UiA University of Agder

Bachelor

Virtual Reality First Aid Training Kit

Understanding the potential of VR technologies for training the general population in broader aspects of first aid

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This is not the end to my learning, it is only the beginning.

Abstract

This project investigates the design, development, test and evaluation of a Virtual Reality-based solution for first aid training, aiming to address the demand of the general public for increased knowledge and practical skills about first aid. The project follows a DSRM methodology for gathering needs of target users, identification of requirements, design and development of a solution, and demonstrating the solution prototype to testers for the purpose of evaluation and proof-of-concept. The project finds that while there are physical limitations to what can be emulated in VR, there is valuable potential for the presented VR-based education concept as a supplement for existing first aid training solutions.

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Chapter 1

Introduction

1.1 Background

First aid refers to medical attention that is usually administered immediately after a medical emergency occurred and at the location where it occurred. Knowledge and trained skills in first aid allows individuals to provide care to injured individuals with the goal of treating the injury or preventing further damage to the injured until the arrival of medical support. The Norwegian Directorate for Civil Protection (DSB) is a government body tasked with maintaining an overview of various risks and vulnerabilities in general; with the intent of preventing accidents, crises, and similarly unwanted events [1]. It issued a document[1] containing advice on emergency preparedness, in which it states that everyone should be able to provide first aid. This is in line with the Norwegian Ministry of Health and Care Service's vision of everyone being able to provide life-saving first aid treatment [2].
This indicates to the uptake of first aid knowledge and skills in the general population being of utmost importance and in the interest of the public. This is supported in findings that public knowledge in first-aid is a key factor in reducing avoidable deaths, and can likely improve the victims' level of recovery [3][4].

Studies show that there is a correlation between the quality of first aid given by an individual, and the time that has passed since they had last received training in first aid [4]. A scoping review of 22 countries was conducted in 2020 [4]. Its purpose was to investigate the public's first aid knowledge and uptake in training, and their confidence in first-aid skills and willingness to help in emergency situations, along with potential barriers to or enablers of learning first aid. It found that in terms of uptake, about 50% had received first aid training at some point in their lives, with only 19% having received it within the last 12 months prior to being surveyed [4].

Virtual Reality (VR) technology has grown from a medium popularly used for gaming, to a tool used for professional development in various domains, such as military, industrial, psychology, medicine, and education [5]. Kamińska et al. in 2019 published an overview of the big trends, opportunities, and concerns of using VR in education [5]. It finds that VR technology has been proven to possess advantages when used as a tool for education. It is inclusive, allowing anybody to participate in the education process. It is also used for efficient blended learning, encouraging self-study and individual pursuit of knowledge [5].

1.2 Problem Statement

Heard et al. have found that there is a correlation between the degradation in the quality of first aid provided by an individual and the time passed since they had last received first

[1] https://www.dsb.no/globalassets/dokumenter/egenberedskap/dsb_beredskap_brosjyre_original.pdf

aid training [4]. In another study conducted in Norway it had been observed that although first-aid training is prevalent, there is a significant lack of theoretical knowledge [6].
The purpose of this project is to investigate how the development of a Virtual Reality (VR) system for training in first aid can support the accessibility and acceptance of and motivation for first aid training.

1.2.1 Research Questions

RQ1: How can VR-technology effectively support first-aid training?
RQ1.1: What expectations do potential stakeholders (trainers and trainees) have for a VR-supported training system?
RQ1.2: How can the needs and expectations of stakeholders be implemented in a satisfying manner?
RQ1.3: Can a VR-based tool for first aid training address and fulfill the general public's demands and requirements for first aid training?

1.3 Scope

The project scope is to develop and evaluate a prototypical VR application following the Design Science Research Methodology (DSRM) with User-Centered Design processes. The application is built with Unity, using the XR Interaction toolkit for performing movement and interactions using Unity's input system [7]. The development puts focus on the learning of theoretical knowledge for placing a person in recovery position, and to allow the user / trainee to deepen this knowledge through a practical exercise. The practical exercise is implemented through allowing the user to interact with a virtual doll, representing a person in the need of help.

Chapter 2

Theoretical Background and State-of-the-Art

2.1 Using virtual reality for education

VR technology has seen adoption as a tool for education and training in several fields. Industrial fields make use of VR for carrying out training in various scenarios in effective and realistic ways [8]. Projects involving VR in engineering education finds that virtual environments allow for the minimizing of concerns regarding cost, risk, and time, of experimental strategies [5]. A study conducted Lackey et al. on soldiers training in room clearing found that participants who reported positive experiences in the VR training task tended to experience lower levels of stress and workload when engaged in a live version of the task [9]. The study concluded that VR training may be efficacious for reducing stress and workload associated with criterion tasks.

Medical education fields have also adopted the use of VR technologies. Alfalah et al. [10] implemented a VR solution for displaying the anatomy of a human heart with the aim of using VR as a training tool to offer additional means to teach students. A project at the University of Agder [11] investigated the use of VR to supplement simulation in the nursing education, motivated by the limited availability offered for nursing students to work with medium- and high-fidelity simulation training.

2.2 The prevalence of first aid training

In Norway, first aid training is offered — and often mandatory as part of a larger safety course — at places of work, higher education, military service, or as part of driving-school programs [6]. These courses are either run by the organizations or businesses themselves or make use of other external organizations which provide the course content;non-governmental organizations such as the Norwegian Red Cross, occupational health services, or by other non-profit or humanitarian organizations. Some organizations also provide learning content through web-based solutions, rather than any formal training, allowing users to learn obtain theoretical knowledge in select first aid topics.

2.2.1 Norges Røde Kors / The Norwegian Red Cross

The Norwegian arm of the humanitarian organization Red Cross, offers first aid training courses in Norway. Courses are grouped into six categories; first aid, first aid with defibrillator, first aid for work with electrical installations, fire protection, first aid towards children, and first aid through online courses. Table 2.1 provides an overview of the different courses; with their duration and brief summary of covered content. The online courses are divided

in similar fashion to the practical courses. Each online course is a live-streamed courses of the theoretical content; practical exercises are substituted with live demonstrations from the instructor, and time is allocated for Q&A [12].

Name	Duration	Content
Førstehjelps kurs	3 - 6 hours	3 hours: examination, obstructed airways, recovery position, CPR, acute diseases and injuries 4+ hours: occupational hazards; burns, cuts, and blunt injuries
Hjertestarterkurs inkl. førstehjelp	5 - 3 hours	5 hours: foundational course, use of defibrillators, practical exercises 3 hours: refresher course (requires previous completion of 5hr course within past 6 months)
Førstehjelpskurs elektrobransjen	3 - 5 hours	3 hours: life-saving first aid, examination, unconsciousness, CPR, electrical injuries 5 hours: 3hr content + acute injuries, workplace safety 5 hours: 3hr content + training in accordance to FSE (regulations on safety when working in and operating electrical installations)
Brannvernkurs	2,5 - 6,5 hours	2,5 hours: fire theoretical and instructions, smoke development and fire prevention, fire escape, extinguishing agents, practical exercise (1 hour) 6,5: 2,5hr content + first aid foundational course content
Førstehjelpskurs rettet mot barn	3 - 5 hours	3 hours: foundational first aid course + techniques for clearing airway and CPR towards children, 4+ hours: cold injuries, cardiac illnesses, poisoning, cramps
Online førstehjelpskurs	1,5 - 4 hours	Live-stream of selected topics from previous courses

Figure 2.1: Table for courses offered by the Norwegian Red Cross

2.2.2 Medco dinHMS

Medco dinHMS is a provider of occupational health services in Norway. They offer an array of services with the goal of improving quality within the workplace. They provide regular Health, Safety, and Environment (HSE) courses across Norway throughout the year. The University of Agder is recipient to one of these courses yearly for first year students as part of ORG001 HMS-kurs. Students are provided with an 8-hour course in which they go through orientation for how to maintain a safe environment at their place of work; or place of study in this case [13]. The course content includes fundamental HSE, safe conduct in laboratories, disposal of hazardous waste and chemicals, first aid training and CPR with practical exercises, fire prevention with demonstration and practical exercise [13].

Mixed training solution

Medco, in collaboration with the Norsk Førstehjelpsråd and FIDL, offers a mixed course for first aid learning. Developed by FIDL, the theoretical learning is provided through a game-based eLearning application available on PC, Mac, mobile phones and tablets. The course content provided via the application includes initial examination, CPR and use of

defibrillators, acute illnesses, allergies and cramps, surface injuries, fire and electrical injuries, fractures, and poisoning [14].

Figure 2.2: Sample of FIDL first aid application demonstrated on a mobile device [14]

2.3 VR projects for training in health-related topics

2.3.1 SimX by Lærdal Medical

Lærdal Medical is a supplier of services and products used for training and education in health and emergency services [15]. SimX is a Virtual Reality simulation software solution targeted towards training professionals in health and care industries. It offers over 250 scenarios in which learners work with virtual patients in adaptable environments [16].

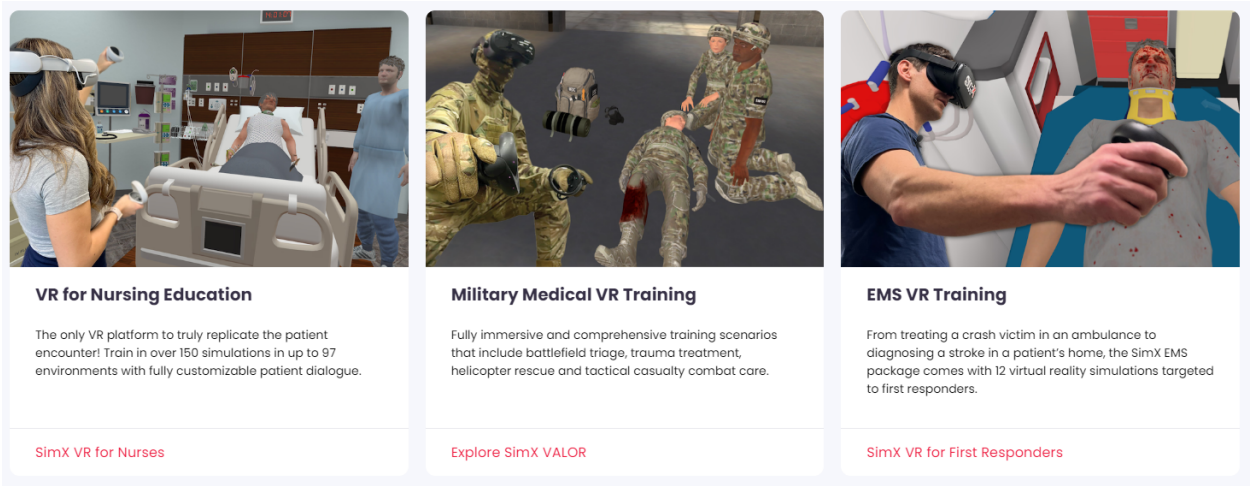


Figure 2.3: SimX offers learning content for nurses, military, and EMT use-cases

Chapter 3

Method

3.1 The Design Science Research Methodology

The following chapter covers the approach used for this project. The project mainly follows the Design Science Research Methodology (DSRM) [17]. The Design Science Research Methodology consists of 6 main phases:

1. Identify Problems and Motivation
2. Define Objectives of Solution
3. Design & Development
4. Demonstration
5. Evaluation
6. Communication

3.2 Identify Problem and Motivation

The research problems and the motivation for this project were provided in Chapter 1. This DSRM-phase was addressed with a literature review of articles obtained primarily through a search with Google Scholar using and combining the following terms:

- first-aid impact
- first aid training
- bystander impact
- first aid VR
- VR solutions in health

For understanding the landscape of first aid training, and the impact of bystander intervention, a scoping review mapping public first aid training was reviewed [4]. Two studies conducted in Norway were analysed to understand the Norwegian first aid training landscape in particular [3] [6].

3.3 Defining objectives for a solution

The project continued with a needs assessment by obtaining relevant insights and expectations from persons representing potential stakeholders and target users through the use of user surveys. The results from the conducted surveys with 40 participants are a major input for the design of the artifact in the next project phase. For that purpose, the gathered information was compiled to assess the needs and expectations from different types of users, which in turn were converted to functional and non-functional requirements of the target system. This is covered further in Chapter 4.2.

3.3.1 User survey

The survey was developed using SurveyXact[1], and contained a mix of open and closed questions. The primary goals of these questions were to elicit the respondents' experiences surrounding first aid, and what expectations they may have for a VR application for first aid training. The survey was distributed and expected to collect data for two to three weeks before moving forward to assessment of the users' needs.

Survey structure and content

The survey categorized the respondents' demographic by age, gender, occupation, and field of occupation. The survey questions aimed to address 4 key areas:

1. Experience in receiving and providing first aid
2. Observed competency and confidence in first aid assistance
3. Previous experiences in first aid training
4. Expectations for VR application in first aid

Respondents were first asked questions regarding their own experiences with first aid assistance. The purpose of these questions was to understand what sort of injuries respondents had been exposed to, where they were either the receiver of first aid assistance, or where they had provided first aid response for others. Respondents with such experiences were asked to inform about what sort of injury had occurred, who had provided treatment, and an optional open comment on how the treatment was performed. A follow-up question asked the respondents to measure the competence in which the treatment was provided, and the perceived confidence of the provider; for questions where the respondent was the provider, they were requested to self-evaluate their competence and confidence.
To understand the average first aid training experience of potential users, respondents were asked when they had last carried out a first aid training themselves. The respondents were also asked an open question as to what form of training they had received; optionally, they could report about what exercises or situations were practiced.
The last set of questions aimed to obtain the opinion regarding the potential of utilizing a VR application for training in first aid. Survey respondents were asked about their familiarity with VR systems, their perception on the usefulness of first aid training in VR, and what expectations — positive or negative — they may have for the implementation of such an application.
The full survey for the user needs assessment can be found in Appendix XXX.

[1] https://rambollxact.no/surveyxact

Target respondents and survey distribution

The intended recipients for the user survey were primarily students and faculty at the University of Agder. Though the survey was intended as open for everyone to participate, students from diciplines within ICT/Computer Science and health- and nursing studies received invitations to participate the study through announcements posted by their respective study program coordinators or members of faculty. The survey was also distributed through an email invitation to at least one company working with health- and safety courses. To improve the participation/response rate, the survey was distributed in both English and Norwegian language.

3.4 Design & Development

Following a two-weeks response time for the user survey, the obtained responses were compiled for processing. The compiled answers from the open question regarding expectations for a VR-based solution formed the basis for needs and expectations to be addressed. Those needs and expectations were then prioritized and refined into requirements for the prototype to be developed.
Artifacts generated from this phase — the processing of the user needs, requirements specifications, and the subsequent design and development of the system — are covered and presented in Chapter 4.
The theoretical bank would address the respondents' expectations of being able to learn about types of injuries, emergencies, guides for treatment, and common accident places. The user

3.5 Demonstration

The DSRM "Demonstration" phase presents the developed prototype to a selected group of test users to gather input and feedback as basis for the "Evaluation" phase. 8 testers were invited for a demonstration of the prototype. Of the 8 testers, four were students from an AI and IoT master's programme, taking a course on digital health theory and praxis, two testers were from the ICT bachelor's programme, with two additional testers from the programme for Health- and Nursing Education. The latter two were faculty members invited as educational experts, to provide feedback based on their experience either as an instructor or as having taken certifications in first aid or first aid related activities.

