystander should achieve skills in the range of advanced beginner to competent. When a learner is in this range, they will have the ability to understand their actions in relation to an actual situation. This awareness of their actions contributes to skill acquisition and motivation to intervene. The learner would theoretically have the ability to engage in decision making activities and this allows the learner to be prepared for the logistical, conceptual and emotional challenges of rescuing a victim. They will also have an awareness of their role in an emergency situation and begin creating a strategy or plan for intervention.

14. Dyson, K., Bray, J., Smith, K., Bernard, S., Straney, L., & Finn, J. (2015). Paramedic exposure to out-of-hospital cardiac arrest is rare and declining in Victoria, Australia. Resuscitation, 89, 93-98. doi: 10.1016/j. resuscitation.2015.01.023

In the context of CPR training, the desire is for the learner to reach the level of advanced beginner to competent in an effective and efficient manner. To help achieve this the communication of learning objectives is vital and learning objectives should be observable, measurable, learner-centered and action-oriented. See Figure 3 for how objectives can be more obtainable through different learning techniques at each stage of the Dreyfus model.

The model depicted in Figure 4 can be used to plan and execute improvements to educational programs not only within the context of CPR training but across any adult learning program which requires cognitive and skill-based learning with real experience. An example can be the training of healthcare providers for clinical settings or even providing first aid training for new parents. The visual summarises how to maintain competence over time and achieve continuous improvement of skills. Using this model within the project can help implement teaching strategies and evaluate the designed solution with regards educational goals.

Confidence and Competence:

Lack of practice leads to skill deterioration. Research show that CPR learners skill retention declines as soon as three months after training. Most laypersons do not have an experience in their life which requires them to use their CPR skills. Some laypersons maintain skills through a renewal course every two year. However, most people train infrequently due to the time-consuming process of organizing and confirming training and additional loss of free time or work hours.

Low-dose high-frequency training is a competence-building approach adopted for training medical professions in life saving skills (Bhanji et al., 2010). This type of training promotes maximum retention of knowledge, skills and attitudes (Dyson

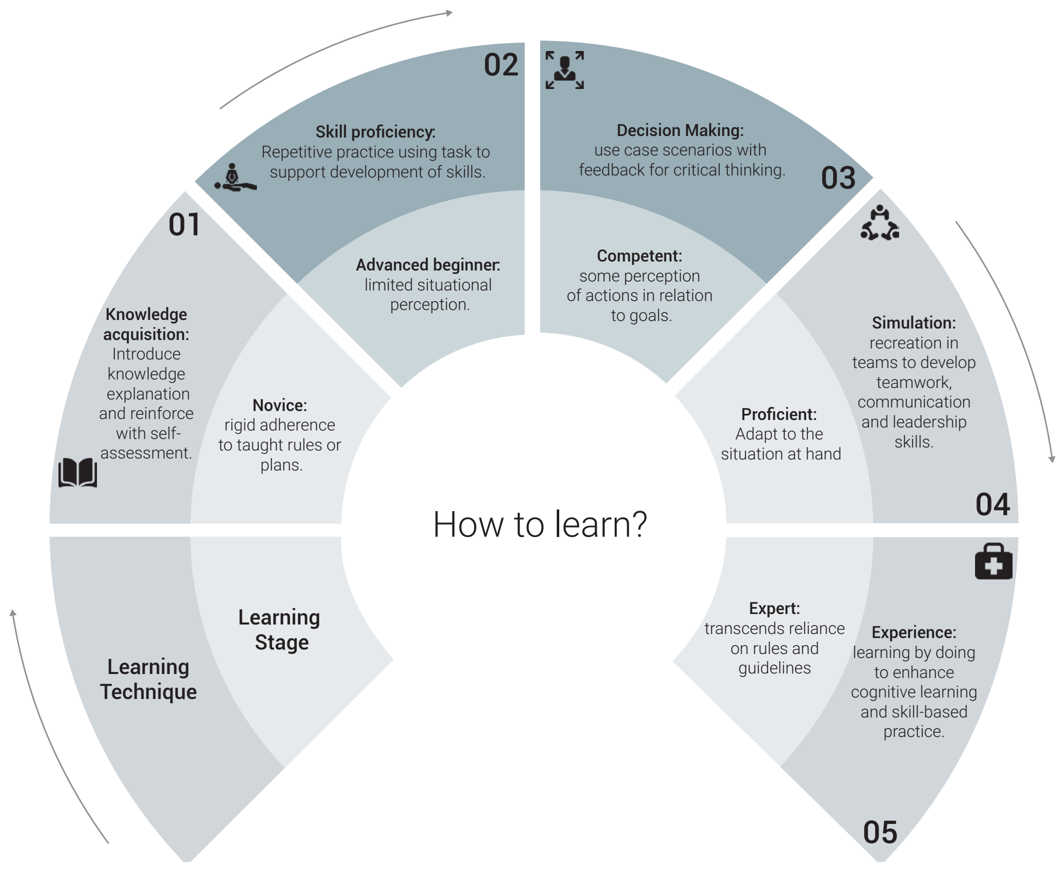

Figure 4: Model for Learning

15. Sutton, R., Niles, D., Meaney, P., Aplenc, R., French, B., & Abella, B. et al. (2011). Low-Dose, High-Frequency CPR Training Improves Skill Retention of In-Hospital Pediatric Providers. PEDIATRICS, 128(1), e145-e151. doi: 10.1542/peds.2010-2105

et al., 2015). This type of training is short and targeted in learning activities and has structured ongoing practice sessions. It is effective for skill building and for maintaining skill competence over time. Texas Health resources hospital in Dallas, adopted a Low-dose high-frequency training for their medical staff. They were able to document a 20% increase in survival rates from cardiac arrest (Sutton et al., 2011). If this approach was to be considered for training laypersons for OHCA then it could be possible that survival rates could also increase.

Many laypersons do not perform CPR on a regular basis and most don't even attend the recommended renewal course. It is clear from research that vital CPR skills deteriorate from lack of practice. CPR training not only has a direct cost for laypersons in terms of fees but it also indirect cost in term of time. If the project could adopt a designed solution that allows for the layperson to train in short, frequent intervals, also referred to as low-dose high-frequency training, then it is possible increase the retention of CPR skills overtime. This training technique enables competence skill level but also confidence to used skills when necessary.

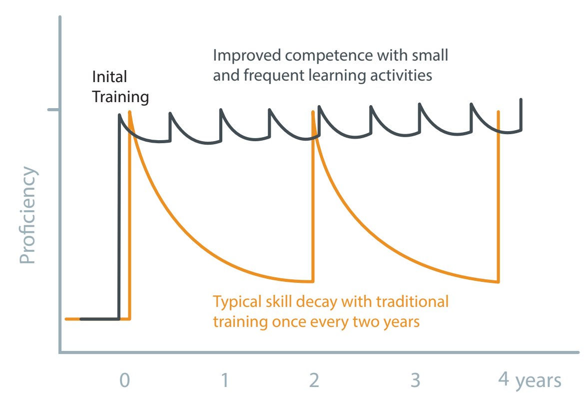

Figure 5: Proficiency with regards training Intervals

Current Solutions:

16. Yeung, J., Meeks, R., Edelson, D., Gao, F., Soar, J., & Perkins, G. (2009). The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. Resuscitation, 80(7), 743-751. doi: 10.1016/j.resuscitation.2009.04.012

17. Highlights – ECC Guidelines. (2018). Retrieved from https://eccguidelines.heart.org/index.php/circulation/cpr-ecc-guidelines-2/part-14-education/highlights-introduction/highlights/

There are some tools which have been a part of CPR training in order for participants to practice compressions and ventilations. Within training for lay persons, low fidelity prompt manikins such as little Annie (figure 6) are the most popular device to guide the learner. A prompt manikin gives a que as a reference for the desired performance during practice. An example is a metronome which provides the compression rate for the learner to follow.

In recent years, the improvement in CPR training has benefited from the development and implementation of feedback aids for hospital training (Yeung et al., 2009). Feedback devices have components or manikins which are capable of giving a direct reaction on the learner's actual performance in relation to the desired CPR performance (figure 7). The results show greater improvement of skill acquisition and retention. However, the implementation of these devices for layperson training has been negligible across Europe.

Feedback aids and manikins allow the user to assess their progress and hence develop skills. It also provides a possibility of communicating a specific desired goal and support the progression of skill development to reach this goal. Aspects which would be difficult to achieve with prompt devices and instructors alone. Currently, the European Resuscitation council (ERC) are recommending the use of feedback aids when possible. However, the American Heart Association (AHA) has released a statement that feedback devices in lay person CPR training will be mandatory from January 2019 ("highlights – ECC Guidelines, 2018). The AHA will require the implementation of feedback devices that provide learners with real-time audio/visual corrective feedback on CPR skills such as chest compression rate, depth and recoil. Feedback devices seem to be the direction for the future of CPR training due to these recent guidelines and scientific evidence that feedback is critical for greater understanding of CPR aspects.

Feedback tools are an aspect of training with could has the greatest potential for increasing skill acquisition and utilizing feedback within the designed solution can give the lay person the ability to achieve an advanced beginner to competent skill level. The future of CPR training will explore the integration of technology to help provide feedback to learners to obtain a standard skill objective and CPR performance assessment. This elevated skill level achieved by learners will help to increase confidence to intervene in an emergency situation and therefore have the potential to increase the number of bystander CPR interventions.

Figure 6: Prompt Manikin

Figure 7: Prompt Manikin connected to Feedback aid

Benchmarking:

Methodology:

Benchmarking- Normally used to identify the best products in their industry, or in another industry where similar processes exist. Within this project it is used to understanding the current means of improving CPR training in terms of design, functionality and application.

Feedback aids and prompt aids are used within training to practice the vital CPR steps. This section now looks at these existing devices to understand their value and limitations within the CPR training context. This benchmarking inspired technique is used to identify opportunity for design direction while also understanding existing solutions to problems with CPR training.

A broad search of prompt and feedback devices within the realm of CPR were gathered and their benefits understood. A selection of products was used for further analysis.

To select products, two variables were used. The first variable is feedback vs prompt device. This is whether the device gives a que based on actual CPR performance (feedback) or gives an audio/visual guide while training (prompt). The second variable is low fidelity and high fidelity. This is the resemblance to a real human or real cardiac situation. See figure 8 for a breakdown of how the products were chosen based on parameters. The products were then evaluated based on certain variables. These variables are:

1. How to use the product?
2. How does the product operate?
3. Ergonomics
4. Suitability of Use
5. Implications of Product

See figure 9 for the results of analysis. The product analysis allowed for an understanding of where products excelled and where they fell short, this lead to the discovery of opportunities. The main opportunities discovered were:

Universal: the various types of feedback are all communicated through audio and visual means which are not completely intuitive and some that can even distract the user from their CPR performance. There appears to be a need to establish an informative feedback aspect which can be universally understood and is beneficial.

Hygiene: Practice devices need to take hygiene factors into consideration

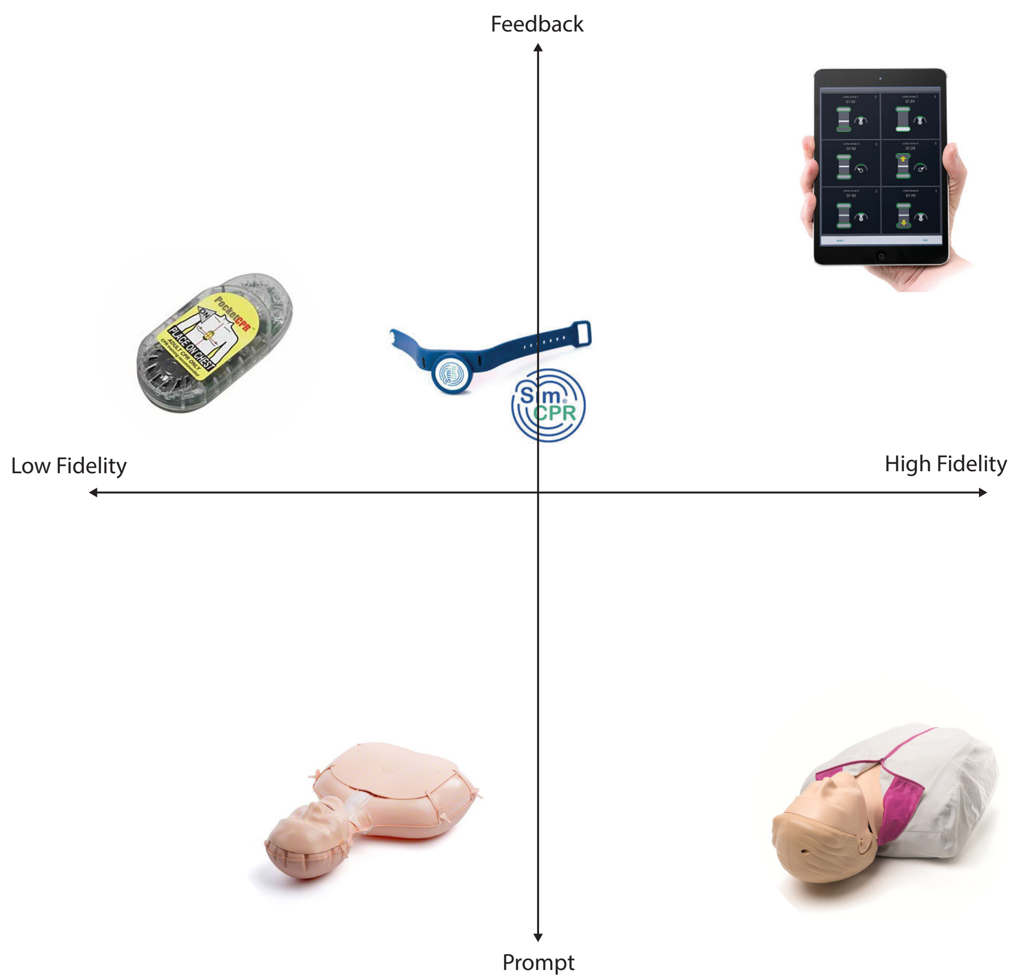

Figure 8: Axis of products to be benchmarked

Product	Mini Anne *Lateral*	Little Anne *Lateral*	Little Anne QCPR *Lateral*	Pocket CPR *Zoll*	Sim CPR *Samaid*
How to use the product?	An inflatable manikin and Self-directed learning programme allows the general public to learn and practice core CPR skills in 30 minutes in their own homes.	Little Anne is a realistic human appearance manikin with audio and Visual prompts. Learner practices compression and ventilation aspects during the practice session of a CPR course training.	Little Anne QCPR is a sensor module attached to the traditional Little Annie. A CPR instructor monitors learners perfor-mance from a hand held device. App provides a visual of performance which aid guidance.	PocketCPR prompts the learner with audio and visual ques to perform CPR compression. The audio cues go through the full CPR sequence from recognition. Must be used to a compressible aid.	Provides visual feedback on chest compressions for hands-only CPR training. Feedback is contained within App visuals and must be used with a compressible aid and smart phone.
How does the product Operate?	A large bladder is inflated manually prior to use. The an integrated clicker gives depth feedback during compressions. The device also has a separate bladder which inflates chest during correct ventilation.	An Inflatable plastic bladder under the chest area provides ventilation feedback during rescue breaths. A Spring mechanism with a clicker gives learner tackle feedback and prompts for compressions.	Using sensors attached to the Little Anne manikin enables tracking of CPR. Results are visualized, logged and stored for feedback during and after training. Encourages instructor to correct performance.	The product uses a pressure sensor and an metronome to promote quality of CPR compressions. A speaker in the device give audio cues for the CPR sequence and flashing lights give some feedback on Compression depth.	It has an accelerometer sensor in the wearable that monitor the trainee's CPR compression depth,recoil and rate. It is designed with to be used with a pillow or traditional CPR manikin.
Ergonomics	A "hard" or "soft" setting refers to clicker feedback for adult or child CPR but labels are not intuitive. No ability to know if the device is inflated sufficiently and incorrect inflation gives incorrect feedback.	The manikin is heavy which make transportation and storage problematic. The clicker sound is not distinctive to decipher from just movement sounds of the device. Hygiene concerns with the "lungs" Bladder	QCPR measures the core skills of CPR. It uses graphics for the instructor or learner to view and follow easily. When graphics were tested some of the feedback was confusing to users and they were distracted.	Thee feedback is located on the display within the device for good usability and viewing. The user must place their hands on top of the device making correct hand position difficult.	Feedback is in the form of a visual within the App. When compression is incorrect the visual is not intuitive as how to improve compression which could cause confusion .
Suitability of Use	The compact aspect of the device through deflation makes it suitable for use in the home and for instructors who need to transport 10+ devices to practicals. However set up time could be extensive and undesirable.	The devices human appearance makes learning the CPR sequence more realistic to a real emergency situation. However practice time with the manikin can vary in training sessions due to limited manikins available.	Q-CPR technology is also found in the Philips defibrillator's within the emergency field. The means which the feedback is communicated to the user throughly tested for usability with medical professionals but not lay persons.	For training with the device you must find a suitable manikin or pillow to track compressions but many manikins on the market have greater prompt and feedback functional-ity then this device.	The only focus is on the quality of chest compressions. However, ventilation is given more priority by the ERC. For training with the device you must find a suitable manikin or pillow to track compressions
Implication of Product	Can deliver training to the "non-participants" of a traditional training course such as elderly and people with low self-esteem. Increases ability to practice skills which has been shown to increase skill acquisition and skill retention.	Suitable for a user who is completely unfamiliar with CPR as they can learn the correct hand position, pressure. The speed to perform CPR can be less intuitive due to no prompts or feedback.	Provides learners with CPR guidance when practicing which is objective however, the instructor must still interpret and communicate the feedback they receive to the learner. This can give subjective errors.	The device is more beneficial for an emergency situation then training. However many AED machines which are also present in the offices have similar functionality and can be more beneficial for the victim.	The user may feel they are prepared for an emergency situation however they are missing vital steps in the CPR training accord-ing to ERC. It does not adhere to AHA feedback CPR device guidelines.

Figure 9: Product Benchmarking Analysis

and easy disassembly for disinfecting between users and between trainings.

Physical ergonomics: The form of the feedback must take physical ergonomics into consideration due to the strained posture adopted during compressions.

Limited CPR aspects: Many vital aspects of CPR which affect quality of compressions + ventilations are not addressed in the feedback. This includes compression tempo, recoil and ventilation pressure

Guidelines: Only some CPR feedback devices adhere to European resuscitation council guidelines.

Aesthetics: The visual aspect of a device should be typical of a medical device due to the context of CPR being first aid knowledge. Devices tend to lack this and also tend to lack a look of sturdiness and suitability for its function.

Ventilation: Ventilation feedback is often considered an afterthought with regards to how it's communicated. It is often limited, poorly executed or non-existent.

Error recognition: Feedback should not only be given when CPR is preformed correctly. It must also be considered when there are errors. In order to identify the error and eliminate possible user confusion to whether the device is functioning correctly.

Environment: Where the device will be used really affects many aspects of its secondary functionality such as its size and weight characteristics.

The opportunities allowed for 3 aspects of improvement to be discovered. These are the feedback optimization, maintenance and suitability for environment. Feedback optimization includes ventilation performance and communication of CPR errors. The existing products are demanding to disinfect and therefore easier maintenance of the aids is needed. The final factor is the products tend to be not suited for their various layperson training environments in size, weight, etc. The main benefit to redesign would be to optimize these aspects within the designed solution.

Limitations + Suggestions:

From the current analysis, CPR training should allow participants to clearly remember skills to perform quality CPR without hesitation in an emergency situation. However, evidence suggests that CPR skills deteriorate within 3 months of training and in order for people to feel the responsibly to intervene in an emergency they must have obtained a high level of skill acquisition.

Evidence supports the use of CPR feedback/prompt devices during training to improve CPR skill acquisition and retention. Feedback aids provide opportunity to gain CPR skills through practice, while also allowing for continued feedback to increase skill development. Therefore, development of a feedback aid with focus on many vital aspects of CPR quality such as compression and ventilation can help people feel ready to help during an emergency cardiac arrest.

Due to the focus on current analysis being about how to increase skill acquisition, the insights gained are on learning methodologies, feedback devices and the current training environment. There has been no exploration of the needs of the possible target users and how to increase user motivation to learn. Just creating solutions upon research about new feedback aids or learning structure would eliminate many possible innovation possibilities and would completely disregard the importance of the user and the successful integration of the concept within the current training system.

Livis have observed limited attendance of practical training sessions and refresher courses. Solutions to these issues can increase their target market. Adoption of new and more effective means for delivering CPR training is central for the continued competitiveness of Livis and vital to participants' increased ability to improve skills.

Therefore, the continued analysis will focus on understanding the needs of the user and the possible future market opportunities for Livis.

CH 2: LIVING FOR CHANGE

Exploring the factors and barriers within the current training context

The possibilities for development in CPR training is becoming more and more apparent. This Chapter explores strengths of the company (Livis) and gains insights about the future context of CPR training. It then documents the current CPR training experience with laypersons.

Societal Changes:

Methodology:

Vision in Product Design- This section has been influenced by the VIP approach. It supports the expression of my underlying reason for my design solutions based on emerging factors.

Out-of-hospital cardiac arrest (OHCA) is a huge healthcare problem. The annual incidence in western societies is about 300,000 per year. This number will only continue to increase due to chronic lifestyle diseases and increase in elderly population. (Moses et al., 2013)

The main problem with OHCA is there is no means for emergency medical services (EMS) to provide the vital medical attention within a time which would improve patient outcomes. Therefore, currently the survival of a victim depends on the bystander to intervene with CPR, but, less than half (30-40%) of bystanders intervene when they witness someone collapse (Wissenberg et al., 2013).

Many resuscitation councils aim to create cultural shifts in attitude towards performing CPR, in an attempt support those who are victims of OHCA. However, this shift to increase bystander intervention depends on many factors, not only people's attitudes, but also their mind-set about the medical system, their consideration of others and their ability to perform CPR.

The probable integration time for the concept of this project is 2020 to 2025 due to development and implementation time. Therefore, the project has gathered information in relation to the societal changes which will be experienced by the Dutch population within this time frame. Therefore, the factors researched which were considered to have a societal effect were the increase in elderly population, the integration of technology in daily life and changes in healthcare systems

The overview in figure 10 provides an understanding of the future context based on multiple reports. This context structure can be seen as areas of opportunity. Some emerging factors identified are:

1. People will experience an increased duty the care for others as the need for informal caregivers increases.

2. The integration of technology into lives will allow for new opportunities to solve existing problems with regards health.

3. Increase of people living with chronic conditions can lead to increased cardiac arrest and people will feel this burden in their everyday lives.

4. The role of the patient is changing and people feel the desire to become more informed.

It is apparent from this research, that there is opportunity to design effective solutions which can take into account these factors. However, the factor which really stood out was the changing role of patients. There are a number of current initiatives to foster patient involvement in the design, planning and delivery of health services. With the increase of technology in lives, patients now have even more opportunity to take control over their healthcare. Patients will desire to become more informed and take a managerial role over their own health. This translates to CPR as it shows the growing desire to obtain more medical knowledge such as first aid skills like CPR.

If we take into consideration the changing active role the general public will have in healthcare, it is really unusual to utilise the label "bystander". The definition of a 'bystander' is one who is present at an incident but does not take part. However, this is the widely accepted term which is used in reports referring to OHCA. The preconception is that people will not act, they are just bystanders who feel the diffusion of responsibility to act. This term should be eliminated in the future, however it did help to spark a design vision within the context of the project. Taking into consideration the changes in healthcare roles and the current underlying attitude towards intervention, the position of the future of CPR training can be defined as:

"There needs to be a connection in peoples' minds between CPR education and personal healthcare responsibility. Creating this connection will instill a sense to act when needed and save a life"

This research insight of patient centered care and design vision are taken forward in the project to develop design directions and product attributes.

