FAKULTÄT
FÜR !NFORMATIK
Faculty of Informatics

SOMA - A Service-Oriented Mobile Learning Architecture

DIPLOMARBEIT

zur Erlangung des akademischen Grades

Magister der Sozial- und Wirtschaftswissenschaften

im Rahmen des Studiums

Informatikmanagement

eingereicht von

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Wien, 01.06.2010

(Unterschrift Verfasser) (Unterschrift Betreuer)

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Klosterneuburg, 01.06.2010

Acknowledgments

We would like to thank:

Philipp Liegl

Who did what no one accomplished before - teach us proper English! Thank you for reading our thesis over and over, and providing so much constructive feedback!

Christian Huemer

Who allowed us to write this thesis although it has no connection to the Core Component Technical Specification.

Our parents

Who encouraged us to finish our academic studies so that we can fund their living when they go into retirement.

Special thanks also goes to:

Twan Geissberger, awesome girlfriend and SOMA image designer
Thomas ”the gnat” Wordie, first aid material provider
Angelika Altenburger, who convinced so many people to participate in our survey
Bernhard Sissolak, survival expert
the members of the Youth Red Cross group ”schnelle Helfer” who participated in our case study
everybody who participated in our survey

and all the others who are not mentioned here.

Abstract

Service-Oriented Mobile learning Architecture (SOMA) is a project focusing on interactive learning using mobile devices, with the main focus on devices running the Google Android operating system. While state-of-the-art solutions mainly cover text-based, multiple choice interrogator-responder concepts, our approach is characterized by interactivity, allowing multimedia-based e-learning concepts. Providing access to different hardware features enables a variety of novel input methods. Examples include obtaining user input through hardware accelerometers or cameras. In order to provide these advanced features we implemented the SOMA framework as part of this work, which acts as wrapper between the e-learning application and the underlying hardware components. Additional features can be developed using the SOMA plugin environment, which enables almost unlimited extension of the main application. Besides that, developers are encouraged to use any functionality provided by the SOMA framework. We use a custom implementation of Java Reflection for the plugin environment to guarantee extendibility.

We will capture all user input needed for detection of learning styles, while the implementation of automatic recognition of learning styles is part of future work. Another important aspect is the integration of the e-learning process into social networks. The system allows users to publish their results online and invite friends to take the same course. We assume this will improve learning motivation significantly. Users can compete and incite each other to enhance their learning progress.

Besides the SOMA framework itself, several sample plugins have been developed as part of this work. For evaluating our solution, we provide a sample course that uses these basic plugins. This sample course that covers basic first aid content has been created in cooperation with the Youth Red Cross Klosterneuburg.

Future work includes the automatic recognition of learning styles, as mentioned before, as well as the implementation of a graphical user interface for editing content used with the SOMA application.

Kurzfassung

Das Projekt Service-Oriented Mobile learning Architecture (SOMA) befasst sich mit dem interaktiven Lernen auf mobilen Geräten, insbesondere jene, die das Google Android Betriebsystem verwenden. Bisherige Lösungen sind hauptsächlich textbasiert und ermöglichen ausschließlich Frage-Antwort-Aufgabenstellungen. Unser E-Learning-Konzept zeichnet sich dadurch aus, dass es sehr hohe Interaktivität und eine Vielzahl von Multimedia-Anwendungen erlaubt. Der einfache Zugriff auf Funktionalitäten des mobilen Gerätes erlaubt außerdem die Entwicklung von innovativen Eingabemethoden, wie zum Beispiel die Verwendung von Beschleunigungssensoren oder Kameras. Um diese Möglichkeiten zu gewährleisten haben wir im Rahmen dieser Arbeit das SOMA Framework entwickelt, welches als Verbindung zwischen der E-Learning Anwendung und den darunterliegenden Gerätekomponenten fungiert. Neue Funktionen können mit Hilfe der SOMA Plugin-Umgebung entwickelt werden, die eine unbegrenzte Erweiterung der Anwendung erlaubt. Um diese Erweiterungsfähigkeit garantieren zu können, setzen wir bei der Laufzeitumgebung auf Java Reflection.

Die SOMA Anwendung zeichnet alle Benutzereingaben auf, die für die Erkennung von Lernmethoden notwendig sind; eine automatische Erkennung des Lerntyps wäre aber über den Rahmen dieser Arbeit hinausgegangen. Ein wichtiger Aspekt war für uns auch die Integration von bestehenden sozialen Netzwerken. Unser System erlaubt es, Ergebnisse online zu veröffentlichen und auf diese Weise Freunde dazu einzuladen den gleichen Kurs zu absolvieren. Wir gehen davon aus, dass dadurch ein Wettstreit unter den Schülern entsteht der die Lernmotivation deutlich steigern könnte.

Neben dem SOMA Framework haben wir auch einige Beispiel-Plugins und einen Demo-Kurs im Rahmen unserer Arbeit entwickelt. Dieser Kurs benützt die entwickelten Plugins und wurde in Zusammenarbeit mit dem Jugendrotkreuz Klosterneuburg entwickelt um qualitativ hochwertige und umfassende Erste Hilfe Unterlagen bereitstellen zu können.

Die zukünftige Arbeit an unserem Projekt beinhaltet das automatische Erkennen des Lerntyps und die Implementierung einer grafischen Benutzeroberfläche zur Bearbeitung von Inhalten der SOMA Anwendung.

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Reader

Introduction - *Andreas Kuntner* This chapter provides an introduction into the topic of e-learning environments and states problems that current state-of-the-art solutions share. In addition, the motivation for developing a novel approach as well as the construction of this solution is explained. Finally, the research question this thesis tries to answer is defined.

Knowledge transfer in digital environments - *Andreas Kuntner* Concerning both traditional learning methods as well as e-learning solutions, there exists a variety of different approaches. This section provides an overview of some of these, focusing on e-learning, and classifies the approach the SOMA framework follows.

E-learning environments and social networks - *Andreas Kuntner* The integration of community aspects into the learning process is one major contribution of the SOMA solution. In this section, online communities are compared to social networks, and characteristic features of both types of systems are summarised. Then, some advantages as well as drawbacks of existing online learning communities are discussed. Finally, the Facebook network is presented in detail and the theoretical approach of integrating it into the SOMA framework is explained.

Learning styles - *Fabian Kromer* Adaptivity is an important aspect in modern Learning Management Systems (LMS), but is even more important for mobile learning environments like SOMA. Learning styles are the cornerstone for adaptation to users' needs. Therefore an overview of available learning style models is given in this section. Besides that, the customised SOMA approach is described in detail.

Designing mobile learning applications - *Fabian Kromer* It is important to know where to start when designing a mobile learning environment, if it is intended for every day usage. We used available information from this field of research for the implementation of the SOMA project. In this section, we give an introduction to the basic principles of designing mobile learning applications.

Game-based learning - *Andreas Kuntner* This section provides a definition of game-based learning systems and identifies two main types of such solutions. Furthermore, requirements of game-based learning solutions that were developed especially for mobile devices are discussed. In addition, the game-based features the SOMA framework provides are presented.

State-of-the-art - *Fabian Kromer* We did a lot of preliminary work before starting the implementation of the SOMA prototype. One of the central aspects was the state-of-the-art research, which is described in this section. We reviewed four existing solutions and determined the benefits as well as the shortcomings of each project.

Introduction to the Google Android SDK - *Fabian Kromer* Our SOMA prototype is built upon the Google Android SDK which is the basis of the current project. We describe the benefits offered by this software development kit compared to other solutions available. In addition, we also provide critical aspects which we encountered during implementation of our prototype.

Support for additional platforms - *Andreas Kuntner* For publishing a final version of the SOMA framework that is intended for productive usage, compatibility is a crucial factor of success. For a mobile application, the availability of the product for different operating systems is the most important aspect concerning compatibility. This section deals with adaptations that are necessary for developing new versions of SOMA for additional mobile operating systems. In addition, the idea of using the SOMA framework on desktop computers is discussed, including possible advantages and drawbacks of such an extension.

Target audience of SOMA - *Andreas Kuntner* The sample e-learning course that was created as part of this thesis in order to test the SOMA framework focuses on children and teenagers. However, the usage of SOMA is not limited to this target group. In this section, several options for using the modularity and flexibility of the SOMA plugin environment for reacting to different age groups' needs are presented.

Java Reflection - *Fabian Kromer* SOMA provides a plugin runtime environment which is based on Java Reflection. This section presents the technical details of the Reflection technology and discusses potential drawbacks of using this technology.

The SOMA plugin environment - *Fabian Kromer* The SOMA plugin environment defines an abstract class which has to be extended by all plugins used within SOMA. This section gives an introduction on how to develop plugins for use within SOMA.

Sample plugins - *Andreas Kuntner* As part of this thesis, three sample plugins have been developed in order to test the SOMA framework during the case study as well as to provide developers with example code for creating additional plugins. This section presents these three plugins in detail, including a summary of their appearance to the user, information about the intended usage of each plugin, and technical details concerning implementation issues.

Additional plugins - *Andreas Kuntner* Course suppliers can only create multimedia-based e-learning courses that use different types of questions and exercises, if a variety of different plugins is available. In this section we list some of the hardware features provided by current mobile devices that plugins could take advantage of. We then concentrate on two of those feature and suggest concrete interaction techniques that could be incorporated in additional plugins.

Extension of the SOMA plugin environment - *Andreas Kuntner* The SOMA framework offers functionality for accessing hardware features, including the output device. Since the current version of SOMA is just a prototype, this includes only simple methods for displaying learning content. This section suggests extensions of the SOMA framework that allow displaying content in a more sophisticated way.

Facebook integration - *Andreas Kuntner* The integration of online community features into the e-learning process is another contribution of SOMA. To incorporate this feature into our

prototype, we decided to use the Facebook network. This section gives a general introduction into the development of applications for Facebook, and explains which features of Facebook the SOMA application should use.

Fields of application - *Fabian Kromer* The SOMA framework has been designed for much more complex fields of applications than single choice or multiple choice questionnaires. Some of these fields of application are described within this section, and concrete instructions for implementation are provided.

Modular build - *Fabian Kromer* Modularity is an important aspect for applications like SOMA which should be easily extensible. There exist several definitions about modularity in applications which are summarised in this Section.

Content structuring - *Fabian Kromer* Every content supplier is interested in easy editing of learning material. Using XML as underlying data structure is one of the steps towards a seamless integration of content editors into the SOMA project. Although no editor has been developed, all information needed is given in this section.

Security - *Fabian Kromer* Besides the editing of learning material, suppliers also want to protect their work from unauthorized access and modification. Due to this reason, we implemented a proof of concept DES encryption methodology. A guideline for implementing an asynchronous security component is provided within this section.

Client application - *Fabian Kromer* The client application is executed on the Android mobile phone and contains the whole SOMA framework. In this section, we describe the architecture and the most important aspects of the application regarding information exchange with the SOMA server.

Server application - *Fabian Kromer* The server application is a Java console application which on the one hand handles requests for plugins and courses, and on the other hand acts as gateway to community platforms. This section illustrates the architecture and the communication mechanisms provided by the SOMA server.

Client-server communication - *Fabian Kromer* We implemented a custom protocol for data exchange between the SOMA application and the SOMA server. This protocol is based on Java Objectstreams and is explained in the Client-server communication section.

SWOT - *Fabian Kromer* Market perspectives are important for commercial purposes, which we want to cover with this section. We created a Strength, Weakness, Opportunities, and Threats diagram to show the tendencies for each property defined.

Survey - *Andreas Kuntner* Before implementing the prototype of the SOMA framework, a survey was conducted for gathering information about the needs and requirements of potential users. This section explains how this survey was executed and which information was requested within the survey questionnaire. In addition, the results of the survey are summarised.

Case study - *Fabian Kromer* A case study was conducted in order to verify the acceptance of our approach. In this section we describe the setup of our study and evaluate the results.

Summary - *Andreas Kuntner, Fabian Kromer* This section gives a short summary of the research work presented in this thesis.

Limitations - *Fabian Kromer* There exist some limitations of our approach which are described in this section.

Future work - *Fabian Kromer* Besides those features which have been implemented within this thesis, there exist some others which may be implemented in the future. Two of these features are described in the last section of this thesis, which provide an outlook on future perspectives.

CHAPTER 2

Introduction

2.1 Motivation and problem statement

In the last years, the use of new media and technologies for teaching and learning, its benefits and risks, have been publicly discussed. In fact, computers and electronic devices are part of every-day life nowadays, the competence of operating a personal computer has become almost as important as the ability of reading and writing. Especially children and teenagers - the target group of learning environments used in school - are practiced with the handling of computers since they grew up using such devices.

The term ”e-learning” has become a popular phrase, frequently used in public discussion whenever referring to a learning process that makes use of electronic devices. To be more precise, one can differentiate several types of e-learning environments: For example, someone may distinguish between environments that are used primarily for teaching (e.g., in classrooms), environments that allow students to learn on their own, and environments that were developed only for evaluating the learned content through electronic exams. Another distinction is based on the type of electronic device a specific e-learning environment makes use of.

When talking about such electronic devices, mobile phones are one option that have become popular during the last years. For many people, the mobile phone is a constant companion when being out. For example, when waiting for or being on the way using public means of transport, the mobile phone is used for reading and writing messages, surfing the Internet, playing games or simply start a telephone call, to name only a few possibilities. Especially mobile access to the Internet provides a bunch of new options. To use this time for learning is a rather new idea. However, there are already several mobile e-learning solutions available - learning software that is developed especially for use on mobile devices.

While the discussion on the right amount of e-learning to be combined with traditional teaching approaches is still going on, in reality new media and technologies are already used in school: For example, for preparing a presentation for school, most students will surf the Internet searching for information on a specific topic rather than going to the library to look it up in an encyclopedia. This way, modern technologies find their way into school. Teachers should be aware of this changing behaviour of students and adapt their teaching style to those new possibilities provided by new media.

A variety of different e-learning solutions exists, many of which are publicly available and can be used by everyone. When integrating such solutions into learning courses in combination with traditional teaching methods, this can increase learners' motivation and thereby enhance the overall learning progress. In fact, e-learning is already often used - especially in combination with traditional teaching methods as addition to existing courses. However, many of those e-learning units are not accepted by the learners and they are not seen as variation of the standard learning procedure since they are not interesting and motivating enough.

In some cases, the reason for this may be that e-learning concepts are used without thinking about the best way to integrate them into the teaching process and how to combine them with other teaching methods. In such cases, e-learning is just used because it is seen as a popular concept. In the majority of cases the reason for uninteresting e-learning courses lies in the limitations of the systems used to present the content. Most of the existing e-learning solutions still rely on interrogator-responder based presentation of exercises, which is repetitive and therefore

quickly becomes boring for the user.

Usually the supplier of an e-learning course and the developer of the application used to present that course are not the same person. The supplier's flexibility is limited since he must rely on existing frameworks that provide the possibility of composing and presenting e-learning courses. Especially in school, most teachers will not be able to develop an e-learning solution from scratch and are forced to rely on existing systems that are publicly available and free of charge in most cases. For developers this means that an e-learning application must be very flexible to use, thus allowing the presentation of nearly every content in an attractive way. Unfortunately, this does not apply for many existing e-learning solutions. Therefore, it is rather difficult for suppliers to establish interesting and motivating courses using these systems.

These aspects lead us to the research question defined in the following section.

2.2 Research question

In this thesis, we present a novel approach of providing e-learning content using mobile devices. We studied recent literature regarding several fields of research that are connected to teaching and learning using modern technologies. Through this research work we established a collection of prerequisites successful mobile e-learning applications should fulfill. Some existing e-learning solutions were reviewed in order to define advantages as well as shortcomings regarding multiple basic attributes of these systems. In addition, we interviewed project managers who were responsible for the development of some of the reviewed e-learning solutions to find out details about the way learners interact with e-learning environments. Finally, a survey helped us in getting detailed information about the users' average mobile phone usage as well as understanding learners' demands concerning e-learning solutions.

Based on the results of the research work described in the paragraph above, we developed a mobile e-learning framework. We called it the SOMA framework, meaning *Service-Oriented Mobile learning Architecture*. SOMA is rather a framework than an application, since it can not be used for presenting e-learning courses itself, but it provides a runtime environment for third party plugins. This environment provides plugins with access to the hardware of mobile devices, such as cameras and other sensors as well as network devices. The SOMA framework itself consists of a server application that manages both plugins and courses, and a small client application that allows starting courses. Plugins are responsible for displaying the e-learning content, executing exercises, and evaluating the results.

This architecture provides a flexible, easily extendable mobile e-learning environment, which bears the following advantages for learners, suppliers of courses as well as developers of e-learning applications:

- For learners, taking e-learning courses using the SOMA framework increases the motivation and therefore can enhance the overall learning performance.
- For course suppliers, the SOMA framework provides the possibility to create engaging e-learning courses that use multimedia-based presentation and interaction techniques.

- For developers, the SOMA framework allows easy access to modern hardware features through a plugin environment. In addition, unlike traditional mobile e-learning applications that need to be developed for multiple platforms, SOMA plugins can be executed on every platform the SOMA framework is available for.

The aim of this thesis is to answer the question if such an interactive service-oriented e-learning environment can improve the overall learning process. We assumed that, on the one hand, the possibility to create and publish interesting, multimedia-based courses would increase the learners' motivation. On the other hand, this increasing motivation should lead to better learning results.

In order to verify these assumptions, a case study was conducted. A prototype of the SOMA framework as well as several simple plugins were developed for use in this case study. In addition, we created a sample e-learning course covering basic first aid content that makes use of these plugins. During the case study, children and teenagers at the age of 8 to 16 years tested the SOMA application using this first aid course.

The following section provides an overview of the structure and contents of our thesis.

2.3 Structure of the thesis

Chapter 3 provides an overview of the most important didactical aspects used by the SOMA approach. First, a summary of knowledge transfer and knowledge acquisition methods is given. Then, some options of establishing an interesting and engaging learning experience and improving the learning progress are discussed and related to similar research fields in recent literature. Finally, for each of those methods the way it is incorporated into the SOMA framework is explained.

In Chapter 4, several existing e-learning environments are presented in detail. This review focuses especially on solutions that were developed for use with mobile devices. Therefore, multiple mobile e-learning systems are compared to one traditional, web-based application. To identify advantages as well as shortcomings of these solutions, several attributes of such an e-learning environment were defined, and each of these attributes is evaluated for every reviewed application. The result of this evaluation is provided in form of a table, thus allowing easy comparison between the different systems.

Chapter 5 gives an in-depth explanation of the technical realisation of the SOMA framework. This includes an overview of the development kit for the Google Android operating system [1], and a detailed explanation of the implementation of all parts of the SOMA framework. Both, server and client application, as well as the plugin system are discussed in detail.

Chapter 6 consists of two sections: First, a SWOT analysis identifies the strengths, weaknesses, opportunities, and threats of SOMA's market perspectives. Furthermore, it is explained how the case study was conducted and a detailed summary of the results of this case study is provided.

Finally, in Chapter 7 these results are discussed. In addition, some open research topics that may offer interesting research work in the future are identified.

First, we describe the theoretical background of our work in the next section that covers didactic principles.

CHAPTER 3

Didactics

3.1 Knowledge transfer in digital environments

When referring to traditional teaching methods, mostly lectures and presentations held by a teacher in classroom are thought of. While such lectures may be necessary to provide students with a basic understanding of a topic, especially concerning highly complex subjects, they lead the learners to memorizing the content instead of thinking it over and really understanding it.

There are many alternatives to such methods that rely on textual presentation, regarding both traditional teaching and e-learning. This section reviews some of these methods and explains how the SOMA framework takes advantages of these approaches. In addition, a basic definition of e-learning is provided, together with a classification scheme for different e-learning methods.

3.1.1 Discovery and exploration learning

As an alternative to traditional teaching methods that rely on textual presentation, Bruner [12] presented the idea of a method of discovery and exploration learning. The basic concept of this theory is that students work on a topic on their own, while the teacher's role is limited to observing the learning process and helping whenever questions arise. The learning process consists of experiments conducted by the learners in order to improve their problem solving abilities.

To activate a learning process, students are confronted with a problem and forced to solve it. This is done by experimenting and trying different strategies for solving the problem. Whenever detailed questions concerning this problem solving process arise, the teacher can be asked. However, the learner should reach a deep understanding of a system on his or her own, without relying on full explanations by the teacher.

This leads to additional didactical requirements for the teacher. To be precise, for discovery learning to be successful, the teacher must consider two critical settings in the course of an explorative learning process:

- First, the problem setting must be presented in a way such that students identify the problem as interesting and important, otherwise they will not be motivated to search for solutions on their own. If students face a problem that seems to be of practical importance, for example problems that they already were confronted with in everyday life, they will start working on a problem solving method for this exercise.

- During this problem solving process, the teacher should help students in finding the right solving strategy. To ensure this, the teacher must not be too reluctant and should definitely provide students with precise hints on the right direction so the solution of the problem can be found. At the same time the teacher may not give too many or too detailed clues - the point of full understanding should be reached by the student and through his or her own train of thoughts.

  Bruner describes this dilemma as: *Given particular subject matter or a particular concept, it is easy to ask trivial questions or to lead the child to ask trivial questions. The trick is to find the medium questions that can be answered and that take you somewhere.* [12]

In addition it should be mentioned that the sensation of success that students experience if they solved a problem on their own is an important outcome of the discovery learning method. This feeling will motivate learners to make use of such personal problem solving techniques more often.

The learning process in an explorative learning environment can be described as a learning cycle: After a problem was identified, the learner develops a problem solving strategy and tests it in form of an experiment. If the strategy is not successful, the learner will think it over, analyze which parts may be inaccurate and can be improved, and try again this time using a more sophisticated strategy. This is repeated until the problem is solved in a satisfying way.

The SOMA framework actively supports this way of learning: The user is presented a bunch of exercises. For each of these exercises he or she needs to develop an individual strategy, try it out and evaluate the result. If the learner is not satisfied with either the overall result of a course or with the results of single exercises, he or she can improve the performance by taking the course again and improving his or her problem solving strategy.

A variety of different approaches exist for integrating such discovery learning methods into traditional learning courses and combining them with lectures and other types of content presentation. Especially most of the methods that are referred to as e-learning provide a basis for explorative learning, due to the fact that usually a single learner is engaged in a digital environment in which he works on the learning content on his own. Incorporating challenging and motivating exercises into an e-learning system can further increase the experimental orientation of this environment.

3.1.2 Classification of e-learning methods

As already mentioned, e-learning itself is not a learning method. Instead, it subsumes several approaches, which all share the common attribute that they make use of electronic devices for enabling easy access to the learning content. This section presents a basic classification of different e-learning methods based on the attributes identified by Reich [39] and compares them.

From a technical point of view, e-learning systems can be distinguished based on the flow of information. There exist bi-directional as well as uni-directional approaches. The term ”directional” refers not to the data flow, because technically interacting in an e-learning environment includes data being constantly exchanged between the two end points, but to the flow of significant information for pedagogical purposes. To understand the distinction between bi-directional and uni-directional systems, the composition of an e-learning system must be reviewed in detail. In general, there are two parties that are involved in the life cycle of an e-learning course: The course supplier and the learner.

3.1.2.1 Parties involved in the execution of an e-learning course

The course supplier decides which topics should be covered in the course, collects content, prepares questions and exercises in a way that is didactically valuable and composes a course consisting of these exercises. In most cases this role is taken by just one person, e.g. the teacher

in case of a course used in school. However, for creating larger e-learning courses several persons can be involved. In this case, the workflow is divided into several parts, and each person is responsible either for a specific topic and the exercises related to this topic, or for one step in the production process, such as content collection, didactical exercise preparation, or digitisation of the course content.

On the other hand, the learner is the consumer of the final product, which in this case is the e-learning course. Usually the group of learners consists of more than one person, since an e-learning course is developed to be used by many different learners. To access the course, these learners either have single user accounts which means that each user should access the course on his or her own and work through the course content when being alone, or a group of learners can use the e-learning environment collectively.