Test procedure

The usability test was divided into three main parts:

1. Project introduction & pre-test interview
2. Prototype Demo & User Testing
3. A post-test questionnaire & interview

The users were first provided with a brief introduction to the project, the procedure for the user tests, and the current state of the prototype. Each user was interviewed before testing the prototype. The questions asked prior to the tests involve the users' previous experiences with first aid, first aid training, and with virtual reality devices. Following the pre-test interview, the test users were provided with the VR device with the prototype application started. The test users were then guided through each implemented section in the following order:

1. Introduction to Basic Movement and Interaction in the VR-space

2. Theoretical First Aid Learning: Recovery Position
3. Practical First Aid Training: Recovery Position

The users were provided guidance and assistance throughout each section of the prototype, most commonly at the start of each section or in areas with known challenges or shortcomings related to the implementation of the prototype.

Usability assessment

During each users' test of the prototype, different usability characteristics were observed and assessed:

- System errors occurred
- User errors occurred
- Notes to specify error
- Comments from User (following a "think-aloud-approach")

System Usability Scale

A system usability scale was used to assess the usability of the prototype [18].
After the user completed the testing of the prototype, a 10-questions-questionnaire was provided to them to calculate a "score" based on the user's agreement to 10 usability-related statements on a scale from 1-5 (1 - Strongly Disagree, 5 - Strongly Agree). The average score for all conducted tests was used to determine the usability score of the system (SUS). The level of acceptability on a scale of 0-100 is determined as the following:

1. Score = [0-49]: Not Acceptable
2. Score = [50-69]: Marginal
3. Score = [70-100]: Acceptable

Interview questions

At the end of each user test, following the SUS questionnaire, a post-test interview was conducted with testers to obtain qualitative information with regards to their experience with the prototype and the concept of a VR-based first aid training application. The users were asked in depth about their initial thoughts of the system following testing, the viability of such a tool, what features they might wish to see demonstrated or implemented for the future, and as with the pre-test interview, a Likert-scale question with regards to whether or not they think VR-technology has the potential to be used to train people in first aid.

Chapter 4

Design & Development

This chapter covers the DSRM Design & Development phase to create an artifact for the Demonstration phase. The artifact in this project is a proof-of-concept prototype for the test and evaluation of the VR-based first aid training solution.

4.1 Scope and limitations of the prototype

The purpose of the prototype was to communicate key activities a user may utilize a full-fledged system for. The prototype goal was to provide theoretical and practical learning content for at least one specific topic within first aid; with similar implementation for a second topic if given time.

4.2 Design

4.2.1 User needs assessment and requirements specifications

The user needs were gathered based on responses to the open question for expectations and needs in the User Survey. These responses were input into a table, as displayed in Figures 4.1 and 4.2.
Each row is an identified need, with a potential solution added to address that particular need when possible. Needs with no practical solution or immediately addressable solution were excluded from further evaluation.
13 initial needs were identified for the proposed system. 9 of the 13 needs were selected as either acceptable for being turned into requirements or to be further considered for requirements specification.

	User Needs	Potential Solution
1. Availability on multiple platforms	Survey respondent expressed wish for system to be available on multiple platforms	(Out-of-Scope) Practical limitation of the project.
2. Low / free of cost	Survey respondent(s) expressed that the system should be low or free of cost	(Out-of-Scope) The project is not aiming for a complete system ready to be distributed, though for discussion purposes it should be argued that a complete system should have low cost to encourage more users
3. Effectiveness	Survey respondent expressed a wish for the system to be more effective. Assumption: more effective in comparison to traditional learning; through courses	(Out-of-Scope) Conceptual and practical limitation; the project has no plan for measuring effectiveness of the system due to time constraints and not aiming for a complete system.
4. Correctness when practising with learned content	Survey respondent expressed expectation or wish for the system to display if work has been done correctly in real-time; proposed using a Heads-Up Display (HUD)	Display progress of the user when practising learned content
5. Easy to understand / learn	Survey respondent(s) expressed expectation for system to be easy to understand / learn	Could be addressed by making instructions and activities short, clear, and easy to read / follow
6. Used for training	Survey respondent expressed how the system could be nice to use for training; specified surface damage, broken limbs	Provide practical exercises which users can work on, based on first-aid content.
7. Provide overview for different types of injuries and emergencies	Survey respondent expressed how an overview of different types of injuries and emergencies may lessen “scare-factor” when encountered in real life; resulting in improved confidence	Provide content covering different types of injuries and emergencies, with instructions on how to address them.

Figure 4.1: User Needs Assessment 1/2: Rows denote inclusion or exclusion further in the project, Green: Included, Red: Excluded, Orange: For consideration

	User Needs	Potential Solution
8. Pedagogical	Survey respondent(s) expressed for the system to follow pedagogical structure; following latest research	(Out-of-Scope) Practical limitation; The project does not plan on addressing in detail how content should be formatted or structured
9. Similar functionality to real life	Survey respondent expressed a wish for the training system to function as if it were real life Assumption: functionality in terms of actions performed when practising	Allow for realistic movements and interactions when practising first-aid. Allow the user to work with a virtual doll
10. Provide impression of potential risk areas	Survey respondent expressed a wish for the system to provide an impression of locations and areas where accidents requiring first aid may occur.	Create environments which the user can immerse themselves into; simulate real-life locations
11. Time-based measurement for likelihood of success	Survey respondent expressed a wish for a system to measure likelihood of patients becoming critically wounded based on how long the user spends.	Could be considered for implementation during project. Though not the initial reason, could be developed for an "exam" mode
12. Allow for users to practise in uncomfortable situations	Survey respondent expressed a wish for the ability to practise in uncomfortable situations to improve confidence when situations arise	Could be considered for implementation, though what constitutes as uncomfortable may vary between users.
13. Unpredictable in first attempts	Survey respondent expressed a wish for the system to be unpredictable in first-time attempts	To be considered; unsure as to how much can be implemented within time of the project. Could be justification for an "exam" mode

Figure 4.2: User Needs Assessment 2/2: Rows denote inclusion or exclusion further in the project, Green: Included, Red: Excluded, Orange: For consideration

ID	Description
1	Provide content covering different types of injuries and emergencies, with instructions on how to address them.
2	Provide practical exercises which users can work on, based on first-aid content.
3	Allow for realistic movements and interactions when practicing first aid. Allow the user to work with a virtual doll.
4	Display progress or instruction(s) to the user when practicing learned content
5	Create environments which the user can immerse themselves into; simulate real-life locations
6	Instructions and activities are short, clear, and easy to read / follow

Figure 4.3: Table for requirements, description based on proposed solution

From table 4.3, Volere Snow Cards[1] were used to finalize the requirements for the prototype. These requirements are divided into functional and non-functional requirements. The selected requirements define the key aspects of the system that the prototype sought to convey.