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Importance of Care
Family caregiving is more intensive, complex, and long lasting than in the past and caregivers rarely receive adequate preparation for their role.
(Schulz et al., 2018)

Limited time
People will live and increasingly fast paced life and not have the time to spend on bettering themselves

Increased risk of cardiac arrest
The next generation more will suffer from lifestyle diseases such as cardiovascular disease, diabetes particularly and these people can be at greater risk of sudden cardiac arrest.
(Wellens et al., 2014)

Importance on care for Chronic Disease
Chronic disease care (prevention) will overtake in importance then communicable diseases (infectious diseases).
(Kostova et al., 2017)

New means of dealing with chronic disease
Chronic disease accounted for 75% of healthcare spending in 2013, there is a shift to changing the infrastructure to make this more efficient with accessible screening.
(Moses et al., 2013)

Information will be power
If Medical cost will continue to rise, then people will start to take more personal responsibility over their health and but a value on being informed.
(Vahdat, Hamzehgardeshi, Hessam & Hamzehgardeshi, 2014)

People will become more technology literate
Increased integration of technology in everyday lives will lead to a higher technology literacy

Increased demand to monitor health
Wearables and mobile devices will monitor health due to increased demand from physicians and patients.
(Mack, 2016)

Aging Population
Due to an aging population demographic more people will be susceptible to experiencing a cardiac arrest.
(Adabag, Luepker, Roger & Gersh, 2010)

Continued advancements in Chain of survival
Recent advancements include AED accessibility and EMS devices. We can only expect continued advancements in cardiopulmonary resuscitation through new technology with resultant improved outcomes.
(Ramsay & Maxwell, 2009)

Figure 10: Overview of the predicted future of context and healthcare system.

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Framework of Livis:

Methodology:

SWOT Analysis- The SWOT study was undertaken to relate the companies strength and weaknesses to the external opportunities. This lead the generation of design direction (initial ideation).

Basic life support (BLS) training is where laypersons learn medical care which is used for victims of life-threatening illnesses or injuries. This is currently how people learn CPR skills. Livis provides the service of BLS training and within this training session they use 3rd party CPR training manikins and instructors. These manikins and instruction styles vary depending on where in the country the participant attends a course.

It is difficult to understand if continuing with the current service system is the best option for Livis and the future of CPR training. Therefore, an analysis of the company was conducted to understand Livis. This analysis relates the company strengths and weaknesses to the complexities discovers within the market.

The internal analysis is based off interview styled discussions with Livis's marketing manager, e-learning developer and managing director. See Figure 11 for a visual summary of Analysis.

Strengths:
Personalised Learning: online e-learning empowers a more student centric experience where participants can learn at their own pace and devote the time they need to learn vital CPR skills. Livis has a vast e-learning portfolio.

Accessibility of Courses: Livis has a vast range of locations for CPR training around the urban and rural areas of The Netherlands. This increases the accessibility of courses for the Dutch population and causes participants to choose Livis courses over competitors.

Customer Relationship: Livis has an NPS score of 21 with its course participants. The success factors include the satisfaction with online material and the quality of instructors conducting the practical's.

Tailored Marketing: Livis targets certain demographics with their courses. Their main target with regards CPR training is young mothers. They have teamed with maternity stores in order to gain access to this market.

Flexibility: Livis views this project as an opportunity to explore all possibilities with regards the future of CPR. Therefore, they are flexible with exploring any valuable avenue with regards CPR training possibilities.

Weaknesses:
Outsourced Instructors: Livis utilises the same instructors as their competitors and therefore, the CPR practical's have similarities.

Limited R&D: Competitors receive grants for research and development for new means to train people in CPR and Livis focuses more on distribution and optimization of their services.

Lack of Technical Knowledge: Currently, there is minimal staff at Livis who are devoted to new product development.

Opportunities:
(For a full description of all market Opportunities see Societal changes, Page 20)

Increase in Informal caregivers: Over half of Dutch adults will be over 50 in 2019 and this will increase the amount of informal caregivers who could benefit from CPR skills.

Desire to advance skills: Resuscitation councils have a desire for learners to obtain quality skills with regards CPR.

Connect to real situation: The current training focuses on transfer of CPR knowledge, however, there is an opportunity to embed training into learners increased healthcare responsibility.

Technological opportunity: The integration of technology has allowed for new training opportunities.

Changing health attitudes: As prevention becomes more relevant, more innovation will be focused on distributing medical knowledge like CPR training.

Threats:
Established Avenues: the means of training with the use of learning material and practical sessions is widely established in every country and is backed by the European Resuscitation Council. Any change to this system could be susceptible to scrutiny.

Unknown domain: People tend to not understand that there could be an alternative to obtain CPR skills. Attending a practical is what they are accustomed to.

Large Competitors: Livis's main competitor is the Dutch Heart Foundation. They offer the same services as Livis (BLS course with online e-learning). They also engage in research about cardiovascular disease. They are much larger then Livis and use a majority of their funding towards innovation within this field.

The main take away from the analysis is the identification of 3 business strategies which Livis implements or aims to implement:

>> The customer relationship is currently very strong. This accessibility to the customer is what can give Livis the edge over their larger competitors.

>> Livis is very successful at targeting certain demographics for their courses. The have been able to team up with other companies to market towards these demographics (e.g. young mothers). Customising courses in the future could lead to even greater success in this area.

>> Livis currently only offers services in this domain. The development of product service systems is what can give them the edge over the competition.

Going forward in the project Livis would benefit from a solution which can differentiate them from their competition. Competition is the greatest threat to their BLS course. This solution should focus on a certain target demographic within layperson training. Emerging markets such as informal caregivers could be viable. This market strategy would help preserve or even enhance current customer relationships.

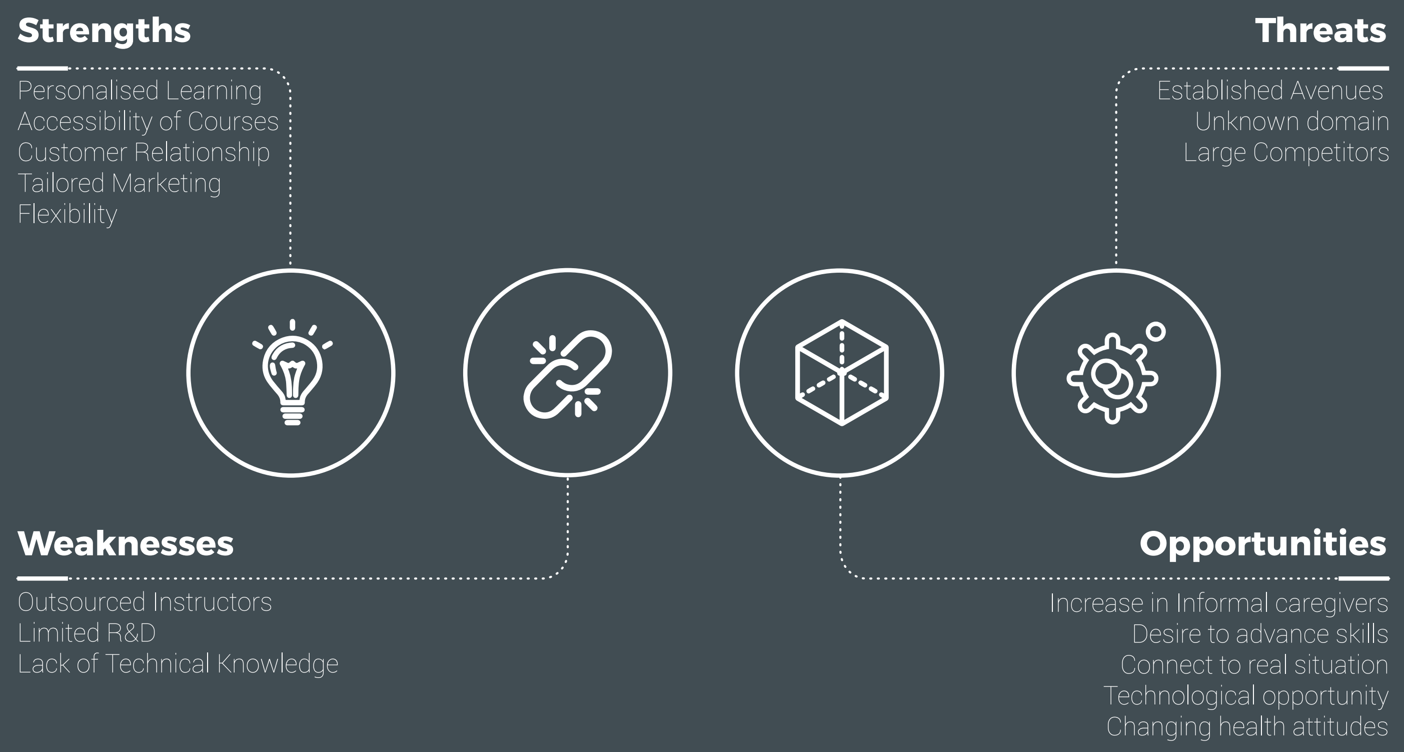

Figure 11: Overview of SWOT Analysis

Session: Training Experience

Methodology:

Context Mapping-user centered design approach that puts the user as the 'expert on his or her experience'. Personal experiences are expressed and the product or service is part of this experience.

The aim of the user research was to understand the needs of the participants of the Livis BLS course and identify the factors which influence their experience. Current literature is concerned with the learning outcomes of different training methodology's, however, there is limited data on participants experience before, during and after BLS training. The purpose of this generative research with participants was to investigate their recent experience with the current BLS course. The approach was conducted in the form of a Context Mapping styled session with the participants conducting exercises to visualise their experience.

The participants of this session had attended a BLS practical with Livis within the past 3 months. This time frame was used as this is the period of time when learners start to see a decrease in skill retention. The participants were all male for this session due to availability. It would have been preferred if there was a mix of genders, as Livis main demographic for courses are young mothers. There were 3 participants in total with an age range from 23 to 63. 2 participants had attended the BLS course to renew their certificate and one participant attended the course for the first time. It is important to note that participants were selected based on their English proficiency and therefore may have an educational background which is not representative of all Livis participants.

Before the session took place the participants received a booklet to document their experience before, during and after the BLS practical. Example of the booklet can be found in the Appendix E. The reason for this sensitising booklet was to stimulate memory about the BLS practical. This activity had happened a few months ago for the participants. The exercises also gave the participants an understanding of the focus of the session. When they attended the session they had already knew they should communicate their personal experience.

In the session, there was one exercise given to visualise the high and low points of their learning journey. This was used as reference when each participant was asked to explain their training experience. See Appendix F for the exercise given.

The session was 3 hours long and was split into two aspects. The first aspect was in depth discussion on the BLS training experience and the second half was the participants evaluation of initial design directions. This section will solely focus on documenting the first aspect with the session and the second aspect is documented in Chapter 3, Value Curve Page 36.

The full session was recorded for analysis purposes. For the full outline of the session see Appendix G. There were trigger questions to allow the participants to talk about aspects which were of importance to the project but overall the participants were willing to discuss ideas and their needs openly.

From the results, a thematic analysis approach was used. A thematic analysis is concerned with emphasising, examining and recording patterns or themes within data (Braun & Clarke, 2006). These become patterns which are important to the description of the experience of BLS training for laypersons.

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Insights:

During analysis it was clear that the themes within the data could be communicated in the form of a Customer journey (figure 13). The main aspect of the journey was the identification of the steps someone takes to achieve CPR knowledge and skills. The first step is the motivation to attend a course and the end of the journey is the possibility to actually intervene in an emergency.

a. Motivation:
Motivation can be different ranging from experiencing an emergency event which required medical attention to discovering statistics about how vital CPR is for survival. The main feeling from these events is insecurity in one's own ability to help and the understanding of the importance to help.

b. Searching:
There is no direct way to achieving and practicing solely CPR skills for laypersons. CPR is an aspect of a BLS course. This course teaches more lifesaving skills then just CPR which is vital for many life threatening events. However, when searching people become confused if this is suited for their needs and what exactly the BLS course entails. This can stop further action to achieve CPR skills due to confusion.

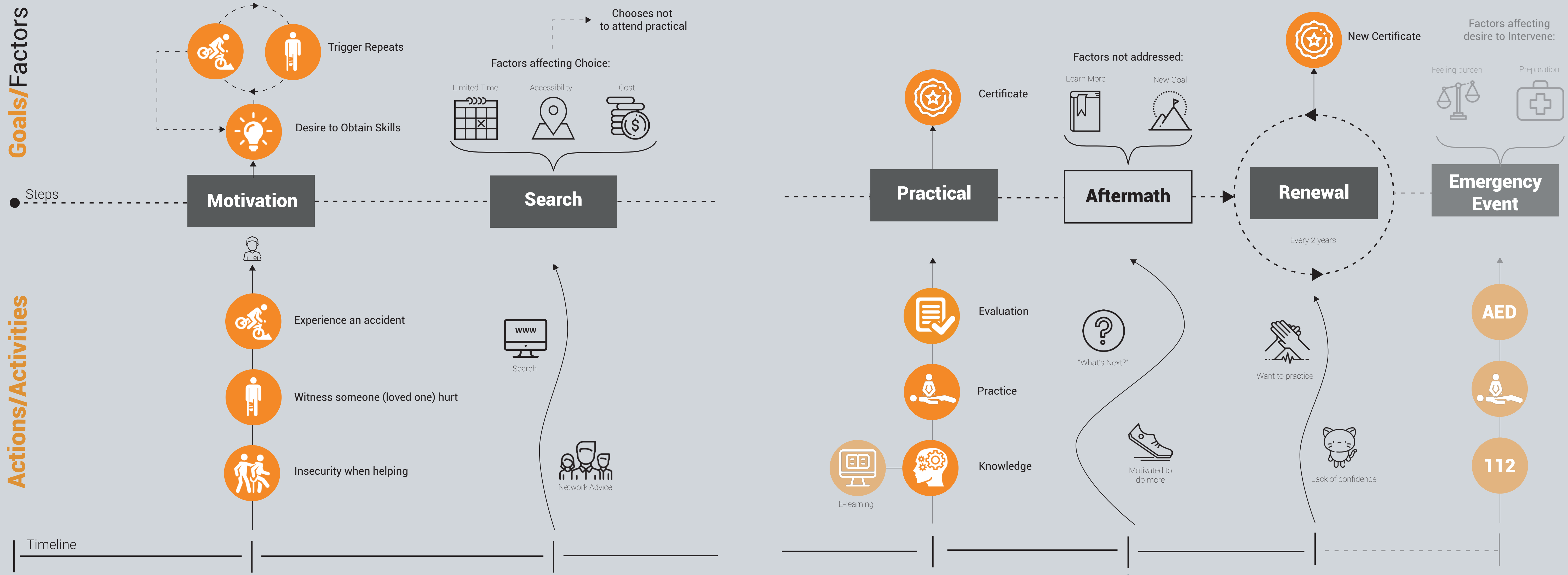
c. Practical:
The BLS practical is were participants apply their knowledge from the e-learning. This is a confrontation point as they now perform CPR for the first time and discover what misconceptions they had. Participants tend to react in two ways. Motivation to get better or recoil to perform minimally within the session.

d. After Practical:
Once the practical is completed participants have a sense of achievement when they receive their certificate. However, they can sometime feel as though they did not deserve it as they begin to question their ability and retention of their knowledge starts to slip away.

e. Renewal:
Not everyone who attends a course will use their skills in real life and some participants journey will end at the previous step. Some participants continue to retain their skills with a refresher course every 2 years. It is important to note that a refresher course is the same as the regular BLS practical, however, the online e-learning is slightly different. For Livis the participants skills are evaluated and then aspects which they performed poorly are refreshed with reading materials.

f. Intervention:
If a participant does witness an emergency event, then, they are faced with the decision to act. The motivation to act comes from a feeling that they have the correct plan and skills to actually make a positive difference. They also understand the vital importance to perform CPR with minimal delay, as they have they have obtained this knowledge from their training.

Figure 12: Image of the Session



Quotes

"But now I meet a lot of Kids.....They see it is important to act when they are older but they see the importance when they go to work and business."

"I think the main problem is to motivate younger people..... That's a really big problem... They would say ""why should I, I could spend my time playing video games""."

"There were interns ....they didn't know how to handle their sports class injuries. They didn't know any first aid or how to handle a situation"

"Accident I had when I was 18...a car hit me when it was raining hard. Everyone was standing there when I was on the pavement but no one did anything."

"That is significant as I don't Like to feel insecure when I help someone"

"So there is a lot of pressure in that moment.....I didn't know what to do....I was insecure.

I don't want to feel insecure anymore so I really trained hard....."

"Then suddenly my mother collapsed and it was really in the middle of nowhere....There was nothing and no one, I didn't know what to do"

It took me almost a year for me to take action. I was mainly myself .....I simply didn't have the time to do it. But that is a poor argument, as if you really want to do something you do it."

"In august/September I did the theoretical training.....I was a bit annoyed that it took me until December until I could do the practical training."

"We had a very interactive session and a very good teacher who really asked questions. These kind of questions which would make you go ""oh sh*t"""

"In order to learn you need to panic. I'm always using this person model in my life."

"I liked it very much (E-learning) because it was online and I can learning my own time. I can go back and forth in the knowledge"

"I liked the individual part of it"

"They (first responders) every 3 months they do it (complete a revision)."

The problem is "what's next?". He (other participant) is in a situation that he had to use it in practice. For me, it is only theoretical."

"The theoretical part was quite wide and broad and the practical more limited"

"The Emotional connection is not strong (in relation to the practical). Especially the theoretical part. It should be much more powerful."

"No I am not confident.......But I have never done a real life thing and (experience) what happens in real life.....But I am not confident."

".....There are deviations (in the App compared to the course)......I think this is unusual. I see one step in the App I'm like OK but I also feel it should be later. I think it could be my interpretations......"

"It should every year and even that is wrong...you have to do it every 3 months....but its more expensive and more time."

"In Holland we are called to the judge. We feel a liability. Also people think not my business."

"They didn't know first aid or (how to) handle an accident. I really felt a weight on my shoulders."

"I am a doer but I also think I must learn the steps. Not only instinct but also plan...I can back up my actions with what I have learned."

Experience

a. Lack of Experience

When you are younger you don't have the same life experience. Experience makes you start to see that your choices and preparation can cause you to make a difference. They start to feel the responsibility to care for others but They simply do not see the importance of BLS training right now.

b. Emergencies and Insecurity

A situation where they do not have the ability to help (people present or not) will motivate them to obtain skills to help people in need. This event sparks a feeling of insecurity about there ability to help others and see the importance of BLS training. They have the desire to never feel insecurity or helplessness again.

c. Time to take action

There is a lack of ability to take immediate action from the first motivation to learn CPR. They can't attend the courses due to accessibility and lack of time. The e-learning is easier to achieve in a reasonable time then the practical doe to the ability to learn in your own time.

d. Confrontation + learning

The training allowed for a confrontation about how much you actually don't know as they must make decisions similar to real life. It gives you the ability to panic in a safe environment. Their is a realisation of how easy it is to learn the BLS steps to help in an emergency situation. Participants want to have the knowledge and spent time going through it.

e. "What's Next?"

The motivation to improve your skills is at it's peak. There is no means to practice the skills. The information is only theoretical and by not practicing it will be forgotten and doubt sets in. Disheartened that there was a lack of connection to a real experience.

f. Consistency makes confidence

Even a few months after the course there is confusion of the steps. There is a lack of confidence in ability to tackle a real life situation. The desire is to practice skills more and a belief that the more you practice the better you will perform and you will gain confidence.

g. The real thing

Many people feel a strong liability and judgment when faced with a cardiac event. People would prefer to stay out of others business and are more likely to choose to not be involved. When people do act they feel the weight of the situation and the incompetence of others. A person who chooses to act will tend to have a plan to act due to their knowledge and training.

Figure 13: Customer Journey

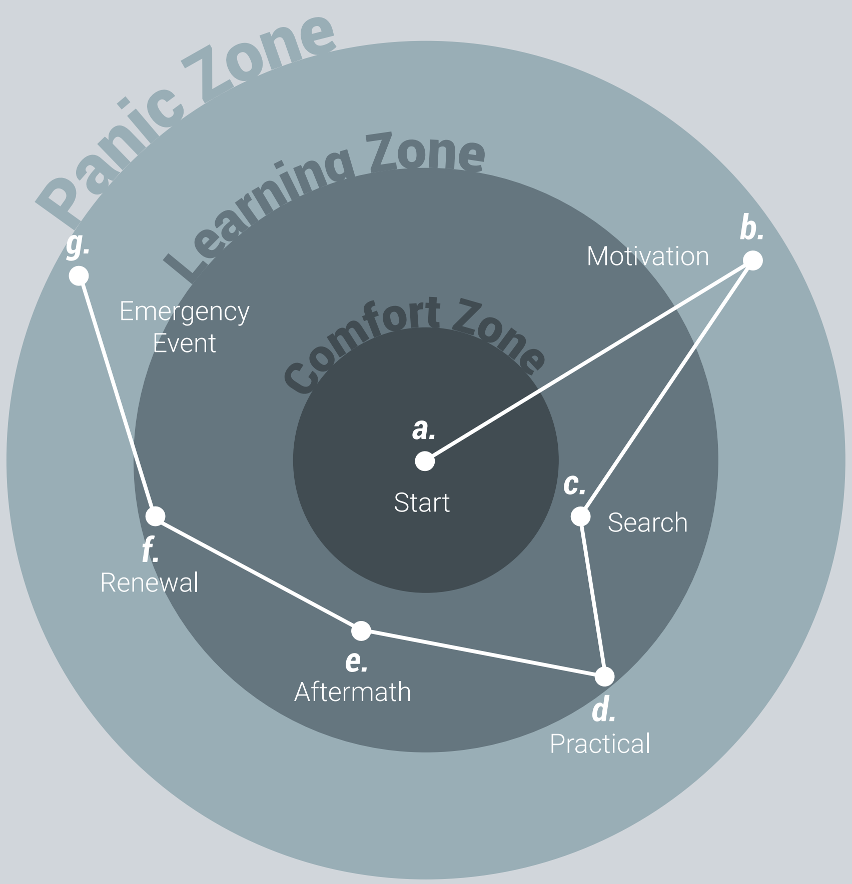


Figure 14: Learning Zone Model

Another insight was taken from the customer journey that seems noteworthy. Figure 14 shows Tom Senningers learning situation model. He states that in order for learning to happen the learner must leave their comfort zone and enter a situation where they feel a slight pressure to perform. This is called the learning zone. Within this zone, the learner is more likely to gain skills and even retain them. However, if the learner feels too much pressure and stress learning possibilities are eliminated. All of the brains resources are focused on reducing feelings of panic and controling the learners emotions.

In figure 14, the stages of the customer journey have been mapped within this learning zone model. It can be seen that there is possibility for learning to take place outside of just the practical context. At these stages, the user is aware of the need to possess CPR skills and therefore has the pressure within them to learn (Learning Zone). In the current customer journey, learning only happens at the renewal and practical stages. Designing a solution that takes advantage of more steps as learning possibilities could benefit the consumer and the potential to retain skills learned.

Conclusion:
There were three main learning themes which were of importance to the target group. The first was the ability to practice and maintain skill level. Currently, the learner finds it difficult to keep their knowledge up to date in-between the renewal courses. The main problem is the ability to practice skills obtained and understand if they are performing these skills correct. The designed solutions should not just focus on the practical setting but create learning opportunities before the practical and even encourage learning after the practical when motivation is at its highest.

The second aspect is related to renewal, participants find that the renewal should be more frequent as they can sense their skills are decorating months after the BLS course. However, they also understood that this was not really feasible due to the time demand of a session, the cost and the availability of regular sessions.

The final learning aspect was the connection of the practical to a real situation. There seemed to be an emotional disconnect within the practical to a real life emergency. This was unsatisfactory aspect to the training and participants wished that real life examples could help understand reasoning behind CPR steps to help retain knowledge.

The insights which regards these three main learning themes are formulated into pains and gains. These will be inspiration for developing more concrete design directions. See figure 15 for summary of main Pains and gains.

PAINS & GAINS

Practice

An accessible means of practicing will eliminate the difficulties people experience when searching.

The customers enjoy the ability to explore knowledge in their own time and would like to do so before and after practical.

Individual aspects of the Livis course (e-learning) is preferred over group aspects as there is less pressure and are more willing to learn.

Retain

The customers desire to learn is at its peak after the practical.

Customers start to lose confidence in their skills few months after the first practical and desire to practice these skills.

Confrontation of abilities through questioning and decisions making can be a powerful motivator to improve ability.

Connection

The practical experience was lacking a connection to the real emergency experience.

In a real life situation people experience feeling of doubt, burden and responsibility. Addressing these emotions in training can give the learner more confidence.

Figure 15: Summary of main Pains and Gains for the Learner

CH 3: GIVING LIFE TO CPR

Strategic formulation of innovation within the future context

The possibilities for development in CPR training is becoming more and more apparent. The possibilities are now formulated into design directions for the project. These directions are then evaluated and selected based on project goals.