3.1.2.2 Uni-directional methods

The learner and the supplier interact with each other through the e-learning environment. The terms bi-directional and uni-directional regard the way this interaction is conducted in practice. There are two possibilities for creating uni-directional methods:

- The teacher prepares learning material and makes it available electronically for students, but he or she does not expect to get feedback. The students work on the content provided by the teacher on their own. The didactical outcome of this approach is similar to the traditional lectures mentioned above: The learner is provided with information about the learning subject, but he or she is not actively involved in the teaching process.

- Information can also flow in the other direction: In this case, nothing is prepared by the teacher, but the students work on exercises and send their results to the teacher in an electronic way, who then corrects them. Using a strict interpretation of the term uni-directional, the teacher even may not send back feedback to the learners, at least not using the electronic system, otherwise information would flow in both directions. In practice, such systems are used in school for collecting homework. In this case, the teacher provides feedback for the learners personally in a face-to-face session.

To be precise, both approaches cannot be referred to as e-learning environments, since they only require a single transfer of information in one direction, which can be easily realized using existing, well-known media. For example, to make learning content available to students, teachers can simply create a web page containing this information. Similarly, to collect information such as exercises or homework from students, using e-mail interaction is sufficient.

3.1.2.3 Bi-directional methods

For creating engaging and challenging e-learning applications, bi-directional approaches provide more interesting ways of interaction. Of course, such methods can also consist only of simple e-mail conversations between student and teacher. However, there are more sophisticated solutions using bi-directional information flows. They can be distinguished as follows:

- Synchronous techniques require both parties to be present at the same time. This bears the advantage that they can interact in real-time, making the learning process more engaging since instant feedback is guaranteed. However, developing and running such an environment is a difficult and complex task.
- Asynchronous techniques are technically more easy to implement and do not require teachers and learners to agree on fixed timeslots used for learning. This means that users can learn anytime they want thus making them independent. In addition, learners need not to be online for working on the e-learning course, but only for sending information to and getting feedback from the teacher, which may be another advantage.

3.1.2.4 Examples

The following list contains some examples of digital environments that can be used as e-learning platforms. Each example is explained in detail and assigned to one of the types of e-learning methods presented above.

- Traditional, well-known Internet services, including for example
  - web pages
  - e-mail
  - Internet forums
  - wikis
  - chatrooms

  can be used for e-learning purposes as described above. For example, publishing learning content on a web page or sending it to students via e-mail can be seen as an uni-directional e-learning interaction. However, e-mail, forums, wikis, and similar systems can be used in a similarly simple approach for providing bi-directional exchange of information. In case of chatrooms, the interaction happens also in a bi-directional way that is synchronous.
- Interactive e-learning courses can be presented using either existing technologies such as web pages, or special client software which is especially useful if multimedia-based content is used. Such courses typically consist of several exercises the student must solve in order to pass the course. In the majority of cases, such systems are made available once in an uni-directional way, but a synchronous bi-directional approach would also be imaginable: In this case, the teacher would be online and available for the student whenever questions arise. In addition, the exercises already passed by the student could be reviewed and corrected by the teacher, followed by instant feedback for the student.
- Audio and video conferences are a synchronous bi-directional Internet medium that is used for several purposes nowadays. It can also be useful for e-learning, especially since it allows teachers and learners to conduct collective learning sessions even if they are geographically remote and therefore cannot meet personally.

- Application sharing: This method is also widely used on the Internet nowadays. Concerning e-learning, it allows teachers to explain especially topics related to some specific software by using the learner's personal computer without the need of being at the same place physically. This approach is always synchronous and bi-directional.

- Virtual classrooms provide both teachers and students with the same information they get in a real classroom environment: They see who is online and they may talk to each other or share presentations without being in the same room physically. This is a synchronous bi-directional approach that relies on high requirements for the technical equipment. For example, to ensure that the interaction of users really happens in a synchronous way without the transmission time being too long, all participants need access to a high speed network.

The SOMA framework cannot be explicitly classified as being either uni-directional or bi-directional. The course is created by the supplier and then made available for users, who download the course and get feedback while using it, but there is no interaction with the supplier included in this feedback loop. This behaviour can be subsumed as being uni-directional, to be precise asynchronously uni-directional, since the publication of the course and the download by the user need not take place at the same time.

However, after finishing a course, the user has the option of sending back his or her results to the server, where the supplier may check and evaluate these results. If the learner makes use of this option, the information flow identifies the system as classical bi-directional approach. In addition, the user may publish his or her results on the Internet using social network sites, and discuss them with other learners. This behaviour leads to an information flow between several learners instead of the learner and the supplier which is an entirely new option not considered by the classification presented above.

Besides the knowledge transfer in digital environments, we spent some research work on the integration of social networks into our approach. We give an introduction to this topic in the following section.

3.2 E-learning environments and social networks

The importance of the Internet has steadily increased during the last years, both for commercial use and for free-time activities. As people spend more and more hours in front of the computer, especially browsing the Internet, online community services and social network sites are becoming increasingly popular. This section defines these two terms, shows which technology they use for providing new communication mechanisms to their users, and how these means of communication can be used by e-learning platforms.

3.2.1 Online communities vs. social networks

The term ”community” has often been reviewed in literature. Some criteria can be identified which most communities and especially all online communities share: Each community consists of persons that are members of the community. These persons communicate with each other, in the case of virtual communities this is mainly done using technical resources provided by the community. Finally, each community is based on certain topics, interests or services some people are interested in and therefore decide to join the community and become members. In addition, it is quite interesting that early definitions of communities mentioned geographical closeness of the members as a supplemental attribute each community fulfills. Lawrence [32] was one of the first to drop this assumption due to the possibilities provided by new technologies.

According to the summary of the evolution of online communities provided by Milz [33], the first virtual communities were established in the 1970s as ”Multi-User Dungeons” - members of these communities were engaged in playing role games and exchanged text messages to inform other users about their status. In parallel, the first Bulletin Board Systems were developed: In those systems, text messages were published and users could discuss these by sending text messages to the system that referred to the original topic. The way messages were tagged as belonging to certain topics in the early Bulletin Board Systems is similar to the organisation of modern Internet forums. At the end of the 1980s, the Internet Relay Chat system was developed, providing a chat-system to enable users to communicate in realtime. In this system different topics are discussed separately in so-called channels. The Internet Relay Chat is still active but today the abbreviation IRC is more familiar to most users. Most of the online communities that are active today use the Internet as communication channel.

During the last years, many social networks have been introduced as an alternative to traditional online communities. Today, the most famous social network site is Facebook, other examples include the German networks studiVZ and meinVZ. Boyd and Ellison [11] define social network sites as *web-based services that allow individuals to*

1. *construct a public or semi-public profile within a bounded system,*

2. *articulate a list of other users with whom they share a connection, and*

3. *view and traverse their list of connections and those made by others within the system.*

In general, social networks are communities. However, there are a few changes compared to the common definitions of communities. The main difference of social networks compared to traditional online communities is the fact that the common topic all members are interested in, an important attribute of communities, is omitted. As a consequence, the aspect of meeting other users that are interested in similar topics for discussion becomes less relevant.

Instead, members of social network sites are mainly connected with people they already know in real life. Therefore, social networks can be used as supplemental communication medium for interacting with friends, either in addition to meeting them face to face, or as an alternative to personal meetings. The latter can be useful especially for communicating with friends that live far away, thus helping in maintaining contacts over large geographical distances.

3.2.1.1 Means of communication

Concerning online communities that use the Internet as communication medium, one can distinguish communities that are integrated into a web page and such that use other ways of communication. This section reviews some of the techniques both types of communities provide for communication, with special focus on the former type since the SOMA framework cooperates with Facebook, which is a typical website-based community.

One example of the second type of communities are mailing lists. Such systems allow members to compose text messages and send them to the whole group of members. In mailing lists, new contributions in form of new text messages are distributed to all members by e-mail automatically. This is one of the main advantages of the mailing list system, since users need not regularly check a website, for example, to find out if new messages were published. However, mailing lists should not grow too large in terms of the number of members, otherwise too many messages would be sent out which would make it hard for each member to decide which of those messages he is really interested in.

Online games form another type of community that is not website-based. Today, many computer games allow to be played in teams of multiple players. These players are usually connected through the Internet. Most online games provide chat systems to allow players to communicate while playing.

One of the oldest types of website-based online community is the Internet forum. Similar to Bulletin Boards, most forums are separated into several categories. Members can post messages belonging to one of those categories, and all other members can write answers to those messages that are usually published on the same page as the original message. In addition, many forums allow users to subscribe to either a message or a whole category. In this case, all subscribers are informed, for example per e-mail, whenever a new message was published related to the favored category.

Another common type of online communication is the conversation in chat rooms. There are several ways chats can be used for building a community. Some communities offer a chat room as part of the community site, other sites only consist of several chat rooms and the community is formed by anyone who enters a chat. The latter need not to be restricted to website-based communities, many well-known and established chat protocols use either proprietary software products or special instant messaging clients. In general, chats can be restricted to two persons or open to all members of the community. In contrast to forums, for example, chat incorporates real time conversation: answers are sent immediately, much like in personal face-to-face conversations.

Weblogs are a rather new communication medium that has become very popular during the last years. Weblogs are simple text-based web pages written usually by one person, referred to as ”blogger”, in a similar way as a diary. A weblog contains reports about the blogger’s everyday life, his ideas and thoughts. If a large number of users follows a weblog by regularly reading the entries, a community can grow. Most weblogs allow members of the community to leave annotations and comments which are usually published after each entry on the weblog homepage.

Twitter works in a similar way as a collection of weblogs - the main difference is that Twitter messages are much shorter. Such messages, called ”Tweets”, are restricted to a length of 140

characters. Therefore Tweets are mainly used as short status messages, allowing the author to tell his or her contacts what he or she is currently doing. Although the service Twitter provides is limited to a simple web page where all Tweets are published, the usage of Twitter is not restricted to browser-based interaction. There exists a variety of applications allowing users to publish and read Tweets in a convenient way without the need of loading the Twitter homepage - these solutions are mainly used on mobile devices. Especially for mobile phones, Twitter also provides the possibility of publishing Tweets by sending text messages via Short Message Service (SMS).

3.2.1.2 Facebook in detail

Since the SOMA framework relies on the Facebook network to incorporate social community aspects into e-learning, this section provides an overview of the way Facebook works and attracts users.

The latest usage statistics can be accessed at [2]. In April 2010 the site stated a total count of more than over 400 million registered users. Compared to older usage data, such as those from April 2009 published in the article [22], Facebook was able to double it's number of users in one year.

For enabling communication between its members, Facebook implements several of the community features mentioned above. A list of all friends that are currently online allows selecting one of those contacts and inviting him or her to a chat. The chat room is shown as an overlay in the same browser window as the main page, which allows using the other features Facebook offers while chatting. However, one shortcoming of the chat functionality is the fact that although several chat rooms can be loaded simultaneously that are shown side-by-side, each of those chat rooms is limited to a conversation between exactly two people.

As mentioned before, Facebook members are mainly connected with persons they also know offline, which is typical for all social networks. However, Facebook provides so-called groups, which act like a traditional virtual community. Each group has a topic it is related to, and users interested in this topic can join groups and meet and communicate with other group members. This group functionality can also be compared to traditional online forums: groups correspond to categories that allow users to post their opinion and discuss it with other users interested in the same category.

The Facebook main page contains a board system that works much like Tweets in Twitter. Users can post short text messages that are then published on their personal message board and can be viewed by the users' contacts. Friends can also add annotations and comments to those status messages. In addition to this simple text message board, users can combine status messages with multimedia-based content such as images or videos.

Finally, Facebook offers an interface for integrating third party applications into the environment. Typical examples of these plugin programs are small games that are started by the user or run continuously in the background and require regular user interaction. Users can add those applications to their Facebook profile, and the plugins publish their results using the text message board mentioned above.

3.2.1.3 Online learning communities

Many modern e-learning environments take advantage of establishing a learners' community to improve both motivation and the overall learning progress. Including features that allow learners to build a community helps in adding a more personal aspect to the learning progress.

This can be useful for both e-learning courses that take place as addition to conventional learning units as well as distance learning courses that are only conducted online. In case of e-learning environments used as extension to traditional courses, possibilities for communicating with colleagues while working on the e-learning can make learning more interesting. For distance learners, it might be even more important since it is the only possibility to get to know their colleagues personally.

In practice, community features as part of e-learning environments can help in quickly providing answers to questions regarding the learning content, which arise during the learning process. When being forced to solve traditional single-user exercises as homework, students may give up easily if any aspect of the exercise is unclear. In an e-learning environment with community features, such problems will first be discussed with other students in the community. If none of the others has encountered the same problem or no solution is found, the teacher can still intervene and help, for example, by providing hints. The main advantage of this solution is that the hints provided by the teacher are instantly available to the whole community - students can learn from problems other students encountered.

The Moodle environment that is presented in detail in Section 4.3 is a browser-based e-learning platform that includes several online community techniques, some of those mentioned above. One feature that is often used in practice is the user forum. A forum can be used for discussing problems and finding solutions like explained before: students can post problems they encountered and discuss them with their colleagues, and teachers can post hints regarding certain exercises and information regarding the course. This information needs to be published only once and all students registered for the specific course are informed.

One possible drawback compared to other online communities is the short duration of stay. While in most virtual communities, new members join regularly and the community continuously grows, in learning communities each time a new course starts, a bunch of new members join and after they finished the course they leave the community. In most cases, learners do not stay members, or they are unsubscribed automatically after the end of the course. In fact, Kazmer [30] showed that this is the main problem of traditional online learning communities: Students are forced to leave behind online community tools they are used to as well as social relationships established in the online community, thus weakening the community network itself.

3.2.2 Integration of online community aspects into SOMA

The integration of online community features is one of the core concepts of the SOMA framework. The original idea was to establish a community as part of a SOMA website that enables learners to discuss courses they have passed as well as the results they have reached in those courses. However, establishing an entirely new online community brings about two difficulties: First, for the users it would mean another network they need to join, and contacts they

have to maintain besides all the other social communities they are already members of. With more networks a user attends the time he or she spends for each of them decreases. In addition, the problems described by Kazmer [30] would apply to such a learners' community, making it difficult to establish a robust network of contacts that stay active for a long period of time.

However, only a few years ago it would have been necessary to be present in several online networks for reaching a reasonable number of interested users. Nowadays Facebook has grown big enough to reach many users, especially in the age-group of children and teenagers that is the most important audience for the first SOMA course. Due to these reasons, but also due to Facebook's flexible application interface and to its dominant market position, we decided to rely on an existing community instead of establishing a new one.

The usage of Facebook for increasing the spread of SOMA courses as well as the learning progress of individual learners basically works in two ways. First, a public community for talking about the SOMA application as well as certain courses is provided. In addition, the possibility of publishing personal results allows learners to discuss courses with relation to their personal experience. The following two sections present these two modes in detail.

3.2.2.1 SOMA as a community within the Facebook network

Starting a community, in case of Facebook for example in form of a group, could act both as advertisement for SOMA and its courses and as platform for discussion between users, developers and suppliers. Learners who already use SOMA should be induced to join the SOMA group since they can use the forum to discuss with other users and ask for support in technical issues. At the same time, other Facebook contacts can be convinced to also join the group, download the SOMA application and try it out. Through this approach, new learners as well as developers and suppliers for SOMA courses and plugins can be attracted.

3.2.2.2 Connection to personal performance and experience

After finishing a course, the learner is provided with the option to publish his or her result on his Facebook bulletin board. This contains the name of the course and the final percentage of exercises the user solves correctly. All this information is treated in the same way as any text message the user would publish on his own: It is published at the message board, it can be removed, and it disappears automatically when other messages are published on the same user profile that replace older ones.

There are three main advantages of this approach:

- Each learner can generate his or her personal highscore list and publish this list for every course he or she has taken.
- Providing the possibility to publish one's personal performance during the course could lead to some kind of competition between multiple learners. This can even induce a user to take a specific course again to improve his or her performance.
- In addition, publishing learning results would act as promotion and may help to convince other users to download the SOMA application and also attend e-learning courses.

Another central aspect of our project is the integration of learning styles. First we summarise the most important approaches, and then we give an in-depth description of those which we used within the SOMA project.

3.3 Learning styles

Many opinions exist in the research field on learning styles. This includes many theories along with a lot of criticism either to the topics discussed or the whole field of research. There is consensus neither on the description nor on the different types available to classify different learning styles. Unsurprisingly no general valid user model exists. However, learning styles are especially interesting for adaptive learning environments like Sabine Graf's approach on Learning Management Systems [26]. An adaptive system is defined as a system that adapts to the users automatically based on the system's assumptions about the users' needs according to Oppermann [37]. While SOMA will have no adaptive capabilities in the first version, we prepare the structure for a future integration. Within our research we identified some approaches which we will use in our prototype. The detection of learning styles on mobile devices and adaptive mobile learning environments have rarely been discussed so far. We will try to take an individual approach, combining several existing approaches and configure them to work for mobile learning.

3.3.1 Common learning style models

There are ten commonly used learning style models based on Coffield's review [15]:

1. Personality Types as defined by Myers-Briggs: Defines a total number of 16 personality types separated in four groups consisting of:
    - extroversion/introversion
    - sensing/intuation
    - thinking/feeling
    - judging/perceiving
2. Pask' Serialist/Holist/Verstilist Model: Only three types of learners can be identified according to a serial, holistic or versatile learning style. Learner's preference can be determined with the *Spy Ring History Test* or the *Clobbits Test*. Both tests are questionnaires which have been developed in order to detect the corresponding model.
3. Entwistle's Deep, Surface and Strategic Learning Approach: Learner's may apply one of three approaches for learning. These are the deep learning, the surface learning and the strategic learning approach. Entwistle's model is based on Pask's approach and combines it with several other concepts. Therefore the questionnaires developed show many similarities with the approaches mentioned before.

4. Grasha-Riechmann Learning Style Model: Three dimensions, consisting of two values each, identify a learner either as participant/avoidant, collaborative/competitive or dependent/independent. Student Styles Scale (SLSS), a questionnaire consisting of 90 questions targeting mainly collage and highschool students can be used to measure a student's preference to the mentioned learning styles.

5. Dunn and Dunn Learning Style Model [20]: This model treats children differently from adults and defines five variables with the properties shown below. There are also two different questionnaires to detect learning style preferences targeting either adults or children.

    - environmental: sound, temperature, light, and seating/furniture
    - sociological: learning alone, in pairs, and in small groups
    - emotional: motivation, conformity/responsibility, persistence
    - physical: visual, auditory, tactile/kinaesthetic external, kinaesthetic internal, food and drink intake, time of day and mobility
    - psychological: global/analytic preferences, right or left hemisphericity and impulsive/reflective

6. Gregorc's Mind Styles Model: Based on the main preferences perception and ordering, Gregorc defines four types of learners which can be determined using a self-report instrument.

    - concrete sequential
    - concrete random
    - abstract sequential
    - abstract random

7. Kolb's Learning Style Model: Experience plays the most important role in this model and can be gained either as Converger (practical application of ideas), Diverger (creative, generate ideas), Assimilator (inductive reasoning) or Accomodator (risk-takers, do things actively).

8. Honey and Mumford's Learning Style Model: This model is based on Kolb's Learning Style Model and uses similiar definitions but different names for existing dimensions. Activist, Theorist, Pragmatist and Reflector are equal to the properties mentioned above.

9. Herrmann "Whole Brain" Model: Four quadrants are used to describe the learning style of students which can be identified using the *Herrmann Brain Dominance Instrument*, which is a self-report inventory, containing 120 questions. These quadrants describe the functionality of the human brain which is separated into a left and a right cerebral hemisphere according to Roger Sperry [44]. Information can be processed in a cerebral mode, which means thinking about a problem, or a limbic mode where experimentation is the preferred way. According to this structure of the brain the following quadrants have been developed:

- quadrant A: left hemisphere, cerebral
- quadrant B: left hemisphere, limbic
- quadrant C: right hemisphere, limbic
- quadrant D: right hemisphere, cerebral

10. Felder-Silverman Learning Style Model: Like most learning style models Felder and Silverman also define four dimensions of preferences with two values each. A learner can calculate his or her preference using the *Index of Learning Styles* (ILS). The following dimensions can be identified:

    - active/reflective
    - sensing/intuitive
    - verbal/visual
    - sequential/global

In summary there are many connections and similarities between the different learning style models, but still no common way to use them in combination. According to Frank Coffield [15], the following conclusions can be identified: *As well as Vak, I came across labeling such as 'activists' versus 'reflectors', 'globalists' versus 'analysts' and 'left brainers' versus 'right brainers'. There is no scientific justification for any of these terms...* to explain the correlation. His conclusion is promising: *We do students a serious disservice by implying they have only one learning style, rather than a flexible repertoire from which to choose, depending on the context.* [28] Because of the mentioned criticism on existing approaches, we made it possible to have different input methods for every exercise within SOMA.

Critics like Greenfield [28] go one step further and contest the whole research field with statements like *The rationale for employing Vak learning styles appears to be weak. After more than 30 years of educational research in to learning styles there is no independent evidence that Vak, or indeed any other learning style inventory, has any direct educational benefits.*. Whether or not learning styles can be applied to a user we make it possible to support different types of learning styles in SOMA courses and even lay the foundation for making SOMA an adaptive mobile learning environment in the future. It is essential for the design of an adaptive system to be based on a substantiated content structure, which is described in the following section.

3.3.2 Content structure

We use Sabine Graf's approach on adaptive systems [26] as basis for content structuring and to contribute new ideas to the detection of learning styles with our prototype. Implementing the detection of learning styles within SOMA will not be part of this thesis because it would go beyond its scope. In spite of this limitation, we want to prepare our implementation for a future integration of these aspects. Therefore, we have to apply certain rules to our application and the learning process. Sabine Graf's approach is based on the Felder-Silverman user model, thus

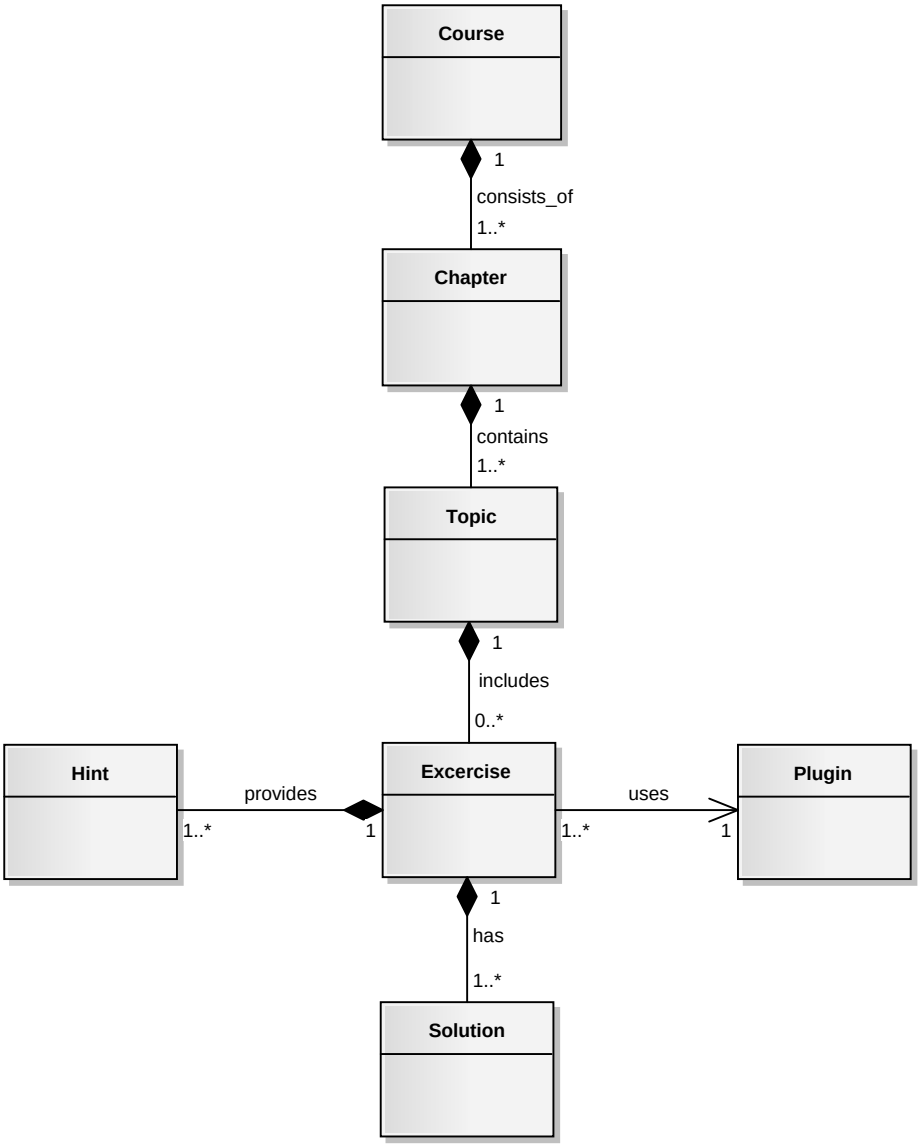

Figure 3.1: The class diagram of the SOMA course structure

enabling the creation of adaptive systems. In order to guarantee compatibility we log all events occurring within a learning session using SOMA.