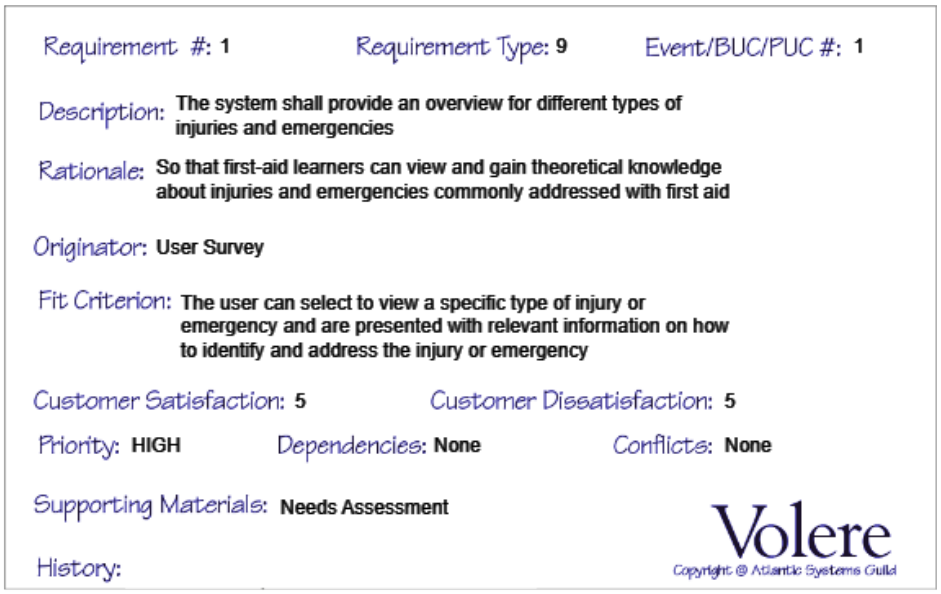


Figure 4.4: Requirement #1

[1]https://www.volere.org/wp-content/uploads/2018/12/snowcard.pdf

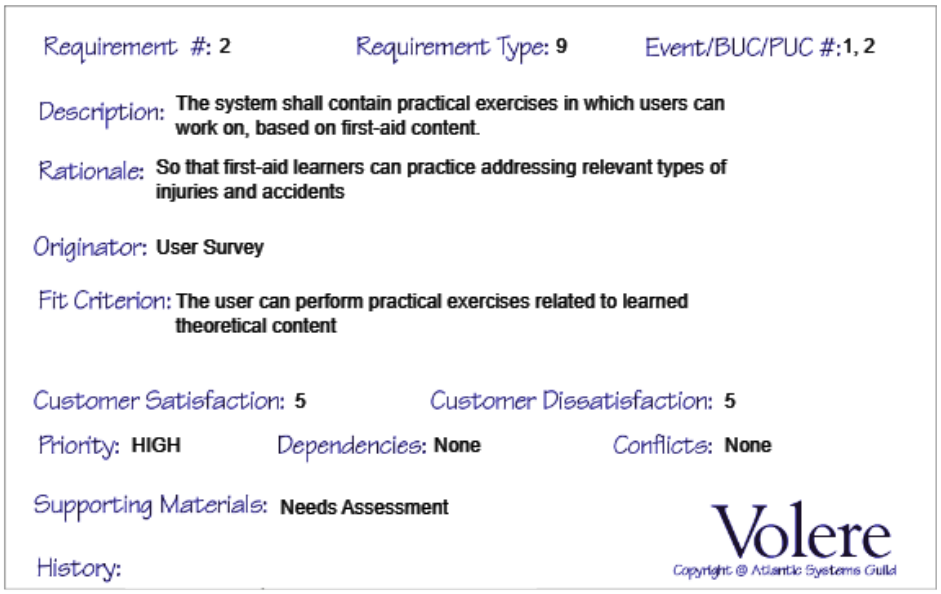


Figure 4.5: Requirement #2

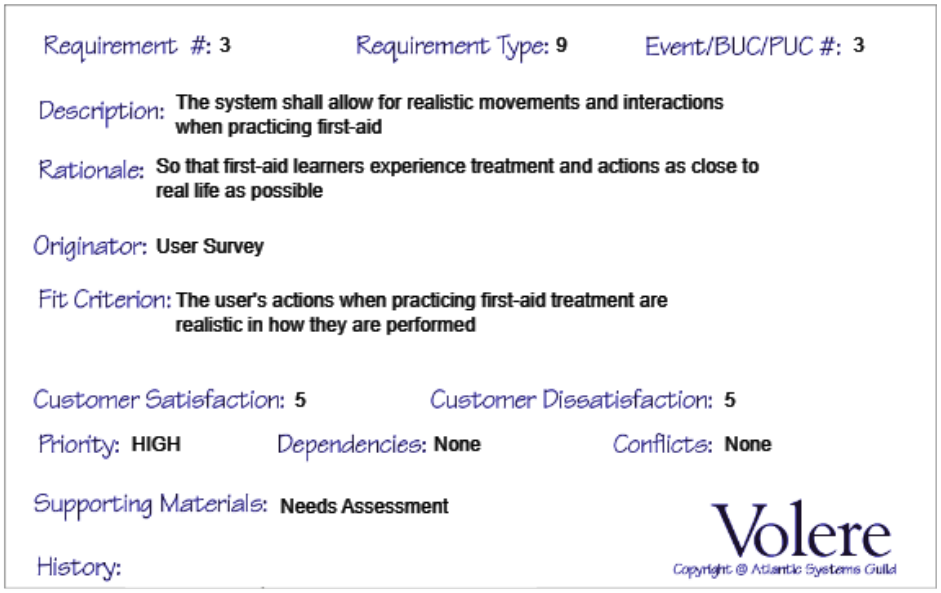


Figure 4.6: Requirement #3

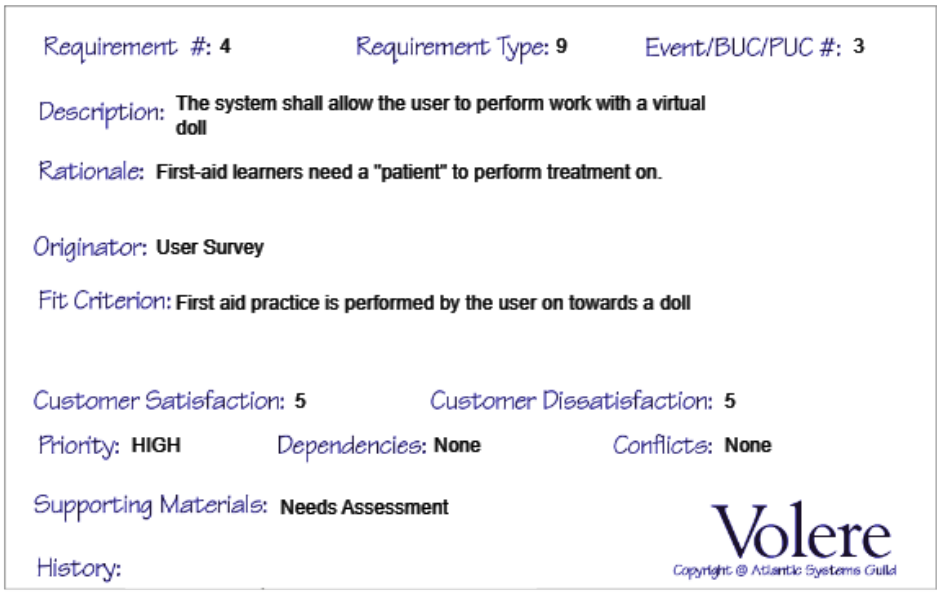


Figure 4.7: Requirement #4

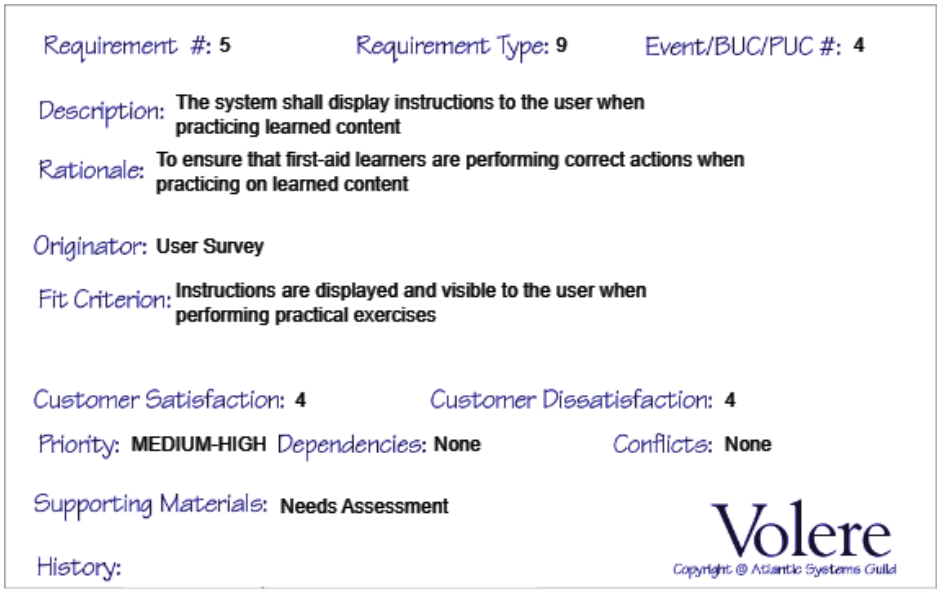


Figure 4.8: Requirement #5

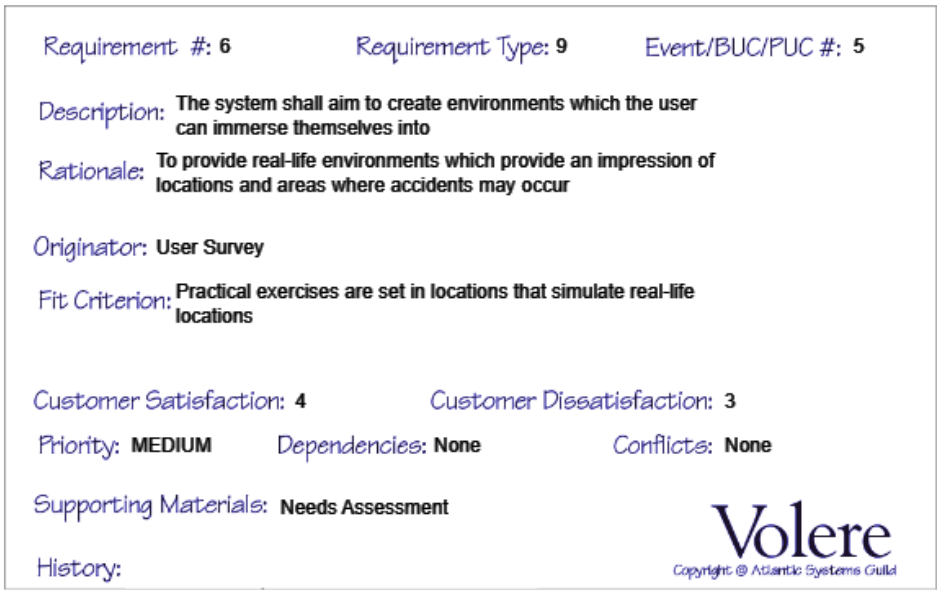


Figure 4.9: Requirement #6

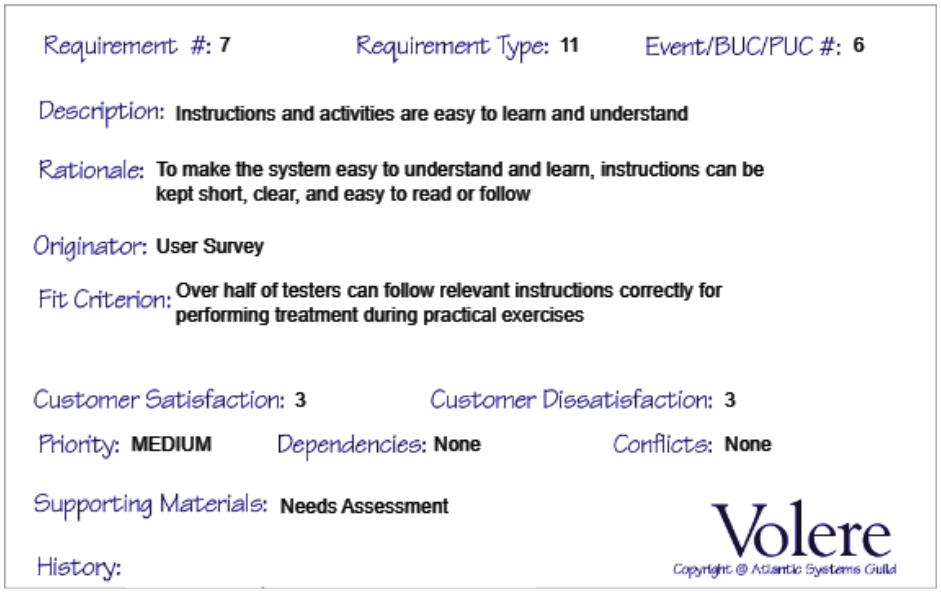
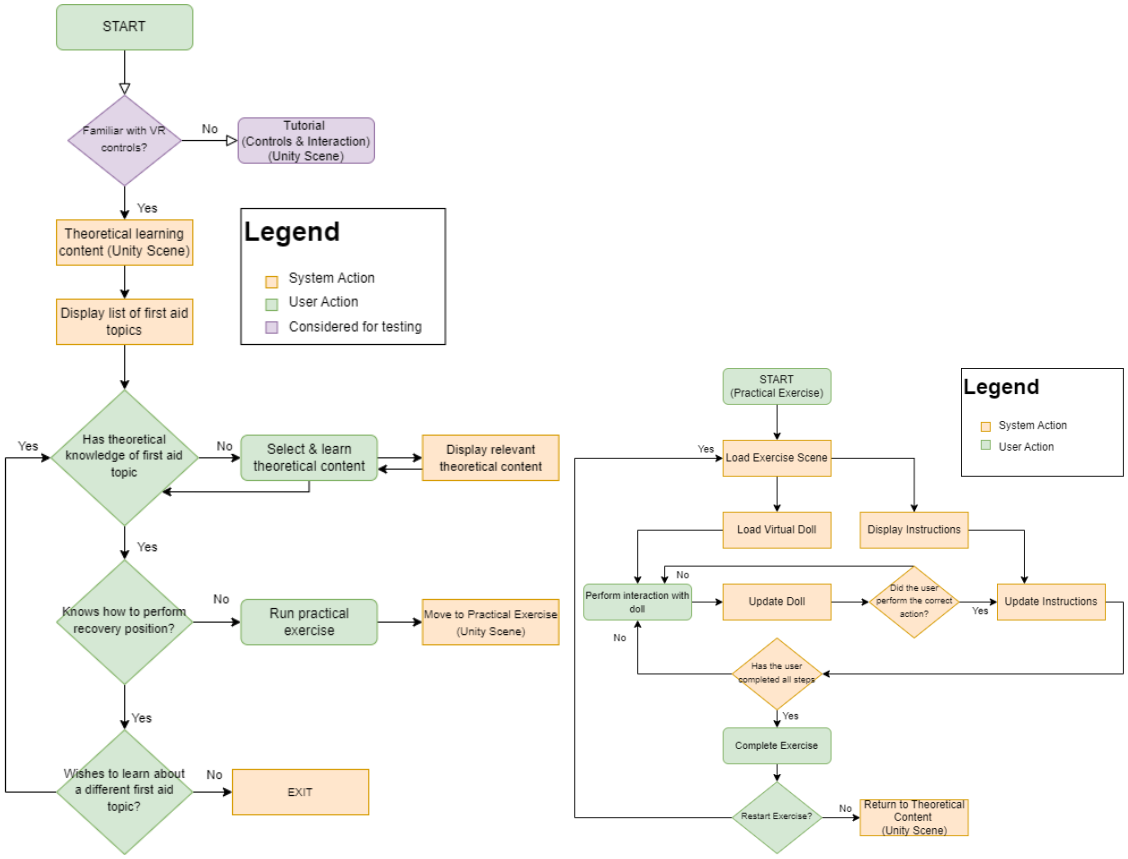


Figure 4.10: Requirement #7

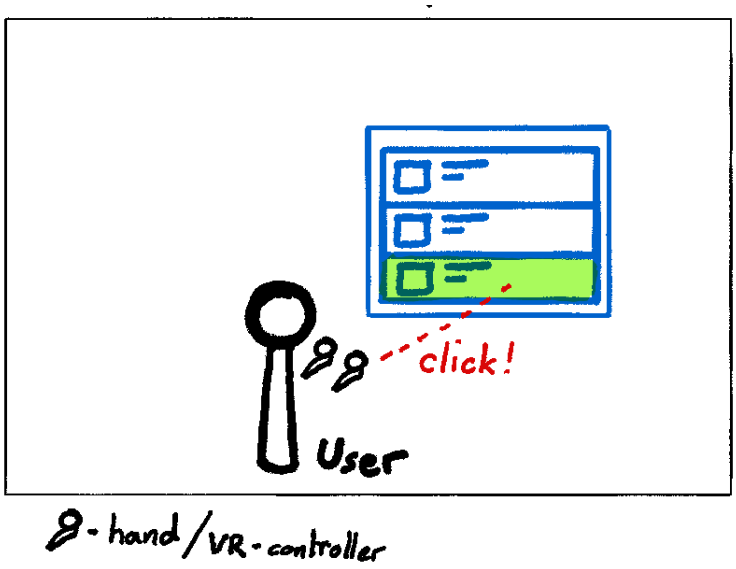
4.2.2 Storyboard and User Flow

The storyboards provide a high-level visualization of how the functional requirements may be implemented, in addition to how an imagined user may use the system. A storyboard was developed to visualize the activity of a user going through a section of the theoretical learning content followed by starting and going through an exercise tied to that learning content. User flow diagrams were produced to visualize decisions and actions to be taken within the proposed prototype. Figure 4.11 maps the path of actions and activities that may occur between the User and the training system for the proposed prototype.

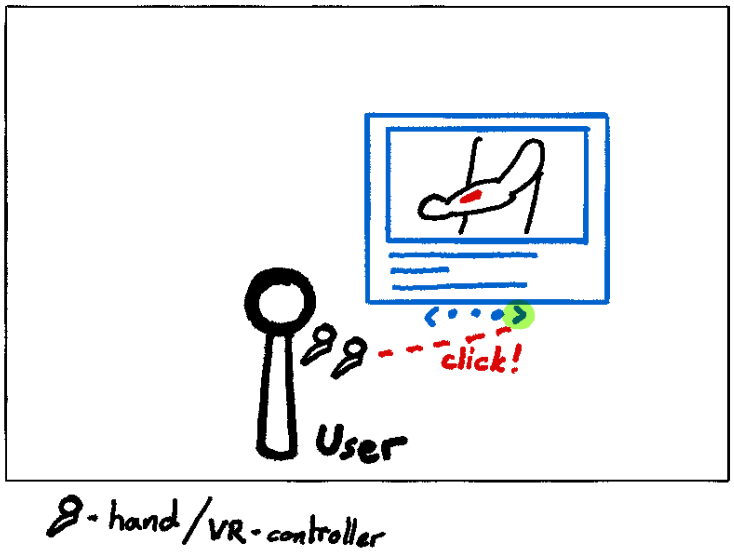


(a) User Flow: Start and Theoretical Learning (b) User Flow: Practical Learning Exercise

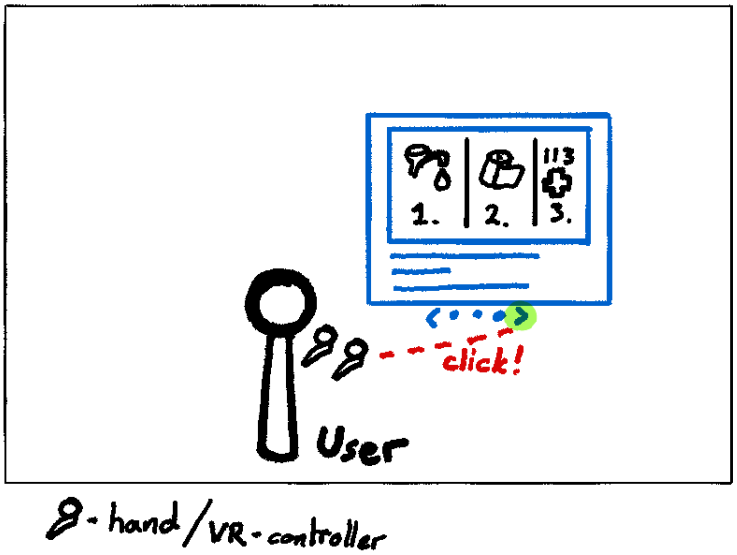
Figure 4.11: User Flow diagrams with focus on Theoretical and Practical Learning aspects



(a) The user selects a topic within first aid

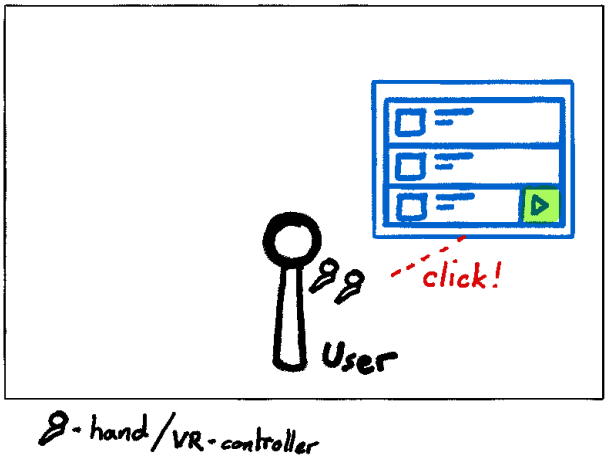


(b) The user is provided with relevant information related to the selected topic

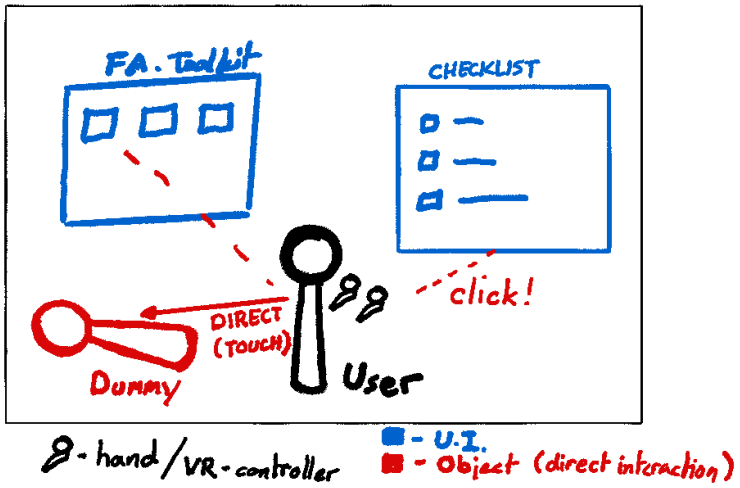


(c) The user can navigate through a set of slides which provide instruction on how to perform treatment of the selected topic

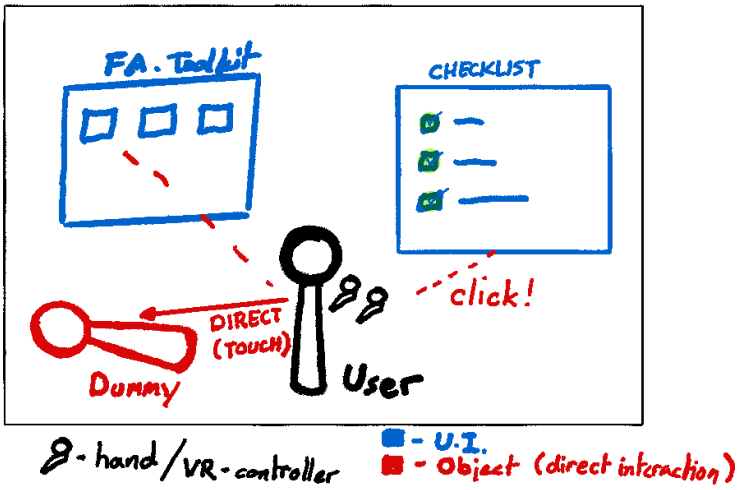
Figure 4.12: Storyboard of user in VR space learning theoretical content for treatment of an injury



(a) After going through the theoretical content for a first aid topic, the user selects to do the practical exercise to train themselves.