Design Directions:

Methodology:

Problem Definition - This section takes the insights from the previous analysis and defines them as a specific problem. This problem is then further elaborated to a design direction and visuals to illustrate how to fulfill the objective in the specific situation.

Within the analysis, an understanding of the problem was gained along with an understanding of the stakeholders values. This section contains a deconstruction of each problem discovered and then a design direction which could be viable to obtain a concrete solution. Each search area was further elaborated with regards embodiment. The visuals and description of these embodiment ideas can be viewed in Appendix H.

Direction 1: Personalised Learning

In the current learning scenario participants achieve CPR skills within a single practical session. It was discussed in the session that participants could easily become lost, and needed further instruction in order to continue learning. However, there is limited time and the instructor may not be able to give everyone individual time to ensure there is the required understanding. This aspect of having limited time results in participants having poor CPR skill acquisition.

Personalized learning offers the ability for the practical to adapt to individual capacities and learning style of the person. Personalized learning refers to the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content may all vary based on learner needs (Stevens, 2017). It also tries to make learning activities meaningful and relevant to learners, driven by their interests.

There are several approaches to personalized learning and currently Livis even using individualized learning in the form of e-learning tools prior to the practical. E-learning allows the learner to adjust the pace of which they receive CPR technique information. There is an opportunity to further incorporate technology into the practical session, which can motivate students to learn and allow them to achieve the specific skills required.

Exploring this design direction is generalized as a personalized learning solution within the practical. An example, could be competency-based learning where learners advance based on their ability to demonstrate competency. This is illustrated in Figure 16 where the practical is set up in stations and the learner has the chance to focus on one skill at a specific station until they achieve competency and then will move to another station to learn a new skill. Another example uses learning objectives to motivate students. In figure 17 the students are working towards a common team goal and can only achieve this goal if all students perform the skill to a specific competency encouraging communication and open transfer of knowledge.

28. Stevens, K. (2017). What is Personalized Learning? – Personalizing the Learning Experience: Insights from Future Ready Schools – Medium. Retrieved from https://medium.com/personalizing-the-learning-experience-insights/what-is-personalized-learning-bc874799b6f

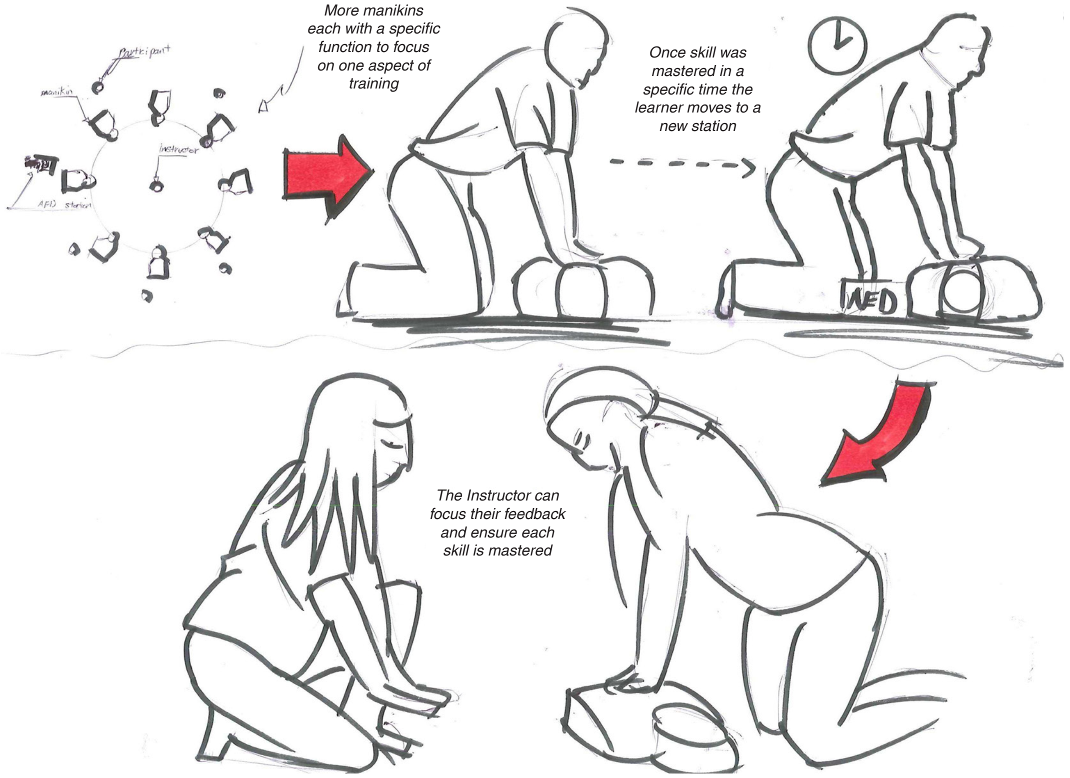


Figure 16: Visualised separate stations in practical to obtaining CPR skills

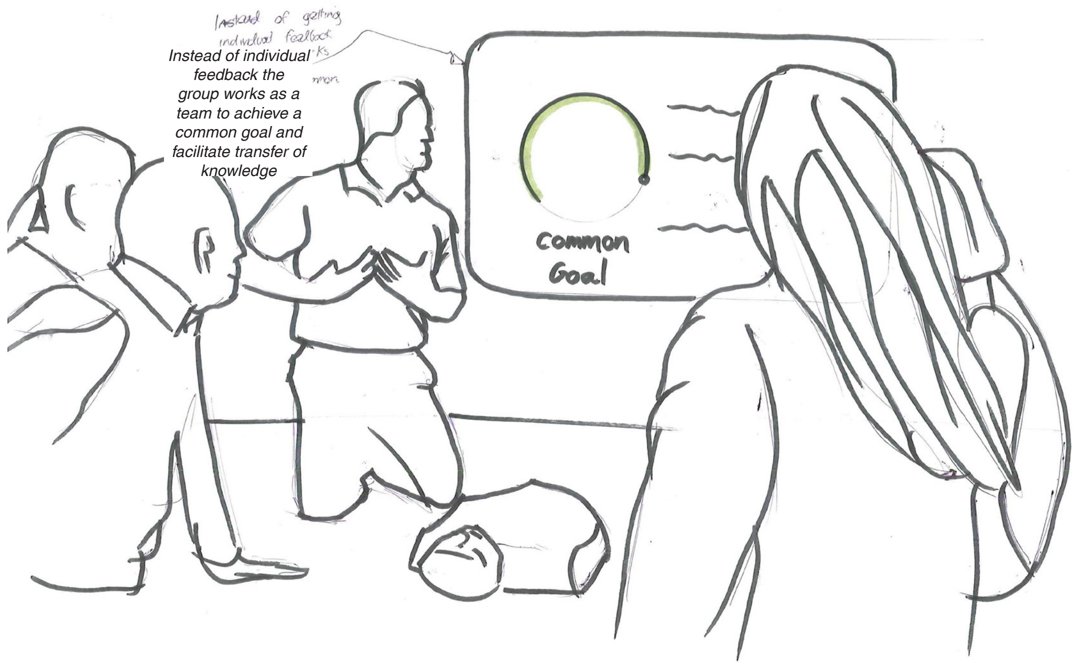


Figure 17: Visualised practical setting where group work towards a common goal.

29. Dracup, K. (1986). Cardiopulmonary resuscitation (CPR) training. Consequences for family members of high-risk cardiac patients. Archives Of Internal Medicine, 146(9), 1757-1761. doi: 10.1001/archinte.146.9.1757

30. Luxford, k. (2010). Patient-centred care: improving quality and safety by focusing care on patients and consumers. Australian commission on safety and quality in health care (acsqhc).

31. What is person-centred care and why is it important?. (2016). Retrieved from https://healthinnovationnetwork.com/system/ckeditor_assets/attachments/41/what_is_person-centred_care_and_why_is_it_important.pdf

Direction 2: Family focused

Patient-centered care is a concept of thinking and doing things that sees the people using health services as equal partners ("What is person-centred care and why is it important?", 2016). It involves dimensions of emotional support, communication and involvement of family. The future of patient-centered care shows recommendations to develop procedures for involving patients, families and carers in their own care through program development, patient safety initiative and healthcare design (Luxford, 2010).

Currently, doctors do not incentivize the family or informal caregivers to be prepared for the patient who is at risk of a cardiac event. Even a majority of physicians are reluctant to recommend CPR training for families due to fears of heavy burden and CPR being performed ineffectively (Dracup, 1986). But results from the session and recent studies show that families want to learn and be prepared for a cardiac event (More details are present in Chapter 2, Pages 24 to 29). With the future of caring giving a greater emphasis on supporting healthcare design that is centered around the patient, there is an opportunity within CPR training to create a means of preparing the family of those at risk of a cardiac event.

The current problem is that informal caregivers are currently not encouraged to learn and do not have training system which caters to their specific training needs. The opportunity lies in designing a solution which encourages family members to train and also allows them to be prepared to perform in a real event where emotions can be heightened.

A possible direction for the project based on this discovered problem is parents of a child who is at risk. Livis have observed that many parents seek to learn CPR before the arrival of their child. The embodiment could be a wearable that has the ability to know when was the last time the parent practiced CPR. Over a period of time, the wearable could notify the wearer to train again as their skills may have deteriorated. The wearable could even track there performance when they would train to give an understanding of CPR competence. The wearable will give support achievement of learning goals and also motivation to continue renewal of skills, in order, to feel prepared for an emergency event. See figure 18 for a visual of this design direction.

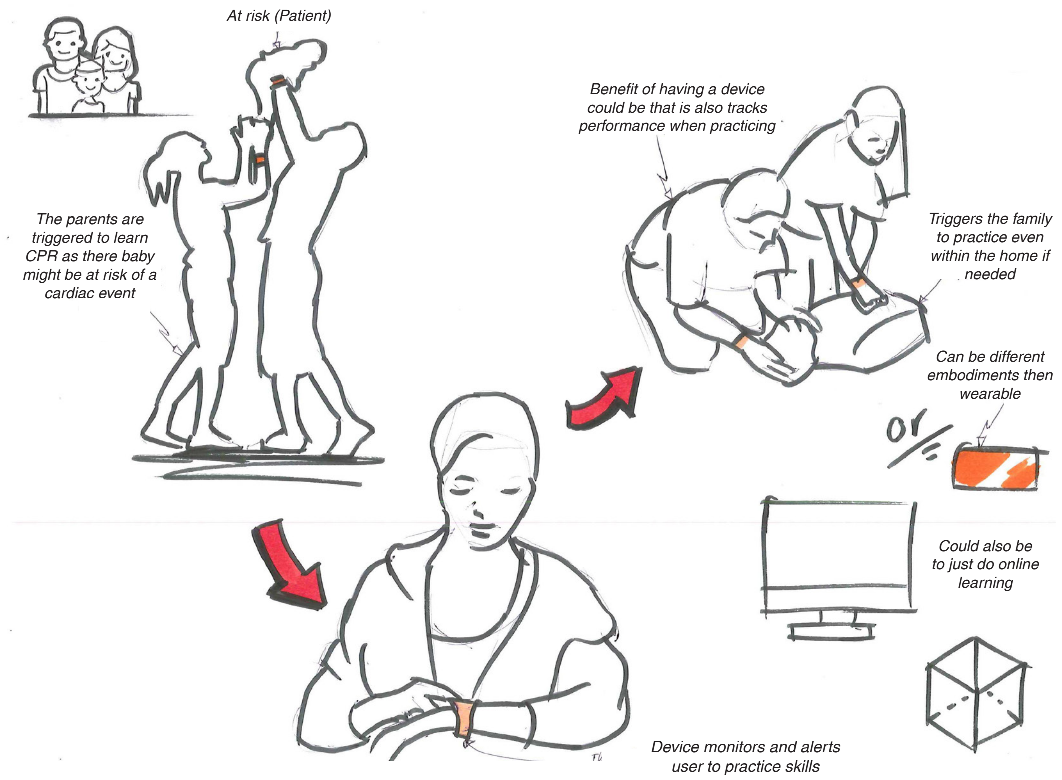


Figure 18: Visualized device to help parents learn CPR.

Design direction 3: Personal Training Aid
In the current practical session, the most popular training aids used are prompt manikins. A prompt manikin is visually realistic with CPR ques but does not give feedback on the learners actual performance. Feedback devices are now recommended by resuscitation councils over prompt devices. These give the user an understanding of their actual CPR performance and studies have slowed dramatic increase in skill acquisition. Even the AHA (American Heart Association) has stated that from 2019 their courses will require the use of directive feedback devices or manikins.

Feedback devices also offer the opportunity to practice CPR outside of a practical session as it reduces the need for an instructor to correct the performance. The session conducted in Chapter 2 observed that the barriers which are preventing people from attending are the availability and time demand of the courses.

The main problem observed is the practical session is using outdated training aids deemed insufficient for skill acquisition, while also being time demanding and rarely accessible for learners. An opportunity lies in developing a training aid which can be used outside of a practical setting (e.g home environment) which can give direct feedback on the learners actual CPR performance. This solution would eliminate the need for learners to find available courses as the aid can be used whenever the user deems necessary. The learner also obtain feedback to correct their performance and reach specific goals.

An example of a possible embodiment is a personal device the user would own and can use to practice CPR. It could give tactile and visual feedback as the user practices to allow the user to correct their performance. It would be suitable for the home and give feedback on vital CPR aspects. This is visualised in figure 19.

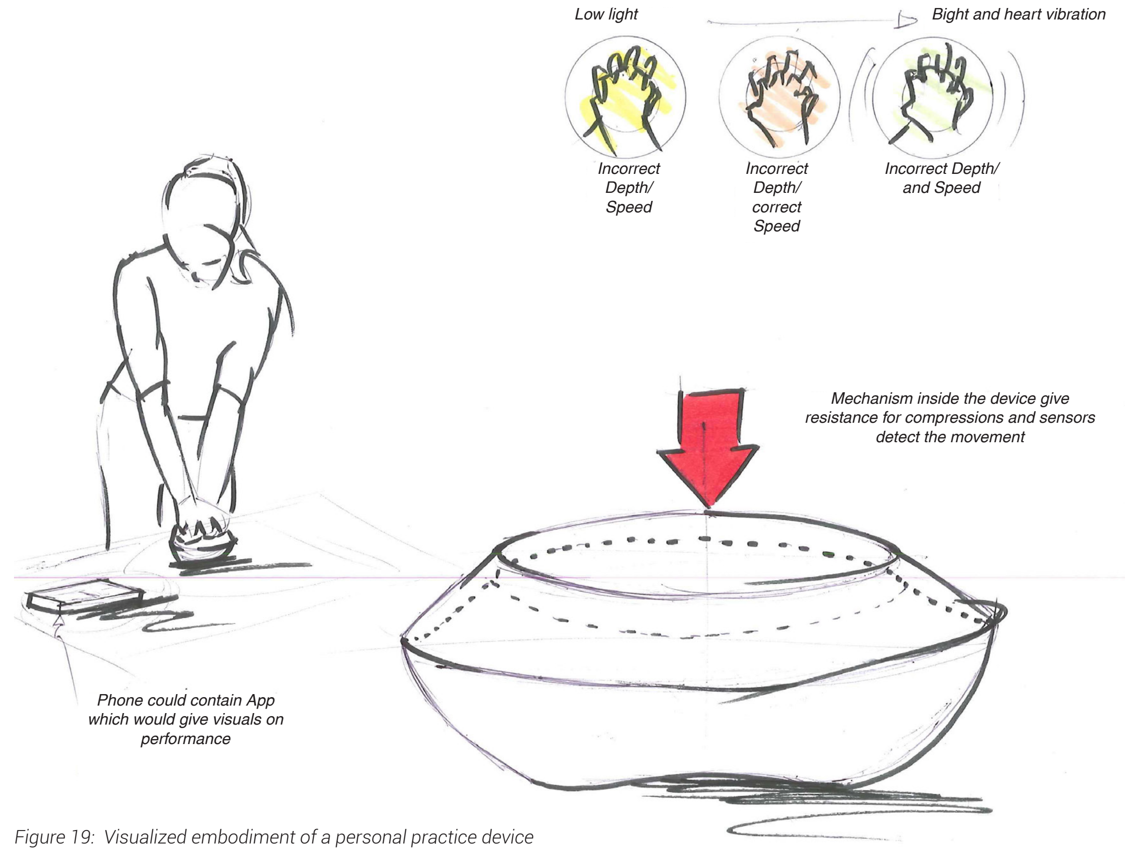


Figure 19: Visualized embodiment of a personal practice device

Personalised Learning
Address the opportunity to have specific goals to obtain in a training lesson. This motivates students to learn. It can create a educational setting which is more personal, more flexible and more user-centred for the learner. Using technology and personalised learning techniques to enhance the experience.

Family Focused
Family members who want to learn CPR but are currently not encouraged to learn and do not have training system which caters to their specific training needs. Family focused looks at the opportunity to encourage family members to train and prepared for the heightened emotional response of a real emergency.

Personal Training Aid
Feedback devices offer the opportunity to practice CPR within the home as an instructor is not needed to correct performance. A training aid which is suitable for self learning in a home environment will eliminate the barriers the learner experiences when trying to attend a practical and retain skills.

Figure 20: Summary of design directions

Methodology:

Value Curve - This tool was used as a method to visual represent what the potential customers think about the possible design directions and understand the perceived benefit of each solution.

Value Curve:

The design directions have been evaluated against company values within Figure 21. This graph show the possible benefits and limitations of implementing each solution within Livis. However, It is also important to understand the benefit of each design direction in relation to criteria that customers find important in order for Livis to take advantage of customer needs.

After the session (Chapter 2, Page 24-29) the participants were presented with a short description of each design direction and its benefits. Then they were given an example of how this could be implemented in the form of a storyboard styled sketch (figures 15-19). Then the participants were asked to give their opinion of this idea bases on certain criteria. The criteria were created from literature reviews analysis, competitor analysis and customer values discovered at the session.

Due to the small representative target group at the session the results were compared with previous Livis market analysis and questionnaire results as to it validity. (See Appendix I for questionnaire) The facilitator guided the participants to give assessments in terms of these criteria:

1. Cost: This is in terms of how much they would be willing to pay to have access to this potential idea and relate this to the cost they have already encountered learning CPR.

2. Accessibility: This is in terms of how accessible the potential idea would be for the participant reflecting on whether it eliminated the barriers which caused previous experiences to be less convenient.

3. Feedback: Generally each idea was presented with a difference in the means of communicating feedback to give the participants and understanding of their CPR quality and gain skill acquisition. The participants would give their opinion on this feedback within the context.

4. Motivation: Each design direction uses some aspect of its design to increase the motivation of the participant to learn CPR, to improve CPR quality or to renew skills.

Figure 21: SWOT analysis overview with links to the integration of CPR training solutions

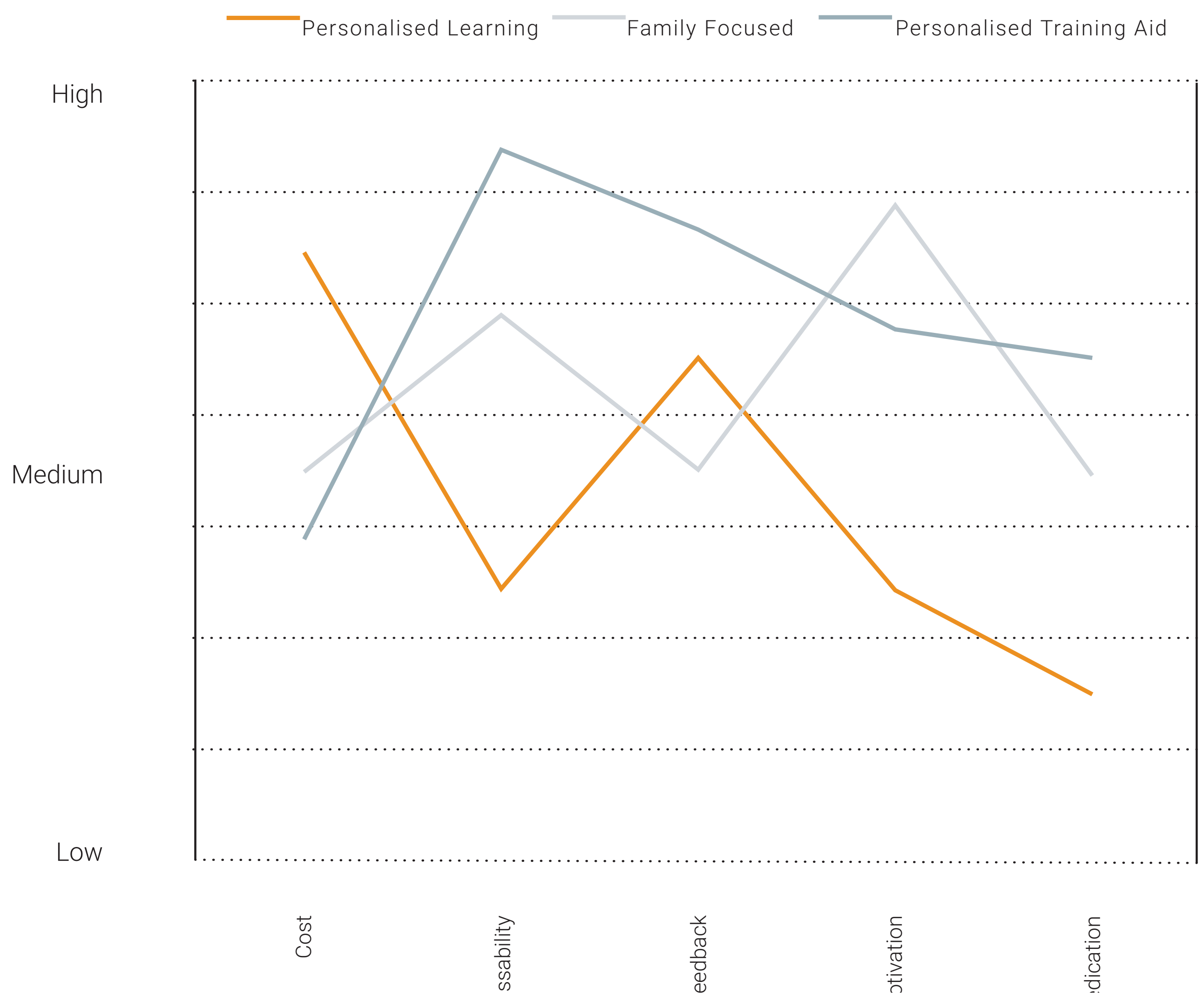


Figure 22: Value Curve of consumers opinion of each search Area

The participant was asked if this aspect would in fact motivate them within this context.

5. Time Dedication: Currently the practical course can be anywhere between 4 to 6 hours but the participant can spend more time obtaining skills due to searching for course, preparing for course, travel, etc. Therefore, the dedication of the participants time can be quite demanding. Each idea did not have the sole focus of reducing time dedication but it could possibility be a side effect of the new means of obtaining CPR skills. Each participant was asked to give an assumption of whether this would require increased or decreased time dedication.

The results are presented in the visualization of a value Curve in Figure 22. It shows the general consensus for the participants with regards each criteria for each design direction. The is arbitrary in terms of Low. Medium and High. Used solely as indication with regards potential customer opinion.

Even though the personalized training aid had some concerns with regards potential cost it scored high with regards the type of feedback desired, accessibility and motivation. Personalized learning had mixed reviews by the participants with some being very interested in the potential learning gains of the direction while others not seeing the benefit and commented that it was too similar to current course layout. Family Focus was also received well but participants felt there was too much reliance on motivation of others which is hard to predict and the device could just be a distraction in an actual real emergency situation.

Selection:

Methodology:

Weighted Scoring Method- is a tool that provides a systematic process for selecting projects based on criteria. In this project it is used to relate stakeholder relevance to design directions.

All four design directions where shown to have potential for bystander rescuers, but not all of the directions are relevant for the stakeholders of this project. A weighted scoring table in figure 23 provides a visual overview of the design directions and their importance for the different parties involved. This potential is based on the SWOT analysis of Livis, graduation project motivations and the mission of the industrial design faculty ("Design for our Future"). The percentage calculation of the weighted factors shows that direction 2 and 3 come out on top.

It is important to note this scoring is only used as a visual indication factor for the design direction. The value curve described previously also influences the project direction in order to cater to consumer needs. However, The primary decision for a design direction is the one which provides most opportunity for innovation in the future healthcare market and provides the most possibility for skill acquisition and retention for bystander rescuers. This is because these factors will ultimately achieve the end goal, which is to save as many lives as possible through quality CPR.