We use the class diagram shown in Figure 3.1 to structure content. The class shown in this figure represents a package which contains all course data including binary streams of media. The `Course` class consists of one or more chapters. A `Chapter` must contain one or more topics and exercises. Every `Exercise` can provide a `Hint` and has exactly one `Solution`. This solution can contain several possible answers, and finally each exercise uses exactly one `Plugin` to evaluate user input.

The event logging is needed for an automatic modeling approach as used in Sabine Graf's implementation and needs both the actions taken and the overall behaviour of the student to classify captured data successfully.

3.3.3 User model

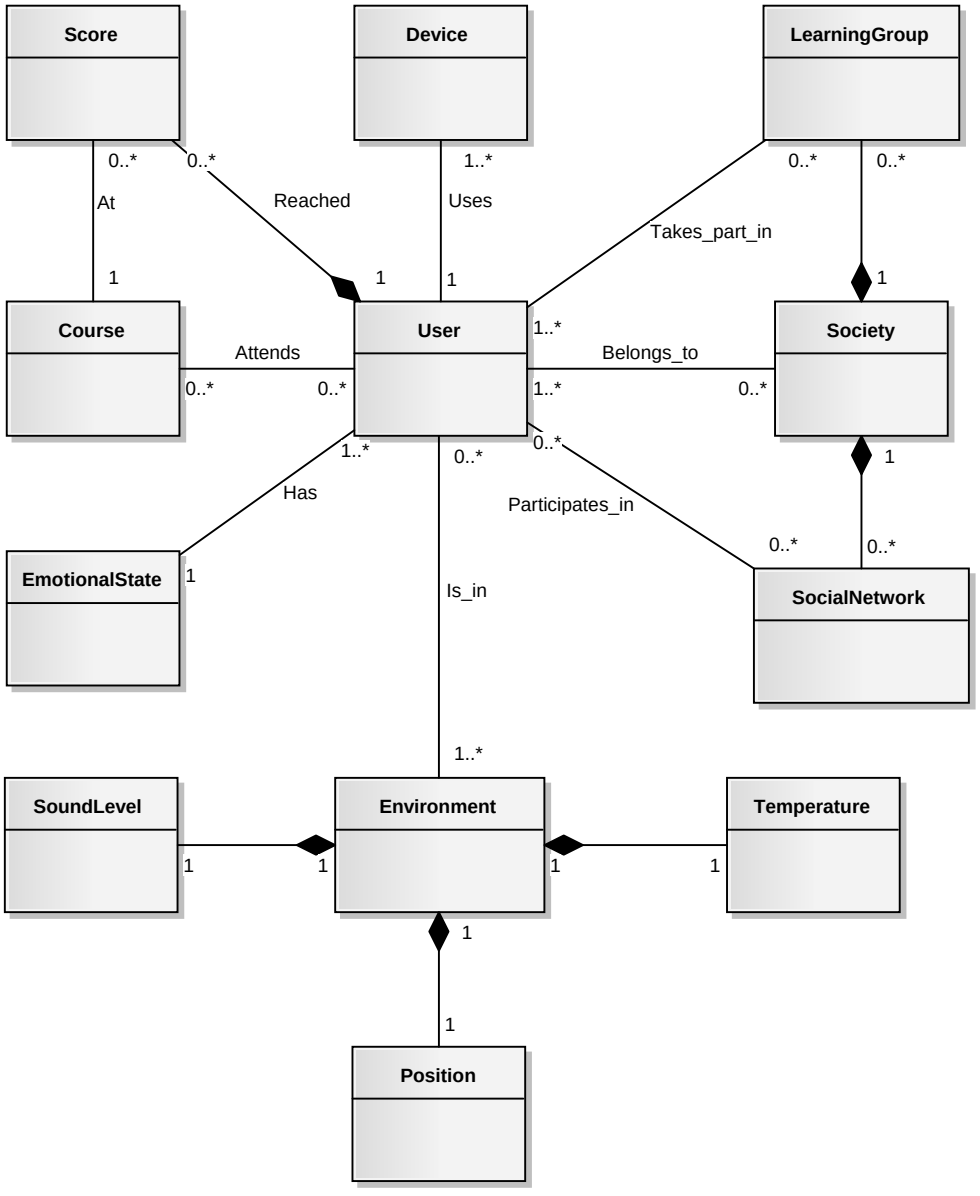

Figure 3.2: The class diagram of the SOMA user model

After comparing the available models, we decided on using the user model from the Dunn and Dunn Learning Style model to classify SOMA users. Furthermore, we want to use an automatic modeling approach to circumvent long questionnaires. In the following paragraph we will describe the categories in detail and show possibilities to detect the values using the Android SDK. First, we will take a look at environmental variables as defined in the Dunn and Dunn Learning Style model because most of them can be easily recognized by a mobile device running the Android OS.

- Sound/Noise level: Using the built-in microphone every application can easily distinguish between high and low background volume.
- Temperature: There is no standard sensor which is available in every mobile device, but the approximately temperature could be fetched from an online weather service like `http://www.wetter.at`. This is not precise, but can at least provide information according to the current location of the user.
- Light: Android devices running OS version 2.0 and above must have an integrated light sensor to measure ambient light which can be immediately used by every application.
- Seating: There is no sensible way of detecting the seating using a mobile technology.
- Layout of Room/Location: The layout could be detected using a camera and complex algorithms, but would likely need too much computing power to be processed on a mobile device with limited resources.

Finally, we assume most of the environmental variables, except seating, can be detected automatically but would need complex code and many resources. The next important category is the emotional state of a user which is an important aspect in the field of research of Learning Management Systems (LMS). We tried to develop new approaches within the SOMA project, targeting mobile applications running on next generation smartphones.

- Motivation: Within our evaluation we found out that users who are less motivated in learning tend to play around with their mobile phone by shaking it around. We therefore propose the detection of motivation by measuring continuous shake using the accelerometer.
- Degree of Responsibility: There is no sensible way of automatic detection of the degree of responsibility using a mobile technology. Of course, this could be determined using the predefined questionnaire.
- Persistence: The persistence of a user defines his consequent learning behaviour. If the learner always completes a course before starting a new one he or she is a persistent learner. This can be detected by counting the number of courses started and subtracting the number of courses finished. If the result is greater than zero the learner does not learn persistently.

- Need for structure: This value can be detected if the learning application offers the possibility to switch between random and linear content presentation. The status of the switch represents the learner's preference for the need for structure.

There also exist some physical properties which influence learning efficiency. It is important for an adaptive system to be compatible with the following needs:

- Modality Preferences: This includes visual, auditory and kinaesthetic/tactile learning for example. These values can be either calculated using a questionnaire or by evaluating exercises of the same difficulty for every modality. The exercise with the best result may indicate a preference to the type of modality of the exercise.
- Intake (Food and Drink): There is no sensible way of detecting intake using a mobile technology.
- Time of Day: This can be easily determined using the `new Date()` constructor from the `java.util.Date` class.
- Mobility: This value can be measured using the accelerometer. The learner has a preference for mobility if her or she moves around while learning which can be recognized by the amplitudes of the accelerometer.

The sociological values are difficult to measure using mobile applications. We will therefore focus on the aspects that can at least show trends to specific values.

- Learning Groups: A possible way to detect a preference would be the integration of Facebook groups into mobile learning applications. User's would then be able to create groups for learning. The number of groups attended by a user will then refer to his or her preference.
- Help/Support from authoring figures: Users can call authoring figures at any time if they provide their contact information. This information could be integrated with shortcuts into the mobile learning application to count the number of accesses. Of course this includes only calls from within the application, but it still shows a trend.
- Working alone/With Peers: There is no sensible way of detecting this value using a mobile technology.
- Motivation from Parent/Teacher: There is no sensible way of detecting this value using a mobile technology.

Research in the field of automatic detection of personality characteristics showed us that it is not possible to include such a feature into a mobile learning application at the moment. In cognitive psychology, for example, monitoring of behaviour is often practiced. This can be a certain activity or measuring the accuracy of the solution to a problem stated. The problem is that the results just show indirect information about internal processes which are subject of other

areas of cognitive psychology research like learning, cognition, attention, emotion, or others. This means that it is not possible to retrieve definite values of personality characteristics using this method either. Still this attributes can be detected using psychological questionnaires [23].

In Figure 3.2 the concrete user model created especially for use in the SOMA project is shown. This model does not fully comply with the properties defined in the Dunn and Dunn learning style model. We combined some attributes from different categories because of technical implementation issues. We also had to remove some features because they could be implemented and extended the model with information needed by the SOMA framework. This model should be portable and available on any device where SOMA is available according to the design principles for mobile learning applications described in Section 3.4. It is obvious that the user is the centre of this model, because he or she is the target of the whole usage scenario.

Besides learning styles, also other aspects have to be considered when designing a mobile learning application. The most important aspects are presented in the following section.

3.4 Designing mobile learning applications

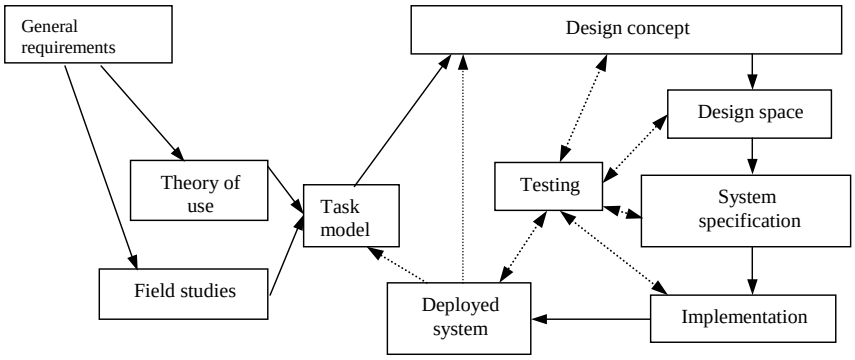

Figure 3.3: A design methodology for mobile learning environments [43]

The HandLeR project developed at the University of Birmingham and described by Sharples et al. [43] did a lot of research work regarding the design of hardware and software for mobile learning environments. Within this project a design methodology was developed which is shown in Figure 3.3. We applied the whole process for the development of SOMA and all components. Starting with a general requirement analysis, we did interviews with developers of existing projects in the mobile learning sector. These include mobilefive and their project Linguamo, which is described in Section 4.4, as well as Brigitte Krenn from project mGBL (see Section 4.2 for details). Our field study evaluated the learning habits and mobile phone usage of students to get an overview of feature requirements. The theory of use is covered with the first part of this thesis and includes the topics learning styles, online communities, and game based learning.

The task model which is meant to be the connection between the preparation work and the actual system design was realized using the Google Code services. We used the Subversion repository for version management and collaboration as well as the included workpackage management provided by Google Code. The next step was the design of a prototype to enable first usability testing. These tests have been carried out within every following implementation phase and the results influenced further development. The system specification was defined in the theory-based investigation of requirements and was only slightly modified regarding SOMA's Android version compatibility. The final steps of implementation include fixing errors and changing the user interface to students' needs.

3.4.1 Requirements of mobile learning devices

While the HandLeR project also contained a lot of research work on designing hardware prototypes, we believe next generation smartphones fulfill all requirements identified in the mentioned results. These requirements, as defined by Sharples [42], are shown in Table 3.1. In the first column the summarised requirement is shown, together with it's full description in the following column. The last column shows the state of support by smartphones and a short description how this information was determined.

Figure 3.4: The HandLeR prototype compared to the HTC Legend

In Figure 3.4 the developed HandLeR prototype is shown in comparison to a state-of-the-art mobile device running Android OS. Sharples et al. [43] provide an applicable description of a mobile learning device: *The device should be light enough to be held in one outstretched hand. It should be possible to operate it on a flat surface or while carrying it. It should be capable of operation by left and right handed people. It should have simple controls to operate the tools such as camera or phone, and it should look appealing to the intended users.* The description of a physical concept given by the HandLeR project also applies to many mobile phones with

Requirement	Description	Smartphone Support
highly portable	available wherever the user needs to learn	**full**, students always carry their mobile phones with them
individual	adapting to user's individual needs	**partly**, smartphones can be customized in many ways, but mobile learning applications also have to be capable of it
unobtrusive	retrieve knowledge without technology obtruding on the situation	**rarely**, even modern mobile operating systems like Android obtrude while interacting with them
available	communicate everywhere with teachers, experts and peers	**full**, that is the main usage scenario of a mobile phone
adaptable	evolving with the learner's skills and knowledge	**rarely**, this depends on the mobile learning environment running on the device
persistent	students resources and knowledge must be immediately accessible despite changes in technology	**partly**, children and teenagers tend to change their mobile devices very frequent. If their next mobile phone runs the same operating system it is possible
useful	supports everyday needs for communication, reference, work and learning	**full**, all of this features are either pre-installed or can easily be added to the operating system in form of applications
easy to use	for novices and experts	**partly**, but almost full. Modern operating systems like Android are very intuitive to use

Table 3.1: General requirements for technologies [42]

touchscreens. We state children are more likely to carry a mobile phone around than a bulky learning device.

Sharples et al. [43] also did a field study based on interviews and questionnaires with 219 children aged 7 to 11 in two schools. *The sampled children preferred to work in a group (67%) rather than on their own, but they preferred to keep the products of their own work private (64%) rather than have it displayed to other children. Their preferences for seeking help with a problem were, in descending order, a friend (53%), a teacher (39%), a book (38%) and parents (37%). These findings suggest that personal technology should support group work, whilst enabling children to own the results. 44% of the children kept scrapbooks and (from an open response) the main contents mentioned were photos, newspaper cuttings and artwork.* This study was very interesting for the work on our approach, because we therefore decided on making the publication of course results optional, so that the user can decide on his or her own whether to publish a score on a social network or not.

E-learning does not always have to be repetitive or boring, there also exist approaches like game-based learning which try to package learning content into games. The basic principles of such an approach are described in the next section.

3.5 Game-based learning

During the last years, media consumption has become an important part in the leisure activities of children and teenagers. Recent studies show that the average time children and teenagers spend using a computer is steadily increasing [40]. Nowadays, especially computer games are a popular activity to spend time with, seen as distraction in contrast to normal daily routines by many users. Since young people are used to extensive media consumption they have learned to register large amounts of information in a short period of time, sometimes even gathering information from several types of media simultaneously. On the other hand, students are increasingly bored by traditional learning process in classrooms and fail to observe lectures for a longer period of time. This leads to the idea of incorporating games to convey learning content, thus using exactly the type of media the audience is used to.

3.5.1 Learning through games

According to Kramer [31], a game can be described as an activity that consists of a set of components that can be used following certain rules, primarily for entertainment. Dempsey et al. [18] define a computer game as a *set of activities involving one or more players. It has goals, constraints, and consequences. A game is rule-guided and artificial in some respects. Finally, a game involves some aspect of a contest or a trial of skill or ability, even if that contest is with oneself.* Norman [34] developed a catalog of seven requirements learning environments should fulfill. Therefore an effective learning environment

1. *provides a high intensity of interaction and feedback*

2. *has specific goals and established procedures*

3. *motivates*

4. *provides a continual feeling of challenge, one that is neither too difficult to create frustration nor too easy to produce boredom*

5. *provides a sense of direct engagement, producing the feeling of directly experiencing the environment, directly working on the task*

6. *provides appropriate tools that fit the user and task so well that they aid and do not distract*

7. *avoids distractions and disruptions that intervene and destroy the subjective experience.*

Kasvi [29] reviewed and discussed these requirements and showed that computer games perfectly fulfill all of them. In fact, the tasks a player performs while being emerged in a computer game are the same a learner will carry out when he or she is fully concentrated on the learning material.

A variety of different educational games has been developed during the last years, all of them trying to convey some specific learning content for a specific audience group. In addition, many guidelines have been proposed and several development frameworks are available to help in developing such educational games. However, both the type of content that shall be made accessible to the user as well as the situation the game should be used in are considerably important for deciding which type of game to develop. Therefore, different types of guidelines and frameworks must be reviewed by developers depending on the context of the game to decide on which one to rely.

3.5.2 Definition of game-based learning

Although in the last years a lot of literature has been published focusing on game-based learning solutions, there is no common definition of the term *game-based learning* itself. In this thesis, we use the term for systems that fulfill the following two requirements:

1. The primary goal of a game-based learning system is to convey some learning content to a specific target group of users. (In contrast, for example, to traditional computer games that primarily aim at entertainment of the user.)

2. For reaching this goal, the systems incorporates the seven requirements listed above.

In general, one can roughly distinguish between two basic design patterns for producing game-based learning systems:

- Educational games

- Game-based e-learning solutions

3.5.2.1 Educational games

The former comprises all products that are generally referred to as educational games. These systems use the basic design patterns of traditional computer games, especially concerning graphics and human computer interaction. Like in most computer games, the user emerges in a story and faces exercises that should be solved to stay in the game.

The main advantage of such solutions is the fact that the learner concentrates on playing a game while the learning content is kept in mind more or less automatically - the learning progress is registered by the user only as a side-effect of playing the game. However, only educational games that are very well designed are able to convey the content in such a way that is nearly unnoticed by the learner. In addition, even for well designed products this works only for a relatively small target group, especially concerning the age of the audience, but in many cases also other criteria such as gender or special interests. Another disadvantage of such a game-based system is that the target group of students that won't play computer games at all is out of reach - it will be difficult to convince those learners to use an educational game for learning.

The difficulty of producing such an educational game is observable when reviewing existing solutions: Some of those focus too much on text exercises, thus failing in the creation of an interesting adventure for the player. On the other hand, there are educational games that mainly concentrate on graphics and visual effects and neglect the appropriate teaching goals. This shows that the development of educational games is a balancing act between creating an engaging game and achieving the learning goals.

3.5.2.2 Game-based e-learning solutions

A completely different approach is to enhance traditional e-learning systems and therefore allow the learner to access the learning content in a playful way. Since this approach of building game-based learning solutions has nothing to do with traditional computer games at first glance, it is often not considered as game-based and generally underrepresented in literature.

However, in contrast to most educational games, for game-based traditional e-learning systems the main focus lies on the e-learning solution and not on game development. For developers this means that additional effort in constructing a playful course schedule is required. To help considering this in the development process, the seven requirements for effective learning environments listed above can be used as some kind of guideline. Following these principles will in most cases automatically bring about a playful e-learning application.

3.5.3 Learning cycle

Aldrich [8] discusses several design patterns for game-based learning applications that are more detailed than those presented in Section 3.5.2. Although the author does not distinguish educational games from game-based e-learning solutions and presents rather general patterns, the paper focuses on how simulations can be used as learning environment. Simulation is a common strategy for learning: The user can experience situations that are *too costly, too risky or even physically impossible to achieve in the real world* [16]. This allows the user to try out,

play around, experience mistakes and therefore develop a sense of how to cope with specific situations.

Especially the system of trial and error simulated environments is worth mentioning: The learner is confronted with a situation that is new to him or her. He or she develops a first solution approach for the problem, applies this solution and gets feedback instantly in the form of a modified situation in the simulation environment. The learner can then decide on his own if this new situation is satisfying to him or her. In most cases, the learner will not be perfectly satisfied - at least after the first attempt. In this case, he or she can think about which parts of the strategy are improvable, re-start the simulation and try again by improving the approach.

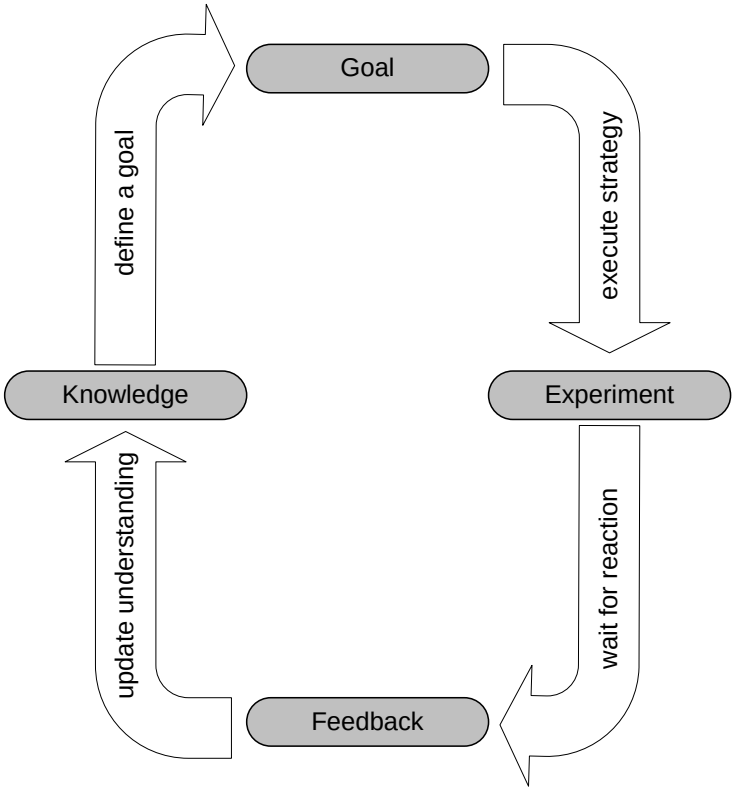

Figure 3.5: The four steps of the full learning cycle [8]

Aldrich [8] presents a similar model which he describes as *full-cycle learning*. It comprises four basic steps that are shown in Figure 3.5 and explained in detail as:

1. Understanding a system: Usually this understanding will be incomplete, which is the starting point for trying to get a deeper insight into the system. This is done by

2. defining a goal, developing a strategy for reaching this goal and executing the strategy. In general, such a strategy will result from the understanding the learner already has as well as the parts that he/she does not understand but wants to find out. Therefore, even if sev-

eral learners experience the same simulated situation, each one will develop a completely different strategy.

3. After executing the strategy, the learner gets instant feedback. In general, the simulated situations are sufficiently complex to allow not only wrong or right decisions - each decision has consequences, and the learner must judge how satisfying these consequences are with regard to reaching the overall goal. Therefore, feedback is not necessarily good or bad, but it depends on the learner's perception and influences his/her further steps. Receiving feedback leads to

4. updating the learner's knowledge. This causes a modified understanding of the system. The learner can now decide which aspects are still not specific enough and re-start the learning cycle by developing a new strategy to deepen his or her understanding.

Although this learning cycle was originally developed for simulation learning environments, it can be used as guideline for the development of many different game-based learning systems. One important factor of success for effective learning environments is to see learning as a repetitive process of improving the learner's understanding of a specific topic. By continuously motivating the learner to analyze his or her knowledge and increase it in small steps, the overall learning progress can be improved.

3.5.4 Game-based learning on mobile devices

Different types of game-based learning solutions, from educational games to traditional e-learning solutions, have been reviewed so far. However, all those systems, frameworks, and guidelines mentioned above focus on either large stand-alone machines (as is the case for many simulation-based environments) or standard personal computers. With the increasing use of mobile phones, PDAs and similar devices, also the demand for e-learning systems that can be used on such devices is rising. In fact, the possibility of learning anywhere at any time using mobile devices opens up a bunch of new opportunities. As Chapter 4 shows, several e-learning solutions designed specifically for mobile devices have been proposed during the last years.