(b) The user enters a scene in which a doll is provide; along with visible instructions on how to perform the treatment. [If Required:] the user is also provided with tools and supplies required for the treatment exercise.



(c) The user works their way through the instruction set until the treatment exercise is completed. They may then exit to select a new topic, or retry the exercise if they wish.

Figure 4.13: Storyboard of user in VR space learning theoretical content for treatment of an injury

4.3 Development of prototype

Following the requirements specifications, story-boarding, and drafting of the planned prototype, the project moved on to development of the system. The developed prototype was a VR-based first aid training system, developed for the Oculus (Meta) platform. The system was developed and built on the Unity Engine, using the 3D Universal Rendering Pipeline as a template. The project also made use of the XR Interaction Toolkit[2] provided by Unity. The toolkit package provided a framework for making 3D and UI interactions with Unity's input system. The core of the framework is a set of Interactor and Interactable components, with an Interaction Manager that ties these components together [7]. Key components of the XR Toolkit that supported the project were as follows:

1. Cross-platform XR controller input
2. Utility for interacting with XR Origin
3. Basic Canvas UI interaction with XR controllers

4.3.1 System Structure

The prototype was split into three scenes; two scenes were used to implement the requirements for theoretical and practical learning content.

- **Scene 1:** User Movement and Interaction Guide
- **Scene 2:** Theoretical Learning: Recovery Position
- **Scene 3:** Practical Learning: Recovery Position

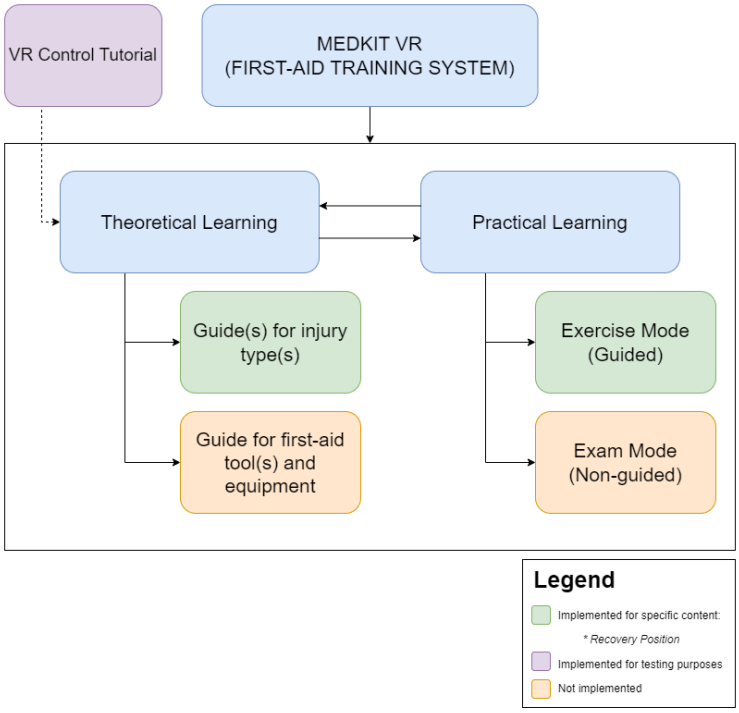


Figure 4.14: Structural overview of the developed system

[2]https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@3.0/manual/index.html

Implementation of requirement #1

Requirement #1 was realized with the theoretical learning scene. In this scene, users are presented with a list of first aid topics; the selected topic is then presented in the form of slides containing images and textual information regarding the specific topic. UI elements were used for displaying the slides and first aid topics Figure 4.15 displays layout for the implemented theoretical scene in Unity.

Figure 4.15: Overview of the theoretical scene: users can select topics from a set list (left), which is then displayed on slides (center) and demonstrated with a dummy (right).

Figure 4.16: UI panels make up the slides used for presenting the theoretical content for how to perform recovery position.

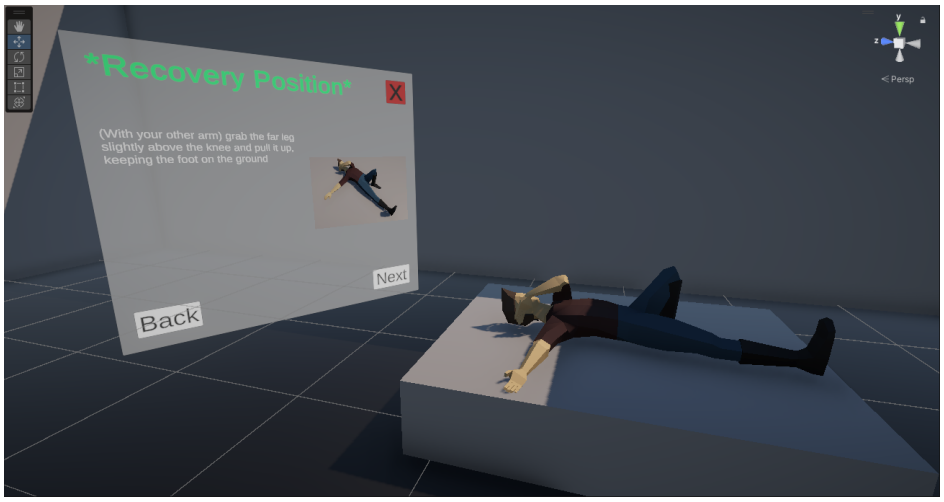


Figure 4.17: A virtual patient (dummy) is implemented to provide a 3D look at how the person is to be positioned at various stages.

Implementation of requirement #2

Req #2 was realized in the practical learning scene. Users in this space followed a guided exercise for placing a virtual doll into a recovery position. The UI slides from the theoretical content was reused as instructions; new instructions were displayed whenever the user had correctly moved the previous limb.

Figure 4.18: The scene used in the practical learning exercise uses environmental props, in this case trees and a park bench (not in frame), to imitate a park environment.

Figure 4.19: The user would move the doll's arms and legs by grabbing onto the wrists and ankles of the doll. Spheres are used and placed at the elbow and knee to indicate to the user where to grab and pull the doll once it was in position to be rolled over.

Figure 4.20: Upon completion of the exercise, the user has the option to return to the main (theoretical) scene.

Implementation of interactions with the dummy, REQ #3 / #4

Interactions with the dummy is implemented using Unity's Animation Rigging system. The dummy is rigged with a skeleton and Inverse Kinematics (IK) applied to the arms and legs to provide realistic movement of the limbs. To address requirement #3 and provide the realistic movement, the IK system uses a combination of targets and hints; the targets are used to determine the position and orientation of a given limb and the hints determine the direction joints will bend towards when the distance between root and tip of the bones become smaller.

Collision boxes were used to perform checks on whether the correct actions had been performed.

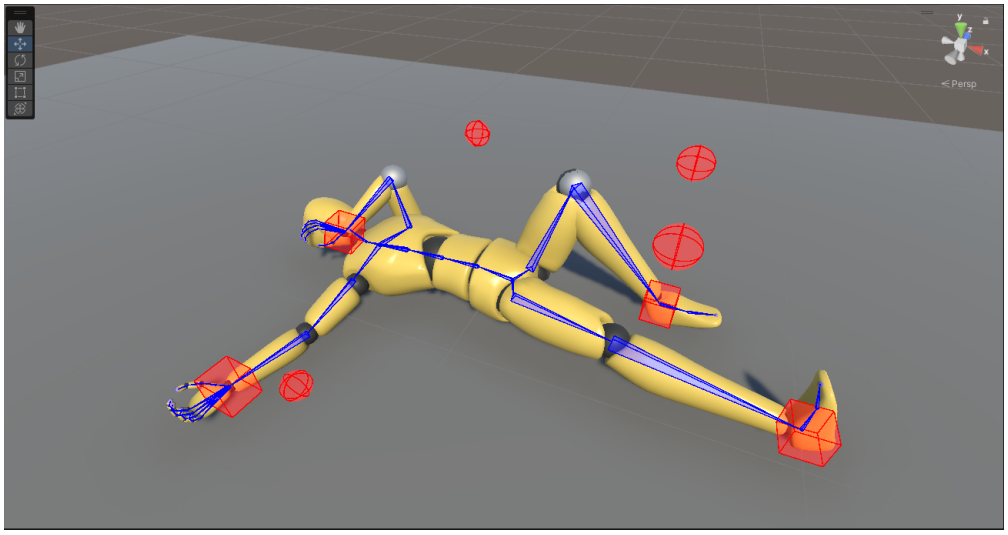


Figure 4.21: The training dummy rigged with a skeleton. Targets and hints are displayed as the red cubes and spheres respectively.

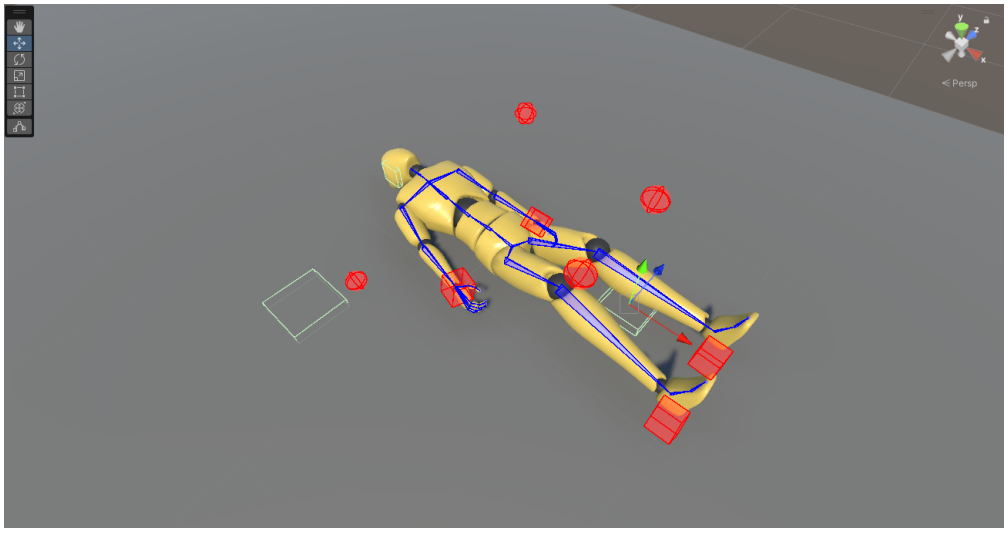


Figure 4.22: Collision boxes for triggering the next steps leading up to rolling the doll

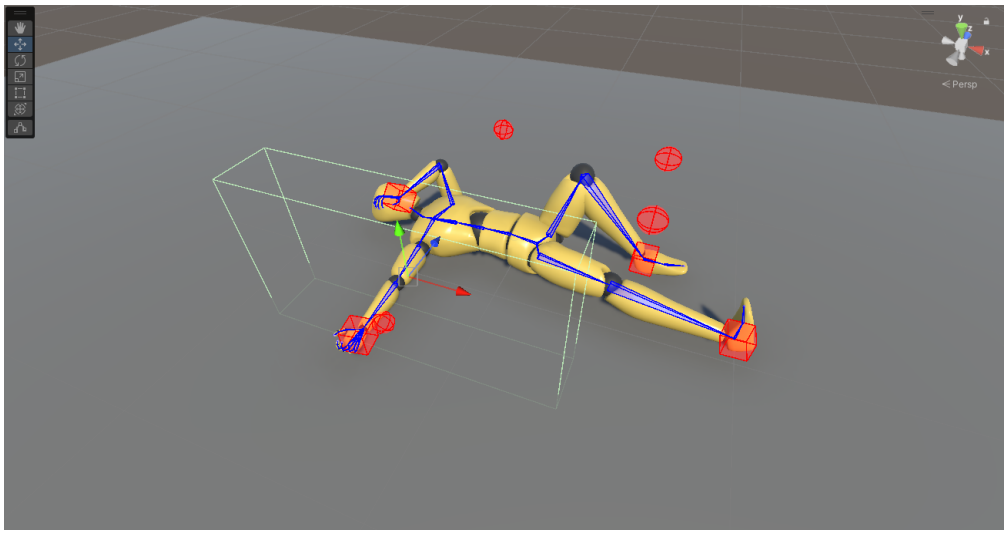


Figure 4.23: To perform the roll, the user was required to grab the two points at the elbow and knee (gray spheres), and pull it towards the collision area

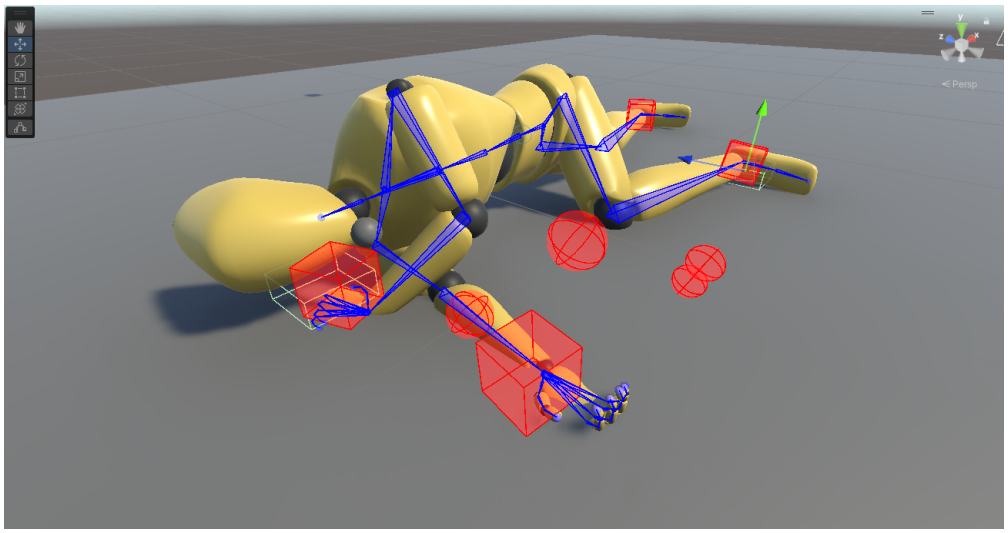


Figure 4.24: Collision boxes for checking the positioning of the foot and chin after the roll

Chapter 5

Results

The results cover the findings obtained from the user survey distributed prior to implementation of the prototype. Section 5.2 covers the tests performed following development of the prototype, as well as the results collected from the user tests, which contains the pre-test interview, the observations made during testing, and the post-test interview. The calculation of the System Usability Scale (SUS) is also covered in this chapter.