The "Family focus" has potential in terms of motivating more people to learn CPR but, the search area is solely based on changing behaviors and attitudes towards CPR intervention. The real objective of this project is to increase the learner's ability to retain and implement knowledge. This search would be limiting in addressing these aspects. The innovation potential is much higher for a personal training aid due to a focus on quality feedback within the learning experience and increasing the accessibility/possibilities for obtaining CPR skills.

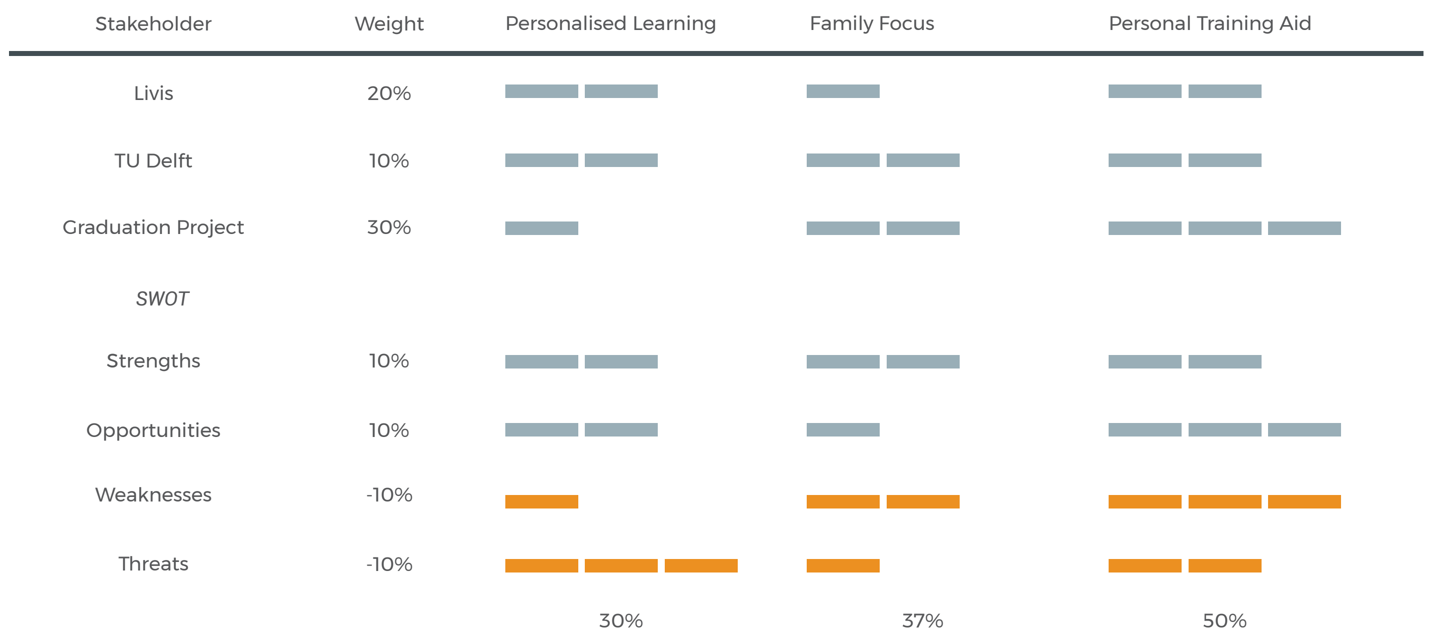


Figure 23: Weighted scoring method results

Design Goal:

Saraç, L., & Ok, A. (2010). The effects of different instructional methods on students' acquisition and retention of cardiopulmonary resuscitation skills. Resuscitation, 81(5), 555-561. http://dx.doi.org/10.1016/j.resuscitation.2009.08.030

The traditional Basic Life Support (BLS) session provides limited time to actually practice CPR skills and self-instruction opportunities can offer a more effective means for training lay rescuers in CPR. It is shown that skills practiced in isolation over several session is more effective in training lay persons (Saraç & Ok, 2010). Hence, several shorter sessions with emphasis on practice can be the most effective system. However, in reality there is no possibility to train in this manner which is realistic and accessible for the average layperson. This is due to the cost of the session, the accessibility of sessions which would focus solely on practice/evaluation of skills and the time requirement.

The design goal is to create a convenient and personal training aid which provides feedback on the learners actual performance to assist in the mastering of vital CPR steps. This practice device would eliminate the need to attend a training session in order to learn or perform CPR.

Feedback within the device should be understandable and designed in such a way that would give the desired connection to training and a real emergency experience. The hope is this connection will allow the user to gain an understanding of the importance of their actions.

The training aid will have functions which allow the user to learn, practice and evaluate vital CPR skills. Firstly, It communicates information about recognition of a cardiac arrest situation, before the user begins to practice the correct administration of CPR. Once the user is satisfied with their practice, they can choose to evaluate their skills. The user can then perform CPR for a duration realistic to a real life situation and summative feedback of performance is then provided. This allows the user to relate their skills to a desired performance and to understand CPR aspects which they have not yet mastered.

The users are people who are motivated to learn CPR ,realizing that this is a vital skill they must obtain in order to help the whose around them. These can be anybody who are responsible in caring for others such as informal caregivers, volunteers, new parents and even a partner of someone at risk. The device provides users with an opportunity to learn the most critical steps in CPR in an environment which the user finds most comfortable. The feedback they receive is informative and educational but it also links the training to an emergency situation. The consistent training in a low dose high frequency manner not only increases CPR skills but increases the perceived responsibility to help those in need due to your training commitment.

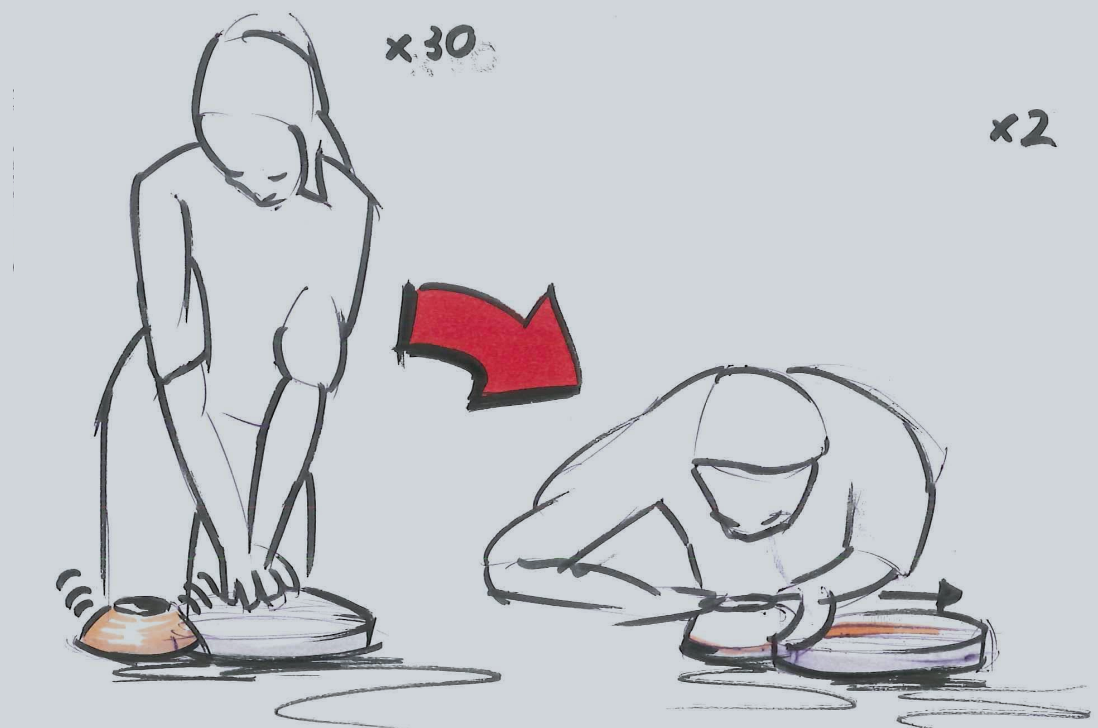


Figure 24: Sketch of design direction

CH 4: PUT HEART IN CPR TRAINING

The advantages, integration and detailing of the designed concept

The potential for making advancements in CPR training system has been documented in previous chapters. It remains unclear how the solution could be integrated to provide a genuine added value and contribute to saving lives. This chapter justifies the design decisions for the concept integration and concept functions. The concept is then detailed further in a use case scenario.

The Design:

Methodology:

Design Criteria- These are the specific goals for the design. Considered important especially for medical design to ensure the adheres to regulation and justify funtionality.

Many resuscitation councils feel the translation of emerging scientific knowledge into CPR practice is the key to optimise the ability for OHCA victims receiving the highest-quality of care. The 2015 AHA (American Heart Association) education guidelines have discovered key recommendations for improvements to practice CPR.

These are the following:

Corrective Feedback: Devices which provide feedback on performance are now preferred over devices that just provide prompts such as metronome, etc. These devices have shown greater assistance in psychomotor skill development.

High-fidelity Manikins: are encourages to use for programs which have the infrastructure and these manikins should resemble the human anatomy.

Emphasis on Practice: BLS skills have been shown to be learned to a higher quality with instructional videos and greater hands on practice compared to traditional instructor based courses and AHA would prefer to implement this possibility more.

Self-Instruction: A combination of self-instruction and instructor led course with hands on practice is considered a more effective alternative to the traditional course structure especially when it comes to lay rescuers.

Pre-course Preparation: Online learning (such as Livis e-learning) to review appropriate content is being promoted over just attending a practical course.

More Frequent Training: Two- year renewal course is not optimal. More frequent training would be preferred for BLS skills especially for lay provides who are more likely to encounter a cardiac arrest.

Many of the resources for these training guidelines are from journals which have influenced and even overlap with the ERC 2015 guidelines. These guidelines have been chosen to influence for design criteria, as they represent the future direction of CPR training. previous research documented in Ch 1 and Ch 2 has also influenced the design criteria .These design criteria will provide an added value to the designed concept which respect to increased learning possibility and would give the concept an advantage over competitors who have not yet adapted training aids to the new regulations and guidelines. The design criteria can be viewed in Figure 26.

32. Highlights – ECC Guidelines. (2018). Retrieved from https://eccguidelines.heart.org/index.php/circulation/cpr-ecc-guidelines-2/part-14-education/highlights-introduction/highlights/

What is the impact of intervention on survival rate of victims of OHCA?

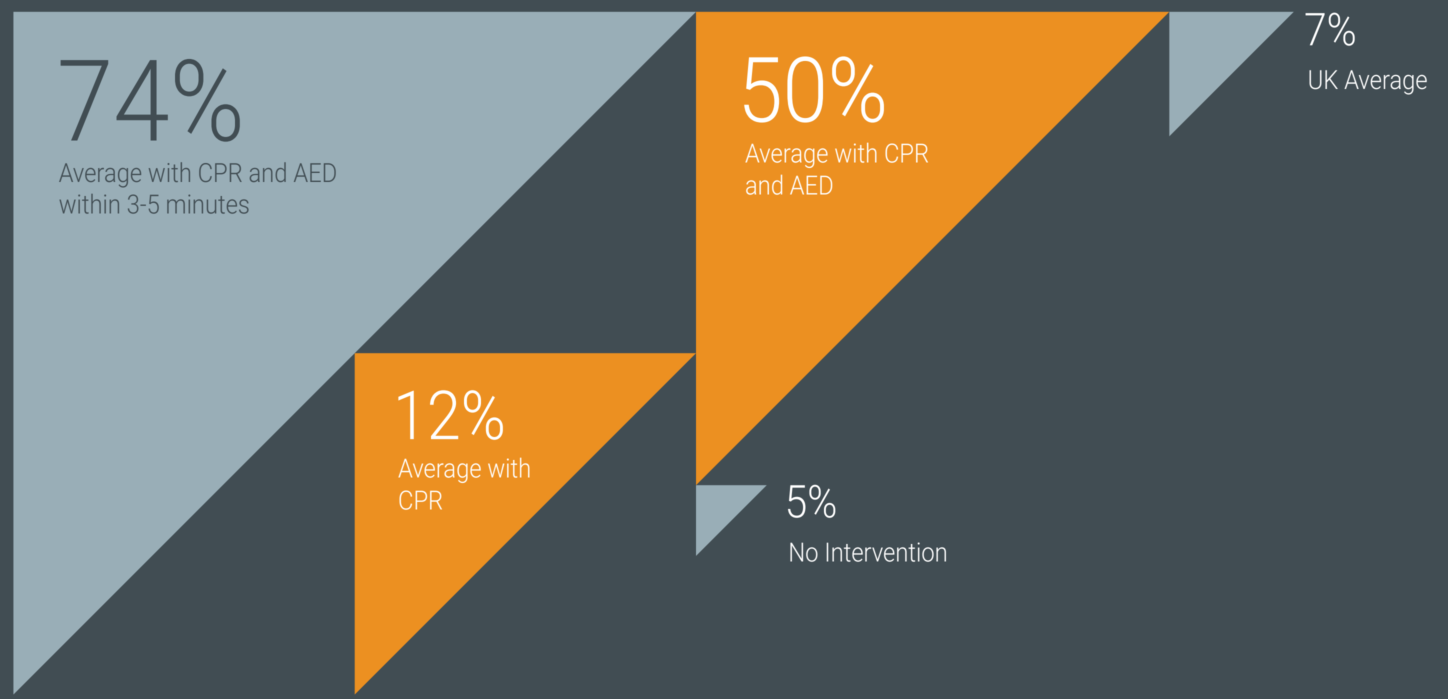


Figure 25 : Overview of the impact of intervention on survival of the victim of OHCA

Design Criteria

Corrective — Feedback should have minimal complexity, both in the presentation of the content and the breadth of content covered to enable the accomplishment of core CPR skills.

Self Directed — Skill demonstration should be presented in a consistent manner. With use of a instructor restricted or significantly reduced. to promote self_instruction

Contextual — Emphasis should be on creating a training which can be applied to the learners' real -world scenario and create a link with the training and a real cardiac event.

Practice — Ability to achieve more hands-on practice is needed to meet the psychomotor skill performance.

De-briefing — Provide summarised feedback or debriefing is a component of the experiential learning which allows the learners to have an opportunity to reflect on their performance and understand how to improve in the future.

Assessment — The concept should ensure an achievement of competence and provide a clear benchmark for learners to strive to complete this can also be the basis of feedback and promote continued learning over time. Ensure these objectives are clear and measurable.

Accessibility — The training should be accessible for the target audience in terms of cost feasibility, training time demand and training location.

Figure 26 : Design Criteria to steer design direction

Concept Advantage

The solution will provide the directive feedback for the lay learner in a self-directed manner to increase knowledge, skill acquisition and retention. The new focus of training to be on quality of skills obtained. This will ultimately effect cardiac victim outcome should the learner utilise their CPR skills.

From the trials of using existing feedback devices in Livis current training session, there, are some logistical concerns in relation to understanding and easily observing real time feedback. Instructors had some reservations to using the device, claiming that "it could be distracting to the participants" and "demotivating". A majority of participants within the trial were renewing their CPR skills and claimed that "practice with the Feedback app was better than without." This showed that within this project the design is especially beneficial when feedback is more comprehensive and motivating for the learner then current solutions.

Their trails were conducted in the traditional practice environment but this concept hopes to have a limited interaction with an instructor. The AHA guideline has not currently linked the benefits of feedback with self-learning but has identified that CPR self-instruction through video and/or computer-based modules with hands-on practice is a reasonable alternative to instructor-led courses ("Highlights – ECC Guidelines", 2018). The ERC has even emphasized the importance of course accessibility for training primary caregivers and/or family members of high-risk patients. Therefore, the self-learning or a blended learning concept would even add to the progression of translation training implementation from scientific discoveries.

Given the rapid decay of skills after training and the observed improvement of skill and confidence among students who train more frequently, the ERC have started to see the limited benefit of renewal courses every 2 years. There is no current recommendation as to how often people should be training but the trend is that frequent refresher training with cost considerations, would be overall beneficial to the learner and training centres. Therefore, this design solution provides a means to explore this aspect of increased training interval and adds to the overall perceived benefit of the design.

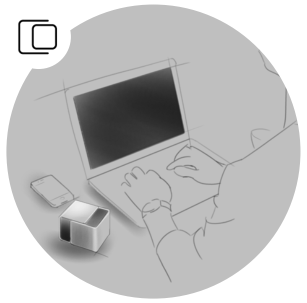
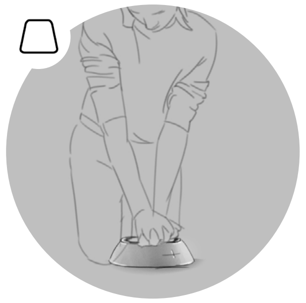
In conclusion, The real value of the design thus lies in its ability to provide comprehensive feedback, self-instruction with hand-on practice and cost effective regular training sessions. Currently, these aspect are non-existent or poorly executed in the current training system with scientific evidence showing the need for change in traditional training. An adaptable training aid with integrated feedback technology, therefore, provides the ability to enhance CPR skills and confidence of those who are likely to utilise their skills. These aspects will be connected to the previous design criteria to further develop the concept.

Concept Integration

There are a few ways in which the designed solution could be integrated within the training system documented in figure 27. This section details three possible integrations of the training aid design. The focus here lies on the infrastructure around the concept and not the actual physical design. It is the use cases for the concept for which the functions of the concept is similar but not exactly the same. This aspect effects not only the functions but also USP and even the ownership of the concept.

CPR novice:
This product would be the first introduction a learner could have with CPR. Designed for a person who is has sparked an interest in learning, but does not have the desire to attend a BLS course or is unsure if a BLS session is suited for them. The product would eliminate the "fear of the unknown" which can cause people to feel uncomfortable with attending a BLS session as the user can purchase the device and train at home, in work, etc.

The device will have instructional aspects to communicate the vital CPR steps and provide the ability to practice CPR with motivating feedback. The user can gain confidence in their skills to continue learning more extensive CPR/ first aid with Livis online e-material and the device. The


Concept &USP	CPR Novice	CPR Advanced	CPR Expert
	"Learn CPR within the home environement"	"Ability to train to improve CPR Performance."	"Full learning system for the highly motivated"
Explanation	A product which brings the experience of learning CPR skills into the comfort of the home. It targets those likely to not attend a traditional BLS course. It would provide instruction on the core CPR skills of compressions and ventilations. The aid will focus on tactile real time feedback.	A product which increase confidence to administer quality CPR. It give the ability to practice in a practical and in users own time with a compact personal training tool. It monitors the users performance and provides feedback to help improve skills.	This product service system focuses on low dose high frequency learning. It consists of a self directed learning with hand's on practice then followed by time with a real instructor to further develop skills. Then an assessment of skills over a period of time to promote skill retention
Ownership & Target Group	Privately owned aid to provide CPR Knowledge and Practice Young Adults New Parent's Informal Caregivers	Privately owned aid to provide CPR practice Informal Caregiver Active Community Members New Parents First Responders (+)	Livis owned infrastructure with a leased device. Companies which provide training to employees. Medical personnel Motivated lay rescuers.
Functions	Instruction: Focus on Core CPR skills. Practice: Ability to practice compressions + Ventilation. Informative Feedback: Real time tactile feedback to understand actions. Retention: Focus on communicating the correct steps & several training sessions	Practice: Easy accessibility to practice skills. Evaluation: User can evaluate CPR in comfortable environment. Corrective Feedback: Real time feedback and summative assessment Quality: Repetition to improve CPR quality	Instruction: Providing knowledge for all BLS steps. Practice: Ability to practice compressions +Ventilations Evaluation: User + instructor can evaluate performance Extensive Feedback: Feedback systems for User, Instructor and Livis.

Integration

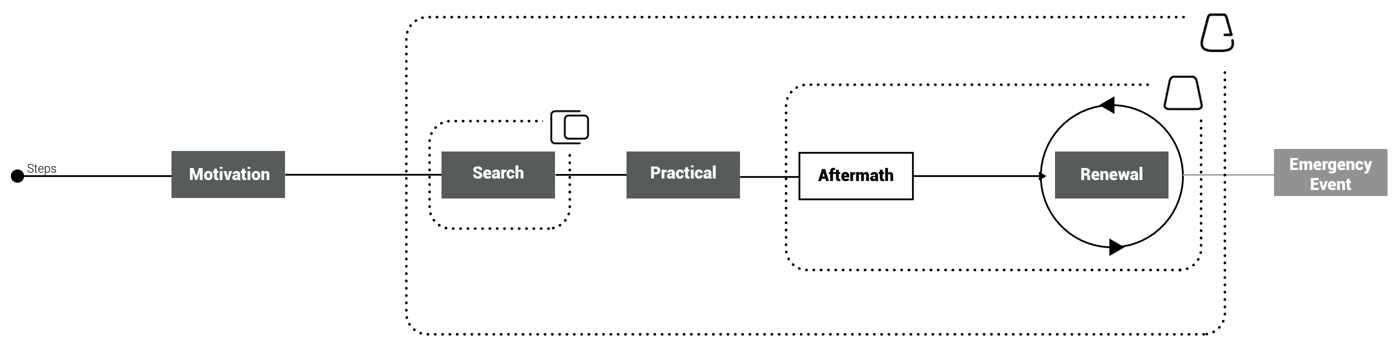


Figure 27: Overview of different integration strategies

value of this concept is giving learner's an alternative avenue to train which eliminate the barriers people experience when searching for a suitable training course.

CPR Advanced:
The device would be used within a BLS session to give self-directed learning and comprehensive feedback possibilities. If learner desires to continue practicing or renewing their skills they can purchase or rent the device to train in their own time. This concept would complement the existing BLS session and would provide a substitute to a renewal course.

It is targeted at those who have attended a BLS session and now desire to practice and improve their skills. After the participant attends a BLS course, their desire to learn and improve skills tends to be high but they find no avenues of practicing skills outside of the BLS session. Even a few months after the course they feel their skills deteriorating they could be triggered to consider purchasing the device in order to practice their skills. The device would be suited for those who are caregivers of a patient who is most at risk of a cardiac arrest and even first responders within a community (teachers, volunteers, etc) who must have confidence in their skills and find difficulty attending renewal course.

CPR expert:
The final integration of concept is designed to bring people though the full training with learning, practice and assessment possibilities. The device would be part of a BLS course which has self-directed learning, practical session and evaluation stages. The device is integrated at each step to enhance the development of skills through learning techniques.

The devices would be leased to a learner as they are completing the course in a low-dose High frequency manner. Firstly, They are provided with an opportunity to practice CPR with online self-directed learning and assessment. Once this stage is complete, the user can then attend a BLS session where the device will the integrated to provide the instructor with objective measures on the learner's CPR performance. Finally, After attending the course the user will be given several assessments of their skills over a period of a few months. This will help the user to increase skill retention with informative summative feedback.

The benefit of this device is that it can bring CPR confidence and competence with training that is spaced over a period of time to achieve quality CPR skills and maintain training motivation. This would be suited for large companies who must provide training for first responder employees, medical professionals or highly motivated learners (volunteers, first responders, etc) who are dissatisfied with the current BLS session.

Each of these concepts has an advantage. Instinctively the more elaborate training experience concepts such as the CPR expert seem more complicated to integrate into the current training system due to the many changes to various training steps. The benefit of CPR expert is targeted at medical professionals, EMS personnel and first responders. This demographic does do not fall into the aim of this project, to increase CPR quality of lay persons. The CPR advanced seems to have an advantages as it tackles an issue of skill deterioration overtime. However, CPR novice has a similar target demographic and promotes more people to obtain CPR skills. The functionality between CPR novice and CPR advanced is not very significant. Therefore, the concept going forward is a combination of CPR novice and CPR advanced. It is a concept which can be offered by Livis as an alternative to a BLS practical but also double as a means of practicing skills regularly for learners.

Functional Detailing:

Methodology:

Morphological Chart - Helps to generate principal solutions for product functions. It deconstruction the main function unto its sub-functions for a controlled and systematic ideation.