With respect to this increasing demand for mobile e-learning solutions, the specific requirements of the devices these solutions are executed on should be taken into account. Some of the existing systems are web-based solutions that can be viewed by the user in a web browser. Since nowadays most mobile phones support Internet access and are equipped with web browsers, such e-learning systems could simply be used on mobile devices as they are. However, in general it is not sufficient to use traditional e-learning software on mobile devices. Such devices differ from that of personal computers basically in two ways:

1. Mobile devices provide different hardware components than personal computers. This includes for example:

   - A smaller screen
   - Different input devices

- Slower access to wireless networks
- Reduced interfaces for connecting peripheral devices

In addition, some of these specifications differ from one mobile device to others. For example, not all devices include a touchscreen.

2. Also the usage of such devices differs from that of personal computers due to the possibility of using the device everywhere at any time.

This leads to the conclusion that special guidelines need to be designed specifically for the development of mobile e-learning solutions. Especially for mobile game-based systems it is important to follow such guidelines for keeping in mind the aspect of continuous motivation of the learner. For example, the Antonellis et al. [10] discuss the specific requirements of game-based learning solutions for mobile users with special focus on contents that are displayed in web browsers. This paper shows that mobile web browsers cannot sufficiently display standard e-learning contents that were developed for larger screens. Especially unnecessarily difficult and nested ways of finding specific information are a main reason for users to give up using certain products on mobile devices.

3.5.5 SOMA as game-based learning solution

SOMA is a traditional e-learning solution for mobile devices that makes use of some of the principles presented above to generate a playful learning environment. We especially focus on the aspect of continuously motivating the user to further improve his or her learning progress. This section shows how the guidelines discussed above are adapted for use with the SOMA framework.

The seven requirements referred to in section 3.5.1 apply not only to game-based learning systems, but to every efficient learning environment. The SOMA framework follows these requirements in the following way:

1. *Provide a high intensity of interaction and feedback*: This requirement is fulfilled by the continuous cycle of exercises the user has to execute: In a variable and interesting course, the learner faces several exercises which he or she needs different interaction techniques to solve. Afterwards the learner is provided with instant feedback before starting the next exercise.

2. *Provide specific goals and established procedures*: Each course consists of multiple exercises that follow a similar procedure: First, the exercise is presented to the user. Then, he or she tries to solve it, and finally feedback is provided on how successful the user was. However, at the same time each exercise can use totally different interaction techniques - this makes the user interested in solving the exercise, which he or she sees as the current goal.

3. *Motivate*: Motivation is a very important aspect of SOMA and is realized in different ways. One of them is the integration into online communities that is described in Section

3.2. This should entail some kind of competition between several learners: If someone reached a quite good score for a certain course, other learners might be motivated to take the same course and finish with a higher score.

4. *Provide a continual feeling of challenge, one that is neither too difficult to create frustration nor too easy to produce boredom*: In fact, fulfilling this requirement is up to the developers of plugins as well as the suppliers of courses. Plugin developers are provided with a rich feature-set by the SOMA framework that they can and should use, while course suppliers should assemble each course in a way that it uses several plugins, demanding the user to make use of multiple different interaction techniques.

5. *Provide a sense of direct engagement, producing the feeling of directly experiencing the environment, directly working on the task*: This is already handled by the various interaction techniques modern mobile devices provide in form of different input methods and sensors. The SOMA framework encapsulates these techniques and makes it easy for developers to use them in e-learning courses.

6. *Provide appropriate tools that fit the user and task so well that they aid and do not distract*: All those new techniques must be integrated into the exercises a course consists of in a reasonable and not a distracting way. Plugin developers are responsible of ensuring this.

7. *Avoid distractions and disruptions that intervene and destroy the subjective experience*: It is always difficult to fulfill this requirement when developing solutions for mobile devices: The usage of mobile devices differs from that of personal computers, and mobile users are in general more susceptible to disruptions, since mobile devices are mainly used in public places with a lot of people around. SOMA tries to overcome this problem by using courses that are assembled of many short exercises, such that the user can switch off after each exercise and continue with the next one later on.

SOMA is not an educational game, but a game-based e-learning solution. Nevertheless it implements the full learning cycle described in Section 3.5.3 in two ways:

- Each course as a whole can be seen as one learning cycle consisting of the four steps described in Section 3.5.3: To avoid simple text-based questionnaires, SOMA focuses on using new interaction techniques for multimedia-based realization of e-learning courses. This allows learners to try out, play around, experiment, and solve exercises using all their senses. This should help the users in defining small goals and try to reach them in order to upgrade their overall understanding of a situation.

- Also each exercise can be understood as one cycle in the learning progress, instantly followed by the next cycle in forms of the next exercise: Every exercise consists of the description of the question, a phase where the user tries to solve the question by experimenting, and finally the display of instant feedback that helps the user to estimate his or her learning progress with regards to the overall understanding of a problem.

Finally, since the SOMA framework is a mobile application, the rules mentioned in Section 3.5.4 apply. In the development process of SOMA, we tried to follow certain principles for developing software for mobile devices. One large decision was not to rely on web-based content that is displayed in a web browser, since there are huge disparities between different browsers regarding the display of information. In addition, we followed the guideline that states that no nested hierarchies of information shall be used. In a SOMA course, each exercise is presented as follows: The basic question is displayed as text, in some cases in combination with additional media such as a picture. If necessary, supplemental information in forms of images or videos, for example, can be shown. This is done either explicitly by the user or implicitly by using a timer. However, only one such hierarchical step of opening an additional layer is allowed.

The next chapter provides an comparison of several existing e-learning solutions, including an overview of which of the theoretical approaches discussed in this chapter are incorporated in these solutions in which way.

CHAPTER 4

State of the art

4.1 Research methodology

This chapter gives an overview of existing solutions concerning e-learning in general, but with the focus on its mobile learning capabilities. These reviews also reveal the shortcomings of the various products to highlight the differences to our approach. We have decided on these projects because of their special characteristics. On the one hand we review mobile solutions in order to show the differences to our approach, and on the other hand we review a well known, platform independent solution which is often used for e-learning.

Within project mGBL 4.2, user experience with mobile applications was evaluated using a widespread case study. We used the results for the development of the SOMA application. Linguamo 4.4 introduces some very intuitive input methods which we review in order to use them in our project. The review of Moodle 4.3 will show the source of success for an e-learning platform. Besides the mentioned solutions we also reviewed alternative learning concepts like micro learning which is used by KnowledgePulse 4.5.

		Value		
Property	**Available platforms**	Only one	Few	Many
	Connectivity	Low	Medium	High
	Input methods & devices	Only one	Few	Many
	Graphical user interface	Basic	Advanced	Rich
	Analysis	Logging	Feedback	Interpretation
	Data structure	XML	Proprietary	Delimiter-Based
	Content administration	None	Web Interface	Application
	Customization effort	Low	Medium	High
	Community	Small	Medium	Big
	Scope	Low	Medium	Wide

Figure 4.1: The basic morphological matrix used for the reviews

Every review will contain a morphological matrix (see Figure 4.1) showing the values of the most important properties. This matrix shows the actual property in the first column of each line and the available values in the following columns. The characteristic for the reviewed project is highlighted in each line.

Based on our prior research, we decided on 10 properties for classifying e-learning solutions. These characteristics include the compatible platforms of the application, which is very important given the wide range of available platforms. SOMA will first be available for the Google Android platform only, but we plan to implement it for other platforms capable of running a Java Runtime Environment (JRE). Another important aspect is connectivity. It can be

basic, using only SMS or GPRS for data exchange, but also very advanced using video streams and UMTS. We want to enable all available connectivity options within SOMA, but encourage developers to keep the usage optional to keep connection costs low. In order to provide outstanding user experience, intuitive input methods and adaptive graphical user interfaces are needed. This is the reason why we included these two properties in the morphological matrix. Within our application we try to use as many input methods as possible. Analysis is a significant need for teachers using e-learning solutions. It can be implemented as basic logging, simple feedback as provided by the SOMA framework, or advanced interpretation. Regardless which analysis method is available, the underlying data structure is important for both performance and maintenance of the product. This is an important reason for including it as a characteristic attribute.

There exist many data structures some of which are easy to read and others which are not. This is the reason why we want to review the content administration of each solution. If none is available and the data structure is not based on an easily readable data structure, this leads to an almost unmaintainable application. The typical value for this property is a web interface, but there also exist some solutions with a separate application for editing. SOMA can be customized through editing of XML files.

The last three properties are most interesting for content suppliers. Customization is interesting, because if the effort needed is too high, nobody is going to use the product. The same applies to the size of the community. It is important for success that many people use the application, making it interesting for content suppliers to reach a wide range of customers. The scope of the project is connected to the customization effort. If the scope is wide, customization effort is less important because the intended application might be covered by already built-in solutions. We keep the customization effort for SOMA low, so we don't have to cover a wide scope. Besides that we envision to quickly create a big community through the integration into Facebook.

4.2 Project mGBL

Within the mobile Game-Based Learning project (mGBL) eleven partner organisations from Austria, Croatia, Great Britain, Italy, and Slovenia have joined forces to work on the development of a platform for the presentation of educational content in a playful and emotional way on mobile devices.

We have chosen to review this project because of its widespread evaluation. Although it was only developed for one platform, as one can see in Figure 4.2 line one, many case studies have been carried out and the results are well documented. All applications developed within project mGBL are written for the Symbian OS created by Nokia. To be precise these applications are only available for mobile devices running the version Series 30 of the Symbian operating system. After a talk with one of the project managers we can presume that it will not be implemented for any other mobile operating system available. Surprisingly there are many different connectivity possibilities including SMS, MMS, and GPRS (WAP) for the transmission of data.

		Value		
Property	**Available platforms**	Only one	Few	Many
	Connectivity	Low	Medium	High
	Input methods & devices	Only one	Few	Many
	Graphical user interface	Basic	Advanced	Rich
	Analysis	Logging	Feedback	Interpretation
	Data structure	XML	Proprietary	Delimiter-Based
	Content administration	None	Web Interface	Application
	Customization effort	Low	Medium	High
	Community	Small	Medium	Big
	Scope	Low	Medium	Wide

Figure 4.2: The morphological matrix for the project mGBL

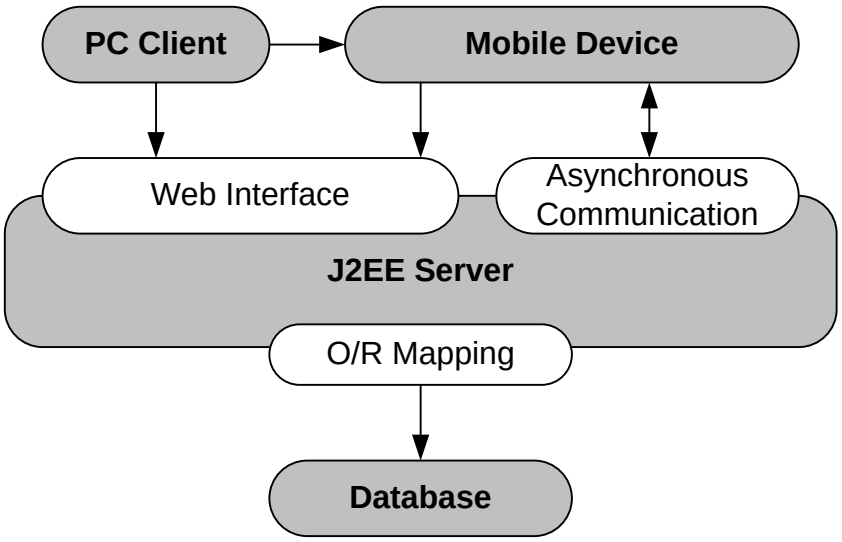

Figure 4.3: The mGBL architecture [4]

Figure 4.3 shows the underlying architecture. Apparently most effort was spent in the server side implementation regarding connectivity issues. This enables also less feature-rich devices to interact with the infrastructure. The data transfer between PC client and mobile device uses a download tool which downloads content from the server and transfers it to the mobile device. For this transfer the mobile device has to be connected directly to the computer via wired connection like USB or serial cable. Both the personal computer and the mobile device can access the web

interface of the server with a browser. In case of Symbian S30, most of the browsers available are limited to display WAP encoded content. The mobile device is also able to communicate with the server in an asynchronous way using SMS or MMS for data transfer. This is an advanced feature where a lot of effort has been put into. All data is stored in a database which is accessed using an object-relational (O/R) mapping.

We can assume that most of the devices running Android OS will have UMTS connectivity and at least some amount of data traffic available for communication. Therefore we did not spend much effort on implementing different communication mechanisms for the SOMA server.

Controlling the application is only possible using keys on the device as shown in line three of the morphological matrix. One prototype exists using a touchscreen but because there is only one device with this feature running Symbian S30 not much effort was put in this project. The graphical user interface is advanced for the devices running it. Besides simple text-based multiple choice applications, also graphical games where developed within the project. This goes far beyond the scope of our project, but did get good scores in the case study. Analysis of a student's solution is available through logging on server side or direct feedback in case of multiple choice questions. This is stated in line five of the morphological matrix. Next, the underlying data structure is described. As in our approach project mGBL uses XML to store the information of the application and courses. These XML files can be edited with a very complex web interface showing all the available XML tags and a text field to change it's value. Within our interview the project manager told us that editing plain XML files directly was much more comfortable than using the web interface. The effort needed to create a new application is medium because everything outside the scope of the project has to be altered within the code which is not publicly available. Content creation is rather complicated because of the complex and not intuitive web interface. The community of people using this applications is very small because it is limited to those who participated in the case study used for evaluation. Because different applications were developed for different usage scenarios, the scope of the project is medium which is shown in the last line.

4.3 Moodle

Modular Object-Oriented Dynamic Learning Environment (Moodle) is one of the most popular Course Management System (CMS) available. Such solutions are also known as Learning Management System (LMS) or Virtual Learning Environment (VLE). Moodle is free of charge and web based, and can be used by educators to create online learning sites. Moodle is provided freely as Open Source software under the GNU Public License. This means that everybody can participate in the development or add additional functionality. It has an impressive amount of users with 46.425 registered sites serving 32.038.611 users in 3.134.829 courses according to [5]. These statistics have been published in December 2009 and may be different today but are still impressive.

In Figure 4.4 the morphological matrix of Moodle is shown. On closer inspection the differences to the other two reviews become clear. Moodle is so superior in almost every aspect,

	Value			
Property	**Available platforms**	Only one	Few	Many
	Connectivity	Low	Medium	High
	Input methods & devices	Only one	Few	Many
	Graphical user interface	Basic	Advanced	Rich
	Analysis	Logging	Feedback	Interpretation
	Data structure	XML	Proprietary	Delimiter-Based
	Content administration	None	Web Interface	Application
	Customization effort	Low	Medium	High
	Community	Small	Medium	Big
	Scope	Low	Medium	Wide

Figure 4.4: The morphological matrix for Moodle

because it is not available for offline mobile devices. Besides this shortcoming it is still available for any platform which is capable of running PHP or a browser with an Internet connection. This is the reason why it still gets a high score in the property “available platforms”. Connectivity is low because a web application always needs the HTTP protocol as underlying connection. This can be extended using PHP plugins but we will not include this opportunity in this review, because we are looking only on mobile aspects of each project. The number of input methods and devices is high, since the modular build of Moodle supports any input method defined. We want to include this within our approach as well. Unfortunately the graphical user interface is only basic, which is the most criticized shortcoming of Moodle, mentioned by many users. Analysis can be done with either logging or instant feedback to the student, which enables a good interaction between teacher and their students. All information from the courses is stored in XML format, which makes it interesting to use both for developers and for content suppliers. This information and any other content can be edited within the same web interface the users interact with, showing just a different view on the data with more privileges. The customization effort is very low because it is most likely that something a developer wants to build is already available through a plugin, and if not he or she just needs basic PHP skills and can use the developer wiki to get started building custom plugins. With one of the biggest communities around, Moodle is the best example to look at when starting with a new e-learning system. This fact is one of the reasons why its scope is so wide today.

4.4 Linguamo

Property	Value			
	Available platforms	Only one	Few	Many
	Connectivity	Low	Medium	High
	Input methods & devices	Only one	Few	Many
	Graphical user interface	Basic	Advanced	Rich
	Analysis	Logging	Feedback	Interpretation
	Data structure	XML	Proprietary	Delimiter-Based
	Content administration	None	Web Interface	Application
	Customization effort	Low	Medium	High
	Community	Small	Medium	Big
	Scope	Low	Medium	Wide

Figure 4.5: The morphological matrix for Linguamo

Linguamo is part of mobilefive's mobile microlearning suite. It is a ready-to-use solution for simple creation and delivery of multimedia learning contents via an application running directly on mobile devices. As shown in Figure 4.5, Linguamo is available for almost any mobile platform available today. This is one of the reasons why we included this product in our reviews. The applications running on the mobile devices are built on server side at runtime for every specific client. For security reasons the IMEI is encoded into the application to prohibit illegal distribution of the software. This is a very interesting concept we use in our solution as well. Besides this advanced feature connectivity is limited. It seems that Linguamo applications are only meant for local execution without any external interaction. Another interesting feature is the number of supported input methods. The application is not only capable of controlling touchscreens and keypads, but also voice input and processing. Unfortunately the graphical user interface offers only basic features which is definitely a trade-off for supporting a larger number of mobile phones. Analysis of input within Linguamo is hard because there is no logging feature available. The user only gets direct feedback if the given answers are correct which makes it hard to find any conclusions. Linguamo's data is stored in a proprietary structure which is not publicly available, but is most likely some XML derivative. The administration of content is achieved with a very intuitive and feature-rich web interface. Compared to the one used with project mGBL it is far more usable. The customization effort is low because of the easy-to-use web interface which enables a content supplier to alter almost any part of the final application. Unfortunately the community using the application on a regular basis is very small. Still the scope is acceptable reaching from simple multiple choice vocabulary trainers to voice analysing

foreign language teaching.

4.5 KnowledgePulse

	Value			
Property	**Available platforms**	Only one	Few	Many
	Connectivity	Low	Medium	High
	Input methods & devices	Only one	Few	Many
	Graphical user interface	Basic	Advanced	Rich
	Analysis	Logging	Feedback	Interpretation
	Data structure	XML	Proprietary	Delimiter-Based
	Content administration	None	Web Interface	Application
	Customization effort	Low	Medium	High
	Community	Small	Medium	Big
	Scope	Low	Medium	Wide

Figure 4.6: The morphological matrix for KnowledgePulse

KnowledgePulse is a research product developed by Research Studios Austria Forschungsgesellschaft mbH focusing on a special knowledge transfer called micro learning. This learning method breaks down content into small parts, called learning cards inside KnowledgePulse. These cards have to be arranged in a didactic sequence by the content author. KnowledgePulse then cares for repeating these cards in order to assure mid-term and long-term memorization. The application also adapts to the user's needs and learning progress. In contrast to other solutions the KnowledgePulse architecture uses push instead of pull for content transfer to the client. This implies that the client needs a continuous network connection. KnowledgePulse was initially developed for Microsoft Windows but it is currently available for Symbian OS also, which is stated in Figure 4.6, line one. Connectivity is low because it is limited to XML-RPC which is used to push content to clients. The client application can only be controlled by point and click operations which limits the input methods to either touchscreen or mouse input. The graphical user interface is basic, because it just displays text and multiple or single choice questionnaires. Analysis is available within the web interface for teachers, but students also receive immediate feedback by the application telling them whether an answer is correct or not. Content is stored using the XML format, but cannot be edited directly, for content administration authors have to use the supplied web interface. Because this solution works well, customization effort is low, but limited to the creation of micro learning steps consisting of single or multiple choice ques-

tionnaires. There are some companies which already use KnowledgePulse for internal training, which creates a medium sized community of users. While the scope is limited to content which is available as questionnaire, many lectures can be easily transferred into micro learning steps. Because there are also some lectures available in very different areas, the scope is identified as medium.

4.6 Impact on the SOMA project

We did the above reviews in order to circumvent the problems of existing projects. To avoid these shortcomings, we created a new solution, combining most of the advantages of existing approaches. We spent a lot of effort in reviews in order to retrieve as much knowledge and experience from them as possible. Besides that, we reviewed several different approaches to get to know different usage scenarios and figure out how to support them in the most reasonable way. The list of projects reviewed is not complete but should give a short introduction into problems of practical appliance.

Regarding project mGBL, for example, we like the idea of asynchronous communication between client and server, which we tried to adopt in the SOMA project. Because the integration of a SMS/MMS gateway in the SOMA server architecture would go beyond both the scope and the budget of this project, we decided on taking a minimalistic approach on this issue. We implemented a custom client-server communication protocol based on Java Sockets used in combination with Objectstreams. Therefore we can define certain rules for the communication, especially stating which exchange has to be synchronous and which not. This has a significant effect on the usability of the user interface, because we allow the learner to decide if he or she wants to publish the reached score of the attended course. In most other data exchange issues we prefer synchronous communication, consisting of a widely used request-acknowledgment methodology. This means that any request made by the client has to be acknowledged by the server to assure consistency. Besides that we want to ensure that server resources are preserved by terminating every connection with a ”close” connection command sent by the client. If the server receives such a command, the socket gets closed immediately. This way we want to prevent an overload triggered by too many open sockets. Another interesting issue of project mGBL was the lack of support for state-of-the-art hardware, especially touchscreens as stated in the evaluation results. Because of this we decided to implement SOMA for one the most up to date platforms available, the Android OS 2.0. Unfortunately this leads to some shortcomings today, because there are few hardware devices which support this platform.

One may be confused about the decision to include Moodle in our reviews, but we believe that it is essential to look at least at one project that is widely used for e-learning. Besides that Moodle can be used on any mobile device with a browser and an Internet connection, which implicitly includes all Android devices depending on the purchased data plan. The most important aspect of Moodle related to our project is the plugin system and the modularity. One of the reasons why they are so successful is that the whole application is written in the PHP programming language, which is easy to learn and very popular among website developers. We believe that

we can adopt this matter of success through the development using Eclipse and Java which are also commonly used by many developers. SOMA plugins as well as the SOMA application are written in the Java programming language and open to contribution by everybody. The SOMA plugin runtime enables seamless integration into the main application as well as easy packaging and distribution. Still the plugin runtime is just a part of the modular application framework which can be easily altered, removed or even exchanged. The whole SOMA system is structured in a modular way and is therefore easy to edit, extend, and maintain.

Mobile learning on smartphones offers many new and interesting learning approaches which have to be evaluated for practical usage. Linguamo is a project focusing on using speech recognition for mobile learning, which represents an outstanding learning approach for mobile devices. Obviously, the project is mainly used for learning languages where the smartphone evaluates the pronunciation. We did not include speech recognition within this project, because it would go beyond its scope, but we prepared our framework to support as many input methods as possible. Another very interesting idea is the encryption using the device IMEI. It is used to generate device specific applications which means they only run on the target device. We do not want to limit application usage to a singe device but try to protect content from unauthorized access at the same time. To enable this security feature, we discuss several encryption methods in Section 5.10. All of them share the requirement of only using the IMEI as parameter.

There exist many different learning methods one of which is micro learning, a discipline KnowledgePulse was designed for. To be precise, KnowledgePulse is not only a software-aided micro learning methodology, but also a piece of software with access to a very complex client-server infrastructure. The content is hosted on a central server and pushed to clients when their operating system is idle. We did not want to use a push system for SOMA, because we want to enable learning even without an Internet connection. However, we like the idea of a central content storage, which does not exist on any other solution reviewed. We implemented this feature through course packages, which are stored on the SOMA server. The difference to the existing approach is that we use a pull instead of a push mechanism for the content distribution, as stated above. The learner can decide on his or her own which course he or she wants to download and attend.

After the review of existing state-of-the-art solutions we will describe the SOMA framework and its components in the following chapter in detail.