5.1 Findings from User Survey

The survey collected 40 responses, 35 of whom had completed the survey in its entirety. Responses from not entirely completed surveys are also considered here (i.e., answers on a subset of the questions).
The demographics from the responses show a near equal distribution between male and female respondents; 19 male to 21 female (with no respondents identifying as ”other” or ”did not wish to disclose”). The majority of respondents were in the age range of 22-30, followed by 16-21. 28 respondents had received an education of undergraduate or lower, with 9 respondents either working or in graduate to post-doctoral positions; the majority being in fields of engineering, technology, and computer science followed by fields within business and administration, education and teacher training, and health- and social care.

5.1.1 Experiences with first aid (passive and active)

The survey found 5 respondents that have required first aid as a result of an injury within the past 3 years; the respondents received assistance from close family members, or from others unknown to the respondent but was present at the time of the injury. Three of the five respondents observed that the first aid provider's competence in assisting with their injury and the confidence of the provider was high; with two either being neutral or disagreeing with either statement.
13 respondents were found to have provided first aid assistance to others, with a near equal divide between those who provided assistance to people familiar to them, and those who had no relation to the person in need of assistance. Injuries encountered by respondents varied in type and severity, ranging from minor cuts to potential overdose. Respondents that opted to describe their assistance followed practices commonly described in first aid treatment guides; practices such as applying pressure and preventing further bleeding from open wounds, disinfection of wounds, and stabilization and recovery techniques were among the described responses.

When asked if the respondents were highly competent in providing first aid towards others, the majority aligned themselves as slightly agreeing to the statement, with only six respondents finding themselves strongly agreeing. The remaining respondents were varying levels of neutral or disagreeing to the aforementioned statement. Similar results can be found with

regard to their perceived confidence; a decrease — and conversely an increase — is observed with two fewer people slightly agreeing to being confident and rather slightly disagreeing to the statement.
Regardless of experience, a combined 22 respondents agreed to the statement of not being afraid nor hesitant to assist others in need of help during emergency situations.

5.1.2 Respondents' experience with first-aid training

Respondents were asked to inform when they had last received any training or instruction in first aid or first aid related activities. The majority of respondents had received training within the last 1-2 years, with only 8 respondents having been without training for the last 5 years or longer. When asked to go into depth about the type of training respondents had received, the majority of answers were:

- Health- and Safety Course at place of study
- Yearly / Regular first aid course at place of work
- Training as part of basic traffic school for vehicle license

Additionally, one respondent received training through military service, with another respondent being an instructor for first-aid providing instruction on varying levels. The majority of respondents had received training in cardiopulmonary resuscitation (CPR), and placing patients in recovery position. Respondents who had received workplace training were more likely to comment on having received additional training due to needs within their fields of work.

5.1.3 Opinion about feasibility of VR for first aid training

18 of the 35 respondents reported themselves as being familiar and having experience in using Virtual Reality devices. 28 respondents agreed either strongly or slightly with the statement that a Virtual Reality application may be useful as a tool for training in first aid. The section which proceeds this covers data gathered from the demonstration of the prototype

5.2 From the demonstration (=test of prototype)

User pre-test interviews

When asked about previous experiences with VR, 6 (75%) of the testers answered to having had previous experiences with VR devices. All of them had varying levels of usage or familiarity with the system. 2 (25%) of the testers mentioned owning personal VR devices; one used it frequently in game context, with the other having used it for recreational purposes, but also had experience with VR solutions implemented at their workplace. Another 2 (25%) of the testers had experiences in trying VR applications only a handful times in the form of playing VR games. The two educational experts invited had previous experiences in testing out demonstrations or prototypes of other VR solutions for research purposes.
In terms of experiences with first aid training, all had received training at some point with only one not having received training within the past 3+ years. 5 of the testers had received their training as part of the HSE course from the University. 2 testers had taken certifications in parts of first aid training or had experience as instructors in first aid.

First aid training was of great importance to all of the testers when asked; unpredictability of when accidents may occur and the importance of readiness, whether it may or may not happen, was expressed by most of the testers.

When asked to rate on a Likert-scale, from 1-5 (1 = strongly disagree, 5 = strongly agree), if VR can be used to train people in first aid, the average response from the testers was measured at 4.125/5.

5.2.1 User Test Observations

During the testing of the prototype, testers were asked to express their opinions and provide feedback on the implemented features of the system. Testers provided feedback as they worked their way through all three scenes for the prototype. As the first scene was only used to familiarize the testers with controls and interactions in VR space, in preparation for the actual content of the prototype, the observations and feedback received while in this scene were documented, but omitted from the evaluation of the system.

Observations and feedback on theoretical content

In the theoretical content scene of the prototype, users were asked about their opinions with regards to the UI slides containing the information for the recovery position and the virtual doll used for displaying the different poses when placing a person into recovery position.

Feedback for the theoretical learning scene was overall positive. Testers were more positive towards being able to view the physical dummy over just a 2D image. One tester commented the ability to view the doll from multiple angles can be useful for guides which can contain a large number of movements. Figure 5.1 contains a summary of feedback provided for the theoretical content.
Testers were observed to spend the majority of the time reading, and at times only provided brief glances at the doll. Some testers were not immediately able to see that there was a doll present upon initial view of the UI slides.

Observations and feedback on practical content

Testers during the practical exercise were also asked for their feedback as they worked through the exercise of placing a dummy into a recovery position. The majority of testers were observed experiencing difficulties placing the doll into the correct position due to the limb being interacted upon not matching the position with where testers were moving the limb up until the limb was released. Testers were advised to perform micro-adjustments and small movements, releasing the limb between each movement; to regularly receive feedback on the position of the limb. The testers were observed to focus more on getting the task done rather than provide feedback. Direct feedback on the practical exercise was reserved by most users to be given during the post-test interviews. Figure 5.2 contains a summary of commonly observed challenges that were regularly experienced across most the tests.

5.2.2 System Usability Scale and Post-Test Interviews

Following the tests, testers answered the System Usability Scale questionnaire provided to them. The table shown below displays the calculation for each tester:

The overall score of the prototype based on the System Usability Scale was 72.5, which places it within the level-of-acceptability bracket: Acceptable.
The testers were asked to provide some final feedback on the VR prototype, and to share their opinions on first aid solutions using VR in general, not necessarily limited to the specific prototype implementation. The general consensus of the opinion about the system among the testers was that the prototype was still in an early stage; it contains significant bugs and issues which make it challenging at times to work with the system. One tester expressed particular frustration with the limbs of the doll not following the position of the tester's

Tester #:	Feedback
1	(about dummy) useful for confirming what actions to take with the doll.
2	(about slides) choice of text color on transparent background could be a challenge to read.
2	(about slides) could be nice to have a voice-over read the content.
3	(about slides) a bit blurry / hard to read.
4	(about dummy) more effective than using an image.
5	(about dummy) appreciates how you can view the dummy from multiple angles compared to a still image; prefers having both.
6	(about slides) positioning makes it awkward; requires user to look back and forth between slides and doll, would be nice for the slides to either move with the user's view or be in a better position.
7	(about dummy) would be nice to see it animated; so that you can view the transition between poses / stages.
8	(about dummy) would be nice to try interacting with the dummy to imitate the images presented in the slides.
8	(about slides) should improve text font and image size, moving around to view the dummy can put the text at an awkward position making it even harder to read.

Figure 5.1: Summary of key feedback for the Theoretical Content

hand in real time while it was held. However, the majority of testers, 7 out of 8, were positive to the idea of a VR solution for training in first aid. One tester of the prototype commented that outside of bugs, the opportunity to learn and practice at your own pace made the prototype a potentially valuable tool.
The educational expert testers provided feedback with regards to supporting the value of having such a system available and offered suggestions on how the system may be improved further for future development. The Likert-scale response for the post-test question as to whether or not VR can be used as a tool for first aid was measured at 4.25/5.

Sub-task #	Observations
2: Place left hand on right cheek	Testers observed unable or encountering trouble placing the arm into correct position when attempting to place the hand by the cheek
3: Raise left knee	Testers observed attempting to grab by the knee / upper leg when instructed to grab the ankle. (Testers are correct based on received theoretical content)
5: Extend the left leg into right angles	Testers observed finding it difficult to place the foot into the correct position when adjusting the leg after rolling the doll
6: Adjust the airway	Testers observed experiencing difficulty when placing the doll's face down and outwards

Figure 5.2: Observed key challenges or issues encountered by testers

Tester	Sum	Usability Score
1	11	27.5
2	30	75
3	29	72.5
4	34	85
5	26	65
6	40	100
7	35	87.5
8	27	67.5

Table 5.1: Calculation of the Usability Score for each tester

Title	Description
Traffic Accident Management	Implement scenarios involving traffic accidents
Acute Injuries	Implement scenarios for treating heart-attacks
Child Assistance	Guides for first aid toward children
Implement high-risk scenarios	Wishes to see scenarios that can evoke the stress of a high-risk situation
Wider selection of dolls / patient types	A wider array of dolls that can be of different ethnicity or with disabilities; tester provided example of how would recovery position be performed on a person with an amputated limb
Silhouette to follow in practical exercise	A "shadow" of the doll that acts as hint by showing the expected movement to be performed on the doll

Table 5.2: Selection of feedback collected from testers for future development

Chapter 6

Discussion

This chapter addresses the ”Evaluation” phase of the DSRM model. The evaluation of the prototype focuses on the implemented features and the test users' feedback and SUS score result obtained from the previous phase. This chapter provides answers on the research questions, and covers also other considerations made and a discussion of further aspects looking at the project as a whole.

6.1 Evaluation of the prototype

The developed prototype attempted to address the requirements provided following the needs assessment. The conceptual design for the prototype covered the functional needs of the system, with certain core features were realized on a level which allowed testers to assess, comment, and generate opinions surrounding them.

Theoretical learning

The theoretical section of the prototype received generally positive feedback; comments were made with regards to how more consideration should be put into the ergonomics of the space, particularly the positions and orientation of the theoretical slides and the dummy.

Practical training

The practical section of the prototype was able to communicate the idea for implementing training exercises in VR space, to mixed-positive feedback. A recurring comment during the post-test interview was the lack of physical feedback, namely resistance and weight. A suggestion was made by one of the educational experts to incorporate a feature in which new users are introduced to the doll sooner and provided with short exercises in which the user may acclimate to how to interact with a mass-less doll.

The idea versus the realized prototype

Although the result of the System Usability Scale returned with an overall score of 72.5 / 100, which sets the prototype at an Acceptable level, there is an uncertainty as to the impact of biases during the scoring. When looking into individual responses to the questions in the SUS, some testers showed responses which did not necessarily match the feedback they provided, or was inconsistent with other questions in the same questionnaire. It is possible that the answers provided to the questionnaire may have been skewed toward an evaluation of the idea as whole, rather than the prototype as was presented. For a more accurate score, a larger test pool should be considered.

6.2 Answering the research questions

6.2.1 RQ1.1: Stakeholder expectations

This project gathered information on the expectations of potential stakeholders for a VR-supported training system through the use of a User Survey, and further through the evaluation of a developed prototype. Following the demonstration, it can be answered that some key expectations for a VR-supported system are:

1. Realism - the system should seek to imitate true to life scenarios, to improve immersion of the user.

2. Correctness - the system should avoid unwanted behaviors, to avoid breaking the users' workflow when performing tasks leading to frustration.

3. Variety - A VR-supported system overall has the benefits of providing virtual environments which the in which the user can perform a large variety of scenarios.

4. Ease-of-Use - To support and encourage the propagation of first aid training, it must be accessible and easy to pick up by most users.

6.2.2 RQ1.2: Implementation of needs and expectations

The prototype attempted to implement and realize the needs and expectations of stakeholders in a satisfying manner within the time allotted by the project. The realized prototype was simplified with regards to all assessed user needs, but allowed for communication of the key ideas behind the VR-based education and training system. Given more time for design and development, a more complete system may be produced. It would benefit the future development of the system to also gather a more varied pool of stakeholders for future testing of the system; the tests and surveys conducted for this project heavily sampled from people within the ICT and technology space.

6.2.3 RQ1.3: Can a VR-based tool for first aid training address and fulfill the demands and requirements for first aid training

Based on output obtained from the demonstration and user tests, there is an argument to be made for a VR-based tool to cover a significant amount of first aid content; even with the understanding that there are physical limitations to what Virtual Reality can or cannot emulate. A VR-based tool may supplement first aid training by, if publicly available and widely distributed, reducing the rate at which learned first aid skills degrade and are forgotten.

6.3 Learnings from the system development

6.3.1 Development towards a more complete system

The prototype scope did not comprise an implementation in which all types of interactions or activities could be assessed and evaluated, such as how an exercise for wound management may have been realized. This does invite for future projects in this space to investigate a more full-fledged system, serving as a compendium for theoretical knowledge in first aid training, and containing other types of practical scenarios in which users may test learned skills.

6.3.2 Challenges with implementations of the doll

Challenges were primarily encountered during the implementation of interactions with the virtual doll. Initial attempts implemented a ragdoll system, but proved to not be viable for grab interactions between the user and doll; the ragdoll solution provided faster implementation of a doll affected by physics, but was sensitive and prone to undesired behavior once the user attempted to manipulate the limbs into the correct position. The current implementation using the IK system can be developed further for to incorporate animations if direct real-time interactions with the limb cannot be fully realized.

Chapter 7

Conclusions

This project aims to address the need for an improved propagation and promotion of first aid training. The project — following a Design Science Research Methodology — designed and developed a prototypical VR-based system for training in first aid, based on needs and expectations gathered from potential users. The developed system, implemented in Unity, allowed users to learn how to perform placing a virtual doll into a recovery position by providing theoretical content and putting users through a guided exercise.
Following the development of the proof-of-concept prototype, the system was demonstrated to a number of test users to gather feedback and evaluate the prototype's usability using a System Usability Scale. The results of the demonstration and evaluation show that there is an interest and positive attitude towards a VR-based solution for training in first aid. A full-fledged system which is open and available to a wider audience, may effectively support first aid training by improving already existing skills or by reducing the rate at which those learned skills degrade.