33. Kim, Y., Yu, B., Oh, J., & Kim, T. (2017). Novel Chest Compression Depth Measurement Sensor Using IR-UWB for Improving Quality of Cardiopulmonary Resuscitation. IEEE Sensors Journal, 17(10), 3174-3183. doi: 10.1109/jsen.2017.2680454

The functions required for the Concept have various sub-functionalities in order to fulfill the desired design criteria. Figure 28 shows the functions of the device (Feedback, Self -Instruction and hand-on practice) and breaks these into various sub functions. A morphological chart in figure 29 shows the explorations of different solutions for the mechanical sub-functionalities of the concept. The following conclusions are:

Chest Deformation -There are multiple ways for a device to deform under a load applied. Each of them have some implication on the cost of the device, manufacturing possibilities and the user interaction. The Ora desires to resemble the movements of real human chest to promote the connection to a real emergency event. This means the stiffness of the device needs to be similar to a human chest to resemble the same displacement for the required force. The human chest also has a dampening property. This means it does not give a strong "bounce back" like a spring when force is removed. It has more of a smooth slower recoil. This is possible to achieve by adding a viscoelastic material or a dampening mechanism to result in a more realistic representation of a human chest.

Evaluation of Compression – Several methods exist today to measure compression depth, recoil and tempo. The main requirement for Ora is a cost effective sensor, minimal hardware and ability to be incorporated within the designed training aid. There is a trade off with regards the design of the chest compression portion of the manikin and the sensor used to detect chest compressions. The chest portion must account for the hardware and internal parameters needed for the sensors used correctly. These parameters also affect how the material would deform.

Most CPR assistance devices used in hospitals are based on pressure sensors or accelerometer sensors (Q_CPR, Laerdal and CPR Help, Zoll). Force or pressure sensors are considered to be inaccurate or difficult to implement when measuring chest compression depth (CCD) with the Ora because of the required dampening effect will achieve a non-linear relationship between the force applied and the CCD achieved. Also, accelerometer based sensors have shown considerably high

Corrective Feedback	Self-Instruction	Hands-on Practice
Compression Tempo	Body Position	Chest Deformation
Compression Depth	Hand Placement	Head Tilt/Movement
Compression Recoil	Compression Guidance	Hand position Markers
Number of Compressions	Head Tilt	Mouth for Rescue Breaths
Airway open/closed	Pinch Nose	
Strength of Breath	Cover Victims Mouth	
Hyperventilation		
Number of Rescue Breaths		
Duration of Rescue Breaths		

Figure 28: Overview of the main components of the Concept

accuracies in the hospital setting (Oh et al., 2012). The algorithms used in compression evaluation measurements for Ora could be complex due to integration, filtering and measuring of depth and tempo. The algorithm would also have to eliminate errors generated in relation to the context of use. For example, movement detected but not related to chest compressions such as general manikin movement or rescue breaths conducted.

There are recent studies which consider time-difference-of-arrival (TDOA) sensor, which measures the signal transmission time between two antennas using impulse-radio ultra wideband (IR-UWB), to accurately measure compression performance during CPR (Kim, Yu, Oh & Kim, 2017). This sensor possibility is in development stages and it is difficult to judge is feasibility for this design. However, it did spark a consideration to use a sensor which could directly detect the movement of a certain point of the Ora. A Time-of-Flight principle (ToF) is a method for measuring the distance between a sensor and an specific surface based on the time difference between the emission of a light signal and its detection at the return sensor, after being reflected by the object ("Time-of-Flight principle", 2018). Further research into the cost and integration of ToF sensors showed that they are feasible solution of compression evaluation (See Page 69, Technical Detailing, Chapter 6).

Airway Management – The mechanism for tilting the head portion of the device can vary. It needs to have the ability to represent a moving head to open the airway. The mechanism used should be simple in respect to the materials used, elements needed and manufacturing required. The main objective is to ensure the titling of the head is possible and to minimise the cost for this element. Since it is probable that the head portion would be made of plastic shell which contains the electronic inside, a built-in plastic hinge component seems to be the most viable. However, other options such as a sliding mechanism or a flexible foam are also still considered viable options if a moulded plastic head is not implemented.

Evaluation of breath – The main requirement for Ora is a cost effective sensor, minimal hardware and ability to be incorporated within the designed training aid. There are very limited training aids on the market which actually measure rescue breaths because as measuring breaths can be difficult. Generally, when measuring breath, it is air flow which would be measured. Air flow is a tricky thing to measure accurately as it is dependent on environmental pressure, temperatures and flowrates (Stamatiadis, 2017). Therefore, several sensors are generally used. There are Air flow sensors which are used to measure volumetric flow rate. They seem a suitable solution, however, rescue breaths are over a short period of time, about one second, and this short sample size could have skewed results.

Exhaled air has interesting properties could be detected instead of flow rate. These are change in temperature, sound detection and C02 percentage. A thermistor is a type of resistor whose resistance is dependent on temperature and can be used to detect when rescue breaths are being performed. This is due to exhaled air having a higher temperature then ambient air. However, a thermistor does not have the ability to detect the strength of the exhaled air, which is important to prevent hyperventilation. An acoustic method to measure breath is when a differential microphone acts as a transducer to detect the acoustic signal generated by expired air flow (Vegfors, Ugnell, Hok, Oberg & Lennmarken, 1993). The strength of the breath would cause change in frequency and therefore the strength of the breath can be detected. Using these two sensors seems plausible to evaluate rescue breaths as they are both relatively inexpensive and easily incorporated into the design.

Feedback + Instruction - The feedback is the aspect of the device which could give the strongest connection to a real emergency event. The feedback should have a connection to the actions performed and relate this performance to victims vital signs. Due to regulations preferring audio/visual feedback, these are the aspects that were explored and considered the most beneficial.

There is also a desire to limit the amount of sensors present in the design to

34. Time-of-Flight principle. (2018). Retrieved from https://www.terabee.com/time-of-flight-principle/

35. Stamatiadis, S. (2017). What factors affect the velocity of a fluid as it flows through a pipe?. Retrieved from https://www.quora.com/What-factors-affect-the-velocity-of-a-fluid-as-it-flows-through-a-pipe

36. Oh, J., Song, Y., Kang, B., Kang, H., Lim, T., Suh, Y., & Chee, Y. (2012). The use of dual accelerometers improves measurement of chest compression depth. Resuscitation, 83(4), 500-504. doi: 10.1016/j.resuscitation.2011.09.028

37. Vegfors, M., Ugnell, H., Hok, B., Oberg, P., & Lennmarken, C. (1993). Experimental evaluation of two new sensors for respiratory rate monitoring. Physiological Measurement, 14(2), 171-181. doi: 10.1088/0967-3334/14/2/008

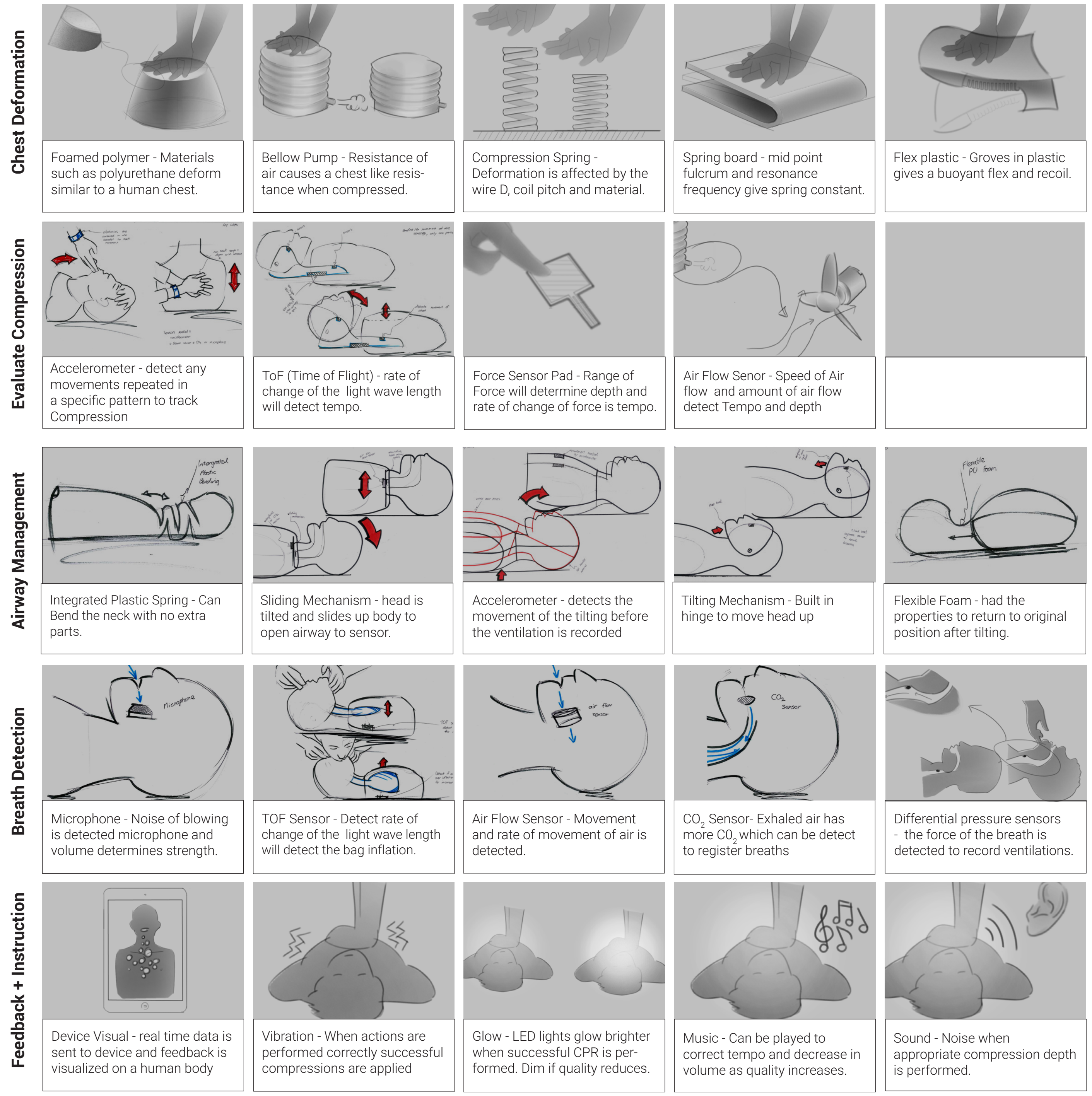


Figure 29: Morphological Chart of Ora development

ensure a cost effective solution. Cheaper actuators such as LEDs and vibration motors were considered to have minimal benefit with regards to design criteria as they have minimal debriefing capabilities (See Page 43,Design Criteria). Connecting the sensors to a visual display would be preferred as all design criteria could fulfilled in order to achieve learning, practice and evaluation aspects. A mobile phone would have all the capabilities of displaying the visual and audio feedback required. Therefore it was considered the most suitable solution

There is a possibility that this feedback could be more distracting than understandable for the learner. It is difficult to understand what a learner would consider intuitive or not. Therefore, going forward the feedback will be tested with the target user to understand aspects which are intuitive and which are more difficult to communicate.

These initial findings for the choices of materials, mechanisms and sensors will now be incorporated into the final design of the LivisOra in the next chapter. There will be further elaboration on aspects of feasible implementation and further justification of design choices.

Scenario: CPR Quality

Methodology:

Storyboard - Is a visual representation of a narrative about the design in a context of use. Helps with an understanding of intended user, context and product use.

The concept will now be refered to as Livis Ora or Ora. This chapter indicates how the design solution would be integrated into the existing system for CPR learning. With the integration of this device it can be consided an alternative to attending the BLS practical course. This eliminates the barrier people experience when they want to obtain CPR skills such as limited availability of courses , intensive time demand and minimal desire to training in unknown setting. Ora provides an excellent opportunity to eliminate these barriers, while encouraging skill acquisition through integrated feedback.

The main aspect of the device is the ability to practice within the home environment but the device can also be offered as a personal practice aid after a learner has attended the practical. The learner can then maintain and even improve their skills within the course to become more competence and confidence.

The resulting scenario of the context of use is the sketches in figure 30. Whereas it does not provide the exact details of the external characteristics of the final concept, it is a approximation. The visualisation is mainly to show the sequence a user would go through in order to:

>><u>Learn:</u> The core CPR skills with minimal complexity on the presentation and breath of the content. This presentation is consistent for every training session as an instructor is eliminated.

>><u>Practice:</u> Creating a training which has an emphasis of hands-on practice to obtain psychomotor skills. This practice has a real time feedback which is informative and has clearly defined targets to achieve competence of skills.

>><u>Assessment:</u> Provides a summarised feedback which gives the learners the ability to reflect on their performance and motivate continued learning to achieve objectives.

Figure 30: Storyboard Sketch of Ora use case

CH 5: WILL IT HELP?

Evaluation of the design proposal to aid in decision making and design detailing

This section details the quality of the design in relation to actual use cases. The current concept is evaluated with experts to understand what is the value of this design to the intended users. Potential users are provides with a mock-up of the interface to gain insights on the usability of the concept. These insights help to create a business plan and analyse the feasibility of the solution.

Design Focus:

38. Atwood, C., Eisenberg, M., Herlitz, J., & Rea, T. (2005). Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. Resuscitation, 67(1), 75-80. doi: 10.1016/j.resuscitation.2005.03.021

For the continuation of this project, to keep the concept manageable, the primary focus will be on the practice of CPR with quality feedback. It is expected that the main value of the product lies in its ability to practice CPR aspects such as compressions and rescue breaths.

The actually concept of LivisOra has more functionality then just providing practice and feedback. The actual concept needs to have a broad number of functions which aid in instruction, practice and evaluation of CPR. All these functions are vital for effective skill acquisition and for the design to meet criteria.

The use case of the concept should be further extended to recognition of when to use CPR, evaluation of CPR skills and training AED use. With this added functionality the full value of the concept is obtained and it can be used in a BLS practical. However, the goal of this project is to increase skill acquisition and knowledge retention and this can be greatest achieved with real-time feedback and practice.

In the current EMS infrastructure it can take on average 8 minute for the ambulance to arrive at the site of cardiac arrest and perform ALS. The layperson should successfully perform accurate chest compressions and provide rescue breaths with minimal interruptions to the chest compressions. Performing these actions can also be tiresome especially with minimal practice. This is a large exertion of energy further complicates performing CPR in an out of hospital setting, with no equipment to rely upon. The concept would allow the learner to prepare for a real situation and practice CPR as often and as long as they desire.

If more people can practice with the use of feedback then the expectation is the increased potential to save lives due to greater CPR quality and confidence. Cardiac arrest is the third leading cause of death with many of these being preventable with quick intervention. If even a small fraction of a percent of these could receive quick and quality CPR treatment due to the use of this concept, then it has value. In conclusion, the design focus, lies on the ability to practice correct CPR with feedback. In doing so, it increases the users confidence in their CPR ability and increases the chance of them intervening in a real emergency event.

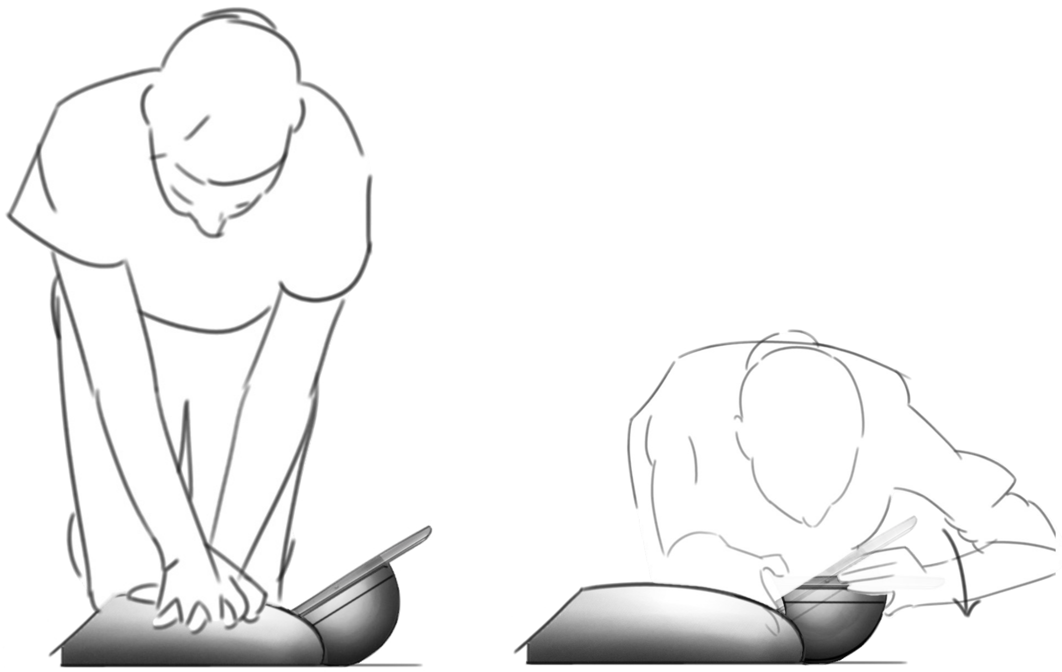


Figure 31: Visual of Concept displaying aspect of focus

Evaluation with Experts:

Methodology:

Product Concept Evaluation - Used to understand how the value in the concept design and determine how to optimize the design.

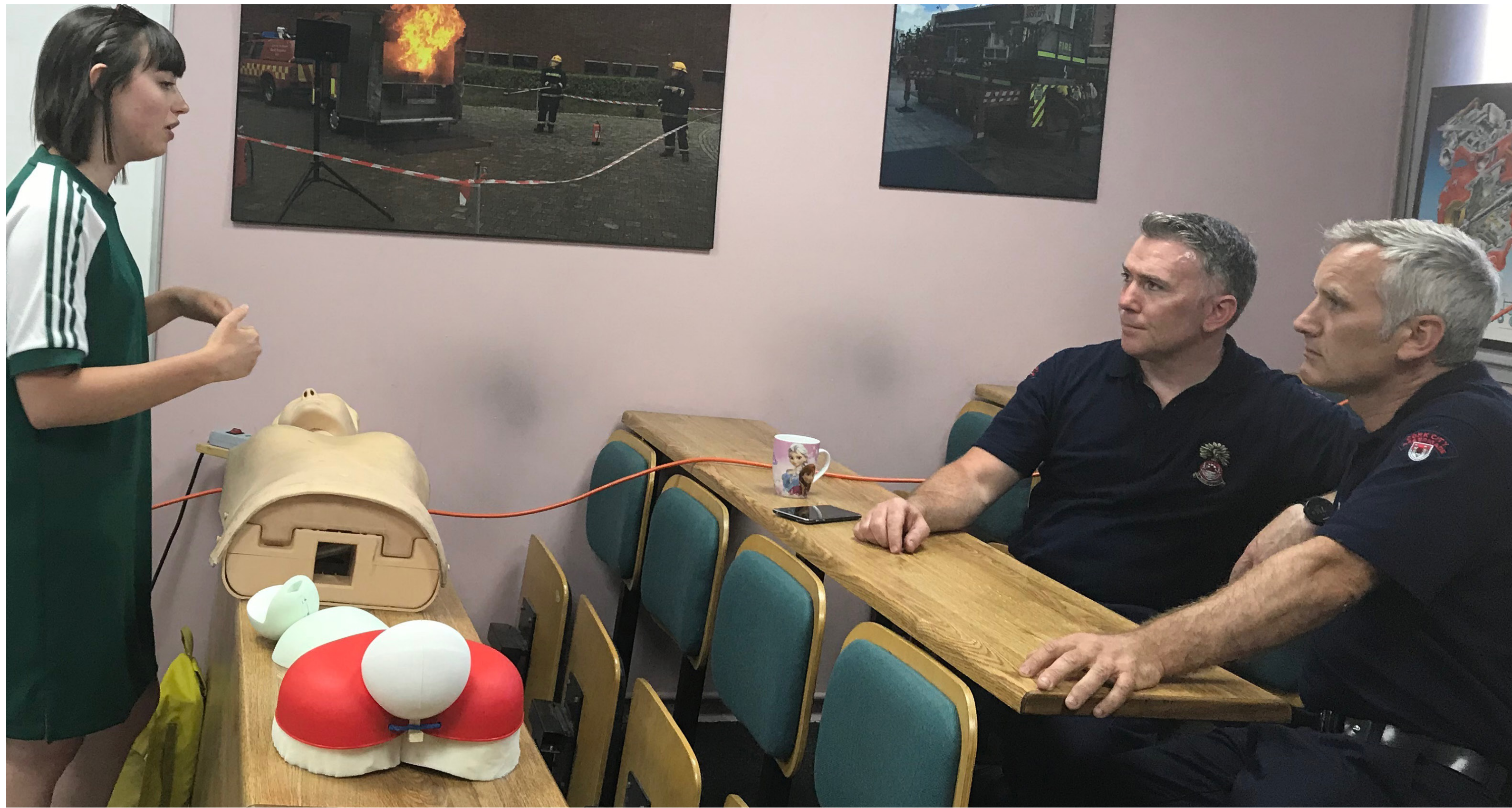
An interview was conducted with the resident firefighters from the Cork City Fire brigade, Cork Fire station, Ireland. The firefighters were considered relevant subjects to interview due to their experience in emergency situations where they have performed CPR on real victims. Two of the four firefighter are also employed as BLS instructors and train laypersons in CPR and other basic first aid techniques. They are knowledgeable about the difficulties people experience when learning CPR and are also familiar with the current equipment available including existing feedback devices in a BLS practical session. Therefore, this target group is considered an expert within the field of my project and the aspects of my designed concept.

The aim of the concept evaluation was to understand the possible issues and limitations of my designed concept. Especially focusing on how feedback is communicated and how the design affects users ability to perform compressions/ rescue breaths for adult CPR training. The experts were presented with representations of my current design, the project goal was described and the concept functions were communicated in detail.

The session was conducted in the first aid training room within the Cork fire station. A traditional manikin used in a BLS session was also provided for comparison purposes. It was used as a benchmark for the designed concept mock-up. Once the project and session goal was explained, the participants were asked to complete a run through of a CPR session using the mock up and voice their thoughts/opinions about using the mock up. Once completed, the facilitator asked the participants questions in order to gain responses directly relevant to the performance of the compressions, the understandability of the feedback and the usability of the ventilation aspect.

All participants saw that the greatest value was the ability to receive feedback within a personal and comfortable environment. They stressed that they are currently reluctant to use feedback devices in sessions as the communication of feedback in this environment can be de-motivating to the students. This is due to the means which feedback is currently communicated within the practical session:

Figure 32: Describing Concept during the Interview at Fire station



"It was absolutely precise and isn't realistic because you wouldn't have to be that absolute to help someone in a real situation. It turns you off if you were getting all wrong, wrong, wrong."

The preferred the communication of feedback was shown through the mock up. This was visual confirmation that the performed action is within a range that is deemed sufficient for adequate CPR support.

It was even mentioned that in the chaotic aspect on a real event, even with their expertise, they cannot perform CPR exact for every situation they are involved with. They prefer to encourage each other when in the field to do their best possible.

"It should be all positive reinforcement. We even do that for each other. We don't have anything, (like) no screen to tell us want to do like the ambulance service. Visuals and give positive reinforcement is preferred."

When verifying these recommendations with other sources, AHA requires a feedback device to "measure and provide real-time audio feedback or visual feedback (or both) on vital CPR skills (compression rate and depth) and this audio or visual information allows students to self-correct their skills in real time.

" Implementing the aspects of providing visual feedback with motivating corrective information, will still allow the device to adhere to regulation guidelines and eliminate problems the trainers have experienced with feedback devices previously.

Secondly, The participants struggled to view the phone screen feedback when giving rescue breaths, but, their main concern was that the learner would not be looking in the correct location for a real situation. In this current design, the phone screen is located on top of the head area of the mock-up. They stated that the existing manikins give a chest rise and they ask participant to view this rise to ensure the airway is not blocked and ensure air is going to the lungs and not the stomach.

"It's good to see it (chest rise) and what we all look for is a good chest rise."

Overall, their recommendation was to separate the phone feedback and ventilation aspect. Then, the feedback would be viewed better and rescue breath aspect would be more representative of real situation through the integration of facial markers (chin, visible mouth and nose) and possible chest movement.

"To make the adequate ventilation you have to make a seal with your mouth.

Figure 33: Testing Mock-up of design during interview at fire station

Maybe some lips or something because then you won't get it correctly. So, that would be something which would be needed. Also, you have to pinch the nose so is important to have."

Another, aspect related to the model aesthetics was the shape of the body portion They preferred the design shape was small and narrow which the participants thought was very similar to an infant CPR manikin.