CHAPTER 5

The SOMA framework

5.1 Components

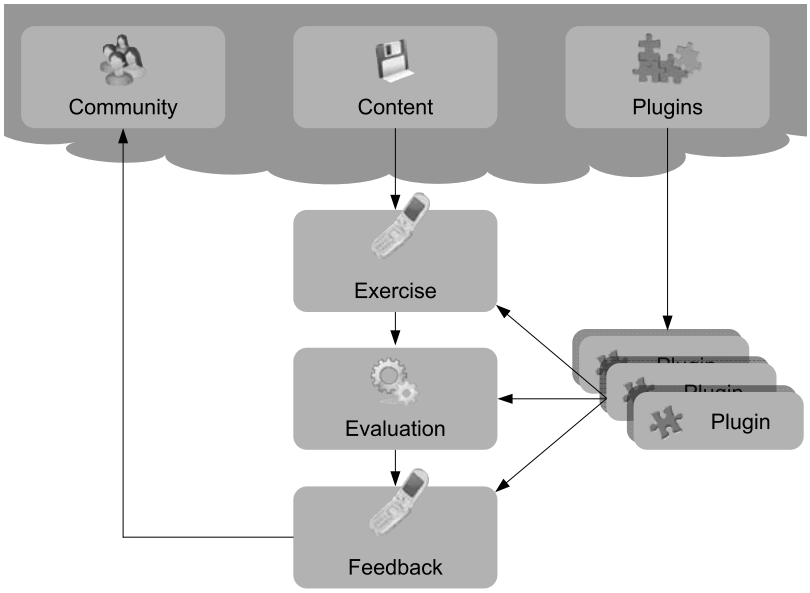

Figure 5.1: The components of the SOMA application

The SOMA framework encapsulates functionality from lower application layers, like the Android SDK. It acts as wrapper to ease the access, version compatibility, and hardware integration to the Android SDK. Besides that it also enables seamless communication with the SOMA Server and security related aspects. In the following chapter we describe the components of the implemented framework, as shown in Figure 5.1. The cloud on the top represents all aspects the SOMA server is responsible for, which includes storage, handling, and distribution of content and plugins, as well as community integration. Content and plugins are provided for the SOMA client which is shown at the bottom of this figure. An exercise needs both content and plugins from the server to display them on the mobile device. Afterwards it can be evaluated using the intended plugin which can either provide feedback to the user or just save the results. In the last step the user can decide on whether to send his or her reached score to the server and / or the community.

In the following sections, we first give an introduction to the plugin environment containing information about the underlying techniques. In Section 5.2, we review the Google Android SDK according to its benefits and shortcomings regarding mobile learning environments. Section 5.6 describes the implementation of our Facebook application in detail, which is one of our most important features according to our research work on didactic principles. Other important advantages of our approach include modular build (Section 5.8), content structuring (Section 5.9) and security (Section 5.10). Because source code of SOMA is publicly available, we want to make sure everybody is able to contribute to our work easily. Therefore we describe SOMA's modularity in Section 5.8. Content suppliers may be interested in the structure used for storing,

editing, and displaying learning material which is described in detail in Section 5.9. Because security of both users and content is an important aspect in practice, we include a description of SOMA's security concepts in Section 5.10.

The technical solution of our approach is described in Sections 5.11, 5.12, and 5.13. In these sections we provide an overview of each underlying architecture and details about available functionality. Section 5.11 illustrates the code of the client application running on the mobile device displaying courses, executing plugins and evaluating exercises. The server application is presented in Section 5.12, which acts as backbone of the SOMA framework where all content is hosted. We describe how the applications mentioned before interact with each other in Section 5.13.

We will begin with an introduction to the Google Android SDK which currently is the basis of the SOMA framework.

5.2 Introduction to the Google Android SDK

After a widespread technology research we decided to build our solution using the Google Android SDK. This has several reasons, but probably the most important is the feature rich integrated development environment within Eclipse. Eclipse is an integrated development environment (IDE) available for many programming languages. It also offers an extensible plug-in system and is written mostly in Java. Although Eclipse is mainly used for Java development, it can also be used to develop applications using C, C++, COBOL, Python, Perl, PHP, and several others using plugins as mentioned before [21]. The Android SDK provides a full featured mobile device emulator within the Eclipse IDE, which simplified testing and evaluating our prototype. Another benefit is the compatibility with the Sun Java Runtime Environment 1.6: except some minor issues most of its functionality is available in the Android SDK. Other software development kits, like the iPhone SDK, are based on proprietary standards and require special development environments. In case of the iPhone SDK, a developer has to pay a monthly fee to get access to certain features, and besides that it is only possible to develop on a system running Mac OS. In order to circumvent this limitations we built our solution using the Android SDK.

Android is a software stack for mobile devices that includes an operating system, middle ware and key applications. The Android SDK provides the tools and APIs (Application Programming Interfaces) necessary to begin developing applications on the Android platform using the Java programming language. [1]. *It was initially developed by Android Inc., a firm later purchased by Google, and lately by the Open Handset Alliance.* [36]. The Android system architecture is shown in Figure 5.2. On the bottom of this figure the linux kernel, which the Android OS is based on, is represented with most of the drivers used together with the power management. Current Android builds are based on Linux Kernel 2.6.29. *The kernel also acts as an abstraction layer between the hardware and the rest of the software stack* [1]. This data is never accessed directly through applications. On the next layer, the libraries reside together with the actual Android Runtime. SOMA currently only uses the media framework and none of the other libraries listed. The Android Runtime is separated into core libraries and the Dalvik

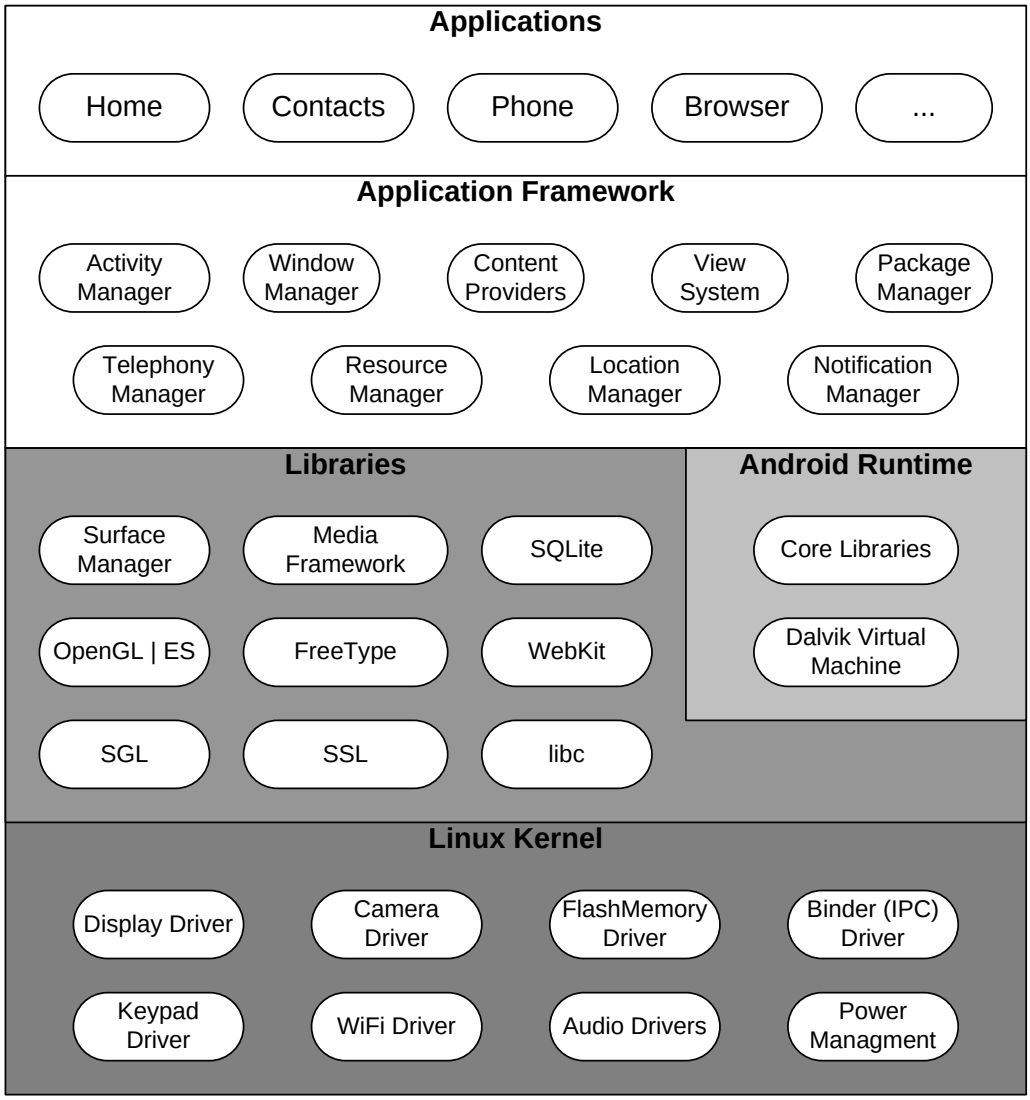

Figure 5.2: Android system architecture [1]

Virtual Machine, which is described later. The underlying layer is the most important for the SOMA framework because it contains most of the underlying features wrapped by the SOMA framework. The top level layer is the application layer where the system applications are located side by side with the SOMA application and the SOMA framework.

Every Android application runs in its own process, in an instance of a custom virtual machine. Due to several optimisations for mobile device processors, it is possible to run multiple tasks in parallel in an efficient way. The interested reader may find more information at the Android developers website [1].

Running on the latest available mobile hardware, Android enables playback of most popular

Type	Format	File Type(s) Supported
Audio	AAC LC/LTP	3GPP (.3gp) and MPEG-4 (.mp4, .m4a).
	HE-AACv1 (AAC+)	
	HE-AACv2 (enhanced AAC+)	
	AMR-NB	3GPP (.3gp)
	AMR-WB	3GPP (.3gp)
	MP3	MP3 (.mp3)
	MIDI	Type 0, 1 (.mid, .xmf, .mxmf), RTTTL/RTX (.rtttl, .rtx), OTA (.ota), iMelody (.imy)
	Ogg Vorbis	Ogg (.ogg)
	PCM/WAVE	WAVE (.wav)
Image	JPEG	JPEG (.jpg)
	GIF	GIF (.gif)
	PNG	PNG (.png)
	BMP	BMP (.bmp)
Video	H.263	3GPP (.3gp) and MPEG-4 (.mp4)
	H.264 AVC	3GPP (.3gp) and MPEG-4 (.mp4)
	MPEG-4 SP	3GPP (.3gp)

Table 5.1: Android Core Media Formats [1]

multimedia formats including MP3, OGG, JPEG, PNG, and MP4, to name just a few. The full list is shown in Table 5.1. The multimedia capability is definitely one of the reasons for choosing Android for implementation because this means that SOMA content suppliers can use any of these supported multimedia formats to add them to learning material. This content will then be displayed in the SOMA application using the Android default playback mechanisms. The upcoming Android version 2.2 will also support the integration of media encoded in the Adobe Flash format, which will then also be available within the SOMA framework.

There exist several versions of the Android Platform which are referred to as API levels in the SDK. All currently available versions and their corresponding API levels are shown in Table 5.2. Since version 3 every release is named after a dessert. SOMA is available from API level 4, also known as ”Donut”, to current level 7, known as ”Eclair”, and should be also compatible with future releases. According to Vladislav Savov [41], the next version of the Android platform (version 2.2) will be called Froyo, a short form for Frozen Yoghurt. It will be based on the Linux Kernel 2.6.32 which should reduce working memory load of the operating system. Besides that, this upcoming release will bring Adobe's Flash 10 to Android, which will attract even more people to buy Android mobile phones, especially those who are interested in rich multimedia applications. This is a real advantage compared to the iPhone OS, where this feature is not available and not planned to be implemented in future versions.

Most of the different API levels are compatible with each other, except level three and below. In version 4 many underlying functions and corresponding API calls have changed. It is difficult to support applications for all Android versions due to this implementation barrier. The changes between level three and four even include different access to the graphical user interface and

Platform Version	API Level
Android 1.0	1
Android 1.1	2
Android 1.5	3
Android 1.6	4
Android 2.0	5
Android 2.0.1	6
Android 2.1	7

Table 5.2: Available Android platforms and corresponding API levels [1]

a new implementation of resource handling. We encountered this issue within development of the SOMA framework and therefore decided to support versions above Android 1.6 only, due to state-of-the-art hardware compatibility. Right now there are only few devices available running Android 2.0, but we believe this will change in the future, because of the improving performance with every new version.

In summary, we identified the following benefits of using the Android SDK for development:

- Good multimedia support: As shown in Table 5.1, Android currently supports nine audio, four image, and three video types for playback on mobile devices. This covers most of the standards used for encoding multimedia content today.

- Seamless integration into the Eclipse IDE: Because most Java developers use Eclipse for implementation, the integration into this IDE is a major advantage for many developers.

- No development fees: The development of Android application is free of charge. Whether the access to the Android market nor the development environment has to be paid.

- Usage of open standards: The Open Handset Alliance put a lot of effort into the integration of open standards and applying the rules for openness.

- Development in the Java programming language: Developers do not need to learn a new programming language, the Android SDK uses pure Java including all benefits and shortcomings. The only differences are the design of the graphical user interface and some XML configuration files.

- Full featured device emulator: The emulator acts like a mobile device running the Android SDK and almost any aspects can be tested out of the box without the need of a real testing device. Unfortunately hardware sensors cannot be emulated, but there exist some workarounds like simulating the accelerometer using the current window position as input.

5.2.1 Critical aspects

The usage of the Android SDK has not only advantages for developers. In the following section we will describe the shortcomings and problems of the current version of Android. We encountered some of this problems during the implementation of the SOMA framework, but will describe all of them for completeness:

- No GIF support: Android currently only displays the first frame of a GIF image. This is very misleading because the GIF format is stated as supported in Table 5.1. Developers as well as content suppliers for SOMA have to consider this limitation.

- Compatibility issues between version 1.5 and higher: Because most of the underlying functionality changed in version 1.6, it is almost impossible to develop applications for all Android versions. We found no solution for this problem regarding the SOMA application and therefore decided to only support version 1.6 and above.

- Separation from the main Linux Kernel tree: We disagree with the decision of separating the Android Kernel from the official Linux Kernel because this does not apply to the rules of openness. Google plans to merge the current Android Kernel code again into the Linux Kernel and keep it up to date.

- Android does not use established Java standard: The Open Handset Alliance decided on implementing a custom Java standard instead of using the Java ME standard in favour of performance issues. We comply with this decision because all modifications apply to the rules of openness and are therefore comprehensible for everybody.

- Different hardware capabilities: Not all devices running the same version of Android have the same hardware capabilities. This can lead compatibility issues, especially with applications like SOMA which require certain hardware sensors. Fortunately the Android SDK offers adequate functionality to determine the presence of these capabilities.

Another critical aspect often mentioned but not listed above is the number of available Android devices. Because Android is a rather new operating system available since 2008, there are fewer devices available on the market than for example devices running the Symbian OS. We believe that the number of Android devices will increase over the next years. Looking at the current development shown in Figure 5.3 it is obvious that the number of devices rises every year. We decided on segmenting the data of available devices into quarters, starting at the fourth quarter of 2008 where the first Android powered phone was publicly available until fourth quarter of 2010. The numbers for 2010 can only be estimated according to manufacturer's release informations. While not fully complete ,the figure still shows a clear trend for the future of available Android devices.

It is important for a framework to support multiple operating systems in order to provide cross platform implementation for developers. Therefore we describe the support for additional platforms in the following section.

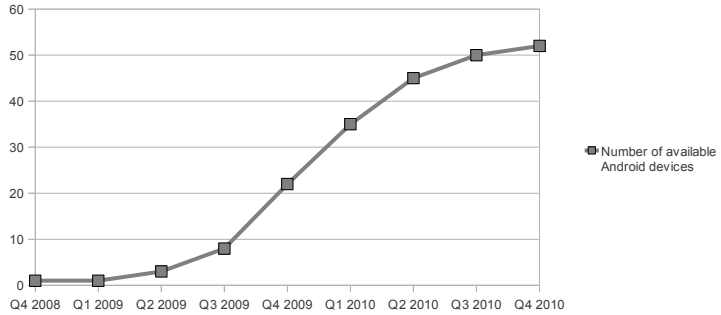

Figure 5.3: Available Android devices from 2008 to 2010

5.3 Support for additional platforms

The prototype of the SOMA framework presented in this thesis was developed for the Google Android operating system. This decision was based on the flexible structure the Android system provides for third party software and on the availability of a sophisticated software development kit. Another important reason was the assumption that although Android is a rather young development compared to other operating system for mobile phones, such as Microsoft Windows Mobile or Symbian, a large number of users especially in our main target group - children and teenagers - uses an Android device. In addition, the Android system can be installed on several netbooks which helped us conducting the case study without the need of providing a large number of devices running Android natively to our test users.

However, for publishing a final version of the SOMA framework that is intended for productive usage, compatibility is a crucial factor of success. For a mobile application, the availability of the product for different operating systems is the most important aspect concerning compatibility. This section deals with adaptations that would be necessary for developing new versions of SOMA for additional mobile operating systems. In addition, the idea of using the SOMA framework on desktop computers is discussed, including possible advantages and drawbacks of such an extension.

5.3.1 Mobile platforms

There exists a variety of operating systems for mobile devices, and none of these has a monopolistic position at the market. For SOMA this means that an existing Android application can only be a basis - to be successful in the market this must be followed by the publication of versions for additional operating systems. This is important for a product like SOMA that depends on third party plugins as well as courses for being useful to its users.

In the case of SOMA, there exists a chain of dependencies: In general, plugin developers are more likely to publish add-ons to the SOMA framework if the base product can be widely used, which in this case means that it is available for the most common mobile devices. Suppliers of e-learning courses can only create interesting multimedia-based courses for the SOMA framework

if there exists a variety of plugins allowing the courses to make use of all the different hardware devices present in mobile devices. Again, if there are not enough courses published for the SOMA system, learners will not be able to use it for e-learning.

In the survey, which we conducted as part of this thesis prior to the case study, we tried to obtain general knowledge about the usage of mobile phones among our target group. As part of this survey we asked which operating system the respondent's mobile phone uses. The results showed that, in addition to Android, iPhone OS, Microsoft Windows Mobile, and Symbian are most popular. Therefore, those systems are the most important ones the SOMA framework should be implemented for.

One interesting aspect of such a process is the question of how to keep the flexibility of the SOMA plugin environment such that plugins, and therefore also courses, can be used by any version of SOMA, independent of the underlying operation system. On the one hand, the core components of the SOMA framework, that encapsulate access options to hardware features must be implemented in an entirely different way on each platform, while on the other hand they must provide the same interfaces to plugins. As this is a rather difficult and complex process, interesting research questions arise. For example, when concentrating only on the presentation of content on the screen, this example shows the complexity of this task: The graphical user interface managers of different operating systems must be encapsulated by a rather simple but still powerful framework that manages the presentation of the content provided by plugins on the screen.

As mentioned before, the availability of SOMA versions for different platforms is a crucial factor of success in the market. In addition, it can even open new possibilities for the usage of the SOMA framework: If SOMA courses could be run on various mobile devices independent on the operating system, this would ease the development of e-learning courses as they need only to be created once for the SOMA framework instead of creating multiple versions, one for each platform the course shall be compatible with.

5.3.2 Adaption for non-mobile platforms

As mentioned in the last section, the implementation of the SOMA framework for various mobile operating system would allow the easy publication of e-learning courses that can be executed on a large number of mobile devices. The SOMA framework acts as a runtime environment, providing access to the hardware for applications, in this case for the plugins. Courses and plugins can make use of these features to easily present individual content.

This idea of a platform-independent creation of e-learning systems using the SOMA framework as underlying runtime environment needs not to be limited to operating systems for mobile devices. In fact, the SOMA framework could also be implemented for other electronic devices that offer a display, at least one input device and are connected to the Internet, such as personal computers.

Providing a SOMA version to be executed on personal computers would offer learners more flexibility in choosing their preferred way of attending an e-learning course. Whenever a personal computer is available, for example when being at home or at school, it can be used for

learning, taking advantage of the fact that the screen of a PC is usually much bigger than the one of a mobile device, and of the faster network connection. In addition, it would still be possible to use a mobile phone or a similar device to continue the course in situations where no personal computer can be used.

To ensure such a seamless combination of multiple devices that allows interrupting in the middle of a course and continuing with exactly the same exercise later using another computer, it would be necessary to develop a system that transfers the current status. This could include a personal learner's profile that is stored on the SOMA server. The current status, including information such as which exercise in which course the learner is currently taking, would be regularly transferred to the server, and can be obtained from the server profile whenever a course shall be continued.

Desktop computers provide different hardware specifications than mobile devices. The most obvious difference between those two types of systems regarding hardware concerns the input and output devices. Personal computers provide a display that is usually much larger than the small screens of mobile devices. In general, this is an advantage since content can be displayed in a more detailed way if more space is available. However, also the mobile device screens have certain advantages when compared to desktop monitors - for example, most mobile devices offer touchscreens that can be used not only for presenting content but also as input devices.

When considering input devices in general, there are additional differences that need to be taken into account. There are several input technologies mobile devices can provide, including touchscreens, numbered or full keyboards, or track points, to mention only a few. When transferring applications, such as SOMA plugins and courses, that make use of those input devices to a desktop computer, all those types of user interaction must be replaced by keyboard and mouse, since these are the only input devices that are usually available on every PC.

In addition to those problems, most of the hardware sensors Android devices provide are not available on desktop computers. Since using a variety of those hardware features to create multimedia-based courses is an important factor of success for the SOMA application, this is a serious problem. In some cases, this sensors can be easily replaced - for example, some notebooks offer GPS sensors similar to the ones available in mobile phones, and the digital camera sensor of a mobile device can be replaced by a peripheral webcam - but this approach may fail due to the insufficient technical equipment of a computer.

On the other hand, desktop computers provide some advantages compared to mobile devices. The most obvious one is the additional flexibility of peripheral devices that are available for PCs. In addition, the faster transfer between the computer and the peripheral devices as well as the usually faster network connection of personal computers can be taken advantage of. However, all those possibilities depend on the actual availability of hardware on a certain computer.

One solution to the problems described above could be the integration of additional statements in the definition of SOMA courses. For each exercise, multiple plugins could be declared optionally, if the first plugin can not be executed due to limitations of the available hardware, for example, the second one is started instead and so on. This would at least ensure that every course can be started on every device.

Besides the support of multiple platforms also different target groups have to be considered. In the following section we present a brief introduction on this topic.

5.4 Target audience of SOMA

Although the SOMA framework does not focus on persons belonging to a certain target group, in this thesis we focused on children and teenagers as main users of the SOMA application. This applies to the development process of the prototype version of SOMA as well as to the case study and the sample course that was created.

During the development, some decisions were based on the assumption that the prototype is created for the target group of children and teenagers, for example the social network of Facebook was used because this is the most popular community among members of this age group. The sample course that was created as part of this thesis covering basic first-aid content was composed especially for learners in the age of 8 to 16 years. This is exactly the age group, the users who tested the SOMA prototype during our case study belong to.

However, the modular structure and the integration of various input methods makes the SOMA application adaptable to every imaginable target group: Through the flexible plugin system, the presentation of content on the mobile device can be adapted to the needs of a certain target group, and courses can make use of exactly those hardware features that are preferred by the members of this target group.

Plugins can easily be developed in multiple versions, each one providing access to a certain hardware feature in a way that is appropriate to exactly one age group of users. In addition, also different version of courses can be published, one for each age level - each covering the same topic, but differing in the way the content is presented and using different input methods for the exercises to be solved by the learners.

There exist several papers exploring the characteristics different age groups demand from learning environments, some of which focusing on e-learning concepts. For example, Ablöscher [7] discusses the needs and requirements of older users - in this case, persons older than 55 years - concerning electronic devices in general and especially e-learning solutions.

It would be quite interesting to combine the results of these studies with the approach the SOMA framework follows to realize an e-learning solution that is applicable to different groups of learners, concerning age levels. This would include the adaptation of the SOMA framework itself in order to make it easily adaptable to follow the requirements of different age groups, as well as the implementation of plugins to be used in courses which focus on exactly one target group. As a basis for plugin developers as well as course suppliers, a guideline could be established, helping developers in the decision of which presentation and interaction techniques to use in which way to serve the individual needs of each target group.