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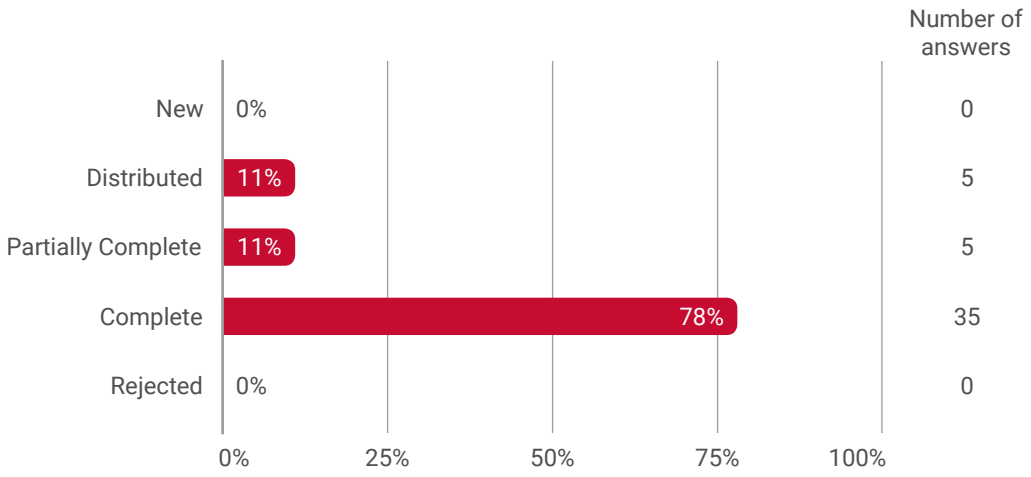
[18] James R. Lewis. "The System Usability Scale: Past, Present, and Future." en. In: *International Journal of Human–Computer Interaction* 34.7 (July 2018), pp. 577–590. ISSN: 1044-7318, 1532-7590. DOI: 10.1080/10447318.2018.1455307. URL: https://www.tandfonline.com/doi/full/10.1080/10447318.2018.1455307 (visited on 05/24/2024).

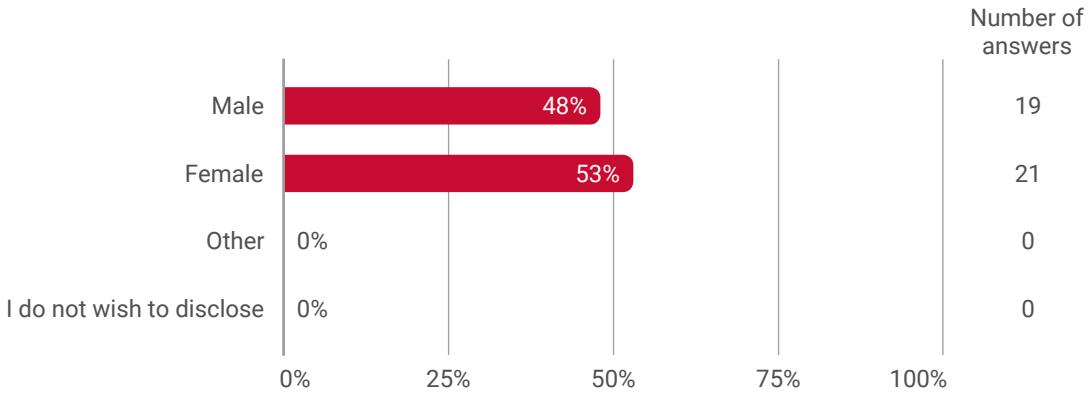
Appendix A

User Survey

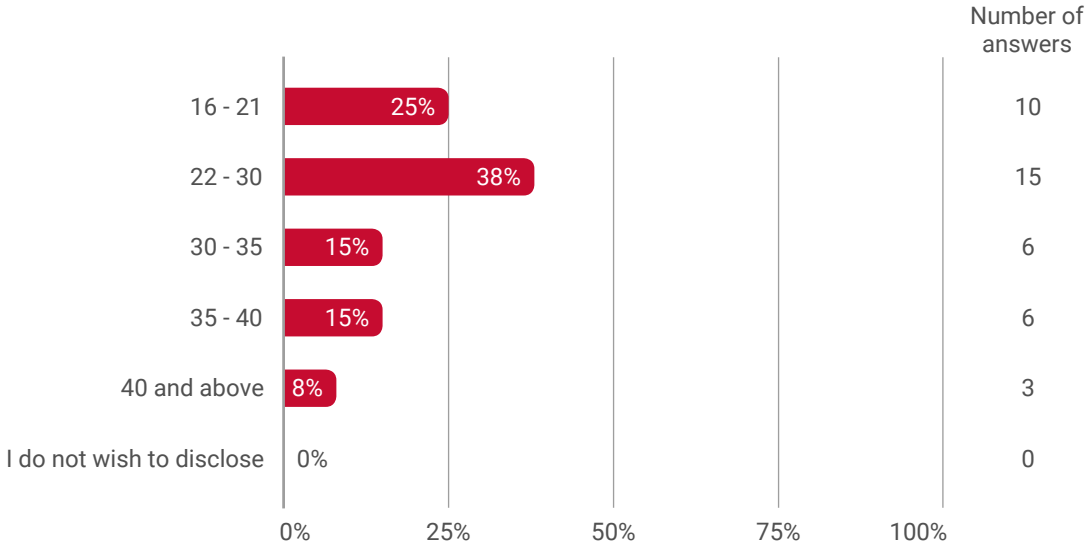
Overall Status



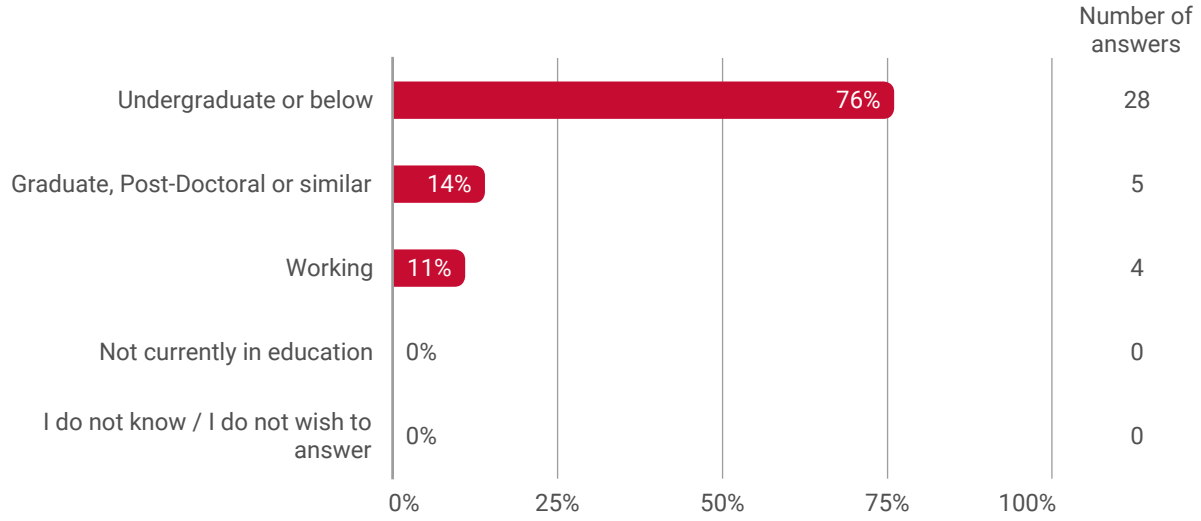
What is your Gender?



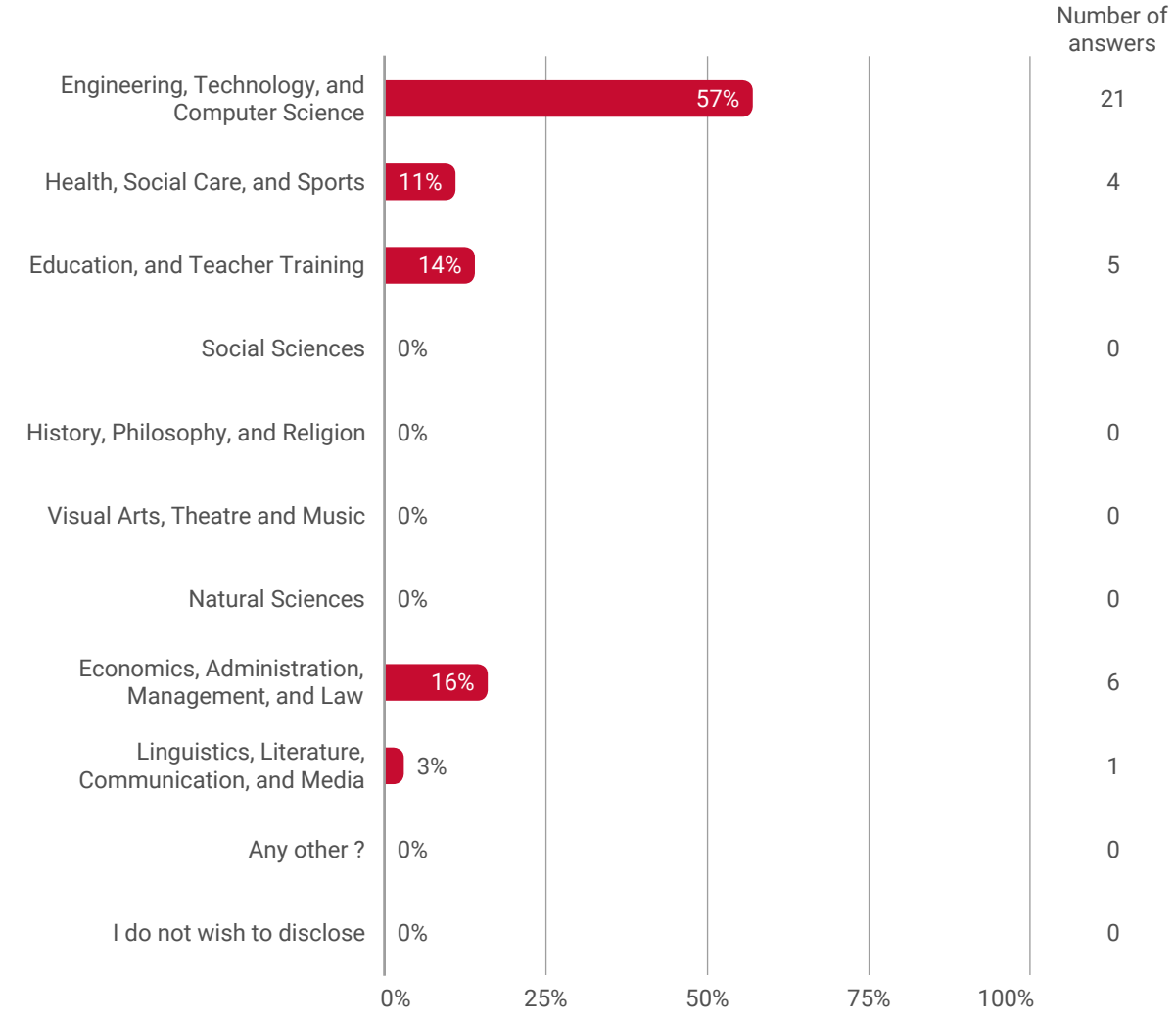
What is your Age?



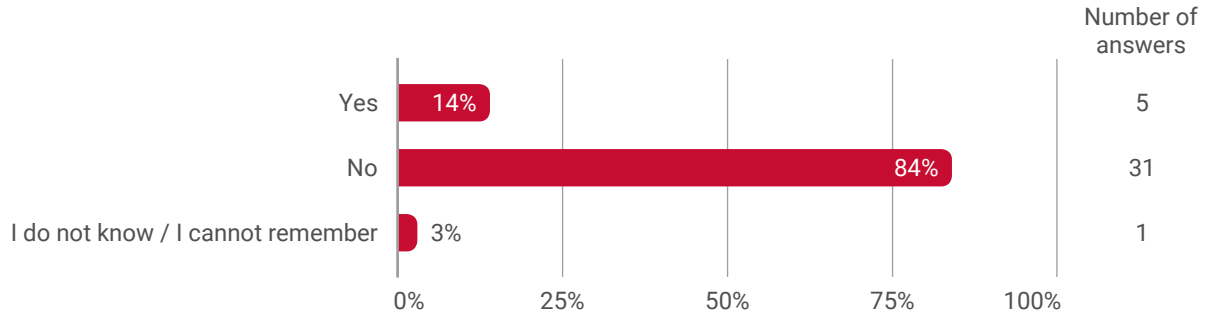
Education / Professional Status



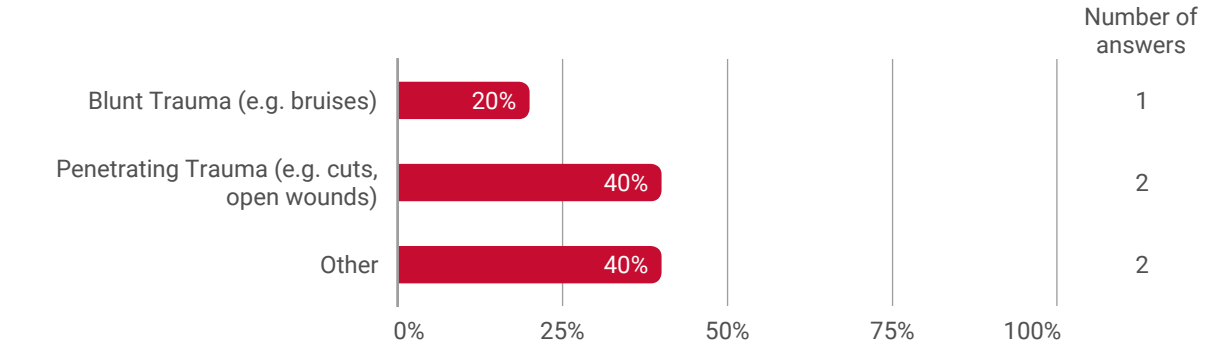
Field of study / work



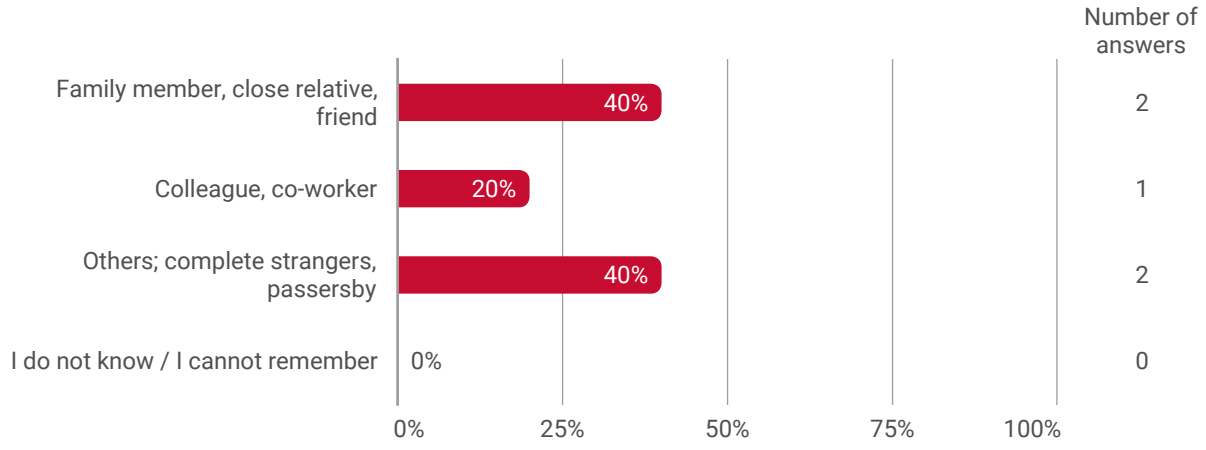
Within the past 3 years, I have required first aid as a result of an injury sustained in an accident



What sort of injury did you sustain?