"Anatomically it would be tiny (the size of the aesthetic model) but for an infant it would be more like that size. The size and head would need to be bigger."

For the concept to be more suited to adult CPR it should have an anatomical human chest shape and be larger in size to represent an adult more. Participants were very adamant that the concept would need to have anatomical markers for correct hand placement and executing correct rescue breaths.

"The sighting for your hands. It would be a good idea to put nipples on it. We say always that it is "central chest between the nipples'".

When designing the concept the aspect of it being realistically human was not considered and the focus was on functionality. The aspect of having a unrealistic human anatomy was considered minimally problematic due to possible gains in functionality and cost consideration. However, after this evaluation is was discovered that more anatomical markers were needed in the design to ensure intuitive learning. When these recommendations were compared with guidelines it was clear that the resuscitation councils also prefer the use of a high fidelity manikin with realistic patient representation.

Thirdly, The aspect of using a viscoelastic foam for a representative human chest recoil was received well. Many participants stated that the manikins they use are not similar to a real person. They also stated the manikin mock-up was too soft but liked the idea and the use of material.

"The recoil is not pronounced (real person), it feels as if you're going down all the time. it's definitely not like the current manikins."

Therefore, for the concept the use of viscoelastic polyurethane foam will be continued.

Finally, In the current BLS session the instructors find the learners have difficulty embodying the required stance and hand position. One participant even mentioning that they can spend up to 20 minutes just communicating the correct body stance.

"We could be on just the posture for 20 minutes, we could even be in debt of time finishing training."

They recommended that if the learner has no previous experience with CPR then they should have the correct stance and hand position communicated within the App as these aspect are important for correct delivery of CPR. This consideration was added to the final development of the App layout.

The participants also stated that the manikin is not suited currently to train AED use but for CPR alone it has all the functionality needed.

Conclusion:
Overall, the participants were very optimistic about the implementation of this concept as they saw the need for there to be an alternative to the traditional BLS training. the found is especially beneficial for caregivers and family members of a patient at risk. One firefighter even volunteers at a young mothers society to teach them the basics of infant first aid.

"I even attend a community group and teach them first aid. They were not interested in doing a formal course but the women's community group have the interest to learn."

The main benefit for the firefights was the use of feedback which is intuitive and motivating for the learner. They see the device ultimately achieves training goals of "giving people the confidence to just do it." Their main concern was the physical shape of the concept not representing the adult human anatomy which could stunt learning and the location of the feedback being difficult to view while performing CPR. Theses aspect will be considered during the detailing of the concept in further chapters and the insights will be translated to design requirements at the end of this chapter.

Usability:

Methodology:

Product Usability Evaluation - Used to validate product usability and understand the actual use case. Modifications were made based on the outcome.

The main focus of the concept evaluation was not to test usability of the concept, as these were not considered the target audience who would use the final design. The experts had vast experience performing and teaching CPR and their experience would be different than someone who is considered a novice (target audience). Taking considerations from the evaluation into account, the feedback was redesigned and the phone location was reconsidered. These aspects of product interaction were tested with the end user.

There were two aspects of this testing. Firstly, the effectiveness and efficiency of the phone application to communicate vital CPR skills and provide corrective feedback when needed. . It is important to note that only visual feedback was presented. There was no audio feedback given, as during the pilot of the test the audio cues make the result difficult to process. It was unclear what factor (audio or visual) was affecting the reaction the participant. However, it is understood that the mix of visual and audio cues could help with achieving better learning experience.

The Second aspect of testing was the most satisfactory location of the phone which allows the user to achieve effortless visibility of the feedback while performing rescue breaths and compressions.

Part 1: App Simulation
The test involved creating a learning scenario which was realistic of the desired learning situation. Firstly the participant was presented with a simulation of how the CPR steps and corrective feedback would be visualized on a screen (figure 34). The user was asked to perform an action or describe an action which they perceive is correct from the visual they are given. Once the action was perform the facilitator asked if they experienced any confusion about the task they were asked to complete. Then the participant would move to the next action.

Firstly, the participants were able to understand and achieve the correct hand position and body stance from the visual. They mentioned there were aesthetic differences from the App visual and the actual model which gave some confusion to the participants. The feedback with regards compression depth was understandable but the participants would prefer if the visual would turn green when correct depth and recoil was reached.

The main problem participants had is

Figure 34: Shows the test set up for Part 1, Computer monitor has Simulated App screen

Figure 35A and B: Shows the 2 CPR stances

they were distracted by the time shown to complete compression. They did not understand is relevance and found it distracting. They would prefer if it stated the number of compressions completed and a goal of how many compressions they should complete before attempting rescue breaths.

The visuals of the actions to open the airway were the most confusing for participants. All participants understood the head tilt but when it came to opening the mouth and pinching the nose the hand positions shown were not representative of the actual hand position needed.

Part 2: Phone placement
After the App simulation test, the participant was given phone mock ups of the feedback screens. The participant was asked to place the phone at a location which they felt would give them the best visibility of the feedback. Then, the participant was asked to take two stances the compression stance and the rescue breath stance (see figure 35 A and 35 B). Once this was completed, they were asked to relocate the phone to a position which they felt might give more visibility. The previous stances were then repeated. Then the facilitator placed the phone at locations which the participant did not explore. The stances were repeated for each phone location. Once the test was complete, the participant was asked to rank each of the phone positions. Appendix J contains questionnaire.

Many participant initially placed the phone by the side of the manikin, in the centre between the head and chest (see figure 36A). Once the ventilation stance was conducted they quickly moved the position to next to the head (see figure 36B). This position was ranked the most favorable by all participants and the least favorable was placing the phone at the bottom of the manikin. The participants expressed that this most favorable phone position should be communicated within the App before starting training.

Conclusion:
The visual communication of CPR skills was considered a success as all 6 participants were able to take the correct CPR stance, hand position and understood all corrective feedback. Design changes included rescue breath visuals and consistency of the design visuals (size, shape, colour, etc). The redesign of the App can be seen in Chapter 6, App Wireframe Page 72-74. The placement of the phone in figure 36B gives best visibility of feedback for both CPR stances.

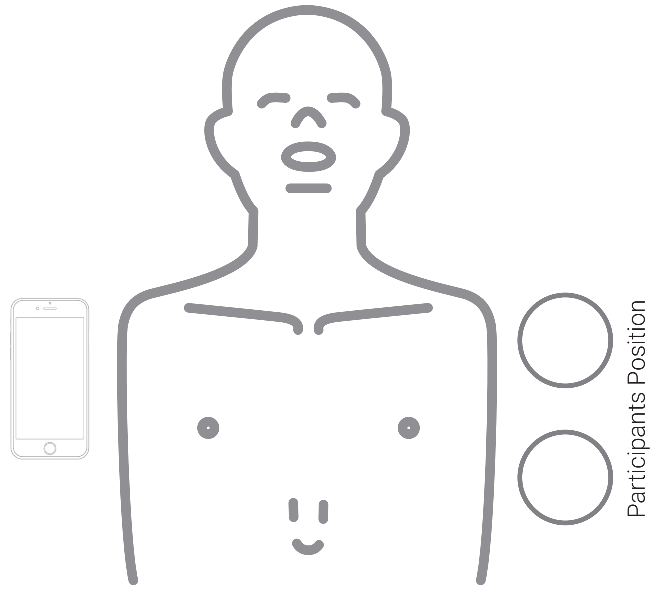


Figure 36A: The first placement of phone by participant

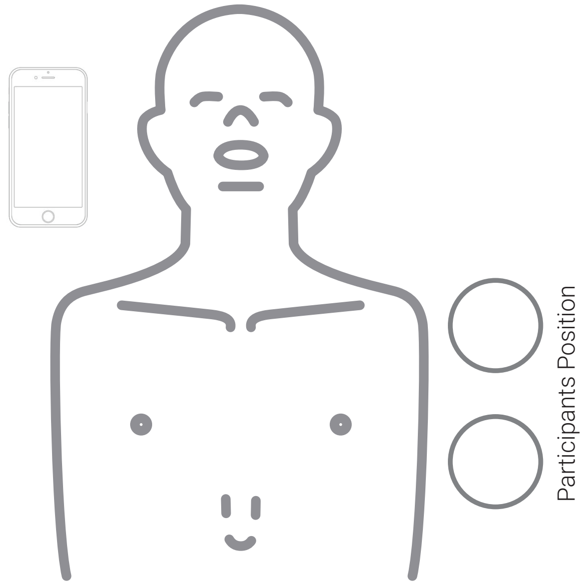


Figure 36B: The most preferred placement of phone by participants

Feasibility:

There are aspects of Ora that influence feasibility of the design. This section documents these aspects.

The proposed concept as an alternate to CPR training is the most favorable in terms of practice and feedback for the possible target market. It can potentially solve many existing issues for people searching to obtain CPR skills. However, the current system of attending a CPR session is already very much established in the Netherlands and highly promoted by mayor organization such as the Dutch Resuscitation Council and Dutch Heart Foundation. To make waves in this established system and to even promote this as an viable training alternative for laypersons further scientific studies should take place on its training effectiveness compared to the traditional course.

In the current system, learners must obtain a BLS certification to verify that the learner has demonstrated a level of providing CPR care to a satisfactory standard determined by a qualified instructor. A BLS certificate is mainly provided as a symbol of your CPR competence under ERC guidelines and does not hold any relevance on whether one should or should not perform CPR when it is necessary. It is mainly used as proof for employers when a job requires such first aid skills such as primary school teacher or a fitness instructor. If the learner only trained with the current Ora concept and never attended a BLS course the learner would not be able to receive a certificate that is recognised by Dutch resuscitation organisations. However, the value of obtaining a CPR certificate for the target group of this project is lessor. The value for this target group is having the ability to comfortably obtain core CPR skills and have confidence in ability (See Chapter 2, Session Page 24-29).

The ERC promotes the use of a high fidelity manikins in BLS training courses. A high fidelity manikin is one which realistically mimics the human body. However, the fidelity of Ora was of lessor importance. One must understand how the ERC ranks what exactly is acceptable fidelity for training aids. Can a training aid that does not focus on realistic human appearance be accepted as a suitable alternative due to its feedback possibilities.

Ora should provide a chest rise when performing rescue breaths to mimic a real life situation. This was a concern for experts with regards suitability of Ora for CPR training. The current design still does not have a means of showing a chest rise as this would require several redesign and tests to see if it if possible to obtain with the viscoelastic material. It would also require the addition of a lung bladder (a balloon under the chest that inflates) which has hygiene concerns for personal and shared use. There are further design complexities and concerns with adding this movement and therefore, it was not fully integrated. It is still possible to add a inflation bladder/chest rise to Ora if this would be a requirement for the product to be accepted by the ERC or Dutch Heart Association.

Methodology:

Price Estimation- Helps to roughly define the cost price of your design in this earlier stage of the design process.

Price Estimation:

It is important to not overlook the cost aspects of the Ora. The Ora concept should be of value to consumers in terms of learning benefit but It also has a direct financial cost. Understanding the cost will help formulate a valid business plan to further justify the products feasibility.

The estimated Cost price was completed qualitatively and quantitatively. For the qualitative approach two existing products on the market were compared to the Ora design. The products are both CPR feedback devices which use similar sensors to track CPR aspects but are different in size, weight and materials used. Ora's less expensive materials, possible labour cost and mould cost were also considered. The resulting estimate is 90 euro consumer price.

For the quantitative method, the starting point was the cost of materials (The CAD model in CH6 was used as reference and the CES programme library). Then the App Development, assembly and packaging were taken as percentages of this materials price to give the manufacturing Cost price. Figure 37 shows how the manufacturing cost price was then used to help obtain the average value for labour, overhead, margin, etc. The resulting Cost price for consumer was €86.20

€88.10 is the average of the qualitative and quantitative price estimations. When discussing this price of the Ora concept with company stakeholders they agreed it was acceptable. Livis charge the same target consumer 100 euro for the BLS course or renewal course. They believe that if this can be offered an alternative to the practical session then users would be willing to accept the cost.

Business Plan:

The desire is to sell the first iteration of the Ora concept directly to the consumer. This plan offers the least amount of risk and requires less infrastructure set-up. Livis already offers online courses and third party products to purchase on their website. Livis can create cross-selling by placing Ora next to other CPR training aids and courses on their website. Cross-selling is inviting customers to buy related or complementary items. Ora is interchangeable with other CPR courses and cross-selling it encourages customers to purchase the product. It also gives a direct line to the target consumers with less marketing and promotion funding.

Also, selling online has financial benefits as it cuts out the third party retailer mark-up. This makes Ora more affordable for the target consumer and passes the profits directly to Livis.

Price Estimation of Ora Device

Details	Euro
Manufacturing Cost Price (Incl, App development, Materials, Assembly + Packaging)	19.65
Overhead Cost/factory Running (15%)	2.95
Labour Costs (5%)	0.98
Factory Margin (profit/risk) (25%)	4.91
Factory Selling Price	**28.49**
Transport, Storage, logistics, etc (25%)	7.12
Buying Price	35.62
Marketing, website, online payment, profit/risk (100%)	35.62
Selling price excl. VAT	**71.23**
VAT (21%)	14.96
Selling price for consumer	86.19
Rounded off Consumer Price	**86.20**

Figure 37: Summary of Consumer Price Breakdown

Methodology:

List of Requirements – design specifications of a product is "good" as it complies with these requirements.

Ora offers distinct benefits that can be effective in tandem with a first aid practical. It could be sold as part of a package with existing online courses to extend the knowledge gained and increase practice time. It could also be sold to learners after they attend a practical and desire extra practice. This is a process known as Customer relationship Marketing (CRM). CRM is when client relationship loyalty and brand value are built through marketing strategies and activities. Livis strengths are its customer relationship (see Chapter 2, Framework of Livis Page 20-21). This marketing strategy would develop long-term relationships and new customers while also streamlining corporate performance.

It is also possible to lease the product as a complementary aspect to the current online and practical training sessions. The learner would use the device at home while they are completing the e-learning before the practical. Within the practical, they bring Ora as their own personal training aid. Once they finish the practical, they return Ora to the instructor who disinfects and returns the device to Livis. The cost of leasing the device would be added to the cost of the CPR training session. This leasing system is deemed viable as it would integrate well with the current training offerings. The main concern is the logistics of continuously sending out the devices to new participants. The size and weight of the device would have to be redesigned to be more suitable for continuous distribution. Also, Livis has a concern that if the user does not actively seek to purchase the device, they would not understand its benefits. The learner could not use Ora before the practical session and forget to return it. However, it could be another business plan if further research shows the cost of purchasing the Ora is excessive.

The product could be sold business to business, such as, selling directly to instructors who would use the device within a session or to schools who can then educate many students at once without the use of an instructor. The cost of the device would be less of a concern. However, there would be hygiene concerns and the device needs to ensure there will be no cross contamination between users, especially for rescue breaths. Also, the current Ora design is still too limited in functionality to be completely suited for all first aid training.

The possible business plans are a viable means of distributing the product based on discussions with marketing experts. The most favorable is selling Ora through the Livis platform directly to consumers. Offering the product to be purchased as a deal with the current first aid training courses is also considered viable. Also, leasing the product to the consumers before they conduct the CPR practical session could reduce the price concern of the product. Selling directly to consumers is most feasible due to investment of funds and minimal mark-up on the consumer price.

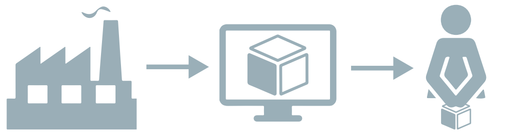


Figure 38: Business Model

Requirements:

The meetings, discussions and evaluations with the close stakeholders and experts have helped to formulate multiple details about the concept. The most prominent and valuable aspects are listed in this section.

1. App Design:
1.1 Recognises and connects to sensors within Ora using Bluetooth connection.
1.2 Visual displays the information received from the sensors with minimal time delay from the actions being performed by user.
1.3 CPR Compression Stance:
- **1.3.1** Visually depicts the correct CPR body position emphasizing to keep your arms straight and legs maintain a 90 degree angle.
- **1.3.2** Visually depict the correct CPR hand position showing heel of one hand in the centre of the victims chest (between the nipples) and the heel of the other hand on top of the first hand with interlocked fingers.

1.4 Performance Corrections:
- **1.4.1** Audibly and visually show when chest deflection detected is not between 5-6cm.
- **1.4.2** Audibly and visually communicate to user when chest deflection tempo is not between 100-120 bpm.
- **1.4.3** Audibly and visually communicate to user when rescue breaths are not between 500-600ml tidal volumes.

1.5 Airway Management:
- **1.5.1** Visually show the correct hand position and head movement to open airway
- **1.5.2** Visually show the correct hand position to maintain head tilt and block nose
- **1.5.3** Visually show the correct user mouth placement and nose pinch for recuse breaths.

2. Chest Plate:
2.1 Made of a viscoelastic material (polyurethane) that has properties which can withstand a compressive load of 1000N.
2.2 Visual External markers (nipple locations) for correct hand position.
2.3 Deforms up to 6cm when pressure of 500N to 600N is applied by the user to mimic an actual cardiac emergency.
2.4 Can withstand cyclical compressions with minimal damage to material properties.

3. Compression Detection:
3.1 Contains a Time-of-Flight sensor placed in a position which tracks the movement of the centre of the chest plate.
3.3 The sensor is located where it is protected from the migration of dust and water.
3.4 Space (air) is between the sensor location of the inner chest plate wall to allow for correct measurement of compressions.

4. Ventilation Head
4.1 Contains tilting mechanism which can tilt head to "open airway position" by the user when a slight force is applied by the hands.
4.2 Retracts to original position "closed airway position" once force is removed.
4.3 External design contains facial markers which represent the chin, mouth, nose and forehead to guide correct hand position for airway management and rescue breaths.
4.4 When head piece s in "closed airway position" rescue breaths are not detected or measured.

5. Rescue Breath Detection:
5.1 Contains a thermistor to register rescue breaths due to the heat of exhaled air.
5.2 Contains a microphone to detect the strength of rescue breaths in terms of frequency of air detected.
5.3 The sensor is located where it is protected from the migration of dust and water.

6. Design:
6.1 Disassemble for easy maintenance, disinfection and cleaning of device.
6.2 Human fidelity is in line with ERC guidelines for CPR training aids/manikins.
6.3 Weight less then 600grams for portability.
6.4 The product should be compact with an overall height and width less than or equal to 400 mm and a depth of 120mm.

7. Interaction:
7.1 The training aid should be portable with one hand.
7.3 The device should have minimal slippage across the ground when rescue breaths and compressions are performed
7.4 Device does not block the feedback visuals when compression and rescue breaths are being performed.

8. Target Cost:
8.1 The consumer price should be less than €100. Aim for a consumer price of 88euro.
8.2 Cost price for Livis should be less than €35.

9. Maintenance and Safety:
9.1 The deflecting material must withstand up to 300,000 compressions in order to compete with the durability of competitor products.
9.2 The compression detection sensor should be reliable to 0.5cm and a tempo between 0-160bpm.
9.3 The device should have a IP54 to protect form the ingression of dust and splashes of water from any direction.
9.4 The aid should have the ability to hold a charge for up to 3 months in the off mode and turn itself off is there is no interaction for 2 minutes.
9.5 The device is not a medical product as it does not possess diagnostic or therapeutic purposes.

10. Ergonomics:
10.1 The feedback provided during CPR must be visible when the user is in the natural CPR position, without the need of twisting or altering their position.
10.2 Any icons or graphics should have the same visual aesthetic with regards colour, shape and size.
10.4 The App should have notifications if device is not performing correctly due to:
o No Bluetooth connection to device
o Low battery of training aid
o Improper set-up of training aid

CH6: LIVIS ORA

Design activities related to product development, the technical and physical detailing.

TThis chapter summarises the detailing of design at the final stages of the project. It goes into depth on the design of the LivisOra. This includes the physical design, mechanism design and circuit optimization. To validate some design aspects prototypes have been made.

Final Design:

39. Moore, R. (2012). A Bayesian explanation of the 'Uncanny Valley' effect and related psychological phenomena. Scientific Reports, 2(1). doi: 10.1038/srep00864

The final design is a compact and portable optimised for individual training. The manikins used in the traditional BLS courses are styled to be high-fidelity to provide a realistic human appearance and size. The prime difference of these designs and the design of a personal training aid is the latter's needs to be integrated into everyday home life and the personal space of the learner.

The design of the Ora will embody the values that would fit the users' lifestyle. It should be distinctive from current devices to demonstrate physically a new smart training experience and distinguish itself on the market. The device should also demonstrate the emotional and practical needs of the learner by creating a training aid that felt personal and approachable, and would fit with the users' personal values. The design creates this visual aesthetic through the use of form, colour, materials and finishes. The principle of the final design should balance between functionality, aesthetics and usability.

An iterative sketching approach was taken in order to define the final shape of the product. The focus was on eliminating the "uncanny valley" effect. The term "uncanny valley" was coined by Masahiro Mori in 1070 to describe the observation of near-human artefacts that cause strong negative emotions in the observer (Moore, 2012). This effect can cause feelings of repulsion and could detract the user experience and inhibit continued interaction with the training aid.

To try to reduce this effect, lines of the product had a curvature which would not resemble human qualities. Any human aspects which were not needed for functionality were eliminated such as ears, eyes, shoulders, etc. Circles and curves were preferred over stark harsh lines to create a friendly appearance. The training aid should be perceived as a helper, an inspirational collage provided insights in existing humid shapes and designs that are considered domestic approachable medical devices. (See Figure 39) The collage helped to extract shapes, colours, finishes and interactions for the final design.

The colour of the final design takes its inspiration from the design of modern domestic medical products. It also adopts the orange colour from the Livis logo. The idea is the colour portrays an understanding that this product has an association with Livis. Figure 41 shows a product render of the final form. See Appendix N for more renders.

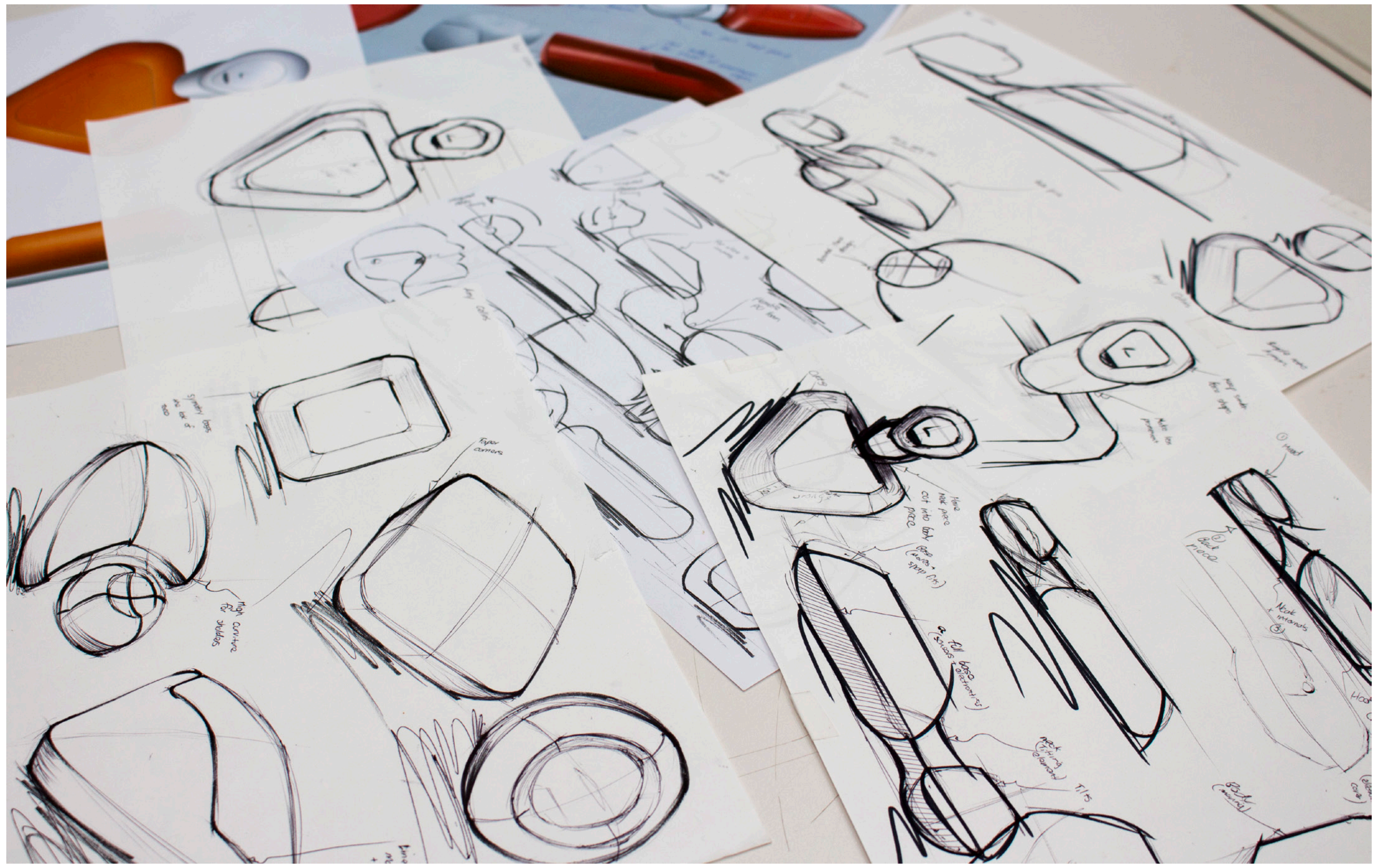


Figure 40: Exploration Sketches of Form

Figure 39: Collage for Device Aesthetic

Figure 41: Render of product form

Technical Detailing:

1. Compression Deformation:
The designed product must deform when a compression force is applied. This deformation of the product represents the same movement of a real chest during CPR.