Each of the mentioned features is either already available or can be easily implemented using the SOMA plugin environment, which is described in the next section.

5.5 Plugin environment

The SOMA framework was designed to be as extensible as possible and therefore we decided to develop a custom plugin environment. It is based on the Java Reflection technology and

enables developers to compile plugins which do not have to be known before runtime. First we describe the underlying technology along with its critical aspects, and then we introduce the architecture of the SOMA plugin environment which includes a guide for getting started with developing plugins for our application. Afterwards we describe our sample plugins which have been implemented within this thesis as proof of concept to show that our approach works. Besides the sample plugins we also provide guidelines for developing additional features, which can be added using the plugin environment.

5.5.1 Java Reflection

The reflection was former known as Introspection. It is a feature of the Java programming language available since version 1.1 that allows an executing Java program to examine or "introspect" upon itself or unknown classes and manipulate internal properties of the program. The provided API offers the following features:

- Determine the class of an object
- Retrieve information about class modificators, members, methods, constructors and super classes
- Determine which constants or method declarations belong to an interface
- Create an instance of a class at runtime
- Read and write values of member variables at runtime
- Execute methods of objects at runtime
- Create or modify size and type of arrays at runtime

For example, it's possible for a Java class to obtain the names of all its members and display them [3].
Within SOMA we use this feature to examine external class files and invoke predefined methods. Because Java Reflection can only execute classes compiled for the same runtime environment it is ran from, plugins have to be compiled for the Android SDK.

5.5.1.1 Critical Aspects

Sun mentions the following three major drawbacks of Java Reflection [38]:

- **Performance Overhead**: Because reflection involves types that are dynamically resolved, certain Java virtual machine optimizations cannot be performed. Consequently, reflective operations have slower performance than their non-reflective counterparts, and should be avoided in sections of code which are called frequently in performance-sensitive applications.

- **Security Restrictions**: Reflection requires a runtime permission which may not be present when running under a security manager. This is in an important consideration for code which has to run in a restricted security context, such as in an Applet.

- **Exposure of Internals**: Since reflection allows code to perform operations that would be illegal in non-reflective code, such as accessing private fields and methods, the use of reflection can result in unexpected side-effects, which may render code dysfunctional and may destroy portability. Reflective code breaks abstractions and therefore may change behavior with upgrades of the platform.

One of the main criticisms regarding Java Reflection is the performance. Because classes are investigated at runtime and are basically parsed text, the usage of Java Reflection can cause a bottleneck if it is used with big classes. We even experience this within SOMA. When a course is loaded, there is a lag lasting several seconds before exercises are displayed to the user. Another critical aspect is the exception handling which is very limited because the developer does not know which exceptions may occur during execution of a external class. This can be figured out for every method before it gets called but this leads to very high programming effort and again performance loss. We believe Java Reflection is not optimized for usage in mobile environments, especially for the Dalvik VM used in our approach. The functionality used within SOMA is not computationally intensive and can be executed on a standard Java 1.6 runtime environment without any performance issues. At this time we can only accept this limitation and conclude that Java Reflection is not intended for this type of usage.

5.5.2 The SOMA plugin environment

Because we wanted to ensure maximum extensibility of SOMA, we decided to create our own plugin environment. Plugins for the SOMA framework can be packaged as `JAR` archives or compiled Java class files. A plugin has to extend the abstract class from listing 5.1 with predefined methods for interaction with the main SOMA application, which offers access to the graphical user interface. Because it is an abstract class it can not be instantiated directly, but has to be extended by another class in order to be used. The default constructor defined in the abstract class has a reference to the `Display` class as parameter which is stored in a private field. The abstract methods `OnClick()` and `OnTimer()` have to be implemented by plugin authors to respond to these events. The SOMA application is notified about the state of a plugin with an event listener called `ExerciseFinishedListener`. The structure is defined in a nested interface within the abstract class and implemented in SOMA's `CourseView` class.

Besides that, plugin authors are encouraged to use any methods provided by the SOMA framework. While most classes act as wrappers for underlying Android SDK features making overall usage much more convenient, some of them are essential for application consistency and functionality.

The architecture of the SOMA plugin environment is based on the Java Reflection technology which is described in Section 5.5.1 in detail. In the course XML file each exercise can define a plugin which processes its content. This value has to be the absolute class path including pack-

ages where needed (e.g.: `soma.Plugin.MultipleChoice`). This class is then executed using the Java Reflection API, calling predefined methods from the abstract class. Afterwards the plugin is responsible for all calculations needed for exercise evaluation and in the end returns the reached score.

The best way to get started with writing plugins is to checkout the SOMA project from the public SVN and work directly in the plugins package. Developers can find our sample plugins for single choice and multiple choice exercises there which are easy to understand and extend. Another benefit is that they are able to provide their plugin source codes to other developers which helps to speed up plugin implementation and enables the reuse of source code.

Listing 5.1: The abstract class Plugin every SOMA plugin has to extend

```
public abstract class Plugin {

    protected Display Display;
    ExerciseFinishedListener exerciseFinishedListener = null;

    protected Plugin(Display display) {
        Display = display;
    }

    public void SetPlugin(Plugin plugin) {
        Display.SetPlugin(plugin);
    }

    public abstract void OnClick(int senderId);

    public abstract void OnTimer(int senderId);

    public void SetExerciseFinishedListener
        (ExerciseFinishedListener listener) {
        exerciseFinishedListener = listener;
    }

    protected void ExerciseFinished() {
        if (exerciseFinishedListener != null) {
            exerciseFinishedListener.onExerciseFinished();
        }
    }

    protected void ExerciseFinished(double result) {
        if (exerciseFinishedListener != null) {
            exerciseFinishedListener.onExerciseFinished(result);
        }
    }
```

```
    public interface ExerciseFinishedListener {
        public abstract void onExerciseFinished(double result);
        public abstract void onExerciseFinished();
    }
}
```

5.5.3 Sample plugins

As part of the prototype of the SOMA application presented in this thesis, three plugins have been developed. These plugins offer basic functionality that can be used to display simple questions in every e-learning course. They can be seen as examples that may help in getting started when developing further plugins. In addition, the first aid course that was used in the case study makes use of these three sample plugins.

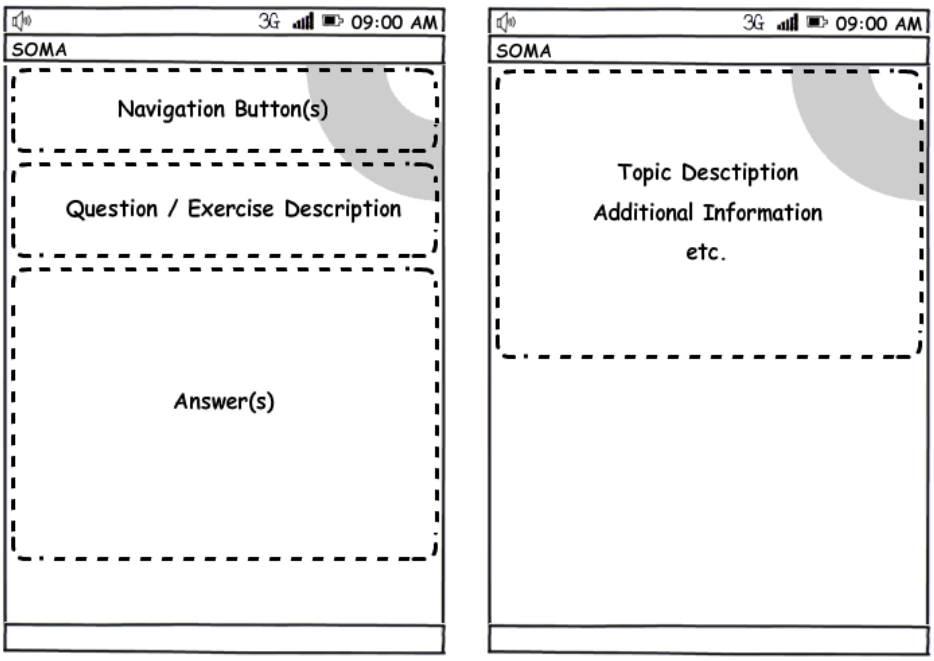

Figure 5.4: The basic layout used by the sample plugins for displaying exercises (left) and topics (right)

The single choice and multiple choice plugins can be used for textual questions with an arbitrary number of predefined answers. The user has to find out which of these answers are correct and which are not. They are located in the `soma.PLUGIN.SingleChoice` and `soma.PLUGIN.MultipleChoice` classes. In contrast, the regular expression plugin which

is defined in the `soma.PLUGIN.RegEx` class allows the user to input the right answer on his own, using a text box.

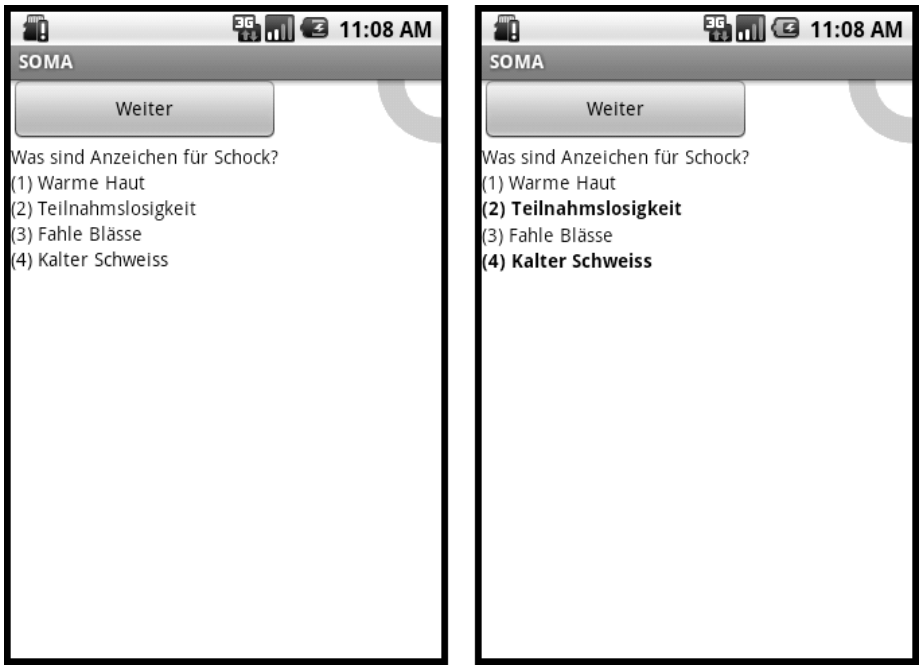

Figure 5.5: Two screenshots of the multiple choice plugin in action

The appearance to the user looks quite similar in all three cases. The basic layout is illustrated in Figure 5.4. On the top, the question is displayed, followed either by a list of possible answers or by a text box. In the single choice and multiple choice plugins, the answers can be selected by the user by clicking on one of them. Once an answer was clicked, it is highlighted through a bold font. When using the multiple choice plugin, multiple answers can be selected in that way. To de-select an answer, it has to be clicked again. This is illustrated by a sample exercise in Figure 5.5. In contrast, when using the single choice plugin, only one answer can be selected at the same time. If an answer is clicked, it gets selected and all other answers are automatically de-selected. Figure 5.6 shows this behaviour. The regular expression plugins displays only an empty text box instead of an answer. The user can apply the standard text input methods offered by Android to enter the correct answer, as shown in Figure 5.7. Finally, all plugins offer a button for confirming the selection. If this button is clicked, the answer is evaluated and the next exercise is loaded.

In general, both the single choice and the multiple choice plugin support an arbitrary number of answers. However, when using the single choice plugin exactly one of those answers must be correct. If the user selects the right answers, the score for the current exercise equals 1, otherwise 0. The regular expression plugin evaluates the answer in a similar way: The answer entered by the user is compared to a regular expression that was predefined by the course supplier. If they match, the score is 1, otherwise 0. To illustrate this, Figure 5.7 shows two screenshots of the

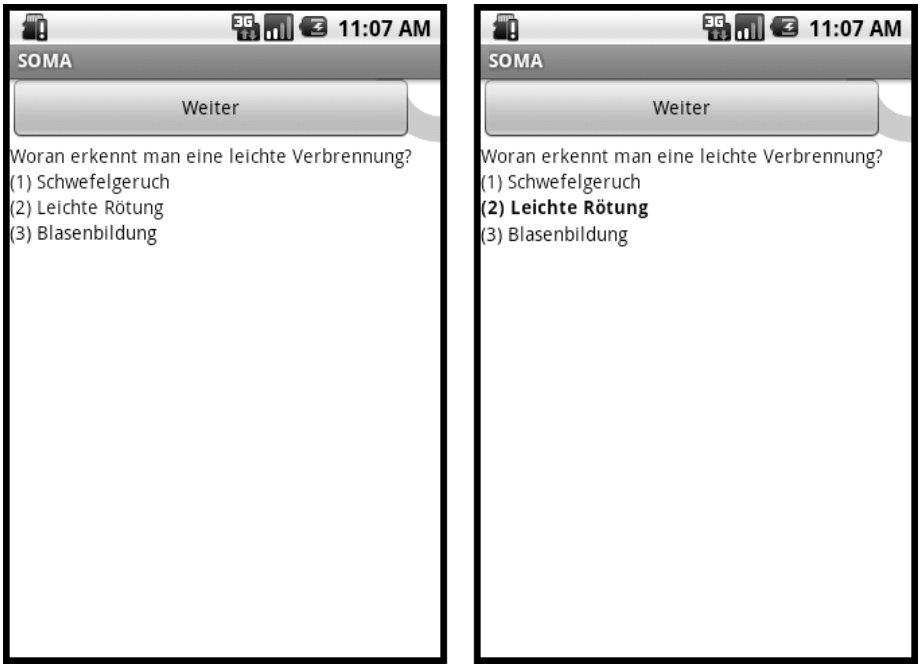

Figure 5.6: Two screenshots of the single choice plugin in action

regular expression plugin in action used with the sample exercise shown in Listing 5.2.

In contrast, in the multiple choice version the minimum number of correct answers is zero and the maximum is the total number of answers. The user must select the right answers and de-select the wrong ones. Since the overall score for each exercise must be a value between 0 and 1, the score for each of the possible answers is calculated as the reciprocal value of the total number of answers. For each correct answer that was selected and for each wrong answer that was not selected by the user, this value is added to the overall result. This means that if all correct answers were marked as correct and all wrong answers were marked as wrong, the overall score for the current exercise equals 1.

From a technical perspective, the three plugins offer functions for displaying text on the screen and for interrupting the application for a certain amount of time. Each of the text objects is assigned a unique ID when it is positioned on the screen. In addition, they make use of two event handlers: The `onClick` event handler is called whenever an object that was placed on the screen in clicked by the user. Through the unique ID the event handler recognises the exact object that was clicked. If the application in interrupted, the `onTimer` event handler is called when the defined amount of time has elapsed. This functionality allows developers to use the plugins not only for defining exercises, but also inside topic objects. In this case, some informal text can be displayed that automatically disappears after a certain amount of time to load the next exercise.

Figure 5.7: Two screenshots of the regular expression plugin in action

Listing 5.2: A sample exercise for use with the regular expression plugin

```
<exercise id="1" plugin="soma.PLUGIN.RegEx">
  <Question text="Wie lautet die Nummer der
    Vergiftungszentrale?" />
  <Answer correct="^\(?01\)? *[\/\-]? *4 *0 *6 *4 *3 *4 *3$" />
</exercise>
```

5.5.4 Additional plugins

To guarantee the multimedia-based user experience that should be characteristic for e-learning courses using the SOMA framework, feature-rich courses must be composed, which make use of many different plugins to enable a variety of presentation as well as interaction techniques. Thus the availability of different plugins that are easy to use for course suppliers is crucial for the success of the SOMA framework.

We encourage developers to create plugins for the SOMA framework and make these plugins available to the community. The SOMA framework provides access to the various hardware features current Android devices offer, however it depends on plugin developers to make these features available for suppliers to make use of them in e-learning courses.

The SOMA framework only provides access to the basic features, the available hardware devices offer, but it does not specify how to use those features in an e-learning context. This

conversion process is at the responsibility of plugin developers, leaving it to their creativity to find new ways of making use of different hardware devices such as sensors. Therefore the variety of imaginable plugins is endless, and each time a developer has a creative idea of how to use some hardware sensor in an educationally sensible way and transfers this idea to a plugin, it can be seen as an enrichment to the SOMA community, helping in increasing the engaging user experience of SOMA courses.

A few basic plugins were developed and presented as part of this thesis. These can be used for simple questions covering almost any possible e-learning content, as they are made for the types of exercises that are most frequently used in e-learning courses: Multiple choice and single choice questions are popular not only in e-learning but in all types of examinations, as well as open questions that can be answered by filling in arbitrary text. For developers, these plugins can act as a basis for creating further plugins as they show the interaction with the SOMA framework using very simple examples. In addition, the plugin environment of SOMA is rather easy to understand and use, making it possible even for beginners without much experience in programming to develop simple applications.

Current Android devices offer a variety of different hardware sensors. There were no plugins developed making use of such additional hardware devices until now since this exceeds the scope of this thesis. However, the following sections describe some basic ideas for two such plugins that are more sophisticated than the existing ones.

5.5.4.1 Motion detection

Most mobile devices running the Android operating system include an acceleration sensor. This sensor allows to identify in which direction and which speed the device moves with respect to its environment. In addition, it is not only possible to measure several features of motion but also the position of the device and if it is held horizontally or in a different angle. Due to these various measurement options, there are several applications of such an accelerometer imaginable in the field of education.

For example, using an acceleration sensor the mobile device could be used as a simplified model of any device the user should learn to handle. This is useful especially to simulate devices the user must actively operate on by hand. A simple example would be a pen which has to be moved in order to write something, other examples include more technical devices.

By giving the learner a simple task he or she must carry out using the device and measuring the directions and the velocity of the device while it is moved by the learner, the activity during this exercise can be evaluated. Based on the results measured by the accelerometer, the learner can be provided with exact feedback on his or her performance. It would even be possible to offer some hints on which parts of the activity were not carried out in an optimal way and how they can be improved, before asking the user to take the exercise again to improve the performance.

To do so, it would be interesting to first evaluate how accurate a typical accelerometer built into a mobile device works and which accuracy is needed for certain tasks. For example, in the simulation of a medical treatment using surgical instruments, accuracy will be more crucial than in a course that allows children to write using the device to simulate a pen.

Related to this, another interesting field of research would be the evaluation of existing, or

the creation of novel techniques for presenting the learner his or her performance after finishing the exercise. An interesting aspect would be to find out which presentation method is best suited for showing the learner his or her exact movement during the exercise on the display of the mobile device. Since the motion captured by the acceleration sensor was carried out in a three-dimensional space, it will be rather difficult to display this motion on a two-dimensional screen. If this problem is solved, it would allow users to retrace their activities during the exercise much like watching a video.

5.5.4.2 Pattern recognition

Nearly every mobile phone that is available today has a built-in digital camera. Nowadays the technical characteristics of most image sensors used by these cameras are quite sophisticated, making it easy to use the pictures taken by such a sensor for further processing. Similar to the approach presented above, there exists an huge number of educational applications of digital cameras included in mobile devices. All those approaches share the idea of integrating the real world that exists outside of the electronic device into an e-learning course that usually takes place only on the screen of the mobile device.

One approach of integrating pictures of real objects in virtual courses is the use of pattern recognition techniques. In a practical application, one exercise of an e-learning course could consist of asking the learner to look for a particular object in his or her environment and to take a photo of this object. This is especially interesting for courses executed by children, as it would allow to test if learners can locate objects in their environment which they have learned about shortly before.

The crucial point in the implementation of such an exercise is the evaluation of the pictures taken by the user. As the task was to find and photograph a specific object, the resulting image must be analyzed and decided if it shows such an object or not. Object recognition is a well-known research field in the area of image processing, and there exists several algorithms for solving recognition problems. It would be interesting to investigate which of these approaches can be applied to the problem discussed above. It should be taken into account that the algorithm must run on a mobile device with limited processing power, increasing the level of complexity of such an exploration.

5.5.5 Extension of the SOMA plugin environment

The SOMA framework provides a basic plugin environment that allows developers to take advantage of the feature-rich hardware options current mobile devices offer and to easily use those features in e-learning courses. Currently, the SOMA plugin environment offers simple functions for accessing the most commonly used hardware sensors as well as basic functionality for presenting content on the screen and allowing users to interact with this content. Especially this presentation framework, mainly implemented in the `Display` class of the SOMA framework, could be enhanced in order to create a convenient development environment for graphical user interfaces.

5.5.5.1 Integration of multimedia-based content

The current version of the `Display` class allows the display of text blocks and buttons the user can click at. An additional option for obtaining user input are textboxes in which the user can enter text individually. Those components can be composed on the screen using some simple layouts. This simple user interface should be enhanced in order to allow the integration of larger amounts as well as different types of content. This includes options for integrating different types of media in addition to text, such as images, video and audio files.

5.5.5.2 Advanced feedback

The current version of the SOMA application gives feedback to the learner in a rather simple way: After each exercise, a short message can be shown depending on the plugin that was used for presenting the exercise. This message can, for example, contain information that tells the learner if his or her answer was right or wrong. In addition, after finishing the course the overall performance is evaluated as a percentage value, where a value of 100% states that all exercises were answered correctly. This final score can then be published online for the community.

The impact on these two feedback presentation methods is limited: First, it depends on the plugin currently used if the short message at the end of an exercise is shown and which content it has. If the feedback message is shown at all and which information it contains, is up to the developer of each plugin. In addition, the overall score displayed at the end of the course can be used for comparing one's personal result to those of other learner who attended the same course, but it does not contain any information about which questions of the course were answered correctly and which were not.

It would be interesting to explore which types of feedback presentation are preferred by learners and how feedback should be displayed, such that learners can quickly capture the content. Of course, there are several imaginable feedback systems that could be integrated into an e-learning environment such as SOMA. One rather sophisticated approach would allow the learner, once he or she has finished a course, to review the whole course. In this case, every exercise would be loaded again in the same sequence as during the course, but this time with supplemental information being shown in addition to the exercise itself. This information should tell the learner if his or her answer was correct, but beyond that it could even convey additional information about the theoretical background of the question.

The integration of social networks such as Facebook does not need a plugin because it is provided by the SOMA server. The functionality of this feature is described in the following section.

5.6 Facebook integration

One of the reasons for using the Facebook social network for the SOMA project was the availability of a convenient, sophisticated application development toolkit. Third party applications

can be seamlessly integrated into the Facebook community. Those applications can access all parts of a member's profile, just as every user can, in an automated way. In addition, a development kit is provided by Facebook that allows the easy creation of such applications, using both the original Facebook API and supplemental libraries made available by third party developers.

This section explains the development and publication of applications to be used within the Facebook network site. Then it discusses which features offered by Facebook are best suited for use with the SOMA application.

5.6.1 Facebook application development

Each custom application has a Facebook page which is usually the starting point for users who want to make use of the application. To this main page, a Uniform Resource Locator (URL) is assigned that allows to access the application from outside Facebook by just entering this URL. Since users must be logged into their Facebook account to use third party applications, every application page also offers a login window, because users who load the application by entering the URL instead of following a hyperlink from another Facebook page can not be guaranteed to be logged in already.

The main page of an application contains basic information that describes the functionality, and offers users the possibility to include it in their profile. This allows the application to gather information, the user published on his or her profile in order to provide services based on personal data. In addition, once a user has included an application to his or her profile, the application may publish information on this profile, for example on the bulletin board.

From a technical perspective, it is quite easy to create the basic framework needed for developing a Facebook application. Each application must be registered to the Facebook network which can be done easily inside the Facebook site. A simple wizard allows developers to add an applications to their developer's profile. During this creation process, the developer must assign basic information such as a name, a short description, an image used as icon and other content that is used to define the application and to build the main page. After this information was specified and the application was registered, a unique application ID is generated as well a as a pair of keys used for accessing API features later on in the development process.