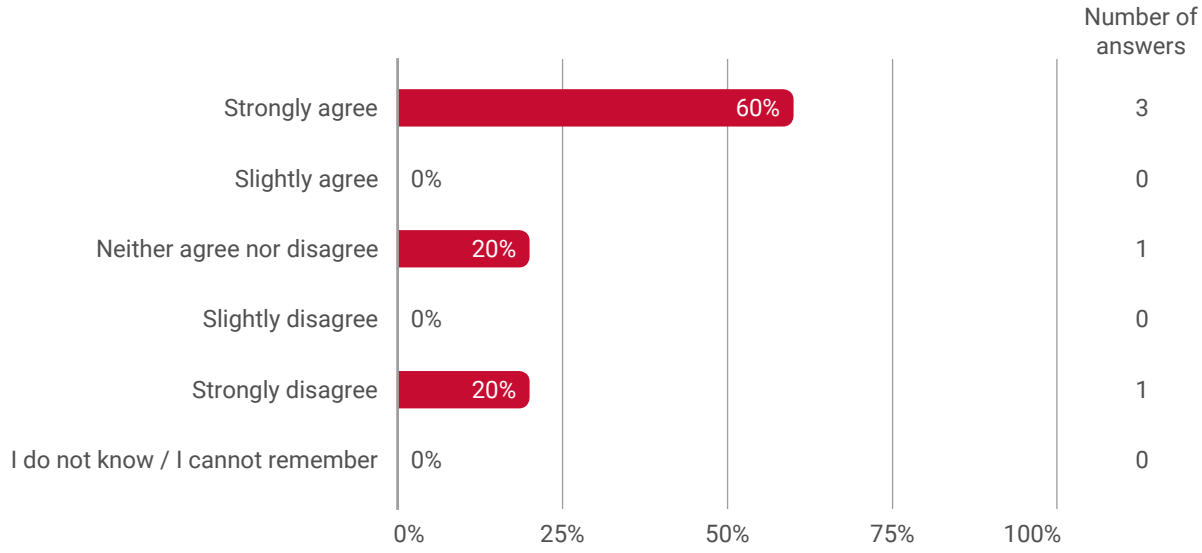


Who provided you with first aid

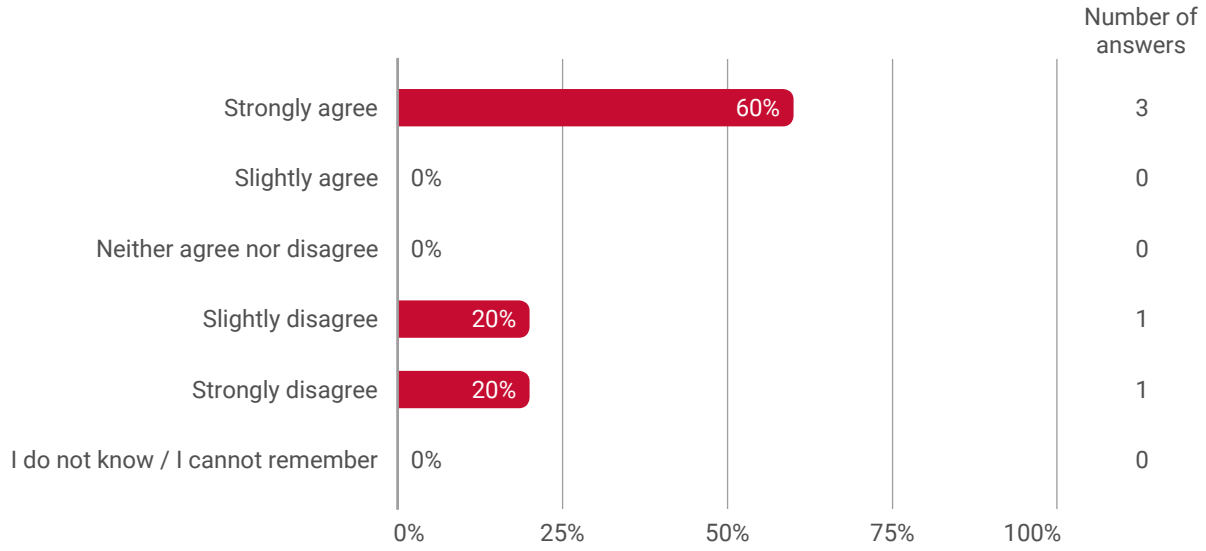


[Optional] Describe how treatment was performed on your injury
Stivne ankelen, ikke belaste den og kjøle den ned med is
Legekontor
Cut myself with a knife, my spouse provided first aid by cleaning and disinfecting the wound and then bandaging it.
Brannskade, vasking av sår. Hentet vann slik at skaden ble nedkjølt. Etter 20 min ble jeg smurt inn i Brann gelé og bandasjer

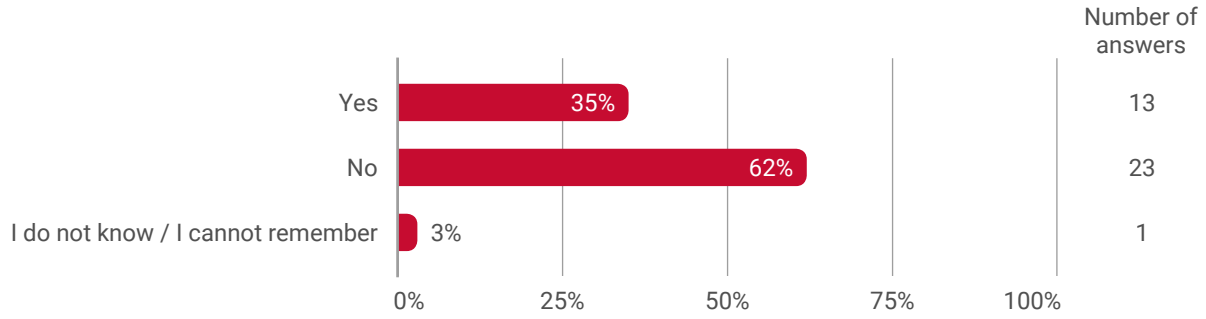
The person providing you with first aid was competent in their work: (competence is defined by the individual's ability to assess the injury and perform tasks to correctly address the injury)



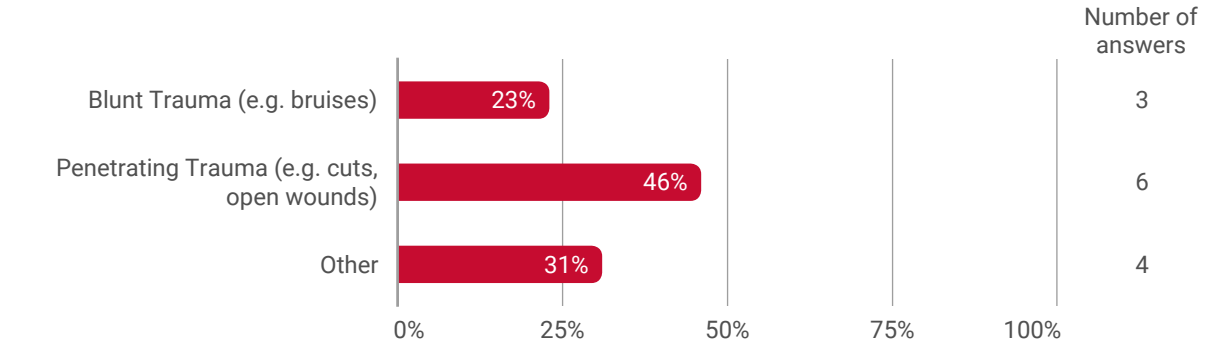
The person providing you with first aid was perceived as confident while providing you with care (confidence is defined as the individual's perceived calmness for the duration of the provided assistance, a confident individual is not afraid to provide care and does not withdraw themselves in situations of emergencies)



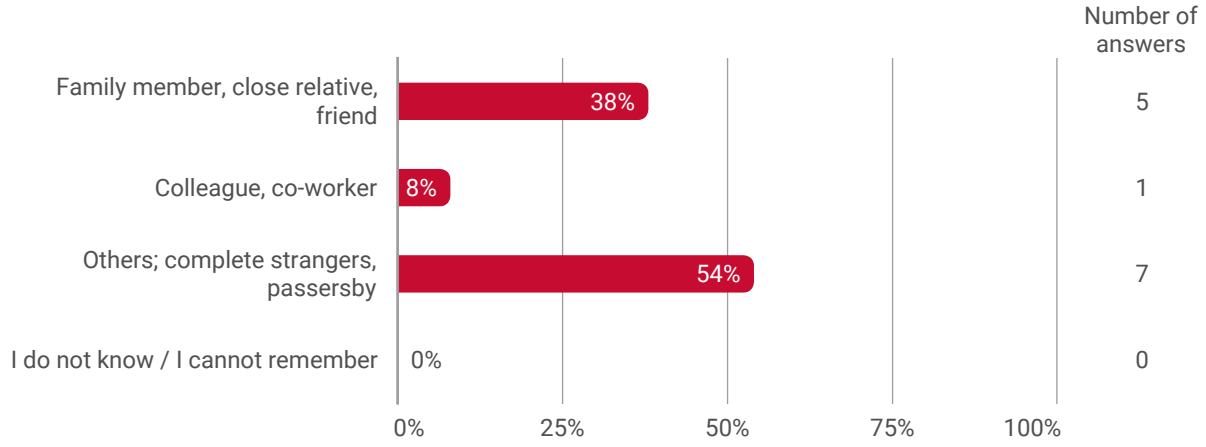
Within the past 3 years, I have been present and provided first aid assistance to someone else who sustained an injury as a result of an accident



What sort of injury did the other person have?

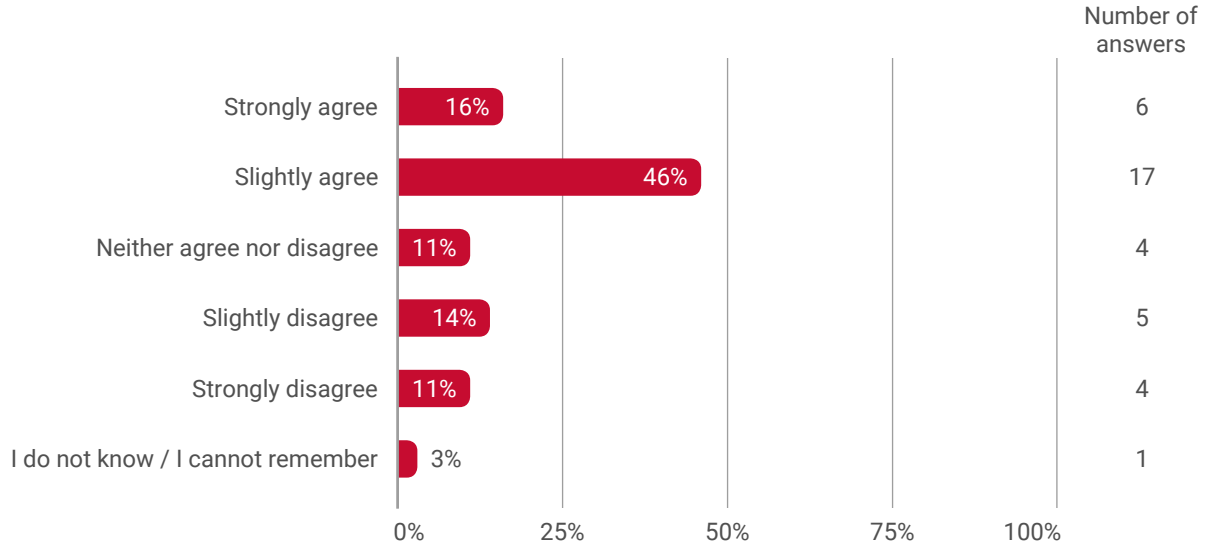


Who did you provide first aid for?