How does a real chest actually deform? Current available training manikins have some shortcomings when it comes to actually mimicking the elastic properties of a human chest (Nysaether, Dorph, Rafoss & Steen, 2008). This is because manikins tend to have a predominantly linear force to depth relationship (Baubin, Gilly, Posch, Schinnerl & Kroesen, 1995) but a human chest shows a progressive, non-linear stiffness. The human chest is not just elastic, but also has a viscous damping component that increases with compression depth (Gruben, Guerci, Halperin, Popel & Tsitlik, 1993). This viscous property will absorb some of the pressure applied by the rescuer making real chest compressions more tiresome then on a manikin.

Because of the chest dampening property it does not "bounce back" as strongly as a spring loaded manikin chest plate. The real chest elevates smoother and slightly slower movement. This slower movement supplies less energy back to the rescuer during the recoil stage of compressions. This can make the real compressions more exhausting, then practicing on a traditional spring-loaded manikin chest. Adding a dampening mechanism to the designed training aid would result in a more realistic representation of a human chest and enhance the connection to a real event.

The dampening effect is created using viscoelastic materials, normally used for sound or shock absorption applications. Viscoelasticity is a property of some materials that exhibit both viscous (thick consistency between solid and liquid) and elastic characteristics when undergoing deformation. The material exhibits a time-dependent strain. This basically means that the material has some resistance to deformation when force is applied and when force is released there is a delay to return to original shape.

There are common examples of viscoelastic materials such as polymer foams used in seat cushions. Cushions allow for a progressive conformation of the cushion to the body over long periods of time. Another example is a foam stress ball. When a force is applied to the ball there is obvious deformation but there is a slight delay in bounce back of the material when the force is released.
There are many types of viscoelastic materials to choose from, these can be flexible polymer foams, natural materials (such as cork) and some elastomers. To try to narrow the choice of materials some criteria have been developed:

1. <u>Functional properties:</u> It is not enough for the material to be viscoelastic. It needs to have a Youngs modulus which would allow for the material to deform 6cm under a pressure of 600N (similar to the average human chest). However, the material must not plastically deform up to or exceeding this force. (max force 1000N)

2. <u>Manufacturing Properties:</u> Processing or fabrication properties should be minimally complex in order to convert the material into the required shape for CPR practice. Such as ease of casting, machining and finishing.

3. <u>Economics:</u> Cost of the material as well as the cost of processing the material in the required shape should also be taken into account.

Viscoelastic materials can be characterised by their young's modulus. A material which can have viscoelastic properties has a young's modulus in the range of 3MPa to 0.15 MPa. However, for this application we want a young's modulus that will deform up to 6cm when a force of 600N is applied. For this application, a material which is acceptable would have a young's modulus between 0.35 MPa and 0.52MPa (See appendix K for calculation). When comparing the cost of materials in this stiffness range in CES Edupack it was clear that flexible foamed polyurethane is the material most suited for this application (Figure 42). Aluminium Honeycomb also falls into this range but it is more costly and it actually doesn't have viscoelasticity due to its atomic configuration.

40. Baubin, M., Gilly, H., Posch, A., Schinnerl, A., & Kroesen, G. (1995). Compression characteristics of CPR manikins. Resuscitation, 30(2), 117-126. doi: 10.1016/0300-9572(95)00874-s

41. Gruben, K., Guerci, A., Halperin, H., Popel, A., & Tsitlik, J. (1993). Sternal Force-Displacement Relationship During Cardiopulmonary Resuscitation. Journal Of Biomechanical Engineering, 115(2), 195. doi: 10.1115/1.2894121

42. Nysaether, J., Dorph, E., Rafoss, I., & Steen, P. (2008). Manikins With Human-Like Chest Properties—A New Tool for Chest Compression Research. IEEE Transactions On Biomedical Engineering, 55(11), 2643-2650. doi: 10.1109/tbme.2008.2001289

Figure 42: Comparing material property Young's modulus against the price of material

2. Compression Sensor:
In the concept detailing section of Chapter 5, it gives details as to why the use of a Time of flight (ToF) sensor is beneficial for measuring compression depth and tempo. The embodiment of the device would use this sensor to monitor the distance that the chest area of the device is displaced during each compression throughout the practice of CPR.

Time of flight (TOF) principle is the time difference between the emission of a light signal and its return to the sensor, after being reflected by an object (Terabee, 2018). The ToF distance sensors can detect how long the light has taken to bounce back from a specific surface to the receiving sensor. It is good to determine the distance of a surface directly in front of it such as this application. Unlike IR distance (proximity) sensors, that try to measure the amount of light bounced back within a range. The Time of flight sensor is more precise as it does not have the 'double imaging' where you can't tell if an object is very far or very close (Industries, 2018).

There are more benefits to a ToF sensor. Unlike common CPR measuring methods like a gyroscope of accelerometer sensors, optical techniques does not have cumulative error and do not rely on inertial measurements that can be affected by the environment (Kok, Hol & Schön, 2018). In a use case scenario, if the user would prefer to practice on a soft carpet to protect their knees (common in practice sessions) then the accelerometer measurement would be affected by the soft surface and track the movement of the device and the soft surface (carpet). ToF sensors are more suited for this application within the home.

To measure depth during compressions, infrared light is emitted from the source adjacent to the sensor. The light illuminates the internal surface of the chest area where compression should take place. The image sensor receives the reflected light from this surface (See figure 43). The distance to the illuminated surface is calculated using a measurement of time. When the chest area receives a force, it is compressed moving the surface closer to the sensor. Therefore, a surface compressed will appear to have a faster time calculation. The sensor will conclude the quality of the compression by analysing the generated time gradient (Figure 44). This results in a collection of distances that is accurate to create a map of the movement. The information is then further refined with algorithms to be used to compute and

43. Kok, M., Hol, J., & Schön, T. (2018). Using Inertial Sensors for Position and Orientation Estimation.

44. Image sensor. (2018). Retrieved from https://en.wikipedia.org/wiki/Image_sensor

45. Terabee. (2018). Time-of-Flight principle, measuring the distance between sensor/object. Retrieved from https://www.terabee.com/time-of-flight-principle/

display compression depth information.

To measure compression tempo, the processor can determine when a chest compression has passed through both its maximum and minimum depth of travel and can record this as a single incidence. This process is repeated, the device can understand the rate of compressions with the use of a timer (See Figure44). A processor will use these relative times from the max and min depth to generate the rate of chest compressions. These measurements will generate the average compression rate.

This will also determine if the chest becomes fully recoiled after each compression. The compression gradient would be used to determine if the chest area returns to its initial start position (full recoil), by measuring the repeated maximum release positions to the initial start position. Discrepancies in measurement would result in a visual feedback to the user.

ToF determines the remaining compressions in a cycle. When the algorithm determines 30 compressions have been conducted through the detection of 30 min depths, then it will create a visual within the app for the user to engage in rescue breaths.

ToF measurement techniques are a highly accurate and inexpensive method of determining compression quality during the administration of CPR. They do not suffer the drawbacks of accelerometer-based sensors and do not experience inaccuracies due the context of use by the learner. The use of an optical sensor allows for the determination of compression depth, compression rate and adequate chest recoil, all parameters determined as vital for the delivery of high quality CPR.

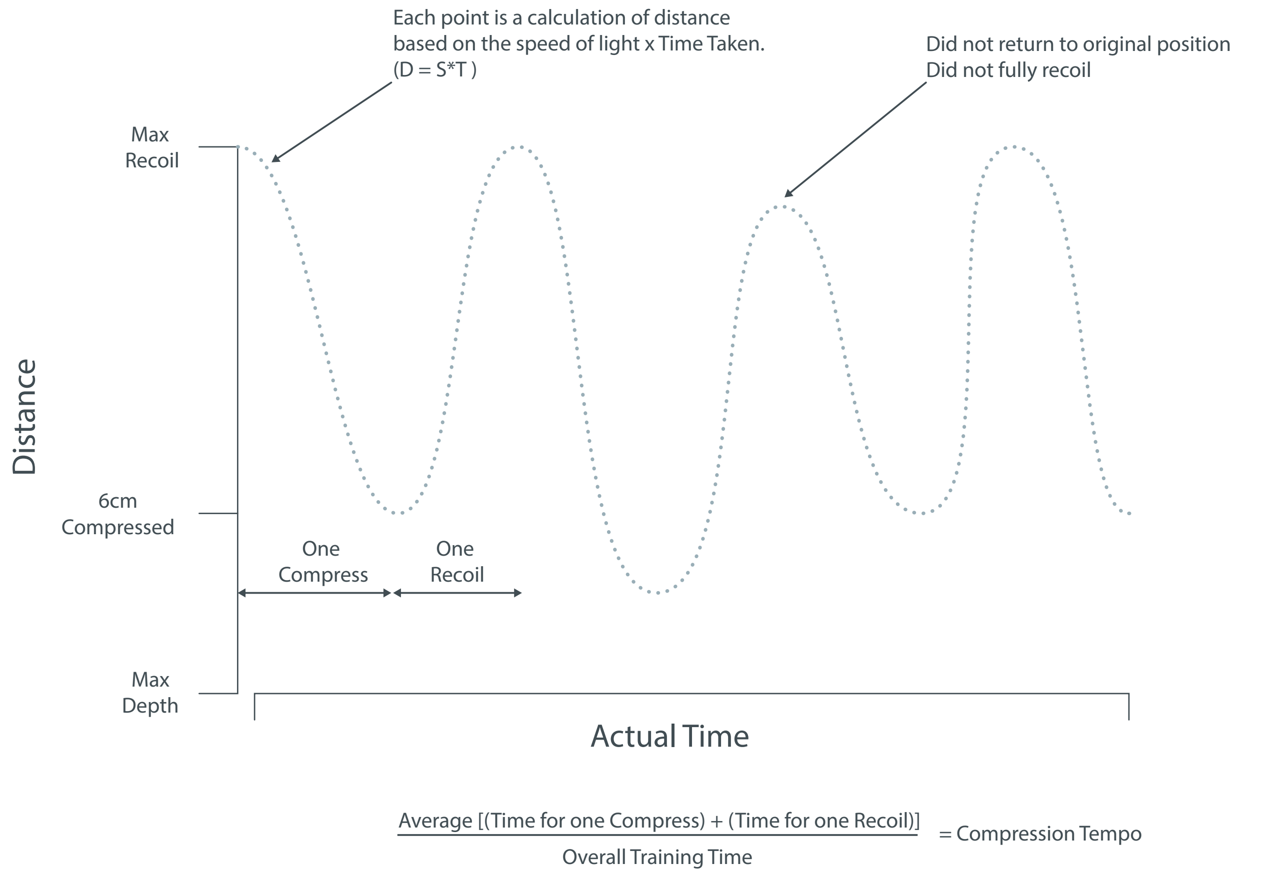


Figure 44: Visual of compression calculations

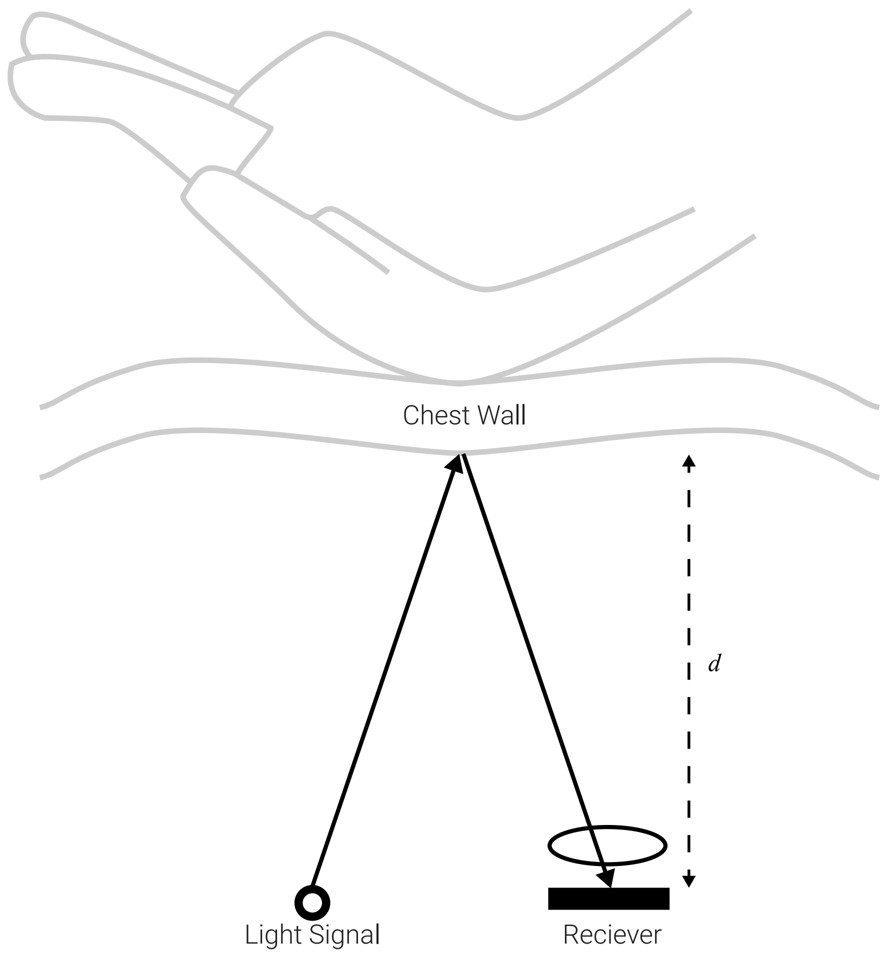


Figure 43: ToF principle visualized in context

3. Rescue Breaths
The sensor is used to detect the performance of the learner, by detecting the act of expelling air from the lungs and transferring this to the ventilation area of the training aid. The expelled air is measured by detecting the low-frequency sounds typical of expiratory airflow, rather than detecting the sounds of breath. This is due to the sounds of actual breath not being correlated with the volume of air expelled but can be affected by constrictions in the subject's airway.

The embodiment uses a microphone to detect air flow sounds and converts this into a signal. The signal is then analysed to determine two parameters and applying these to an algorithm. The first set of parameters is the expiration time. The second set is determining the strength of the expiration breath. This aspect is more difficult to capture as the signal must be filtered. The respiration sounds must be converted into a sound signal. This signal is then amplified and filtered to remove background noise using defined parameters. For this application, non-frequency related noise is noise from device movement or general background noise.

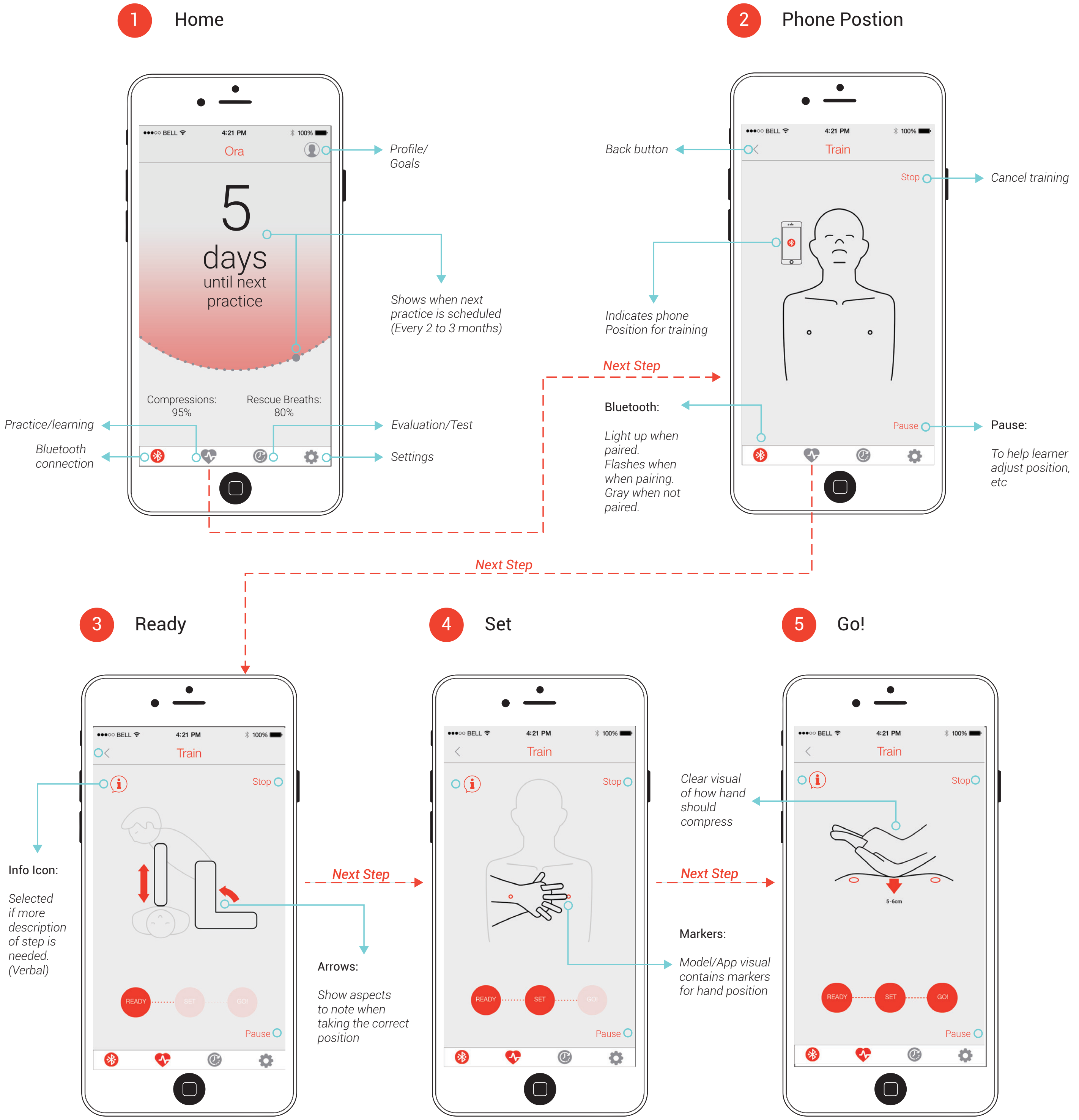
The detection is based on an acoustic respiration detector. The detector will have an air transmission tube with one end connected to a microphone element. The other end will have an opening at which turbulence of the exhaled air will cause acoustic signals. The head element will have its mouth opening located directly above the tubular opening, when the correct head tilt action is performed.

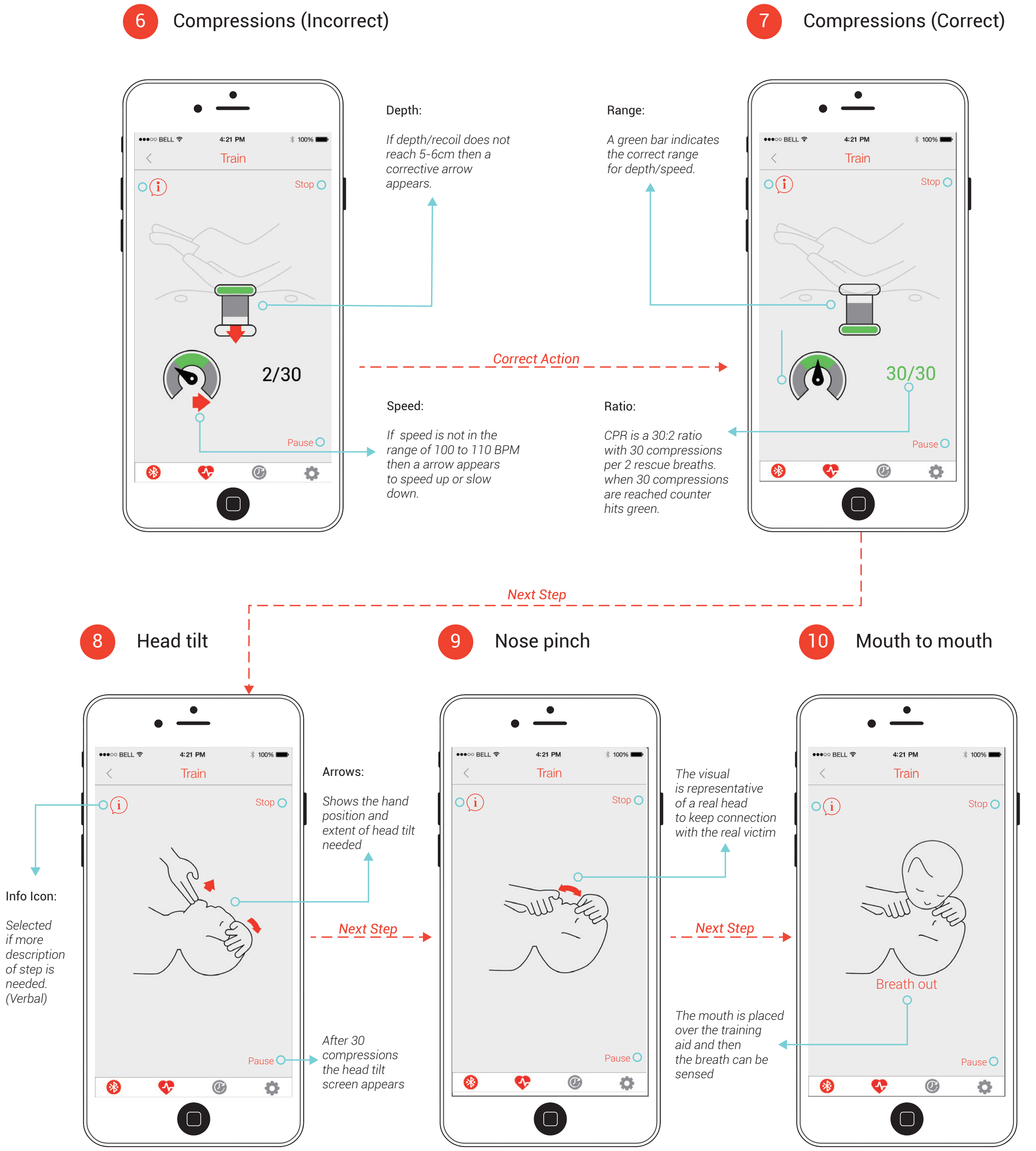
The microphone element is connected to a bridge circuit which is capable of supressing sensitivity of mechanical and acoustic disturbances (background noise and device movement from compressions). The observed possible frequencies of expelled air can be between 30 to 50 Hz but this should be tested further. At this filtering step the control unit will periodically perform a spectral analysis on the buffered data and remove data not related to exhaled air.

Once the data is analysed the signal can be transmitted to the App. The user can then alter their rescue breath technique to improve their CPR quality.

Wireframe App:

Figure 45 shows the wireframe of App. It Imaps out the user journey during a training session.