Facebook provides the main page for each application as well as functionality for accessing Facebook services, however the main program logic must be provided by the developer, which is done using the PHP scripting language. Application developers create PHP scripts that together form the program logic of the Facebook application. As Facebook does not provide hosting services for those script files as well as for any additional data the application needs, for example a database, a web server must be available where these contents can be hosted on.

The PHP scripts can only implement the basic logic of the application. To take advantage of the integration into a large social network an API is provided by Facebook, called the Graph API. Developers can access functionality the Graph API offers from inside a PHP script using the unique API key that was assigned to each application during registration. On the one hand, the Graph API offers functionality for gathering information stored in the Facebook network. On the other hand, it also provides access to the Facebook pages such as the bulletin board of

users who added the application to their profile. This can be used to publish the application results on this board, for example.

5.6.2 Integration of SOMA into the Facebook network

As already discussed in Section 3.2, the main target of the Facebook application developed as extension to the SOMA framework is to allow users to publish their results after taking e-learning courses as well as to discuss these results. In addition, it should advertise the SOMA application and the existing e-learning courses available for SOMA and allow direct downloads of these components.

Since each application has a main page showing a basic description, this page can be used for presenting not only information about the Facebook application itself but also about the SOMA project, including hyperlinks for downloading the SOMA application and optionally for accessing the SOMA web page located at `http://code.google.com/p/soma-project/`.

Once a Facebook application is registered, the developer can submit it to the Facebook application directory. All applications that are referenced in this directory are listed in the search results, which means that users can start using the application by simply entering "SOMA" into the search field that is shown on the top border of every Facebook page. The list of search results will then contain a link to the main page of the SOMA application, as described above.

To provide a platform for discussions between users or developers regarding the SOMA framework in general, a Facebook group can be used. A group works similar to an Internet forum: Members of the group can post their opinions and experience and discuss them with other members. The application's main page should include a link to the SOMA group and vice versa. In addition, group members can invite their contacts to also join the group which can incorporate additional impact on the advertisement aspect, contributing to the distribution of the SOMA application.

To incorporate the main aspect - the publication of the results of finished courses - the bulletin board can be used. Each Facebook profile contains a board where the user the account belongs to can post short text messages as well as multimedia-based content. In addition, authorized contacts of the profile's owner as well as applications added to the profile are allowed to publish messages on this board.

After a learner has finished a course on his or her mobile device and he or she took advantage of the option of publishing the results, the overall score as well as the ID of the course and the user's name are transferred to the SOMA server, which checks if the user has already added the SOMA application to his or her Facebook profile and uses a PHP script and some Graph API calls to post a short message to the user's bulletin board. In addition to the user's name, the course description and the final score, this message should contain a short description of the SOMA project and a link to the SOMA main page. This allows other users who read this message and are interested in taking e-learning courses using SOMA to find more information about the SOMA project and to download the SOMA application as well as sample e-learning courses.

There are many fields of application which are more interesting than multiple choice or

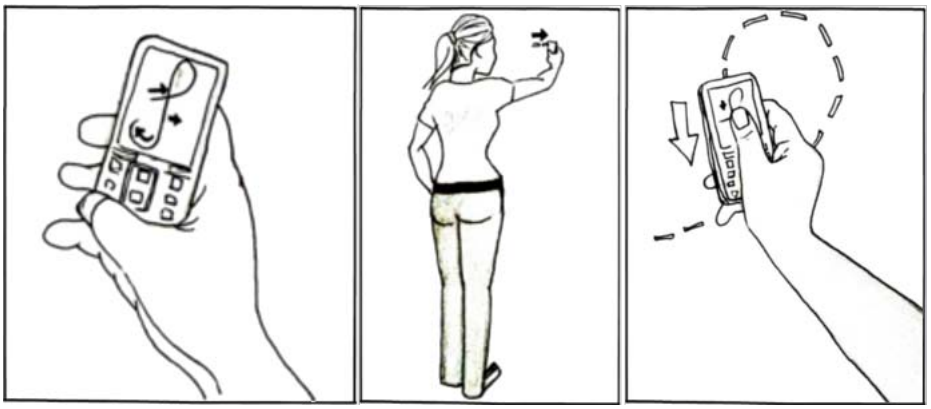

Figure 5.8: Write it! - teaches children how to write letters

single choice questionnaires, some of which are described in the upcoming section.

5.7 Fields of application

SOMA was designed for much more complex fields of application than multiple or single choice questionnaires. Therefore this section describes possible fields of application. The functionality of our prototype is limited because it includes only plugins for multiple choice, single choice and regular expression exercises. We will include descriptions of the required plugins for the following courses and give short guidelines on how to implement them properly. The aim of this chapter is to give an introduction on further development of the SOMA project. Some of the courses are also illustrated using drawn graphics which should help to understand the usage scenario discussed in the corresponding section.

5.7.1 Learn to write

One of the most interesting usage scenarios is the ”write it!” course, which should enable children to learn writing letters at home or on the run using only an Android powered mobile phone. The idea behind this project is to use the accelerometer to capture movement of the mobile device and evaluate the correctness. First the children see an animation of the correct movement to draw a certain letter, and when the user is ready he or she can perform the movement again and see the result on the screen. We define the target of this course as children not yet capable of writing, but there are also other types of usage imaginable where adults could use such an application. An example would be learning chinese letters which would be much harder to implement because it is even hard for humans to distinguish certain of those symbols.

The implementation of this course requires a movement plugin which retrieves the values of the accelerometer. It should be capable of capturing the movements between a period of

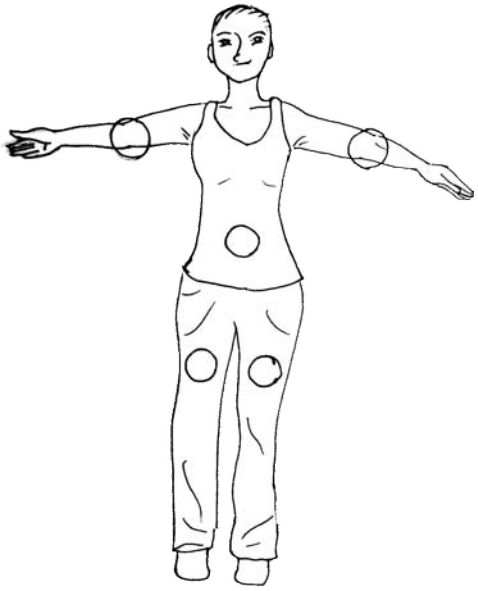

Figure 5.9: The important points of orientation have to be marked, in order to be tracked by the first aid application

time defined in the course XML properties. These values have to be compared with the results defined in the current exercise. The user should get feedback representing the correctness as a percentage value. The evaluation of the movement could be calculated by several checkpoints in the movement. A letter would then consist of several predefined positions the mobile device can be pointed at. The plugin would also have to provide a result generator which has to generate a structured result written in XML containing the values of a correct letter drawn. Otherwise it would be to difficult to calculate the movements of each letter in the alphabet.

5.7.2 Advanced first aid

During our case study which covered basic first aid content, we figured out that much more complex requirements exist in this area of e-learning. Practical tasks are hard to train without a teacher giving feedback on the current situation. A SOMA course could cover this evaluation using the camera of a mobile device. We entitled this course ”Advanced first aid” to differentiate it from our course used during the case study and to show that it should cover advanced first aid content. Using pattern recognition algorithms and predefined visual goals which should be accomplished, the smartphone should be able to tell the user whether his or her current solution is correct or not. The computation of the position of a human body is desirable but would unfortunately exceed the capabilities of modern smartphone processors. To circumvent this limitation we recommend the usage of a limited number of points of orientation as shown in Figure 5.9. These should be coloured in a way a pattern recognition algorithm can easy distinguish them

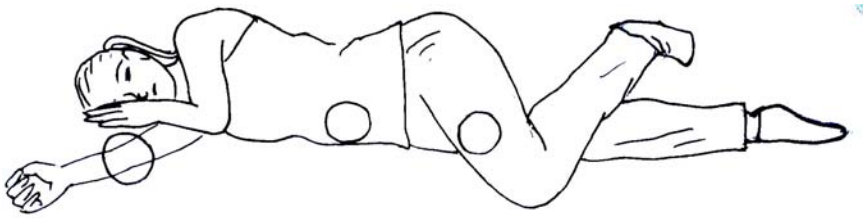

Figure 5.10: The first aid application can track and calculate the accuracy of the current position

from the background. Using this approach even complex tasks like the recovery position can be defined and evaluated on mobile devices with limited processing power. An example of a trackable recovery position is shown in Figure 5.10.

In order to achieve the creation of such a course, the implementation of a pattern recognition plugin is essential. This plugin must be able to compare a predefined image with a picture taken by the internal camera of the mobile device. Furthermore it should give the user feedback on how correct his or her solution was. Like all other SOMA plugins, this value should be displayed in percentage. For such a plugin the solution of an exercise described in a course XML file has to be a string representing the path to the file containing the target image. This will be a challenge for the graphical content editor discussed in Section 7.3 because it has to be flexible enough to handle such utilisations.

5.7.3 Geocaching

Another hardware feature available in most smartphones can be summarized as location-based services. There are a number of possibilities to discover the current location of mobile device, but the one we use for our application is the Global Positioning System (GPS). There is a very popular high-tech treasure hunting game, which is played throughout the world by people equipped with GPS devices. This game is called Geocaching and the basic idea is to locate hidden treasures which are called geocaches. It is played by people from all age groups and can be also used for educational purposes. There are lots of online platforms available offering coordinates of geocaches around the world, but we want to create a more educational application. The goal should be to find a target based on its coordinates and acquire all knowledge about it. An example would be the discovery of the Stephansdom in Vienna based on its GPS coordinates, which is illustrated in Figure 5.11. After arrival the students can use all features available on their mobile device to save information found. Most probably this will be pictures of the target and informative texts around the building or target place. This course is not able to give the student instant feedback but guide him or her to the target and offer possibilities of information acquisition.

The most important plugin for this type of course is a location plugin. It should be able to detect the actual position of the mobile device. The best solution would be the usage of the GPS receiver which is available in most of the modern smartphones, but it could use any other location-based service available. The plugin has to measure the distance from the current posi-

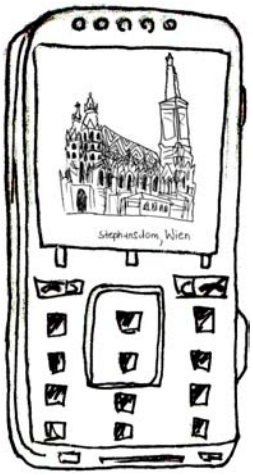

Figure 5.11: Geocaching - a new way to teach geography

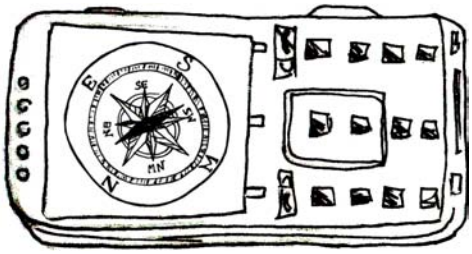

Figure 5.12: Geocaching - finding the way to the target using the SOMA navigator

tion to the target position and show directions on the display. A possible solution is shown in Figure 5.12. This plugin is one of the most complex discussed because it needs a lot of interaction with the graphical user interface. The solution described in the XML file of a corresponding course has to contain GPS coordinates of the target and the exercise content could be an image of an arrow which can be rotated by the plugin according to the current GPS position.

5.7.4 Yoga course

Another interesting usage of the accelerometer is the implementation of a yoga course. Like in the ”write it!” course the user first sees an animation of the upcoming exercise and is then asked to reproduce it. In this scenario balance will be more critical than the correctness of the movement. The user has to take a position and hold it for a defined period of time without loosing balance. Because the user cannot see the display of the mobile device in many positions it is preferable to use speech to give the user instructions. This instructions include correcting the position and warnings about balance issues. A possible application is shown in Figure 5.13, where a user trains the tree pose by holding his or her hands above the head and place one foot

Figure 5.13: Yoga - a course for the special experience

on the inside of the thigh.

Even though this course also uses the accelerometer, a custom plugin is needed which is responsible for detection of balance. When a user starts training a position, the plugin will offer some time to take in the intended position. During this period the device gives instructions, both on the display and over speech output in order to assist the user. If the correct position is reached, the plugin has to start a countdown for a certain period of time defined in the course XML file. If the user tends to loose balance, the plugin first gives a warning and then aborts the exercise and asks the user to try again.

Such fields of application would not be possible without a modularly structured application. We present guidelines for such an implementation in the next section.

5.8 Modular build

Modularity in general means the splitting of applications into smaller parts, called modules. The goal is to reach a maximum amount of transparency and overview of the project. Using this concept generates many benefits including shared programming, better reuse of code, and separate compilation of standalone modules. This leads to higher efficiency along with improved quality and lower costs. Besides that it is important for an extensible framework like SOMA to enable the reuse of source code. In this section we give a brief summary of best practice approaches for modular applications and then present the modular structure of the SOMA application.

5.8.1 Best practice approaches for modular applications

In order to reach these goals several aspects have to be considered. The most important aspect is the strict separation of interfaces and implementation. Interfaces are responsible for import and export regarding interaction with their environment. On the one hand, import tells which functionality the interface expects and on the other hand, export gives information about functionality which is provided to the environment. While interfaces do not contain code but only structures, implementation holds all data and functions.

There are some rules which help developers to stick to good modularity. Modules should be capable of well defined, understandable and module-independent functionality which can be tested in a convenient way. Looking at the overall application, effects of designing decisions and hardware dependencies should be limited to few modules. It is also important to differentiate between intra- and inter-modular views. Regarding intra-modular concepts, methods containing similar functionality or such operating on the same data structures should be located in the same module. It is important to prevent different implementations of logically similar functions or random functions to be contained in the same module. Inter-modularity describes the import and export capabilities of modules. Where possible, communication between functions of different modules should be achieved through exchange of data. An application is well modularised if intra-modularity is guaranteed through tight definitions and inter-modularity through few and loose dependencies of modules. We encourage developers to write plugins in order to extend our implementation. The SOMA application cares about most of the hardware capabilities available on the mobile device and provides access for the plugins.

5.8.2 Modular structure of the SOMA application

SOMA was designed to be modular in order to ensure easy manipulation and contribution to the existing code. Figure 5.14 shows the package structure used for SOMA development. The GUI plays an important role in our architecture because it is responsible for the interaction with the user. It provides different dialogs which are called views in the Android SDK and a main class to start the graphical user interface. `SomaMain` is responsible for starting each of the other views and for interaction with the SOMA framework. The main class will immediately start the `FinderView` which displays available courses on both the server and the local device. This view also takes advantage of the SOMA framework, in this case the `InternetConnection` class for the connection to the server as well as the `Filesystem` for the local file handling of existing courses. When the user selects a course, the selection is handed over to the `CourseView` which processes a course object containing the elements described in Section 5.9. The concrete implementation slightly differs from the proposed structure due to technical limitations and optimizations. Besides the actual structured content, course objects also contain the reached results and a package with multimedia files encoded as byte arrays.

Every `Exercise` must define a `Plugin` which is then responsible for displaying its content to the user and evaluate the given solution. In the plugin package resides the `Plugin`

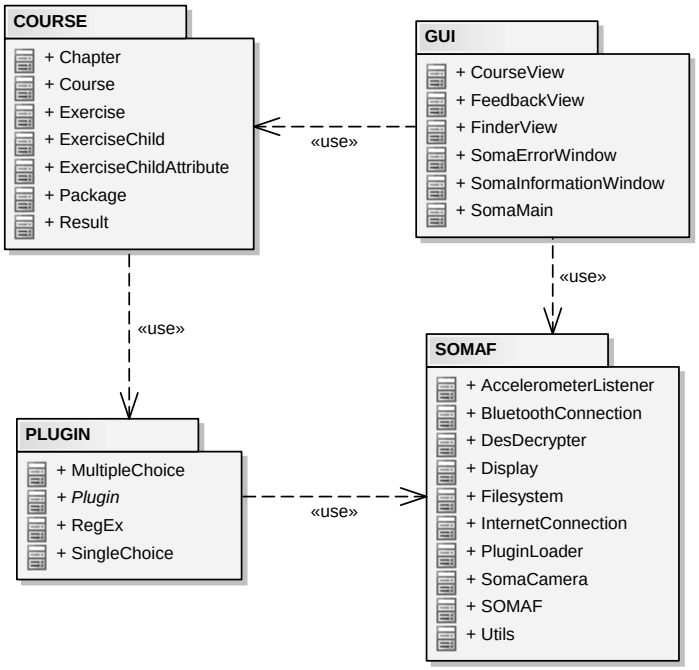

Figure 5.14: The modular SOMA package structure

interface and our three sample plugins. These include a multiple choice (`MultipleChoice`), a single choice (`SingleChoice`) and a regular expression (`RegEx`) interpreter. Each of the mentioned plugins uses parts of the SOMA framework. For a matter of completeness we describe the classes of the SOMA framework which were not mentioned already. The `AccelerometerListener`, `BluetoothConnection` and `SomaCamera` classes are responsible for hardware interaction, but are currently not used by our sample plugins and therefore we don't describe them any further. The `DesDecrypter` enables decryption of encrypted objects received from the SOMA server. It reads the IMEI from the device it is running on and uses it to decrypt the object and retrieve plain text information. More information about security aspects of SOMA can be found in Section 5.10.

In order to interact with the graphical user interface, a reference to the current displayed screen is required. This is realized within the `Display` class which handles the display of text and media on the target screen. One of the core functionalities of SOMA is implemented in the `PluginLoader` class which is responsible for running the plugin environment using Java Reflection. This process is described in Section 5.5 in detail. The `Utils` class represents a facade which instances some other classes of the SOMA framework and combines them in a single access point.

Many of these features need access to content stored either on the server or the local device running the application. Therefore we present our approach on content structuring in the next section.

5.9 Content structuring

A flexible and straightforward content structure is very important for easily editing and maintaining the content of an application. It is even essential in an environment like SOMA where content suppliers are different persons than developers. Because we cannot expect that these persons have any programming skills we plan to develop a graphical editor which will be part of future work and is described in Section 7.3 in detail. While this editor is not available we believe persons without any knowledge of a programming language will be able to read, understand and alter our sample course to fit their specific needs. We use the Extensible Markup Language (XML) as basis for content structuring. Therefore we give an introduction to the basics of this markup language in the following section.

5.9.1 Extensible markup language

The eXtensible Markup Language (XML) is a recommendation developed and maintained by the World Wide Web Consortium (W3C) and is widely used along content management systems and other areas where data is exchanged electronically. In summary, the most important fields of application include document-centric standards which describe how documents have to be structured in order to be exchanged without interoperability issues as well as certain industry-specific standards which are used inside branches for communication. Other interesting areas where XML is a main aspect are scalable vector graphics, user interface markup languages and web services. All of the mentioned examples use XML for content structuring and storage, in total there are over 250 different standards available today, but a correct number is hard to determine.

XML is a subset of the Standard Generalized Markup Language (SGML) which is an ISO standard since 1986. Therefore it does not try to replace SGML or the Hypertext Markup Language (HTML) but supplement it with a simplified version for information representation. XML files can be edited using any text editor available. An XML document has a tree structure consisting of elements, attributes, headers, comments, CDATA, entities and Unicode characters. There is no predefined limitation to this tree structure but it can be customized using XML schemas. An XML schema is also written in XML syntax and is capable of object-oriented concepts like inheritance. It is used to define the structure and valid content of the instance of an XML document and can be used to validate any XML file.

An XML file is self-explanatory and the order of elements is significant. Elements are defined as markup using the "< >" brackets. Usually markup defines the document structure while concrete information is settled in between two such elements. Optionally information can also be stored in attributes, but this should not be intended by default. An attribute should describe characteristics of an element. There exists no limitation to the number of attributes an element can possess. It is important that every markup element must have a corresponding end element, an empty markup element can be defined by using the proper `<markup/>` syntax. Besides this limitation it is also important that an XML document has only one root element. On the same layer as the root element only comments and processing instructions are allowed. XML

comments are enclosed between <!-- and --> characters and are used to explain parts of a document for human readers. Those comments are not interpreted by the parser and can be placed either before or after markup but not in between.

5.9.2 Content management in SOMA

We take a pragmatic approach regarding structuring and editing of content within our solution. Because XML has proven to be the most commonly used structuring language available [35], that is both human and machine readable, we will use it as data basis and encourage users to add or modify content directly within plain XML files. A graphical editor for these files will be part of future work. We created both a class diagram and an XML schema for easy authoring and validation of XML instances. The SOMA Server validates XML files against this schema before processing it with the custom SOMA SAX parser, implemented as part of this project. The SOMA SAX parser is part of the SOMA framework and is used to create course objects out of XML files.

One of the advantages is fast, reliable, and platform independent content editing because only a plain text editor is needed. The creation of the example course for evaluation has shown that if only one plugin is used it does not take much time to transfer existing content into a SOMA course. This comes off the fact that one can create a template once including the whole structure of an exercise and use it for all upcoming exercises. We used such a template for our example course which is shown in listing 5.3. It was convenient to create a structure using this template first and then copy the content from the actual learning material which was only available in the Adobe PDF format. The only annoying circumstance was the filling in of the exercise ID. It would speed up the whole process a lot if this number would be generated, for example using our graphical content editor described in Section 7.3. Still it is possible to create even long courses using basic manipulation utilities and templates.

Listing 5.3: The template used for the creation of the first aid sample course

```
<exercise id="" plugin="soma.PLUGIN.MultipleChoice">
  <Question text="" />
  <Answer text="" correct="true" />
  <Answer text="" correct="false" />
  <Answer text="" correct="true" />
</exercise>
```

After converting content to the SOMA structure, suppliers may want to define who is able to view it and who is not. For this reason we included the upcoming section about security features provided by SOMA.

5.10 Security

Securing application content is an important feature for content suppliers. There are several cases in which it is desirable to control access to certain content. That includes material under copyright or content that is for sale. We want to prepare SOMA for such a business model as it is used in the application stores for iPhone and Google Android OS. Therefore we did some research work on symmetric and asymmetric encryption methods to identify the best solution for our application. We start with an introduction to a symmetric encryption method which we used in our first prototype and then describe the more secure asymmetric approach that uses a public key infrastructure. Finally we describe the concrete process of encryption used in our prototype.

5.10.1 Encryption methodology

Our first idea was to use public key cryptography like Pretty Good Privacy (PGP) because it is the most secure way of encrypted communication available today. The reason for this is that there is no need for exchanging a shared key, which is the biggest problem of all other symmetric encryption methods available. Unfortunately we could not easily realize this, because of the lack of support through the Android SDK. A custom implementation was needed to achieve this goal, which is described in the next section.

As an alternative, we use the International Mobile Equipment Identity (IMEI) as key for a slightly modified Data Encryption Standard (DES) cipher. The IMEI is a number unique to every GSM, WCDMA, and iDEN mobile phone, as well as some satellite phones. The IMEI number is used by the GSM network to identify valid devices and therefore can be used to stop a stolen phone from accessing the network [27]. This makes it a perfect key for encryption of content through SOMA.

The DES Salt is a 12-bit number, between 0 and 4095, which slightly changes the result of the DES function [6]. Our custom implementation uses such a Salt to retrieve a predefined encryption methodology. UNIX uses the Salt to change the DES algorithm every time a user attempts to change his/her password.

5.10.1.1 Public key infrastructure

As mentioned before, the Android SDK currently lacks support for PGP, which we would like to use for content encryption in the SOMA project. Classic cryptographic approaches often fail because of a shared key being the single point of failure. In such an environment the key has to be sent at least once in plain text to the server for encryption of the following message with the defined secret key. We decided on using the IMEI as shared key for every communication. The biggest problem of this implementation is that the secret key is exchanged over the same communication channel as all other data exchange. This should be definitely avoided, but we are not able to use any other channel at this time. The problem is illustrated in Figure 5.15, which shows the communication between two individuals called Alice and Bob. They are not aware of

the fact that Mallory is a malicious attacker who monitors their interaction and may alter it at any time. Even if Alice and Bob decide on using a secret key to encrypt their communication, Mallory can easily decrypt it if the key was exchanged over the same medium before.