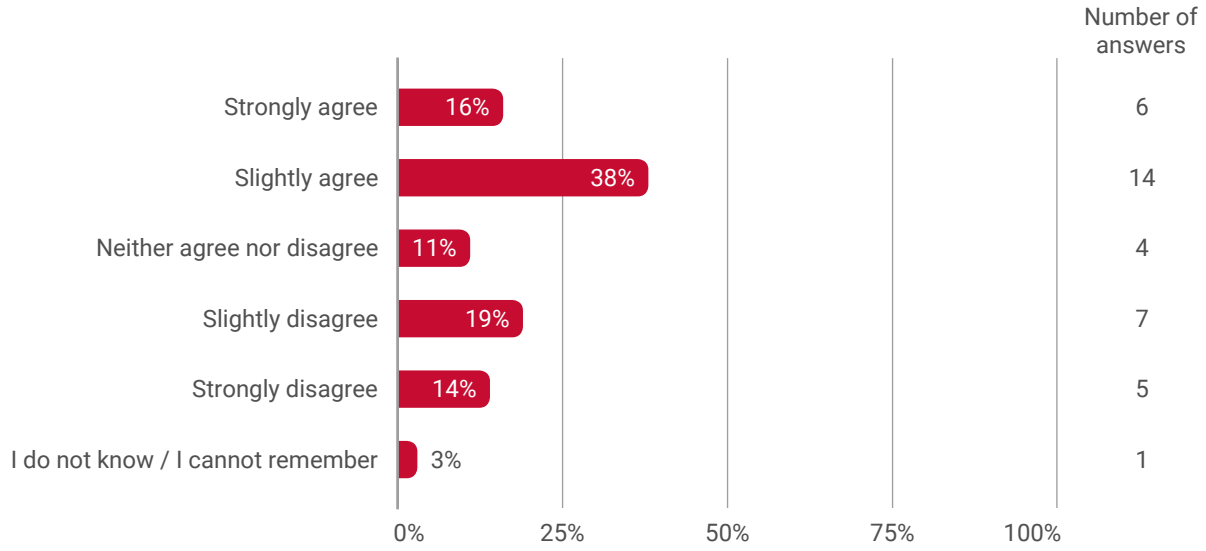


[Optional] Describe how you performed treatment on the injury
barn fikk stygg skade i hodet, stoppet større blødning med å legge trykk på skaden
Vi var på telttur ute på en øy, og venninnen min fikk kokende vann over seg. Vi hadde ikke med førstehjelpsutstyr, og venninnen min visste ikke hva hun skulle gjøre. Så jeg sa hun måtte gå ut i sjøen for å kjøle skaden ned. Jeg ringte så til 113, og de sa seg enig med at hun skulle være i sjøen og prøve å holde foten høyt. Tilslutt kom ambulansebåten å hentet oss.
Similar knife cut. I cleaned and disinfected the wound and put on a band-aid.
Potensielt overdose. Person funnet bevisstløs på sin celle. Personen ble lagt i stabil side leie før han våknet til og plassert i sengen. Personen var da inn og ut av bevissthet flere ganger. Helsepersonell var til stede rimeligt kjapt og jeg bisto de til hendelsen var over. Har også vært tilstede ved forsøk på gjenoppliving av et person. Bisto med å hjelpe fram med hjertestarter og sto beredt til å ta over med hjertekomoressjoner. Blant andre oppgaver
Personen slo hodet i en utelykt med skarpe kanter. Det medførte et kutt i hodet. Personen blødde litt, men sliter også veldig med å takle å se blod. Jeg hjalp personen til å sitte, og etter hvert ligge litt skrått (var i bil) for å hjelpe på kvalmen og bevismelse tendenser. Samtidig som personen fikk et papir (var det vi hadde tilgjenngelig) for å dekke såret og legge press på kuttet. Heldigvis var ikke kuttet for dypt, så det trengtes ikke noe mer helsehjelp.
Motorsykkelulykke, i grøft, stabiliserte, fri luftveier, holde pasienten varm.
Elev på skolen

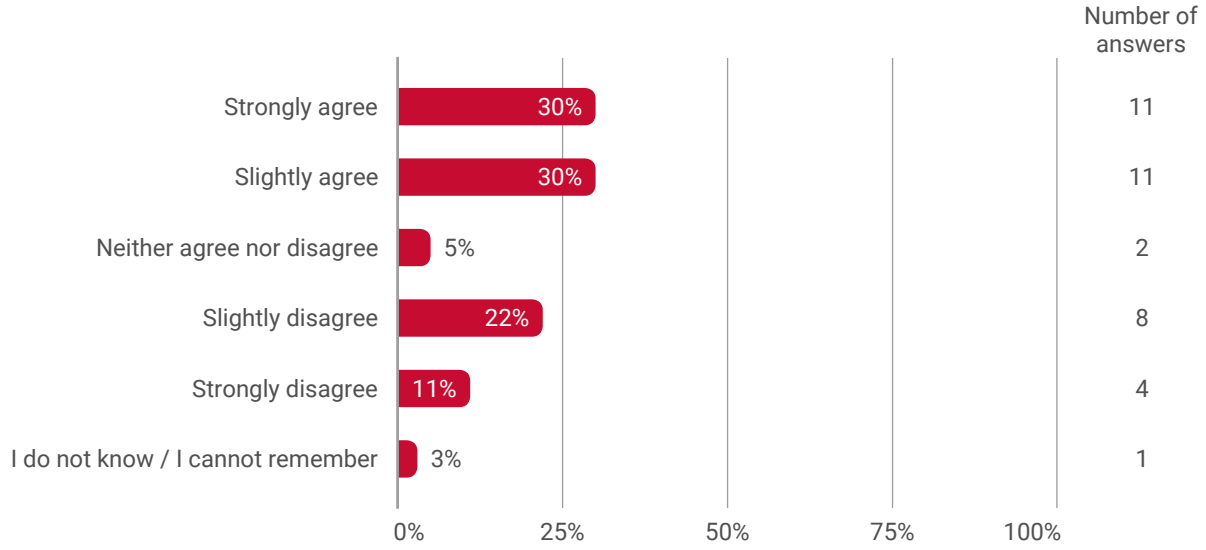
I am highly competent in providing first aid toward others in cases of accidents



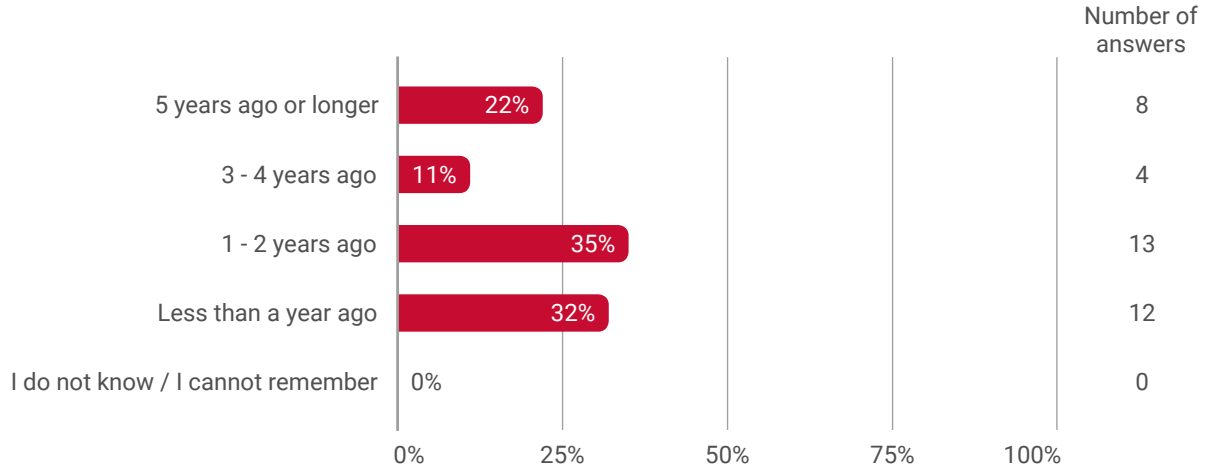
I am highly confident in my own abilities to provide first aid toward others in cases of accidents



I am not afraid, and will not hesitate, to assist others in need in emergency situations

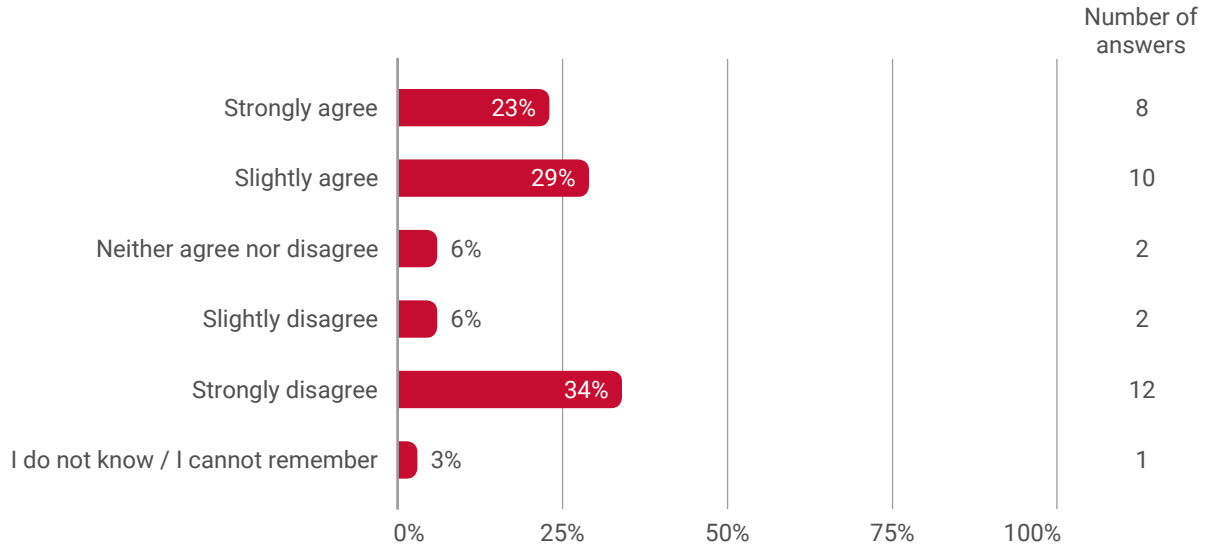


When was the last time you received training in activities related to first aid?

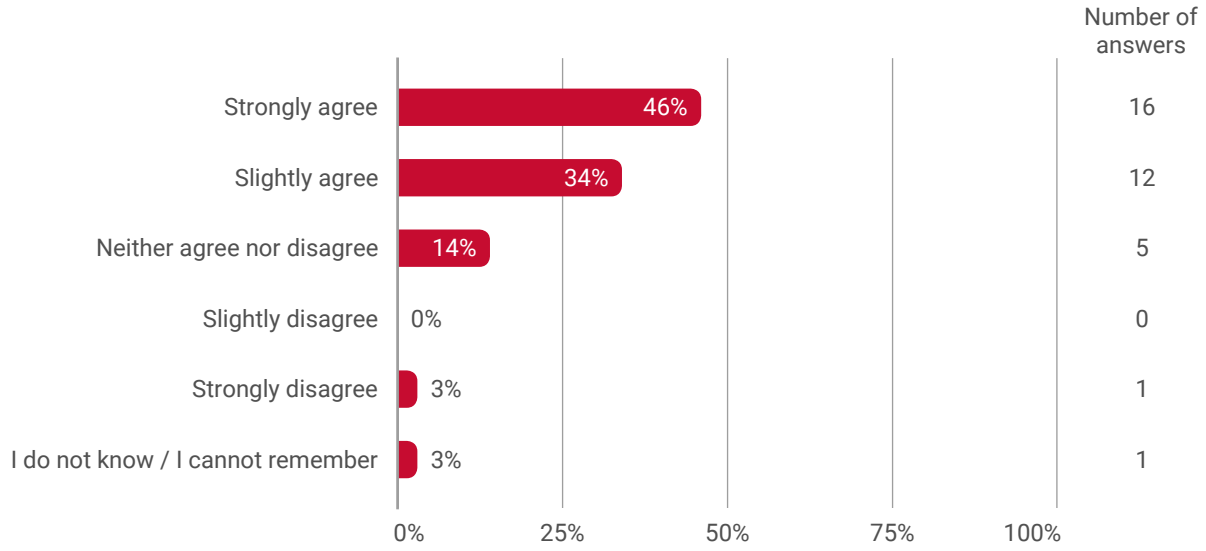


If possible, provide in detail what sort of training you received, for what situations / emergency cases
har hatt omfattende førstehjelpskurs hvert andre år over en 8 års periode, og har erfaring på grunn av tidligere arbeid. har også hatt deltidsjobb som markør på sikkerhetssenter.
Vi går gjennom førstehjelp årligvia jobb. HLR, oksygenmasker, kutt, skader, BLÅ, Angina, slag osv. Bruk av ulike medisiner som paracet, reisetabletter, tabletter mot sure oppstøt, nitromex og aspirin.
Vernedagen på UIA
VR, og dukke
Trafikk førstehjelp
Pustedokke, enkel HLR
Opplæring i førstehjelp og bruk av hjertestarter i forbindelse med jobb på elektrisk anlegg
Månedlig opplæring på industrivern øvelser
Kurs gjennom UiA for nye studenter. Enkle øvelser for hjertelungeredning med bruk av en dukke
I studied 2 years of nursing in 2013-2014 and had extensive first aid training. Got a first aid course when taking my drivers license in 2018. Did an online first aid course during my previous work in 2020. All for a wide spectrum of situations, car accidents, heart attack, burn, acid, electrical, fall, stroke, allergic etc
Hvordan ligge i stabil sideleie. Hvordan gjøre munn-til-munn-metoden.
Hlr med dukke
Har aldrig fått noen læring
HMS-kurs
HLR og stabilt sideleie
Førstehjelpkurs ved kjøregrunnkurs. Ingen utstyr brukt, bare en medperson som var på kurs som skulle ligge og spille som om de var bevisstløs så skulle vi spør de om de var bevisst hvis ikke noe svar så skulle vi ta av de motorsykkelhjelm, orientere kroppen deres i side liggende posisjon eller noe sånn, husker ikke helt xD Var også noe med å spille som om vi gir de CPR, husker ikke helt når det skulle utføres, men at man skulle telle til 30 eller noe og utføre håndpress mot bryst eller noe og holde hode deres vinklet opp slik at du holder luftrør åpent for å blåse inn.
Full HMS course offered by the university.
First aid course, fire related stuff, emergency protocol and such. Did not get a physical first aid course or tour at my school tho UiA because of covid time. But i done det mentioned stuff through my job
First Responder kurs i førstegangstjenesten
Er utdannet instruktør, undervist i de siste 30 årene på ulike nivåer.

I am familiar with Virtual Reality devices (Meta / Oculus, HTC Vive, etc) and have experience in using them.



A Virtual Reality (VR) application may be useful as a tool for training in first aid



What expectations or wishes may you have for such a system (expectations can be with regards to features, costs, availability, functionality, and such.)
tilgjengelighet på flere platformer, hybrid VR/AR funksjoner.
lavere kostnad, mer effektivt, men mindre relasjonsbasert
gratis, kan kjøre på ikke bare de nyeste og dyreste vr produkter, har kanskje en HUD som viser deg om du gjør ting riktig i real time
Vr is a great thing, costly but effective. Physical training is still very important for irl hands on experience and not through the system. Both should be experienced
Så billig som mulig, lett tilgjengelig, og enkel å forstå
Such a system would be nice to train how to handle specific surface damage injuries (cuts, bruises) and how to stabilize broken bones/dislocated joints. But for things like CPR or anything that requires forceful application (stopping blood flow from a deeper laceration) I don't know how well VR could teach that. Maybe a (not very graphic) overview of different types of injuries and emergencies would be nice to see in VR so the scare-factor is lessened if such an injury happens in real life. This should hopefully also result in higher confidence for treating such injuries.
Realistisk, og pedagogisk, enkelt å lære.
Pedagogisk opplegg, som følger nyest forskning. Lav kostnad, høy tilgjengelighet og funksjonalitet. Det må tilføre noe RQI (hlr-simulator) sammen med gruppeveiledning ikke kan gi. Det et nok ett poeng å skille mellom helsepersonell og lekfolk
Lik funksjonalitet som å skulle gjøre det på ekte.
Lett tilgjengelig
Forventer der kan gi et bra inntrykk av steder og plasser hvor hendelser kan skje om trenger førstehjelp. Det kan være et nyttig verktøy til å informere om potensielle farer på steder og komme med tips og opplæring til hva en kan se etter. Tenker at fysisk øvelser med personer og dukker er svært viktig og kan ikke erstattes, men VR kan vær en meget bra supplemterende verktøy
Et system for å tilsi sannsynligheten for at pasienten man utfører øvelser på har blitt kritisk skadet mtp tid man har brukt
Det kan få folk til å øve på situasjoner som de er ukomfortable i slik at de blir tryggere i situasjoner dersom det skulle oppstå. Veldig bra å kunne øve med VR-headset
Billig, realistisk, første gang Man spillet igjennom vet man ikke hvilken situasjon man blir å ende opp i