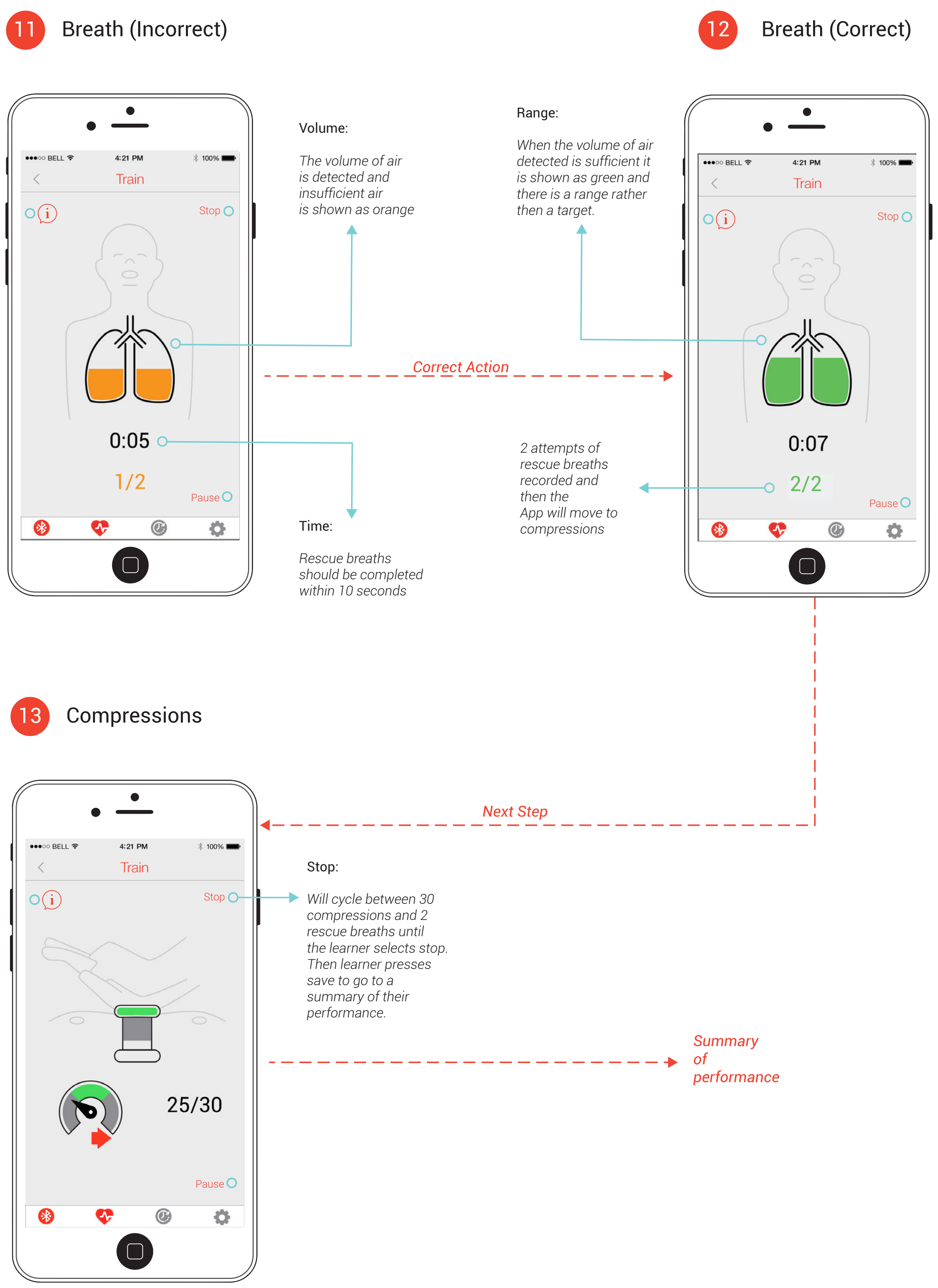




The ready, set and go steps help the learner to understand the correct body and hand position. Before you start compressions it is important to have the correct stance as this will help with delivering better quality CPR, better endurance and relates the CPR to a real person. The correct hand postion will also help the sensors to give feedback which is correct and accurate. If the learner is confused by the visual they can select the info icon to pause the step and recieve verbal instructions with regards correct stance and compressions.

The air way must be opened before rescue breaths can be given (airway management). These visuals show each step in sequence to let the learner understand the hyperextension of the neck, closing the nose and making a seal around the mouth. These steps must be done correctly for the sensors to record extent of breath. If these steps were not done correctly the sensor will show screens again to remind the learner. The learner can also use the info icon to pause training and recieve verbal direction on how to complete the step.

Figure 45: Wireframe of Ora App



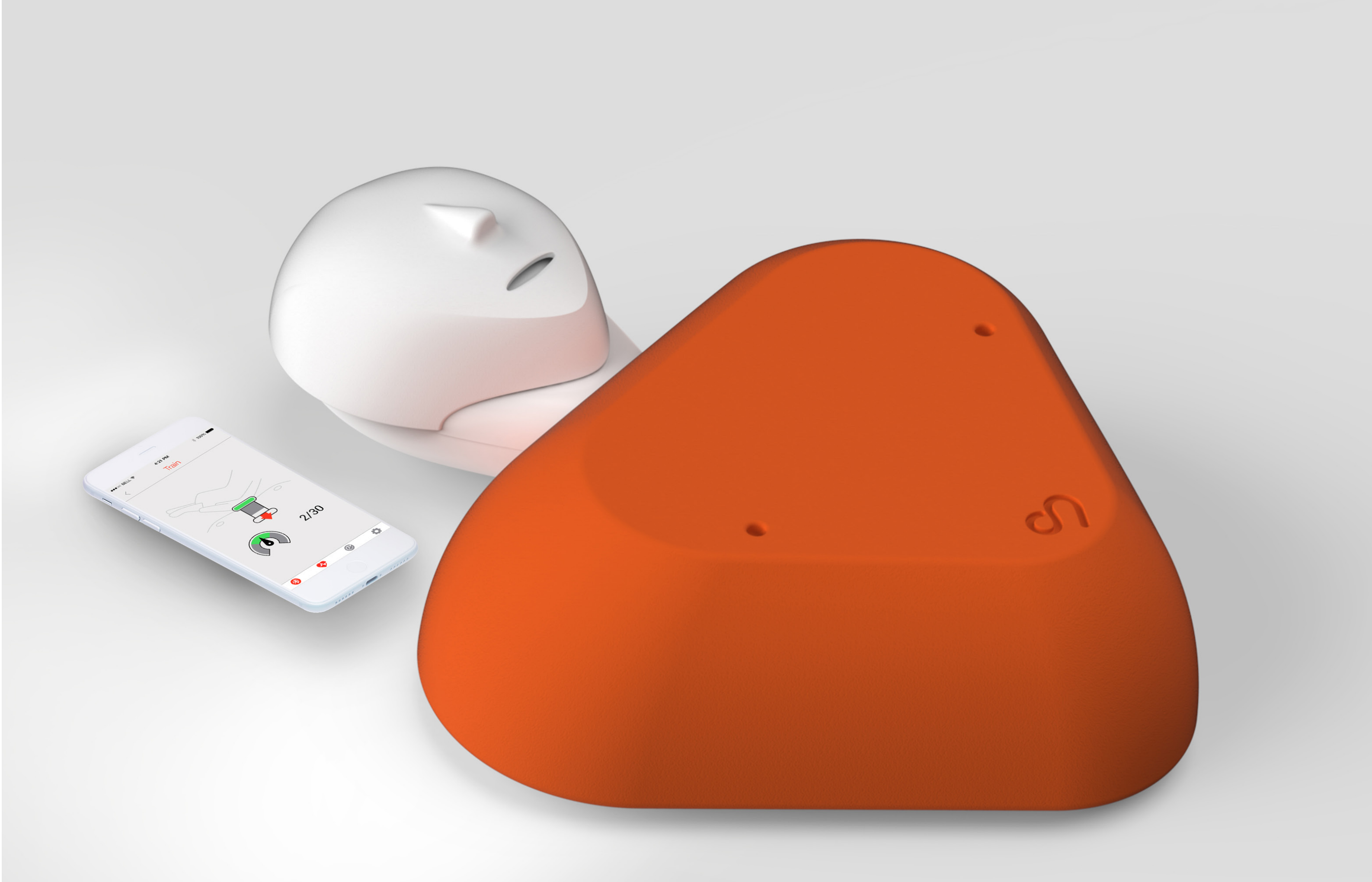


Figure 46: iPhone with App next to product render

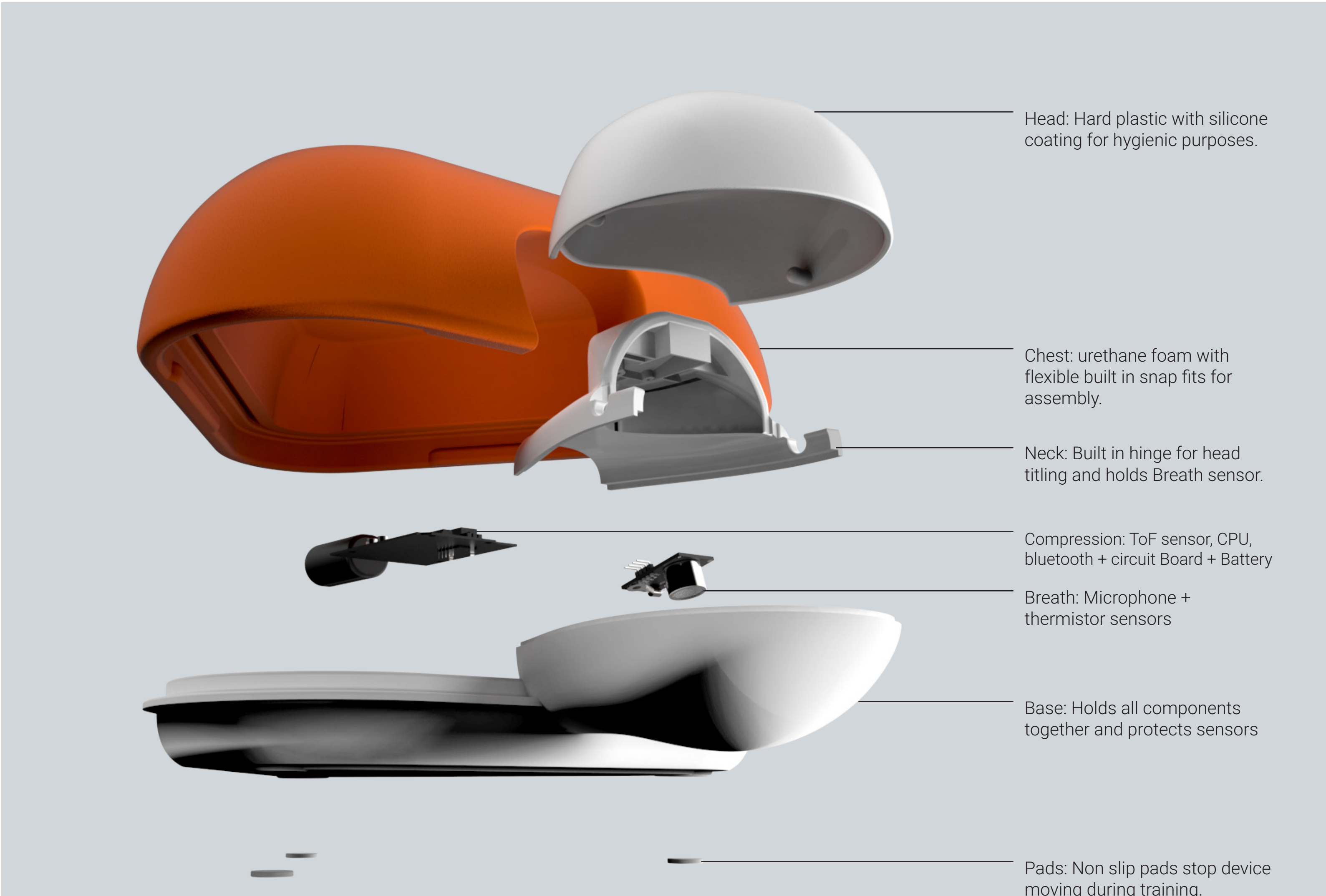


Figure 47: Exploded View of Components with Labels

CH7: CONCLUSION

General conclusion of the overall report with discussion, recommendations and next steps after completion of the project.

The design process lead to multiple insights with regards advantages of learning innovation for cardiac arrest survival and how laypersons experience the current training journey. This lead to the creation of LivisOra. This chapter discusses the process, draws a conclusion and states recommendations.

Discussion:

The final concept, developed over the past 20 weeks shows clear potential to improve the quality of CPR skills obtained by laypersons and gives them confidence to use these skills when needed. It is clear that Ora addresses two main issues with regards CPR training. The first is the ability to practice CPR skills in a means that is clear, accessible and beneficial for the learner. The second is the ability to retain knowledge and gain muscle memory of psychomotor skills with short and frequent exercises. The implementation of the device contributes to the changes in how medical skills are learned and retained through low-dose high-frequency training. The outcome of the project is the result of many design decisions, which were predominantly based on discussions with stakeholders, project goals and perceived benefit for end user.

Ora aims to help achieve a skill level of advanced beginner to competent based on implementing learning techniques such as repetitive practice and feedback for critical thinking. LivisOra' s main function is it' s ability to communicate feedback and this aspect was evaluated with laypersons. When evaluated the visuals were considered understandable and linked the actions performed to the corrective feedback. Users could perform the skills shown and gain knowledge on vital CPR aspects.

Current feedback tools on the market were analysed at the beginning of the project and were considered insufficient at providing comprehensive feedback. The designed solution addresses feedback concerns though providing all vital parameters on compressions and ventilations. The Ora addresses hygiene concerns by eliminating the use of a plastic bladder for ventilations and the face portion can be removed for cleaning. The trade off by eliminating the bladder is the chest does not rise when ventilations are performed. This was a concern for the experts as a chest rise as an indicator that the airway is open and not obstructed. Further iterations of the design should address this training concern.

The product is also suitable to train outside of a practical environment to practice skills repeatedly. Ora is suited for its training environment as it can be transported and stored easily due to its smaller size and weight. When testing the size, CPR experts reported that they had concerns with how the users would relate the training with the aid to a real situation if it is not the same size an adult. This is addressed by adopting a similar shape to an adult torso and having the human markers for CPR such as nose, mouth and nipple placement.

With regards the users of the Ora, there were 3 learning gains which can be summed up as practice , retention and connection. Practice refers to having a longer time actually performing the CPR knowledge gained and Ora puts practice first with feedback on performance to improve skills. Retention refers to ability to keep skills up to date and Ora is built around bringing the practice to the learner in new environments so they can train whenever they feel it is necessary, encouraging retention. Connection refers to the ability to connect practice to a real emergency event. The future iterations of the Ora design can have the assessment and evaluation functions in the App to help the learner establish decision making capabilities and gain reasoning behind real life actions.

The current leader in personal CPR training can be used as a benchmark for the Ora Concept. A comparison in figure 48, summarises the difference between the prompt device (MiniAnnie) and the Ora concept. The primary concern is the cost difference that might eliminate some possible users. However, the designed solution far outweighs the "miniAnnie" in terms of functionality, addressing main training issues and also suitability for the future of CPR guidelines and legislation. The existence of the "miniAnnie" and its popularity first and foremost confirms the need for a personal CPR training device, specifically a device which provides clear feedback communication.

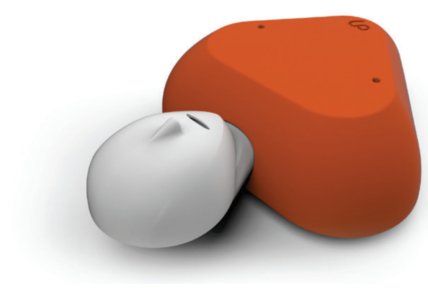
Compact, Portable + Reusable

Compression depth feedback

Head Tilt mechanism

Breaths: Lung Bladder

Price: 55euro



Compact, Portable + Reusable

Compression depth, tempo, recoil feedback

Head Tilt mechanism

Breaths: strength + duration feedback

Price: 88euro

Figure 48: Comparison with existing product

Conclusion:

The scope of this graduation project was to design a means of improving the effectiveness and quality of bystander CPR for OHCA through increasing education efficiency. The goal was to design an application that would increase skill acquisition and motivate participants to utilise their CPR abilities when witnessing a cardiac arrest – "Putting life in CPR". The innovation in training laypersons' is one of the best options to save a life, as quick resuscitation is the first and most critical link in the chain of survival.

Learning techniques which can aid in the transfer and retention of knowledge include assessment, repetitive practice and objective feedback. A new type of compact, portable training aid creates self-learning in a home environment with feedback on performance of vital CPR aspects. It aids in the retention of knowledge through low-dose high frequency training sessions.

Evaluation of the training aid concept (LivisOra) proved the idea was desirable, feasible and viable. The design of the LivisOra device physically distinguishes itself from existing manikins on the market, visually communicating its new smart training experience. The real time feedback visuals within the Ora App are simple to understand and create a graphic link to the user's current CPR action. The materials used to simulate the compressions are durable and realistic to a real human chest deflection and sensors used to evaluate users' performance are cost effective and accurate.

The design promoted discussion with the project stakeholders to understand how the product can be successfully integrated into the current CPR training experience. The means by which people could train with LivisOra would remove the current barriers of accessibility and time demand experienced by laypersons when trying to attend a practical lesson . The type of training Ora promotes is considered to be a future outlook on how people could learn complex medical techniques.

The advantages of LivisOra are:

1. Accessible practice of vital CPR skills within the learners' comfortable home environment.

2. Ability to retain CPR knowledge through low-dose high frequency self-learning.

3. Objective and informative real-time audio/visual feedback provide the learner with defined obtainable goals.

In the Netherlands , it is expected that an ambulance should reach the location of where it is needed in less than 20 minutes. However, it has been shown that if proper CPR medical attention can be administered by a bystander within 6 minutes, then it will increase survival rates by 15% (Slot, 2010). This is a total of 52,500 real human lives that can be saved each year within Europe. Ora is a concept which has the potential to contribute positively to people's ability to perform CPR and enables them to feel confident in an emergency situation, to help those in need.

Recommendations:

There are several developments required before this concept can become a reality and be combined into the Livis product portfolio. The detailing and visuals within the report aid in the communication of the concept but there are several design steps which need to be conducted before the product could be produced.

The technical aspects detailed in Chapter 6 such as the compression detection, rescue breath detection and compression deformation material need to be prototyped and tested. This is to ensure they perform as they are intended (proof of principle) and adhere to the product requirements.

Prototypes of the product should be built. There are several types which can aid in the development such as working prototype, proof of concept and visual prototype. A working visual prototype featuring some of the product functionality would be beneficial for communicating the concept and further user testing.

Future research and development should be conducted to see if the design does in fact increase skill acquisition and retention of CPR skills. This would be a test where several participants would attend a traditional BLS course and then another set of participants trained with a working prototype of LivisOra. Then after a period of time (possibly 3 months) their skills would be objectively evaluated. It is expected the Ora participants would have a higher skill acquisition and knowledge retention due to the learning principles integrated in LivisOra. This is the ultimate goal of this project; therefore, it is important to validate this aspect.

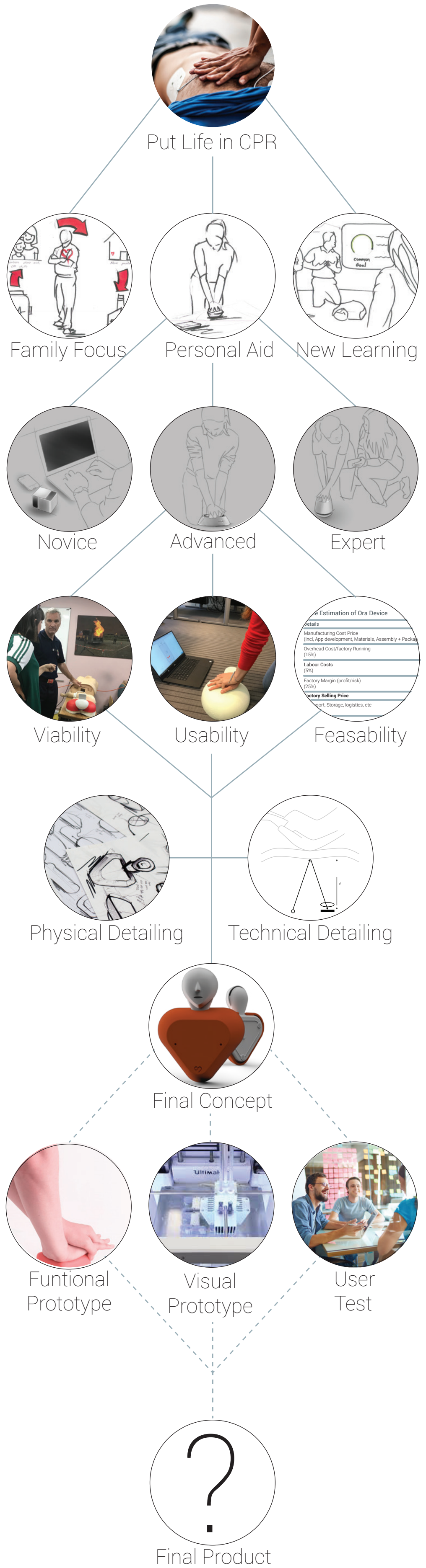


Figure 49: Process Overview

Reflection:

In order to better interpret and evaluate the research presented in this project and its results, some points of reflection are provided.

Methodologies:
Overall the value of this project is the different implementations of methodologies which assisted in the creation of a feasible and valuable solution. Application of design theory and tools within the project were selected based on the desired insights or effective communication of a vision.

For example, generative research methods were used to understand the current training experience. The project interpreted that there are many barriers and psychological factors which the target user experiences. Literature focused more on comparing the learning outcomes of training methods rather than understanding the participants' viewpoints. The user is central to the project motivation; therefore, implementing generative research in the form of a session brought relevant insights. Recruiting the desired participants was difficult and time consuming. The outcome of the session was treated with caution due to the limited sample size and results were compared to existing marketing research to ensure there was limited bias. Overall, the research is extensive and uses various design methodologies but, took more time than anticipated.

Planning and Process:
The planning overview was broken into activities and tasks to complete on a weekly basis. Overall, the project completed stages on time with some slight delays in smaller tasks at points but this had minimal effect on the overall scheduling of the project . At meetings, discussions about planning were conducted in order to receive advice on how to progress. This advice was vital in understanding the priority of tasks.

Within the planning, tasks were conducted in parallel rather than sequence to cope with the time demand of the project. However, this approach limited the new knowledge which could be gained as effort was given to controlling the amount of activities being completed. A clearer goal should have been communicated at the beginning of the project to indicate the time needed to explore new design skills.

During the project, priority changed to document design ideas and this considerably narrowed design direction. However, the researcher was a reluctance to make design decisions without proper evaluation and justification, to ensure quality of academic level. This had resulted in time consuming activities. Adopting decision making activities earlier would have aided in faster progress of the design.

Learning Points:
The project brief (Appendix A) had learning ambitions defined. This is a reflection of these ambitions.

A personal ambition was to utilise psychological methods and theories in the design process. Exploration of learning theory in the literature review helped in understanding the learning process and the stages of skill acquisition. This aspect benefited the project as it gave reasoning to the importance of feedback tools. It also helped in the understanding of how feedback should be visualised in order to achieve increased skills acquisition and retention.

The second personal goal was to utilise some generative research techniques in order to identify user needs and obtain desirable solutions. This ambition was successfully completed in the form of a session with the target user group. The devotion to this ambition brought an overall better understanding of the context around the desired solution.

The third aspect was to focus on the engineering and technological side of the final concept in order to fully realise its feasibility. This was completed by defining the exact mechanisms and sensors which could be used to accurately detect the vital CPR actions. However, the affordability and value of the solution was also considered an aspect of feasibility. The final stages of the project focused on validation and enhancing the communication of the design, rather than building and testing technological mechanisms. These activities were given higher priority as they would be more beneficial for communicating the full story of the design and justification of design choices.

The final ambition was prototyping skills. The type of prototype was not initially defined. After discussions with the supervisory team it was decided prototyping would be the creation of mock-ups for usability testing and expert evaluation. This was the creation of a realistically sized device made of viscoelastic material with a head tilting mechanism and a simulation of the App feedback (See appendix L and M). These prototypes were discussed to be "unrefined" in nature to promote participants to give more constructive feedback. This feedback aided in gaining insights for finalising the design.

Conclusion:
To this end, a strong point of this project was the early involvement of users and the evaluation of the design concept with experts in the field. Theses insights were the greatest influence in the understanding, merging and communicating of the concept. The limiting factors were the constant trade-off between time management and quality of design activities.

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