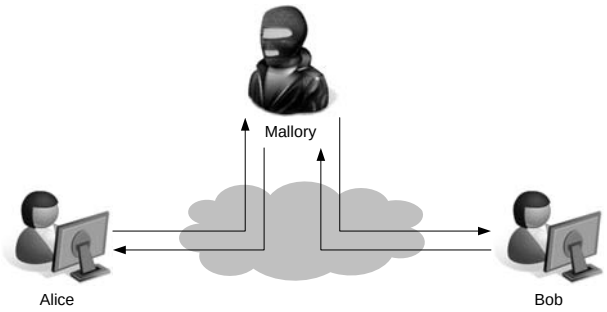

Figure 5.15: A typical man-in-the-middle attack

The best solution for this problem is to use a public key infrastructure. In such a environment there is no need for the exchange of a shared key because everybody owns a private and a public key. The public key can be publicly available and is used to encrypt a message. This message can then be only decrypted using the private key which only the receiver is in position of. For usage in the SOMA project we use the Diffie-Hellman key exchange, because it enables easy generation of public keys out of predefined private keys. This procedure is not that easy with the commonly used RSA algorithm. With this new infrastructure, the client and the server just have to agree on a prime number p and a base g which has to be an element in a predefined finite cyclic group G. This information can even be hardcoded into the application without any security concerns because a malicious attacker would still need the private key to decrypt the message.

The changes to the current client-server communication are minimal because only the procedure of encryption has to be changed, but not the underlying protocol. The client no longer sends the IMEI before every transaction but has to compute the public key g^{IMEI} which is then sent over the socket. The SOMA server then has to generate a random number b and encrypt the course using the symmetric key $(g^a)^b$. Finally the server transmits the encrypted course object together with the result of g^b. On the client side again, the object can be decrypted using g^b and the IMEI.

5.10.2 Content encryption

Our current approach is sufficient for evaluation, but it is vulnerable to attacks like the man-in-the-middle attack. In this scenario an malicious attacker listens to the traffic between client and server for information like the shared key. It is easy for the attacker to decrypt the course content if he is in possession of the secret key, the IMEI in this case.

In our implementation we use Salt together with the IMEI and an iteration count of 19 to create a password-based encryption (PBE) keyspec. Using this keyspec we are able to create a

secret key based on the PBE with MD5 and DES specification. We then use the final cipher to create a sealed object as defined in the Java SDK. This sealed object can be sent over sockets or serialized for further processing. It can only be decrypted with the password used for encryption, which equals the client IMEI.

Every action received by the SOMA server includes the originators IMEI, which is not only used for encryption, but also for access control. This does not mean two users should not be able to use SOMA on the same device, but will provide protection of abuse or fraud for the SOMA server when used in a potential commercial environment. For each new client connected to the SOMA server an entry with its IMEI will be created in the local database. A suspicious user can then be easily banned from the system by marking the entry with an ”evil” flag.

The security features are distributed among the client and the server application which will be described in the following sections, starting with the client application.

5.11 Client application

The SOMA application acts as client in the client-server infrastructure. It is running under the Android operating system and packaged as APK file. An Android package basically is a variant of a `JAR` package and consists of the following contents:

- AndroidManifest.xml
- classes.dex
- resources.arsc
- res (folder)
- META-INF (folder)

This packages can be generated using the Eclipse plugin and can be signed using the Android Keyfactory to create signed APKs. SOMA can be downloaded as such an signed APK from our Google Code repository located at `http://code.google.com/p/soma-project/`. There are different versions available, according to the Android version running on the target mobile device.

After installation, the client will connect to the SOMA server to retrieve a list of available courses and display them to the user. If the connection to the server cannot be established, the SOMA main menu will be empty and the user is not able to work on any courses. When the download of the packages available on the server is completed, they are displayed to the user who may then select any course listed. The selected content is then transferred to the local storage of the client application. The next time the application is run, the user can choose between local available courses, and if a connection to the server is established, also all courses available online. Besides these two views, there is also a third view displaying the courses that were accessed recently.

5.11.1 Architecture

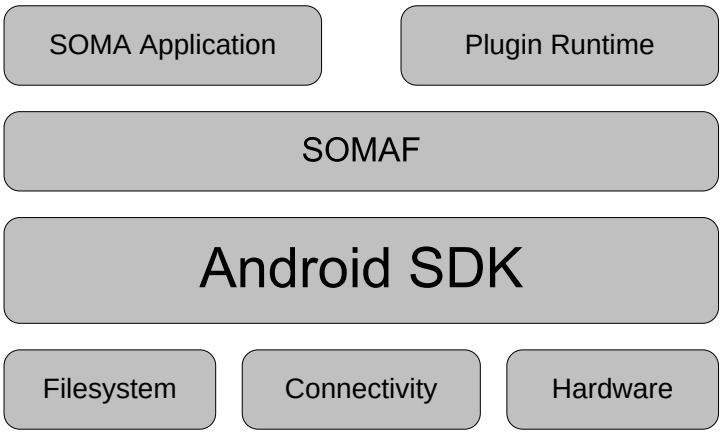

Figure 5.16: The SOMA client application architecture

Figure 5.16 shows our modeling approach for the client application running on the Android powered mobile device. We decided on this architecture because it has several similarities with the structure of the Linux kernel, which has proven to work for operating systems. The lowest level represents the direct access to hardware, which is wrapped by the Android SDK that represents the second layer. Our SOMA Framework is located at the third layer and is responsible for every interaction with the Android SDK. On the fourth Layer which is the highest layer in our architecture the SOMA application resides side by side with the plugin runtime. This offers plugin authors to access any functionality from the SOMA Framework. With this solution we want to ensure a maximum amount of modularity and reuse of existing functionality.

One benefit of the SOMA framework, besides many others, is the possibility of unit testing without the need to launch the complete Android SDK. While implementing our application we encountered several performance issues regarding the Android Emulator. In order to save plugin authors this effort we will provide a basic mock up stub of the framework to enable high performance unit tests.

The client application retrieves content and plugins from the server application, which is described in the next section.

5.12 Server application

The SOMA Server is responsible for hosting content and plugins in a way that allows the SOMA client to easily access them. Besides security and access control it also acts as gateway to community and social network features. The SOMA server has to be started with a folder path as argument. This folder is then watched for occurring changes, including the addition, deletion, and alteration of files. The timespan of the thread which checks for changes can be declared

before runtime. Whenever such a change occurs, the list of available packages on the SOMA server is updated. Only files with the correct structure and content are being processed. The files have to be compressed into a ZIP file containing a single XML file and an unlimited amount of custom files which can be of any type except XML. Folders within this compressed files are not being processed, therefore a flat hierarchy is suggested. If the altered file has the correct format, its course file is processed by the SOMA SAX parser and stored as course object in the newly created package. After that the content of all other contained files is added as byte array and stored in the package data structure.

5.12.1 Architecture

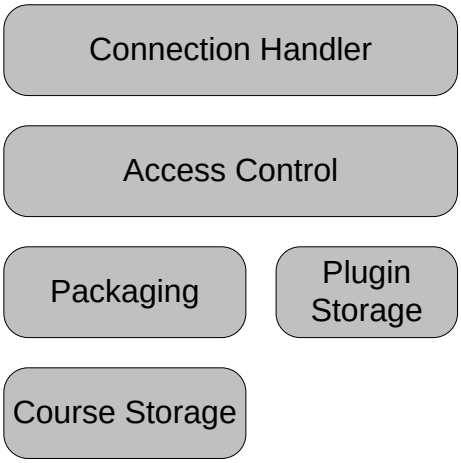

Figure 5.17: The SOMA server architecture

In Figure 5.17 the basic structure of the SOMA server application is shown, again starting with the lowest level layer where the course storage is located. Within the course storage, course objects with the content of the provided XML files are stored. These files can only be retrieved through the package class of the next layer. Within a package object all files from the uploaded container file are stored in byte arrays together with the processed course objects.

Side by side with the plugins, stored as `JAR` files, the package layer resides on the second layer. Both the plugins and the packaging class can only be accessed through the access control class which represents the third layer and is responsible for all security related access control mechanisms. For further information about security in our approach see Section 5.10. All mentioned layers are spawned from the fourth layer within the connection handler.

Each arriving connection creates its own access environment. When a new client connects, it has to send its IMEI first. If it is blacklisted based on its IMEI, further access limitations may be applied. If the client passes all security checks, it is allowed to send one of the commands `getAvailablePackages` or `getCourse` followed by the globally unique ID (GUID) of the desired course. When the server receives the `getAvailablePackages` command it will

create a list of available titles and descriptions and send it to the client. The client may then choose a specific course and reply `getCourse`. The server retrieves the package from its storage according to the submitted GUID and encrypts it using the IMEI provided at the beginning of the conversation with a DES cipher. Therefore we can assume that only the connected client which sent the request is able to decrypt the information. A successful transfer has to be acknowledged with the `done` command after which the server closes the client connection.

This was just a brief overview on how information has to be exchanged between the SOMA client and server application. A in-depth description is given in the following section.

5.13 Client-server communication

Our approach uses a client-server architecture in order to provide rich content for our application. Because storage on mobile devices is limited and users are only interested in content they are currently working on, we decided on hosting all content on an external server and only download content to the device which is actually needed. This leads to some benefits because users have access to an almost unlimited amount of content from the server side and there is no need for a continuous network connection. We have chosen this method because we want to keep mobile data connections at a very low level. This way users can work on their specific course offline and can then update their statistics or content later when they are connected to their Wireless LAN at home, for example. The server also takes care of plugin and content distribution including access control to all resources hosted. All data that is exchanged between client and server over sockets is handled as an object which is encrypted using the DES cipher described in Section 5.10. This means that all objects intended for this usage have to implement the `java.io.Serializeable` interface.

5.13.1 Architecture

Figure 5.18 shows the concrete interaction between client and server application. On the top the server is shown as described in Section 5.12.1 with its separate course and plugin storage as well as 3rd party communication mechanisms. This architecture is hidden by the the SOMA server connection handler which listens for client connections on port 3000 by default. The commands which can be interpreted by the SOMA server are limited to course or plugin requests as well as the sending of scores.

The SOMA server will answer a `RequestCourse` request containing a GUID as parameter with either a package containing the intended course or `null` if the server does not know any course with the provided GUID. The `RequestPlugin` request works the same way as the `RequestCourse` communication, except that it expects a plugin class name including its class path (e.g. `soma.PLUGIN.MultipleChoice`) as argument. The client will either receive the requested plugin as `Class` or `JAR` file or `null` if the plugin is not available on the server. Finally the client can send the `SendScores` command with a result object containing

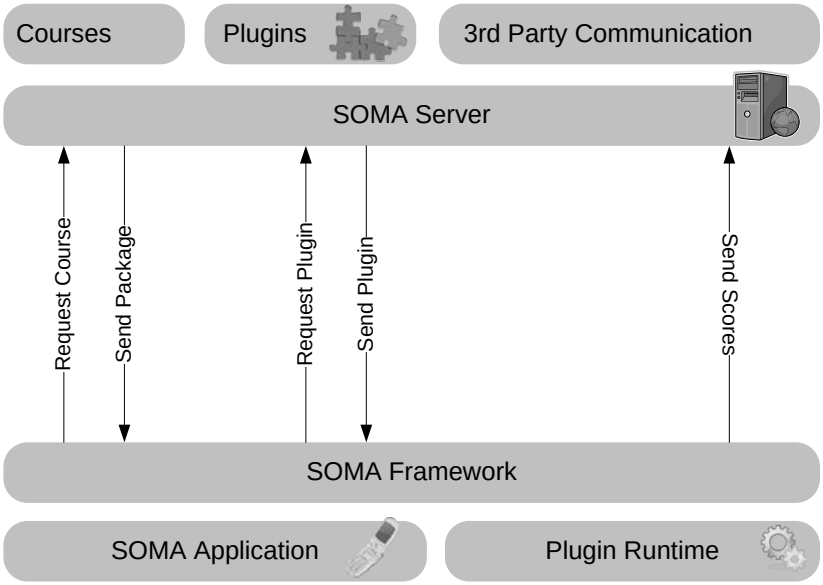

Figure 5.18: The SOMA client-server communication architecture

the reached score as parameter which will then be processed by the SOMA server, formatted and forwarded to available social networks.

On the bottom of the figure, the actual SOMA application is entirely hidden by the SOMA framework, showing that all communication is routed through the underlying framework. Side by side with the SOMA application, the plugin runtime is given the same access to the SOMA framework and its features.

After implementation of our prototype we arranged a case study in order to verify the achievement of our goals. This case study and other evaluation methods which we used are described in the following chapter.

CHAPTER 6

Evaluation

6.1 SWOT

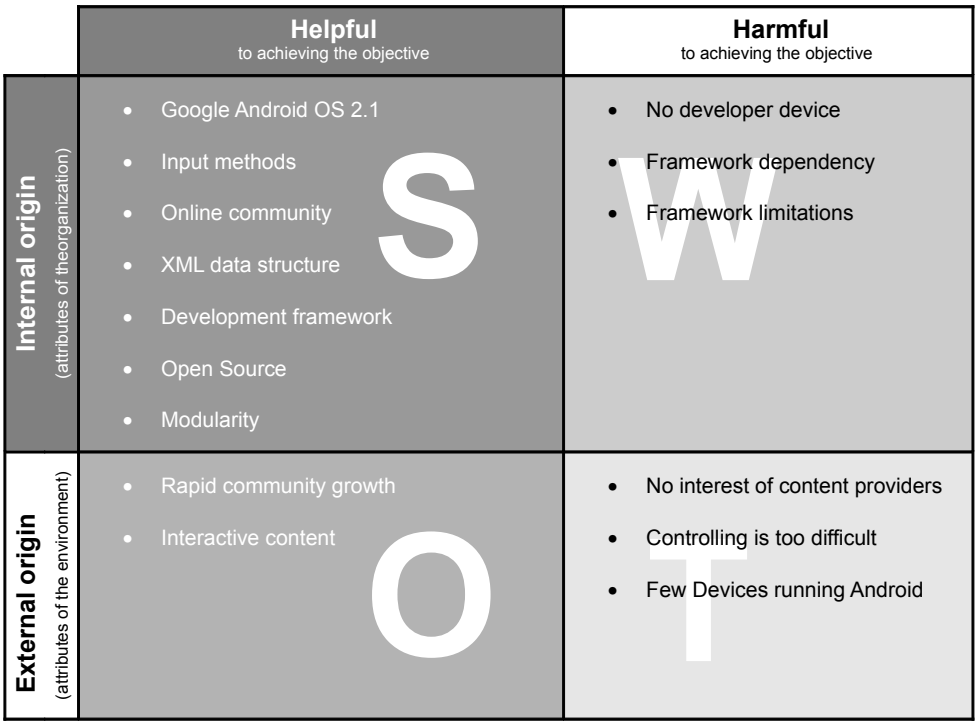

Figure 6.1: SWOT diagram for SOMA

We use a Strengths, Weaknesses, Opportunities, and Threats (SWOT) diagram to analyse SOMA's market perspectives. SWOT is a strategic planning method which is used to specify the objective of a project and identify internal as well as external factors, which have influence on achieving it. The properties of a SWOT diagram are defined as follows [13]:

- ***S**trengths: attributes of the person or company that are helpful to achieving the objective(s).*
- ***W**eaknesses: attributes of the person or company that are harmful to achieving the objective(s).*
- ***O**pportunities: external conditions that are helpful to achieving the objective(s).*
- ***T**hreats: external conditions which could do damage to the objective(s).*

The diagram is shown in Figure 6.1 and will be described in the following paragraphs. We decided on the main strengths of SOMA, which are the underlying state-of-the-art SDK, the

usage of almost unlimited input methods as well as the access to online communities. Regarding further development and content supply, the XML data structure eases content supply for providers and the development framework together with the open source nature of the project and the modularity are definitely strengths of our approach. But there also exist some weaknesses like the dependency to and the limitations of our implemented framework. The lack of a testing device makes evaluation difficult, but we could circumvent this problem by installing the Android OS to a variety of netbooks. We see many opportunities in the power of community growth with social networks and the integration of interactive content. Still some serious threats exist like the interest of content providers which may need tools for conversation of existing e-learning content or an easy to use editor. Some users may have difficulties with controlling the application because they are not used to touch or movement sensitive controls. One of the problems we don't have any influence on is the limited number of available Android powered devices, but we are convinced that this is going to change in the near future.

6.1.1 Strengths

6.1.1.1 Google Android OS 2.1

We develop SOMA and the SOMA framework with the latest Google Android SDK version 2.1 also known as Android Eclair. This way we ensure compatibility with state-of-the-art hardware and newest mobile devices. We assume Google's Android being the main competitor for iPhone and Symbian powered devices, continuing to claim the mobile market sector. However, we try to use no new features to enable compatibility with previous versions of the Android OS.

6.1.1.2 Input methods

Using the SOMA framework to build learning applications on mobile devices offers the possibility to use any hardware supported input method. Because of the modularity and the plugin runtime environment, SOMA's input methods can be extended with any functionality provided by the Android SDK. Still developers are encouraged to use the SOMA framework where possible to circumvent the direct Android SDK dependency. Imaginable usage scenarios include the usage of an accelerometer, camera or touchscreen which are described in Section 5.7.

6.1.1.3 Online community

The integration into Facebook with a custom Facebook application will enable users to exchange scores and compete with each other using one of the biggest social networks. We believe this will not only increase learners' motivation, but also help the SOMA community to grow quickly.

6.1.1.4 XML data structure

Using XML as underlying data structure needs less effort for both maintainance and further development. In addition, it also reduces the immediate need for an administration interface. Content suppliers can easily contribute by editing XML files.

6.1.1.5 Development framework

Building a development framework should ease the access to Android SDK features for developers and therefore help focusing on content presentation. It also reduces implementation effort and enables shorter time-to-market periods.

6.1.1.6 Open Source

SOMA and all its components are open source and everybody is welcome to help extending the framework. We think that developers will at least reuse parts of our framework and hopefully contribute in further development.

6.1.1.7 Modularity

Due to the modular build of SOMA, it is possible to develop different modules simultaneously without effecting the main application. This also reduces complexity and effort for further development.

6.1.2 Weaknesses

6.1.2.1 No developer device

The lack of a developer device reduces testing to the emulator provided by the Android SDK. While most of the features of a real Android device can be emulated some are not easy to reproduce. An example is the accelerometer for which some workarounds exist, for example using the emulator's window position and converting it to accelerometer sensor values. However this is still under development. This problem also makes evaluation rather difficult.

6.1.2.2 Framework dependency

While the SOMA framework makes access to important features of the Android SDK much easier it is another dependency for the developer. This is no real weakness, but has to be mentioned for completeness.

6.1.2.3 Framework limitations

Similar to the dependency mentioned before the limitation of the SOMA framework is no real weakness. Of course not the whole functionality of the Android SDK is wrapped within the SOMA framework, because this would remove most of its advantages.

6.1.3 Opportunities

6.1.3.1 Rapid community growth

We want to use the viral effects of social networks to create a constantly growing community, as described by Domingos [19]. We want to achieve this with a Facebook application which allows users to publish their scores online.

6.1.3.2 Interactive content

The Android SDK supports a wide range of multimedia formats, which we can also use within SOMA. This leads to seamless integration of popular video, image, and audio into individual courses. The full list of available media formats is shown in Figure 5.1. Beside that it is also possible to use the sensors provided by the mobile device like an acceleration sensor or a camera.

6.1.4 Threats

6.1.4.1 No interest of content providers

Content providers may not be interested in SOMA because of the lack of a graphical editor or the threat mentioned in Section 6.1.4.3. If they decide to use SOMA, they should adapt their content to take advantage of SOMA's features. Of course this is not obligatory, but could frighten someone off using our application.

6.1.4.2 Controlling is too difficult for users

Although new input concepts should improve usability it is not guaranteed that the users are used to them. Within our case study we encountered many persons which were overstrained with the controls.

6.1.4.3 Few Android Devices

Currently there are about 35 Smartphones, 4 Tablets, and 3 E-Reader Devices on the market which are running the Android operating system according to [9]. A detailed listing is given in Section 5.2.

After the SWOT analysis we provide an overview of the survey which has also been conducted before we started with the implementation of our prototype.

6.2 Survey

As mentioned already, we used literature research as well as informative talks with project managers of project mGBL and mobilefive as preparation for the implementation of the SOMA framework. With respect to the development of the prototype version of SOMA, the main aim of this research work was to gather information about advantages and drawbacks of existing e-learning solutions and about users' demands on mobile applications in general and e-learning environments in particular.

In addition to this basic research work, we conducted a survey in order to get to know details about the typical usage of mobile devices among children and teenagers, and about their experience with e-learning environments. For this survey, we created a questionnaire consisting of 14 questions which was then published on the Internet.

6.2.1 Realisation of the survey

For publishing the survey, the Kwik Surveys service was used, which is available at `http://www.kwiksurveys.com`. This service allows an easy web-based publication of surveys. Questionnaires consisting of several types of questions, including single and multiple choice questions, open questions, but also combinations of both types, can be arranged through a simple web-based user interface. These questionnaires are displayed on a web page that allows users to fill in the question directly in the web browser. Each questionnaire can be accessed by loading the address of its associated web page.

The decision of using this web-based service for publishing our survey was based on the following reasons:

- Convenience for the respondents: Users could fill in the questionnaire using a web page and submit the answers by simply clicking a button. When using traditional methods of distributing such a questionnaire it would have been necessary to print out the forms, fill it out manually and hand it in personally or send it back via e-mail.

- Easy invitation of respondents: Since the survey could be accessed through the address of a web page, invitations to attend the survey were sent simply per e-mail, including a hyperlink to this page. There was no need for respondents to answer this email, but they could forward it to invite their contacts to also answer the questionnaire.

- Higher number of responses: When using traditional ways of inviting respondents and distributing the questionnaire, less people may have been convinced to attend the survey. Due to the convenient way of answering the questionnaire as well as the easy publication of a large number of invitations, the number of responses was high.

- Higher number of correctly filled in responses: Traditional printed questionnaires allow respondents to answer questions in other ways than originally intended, making it difficult to evaluate the responses. Using a web-based form, which can be filled in by users limits these possibilities, thus increasing the number of correctly filled in responses.
- Easier evaluation: For each questionnaire published using the Kwik Surveys service, a page showing a summary of all results can be displayed. The results can then be downloaded and used as basis for evaluation.

The survey was primarily designed for children and teenagers, since this age group was the target audience of our case study. Therefore, most invitations to attend the survey were sent to contacts in this age group. It is important to mention that the survey was not intended as preparation for the case study - the survey was conducted before implementing the SOMA prototype, while the case study was conducted after finishing the implementation in order to test the prototype. Therefore, not all participants of the case study also filled in the questionnaire, and vice versa.

6.2.2 Content of the questionnaire

The exact contents of the questionnaire are shown in Appendix B. The questionnaire is divided into three groups of questions: First, some information about the respondent is requested. The second group of questions aims at e-learning environments and the respondent's experience with such systems, focusing on solutions for mobile devices. The last group of question gathers information about the typical usage of mobile devices as well as the use of social networks among our target group. This section presents the questions in detail, with regards to these three groups of content.

1. The first two questions collect personal information about the respondent in order to provide an overview of which persons attended the survey. The respondent's age is requested because the target audience of the SOMA prototype and of the sample course developed as part of this thesis is the age group of children and teenagers. Therefore, answers given by respondents among this age group are the most interesting ones. In addition, the type of education is requested to find out if there is a relation between certain schools and the use of e-learning environments.

2. This group of questions concentrates on e-learning environments and the respondents' experience with such systems. The answers should provide an overview of which e-learning solutions the respondents have already used and which of those are most regularly used, for example in school. In these questions a distinction is made between e-learning environments in general and e-learning systems for mobile devices in particular.

   In addition, one question asks for the expectations from and requirements of mobile e-learning solutions. In this case, several options that the SOMA framework especially concentrates on were predefined. Respondents could select multiple of those predefined options, but also enter individual answers. This question may be interesting for further

enhancements of the SOMA framework as well as for the development of SOMA plugins, since the answers show which features are most important for the users.

3. This part starts with two questions concerning social networks: The users were asked for social network sites they use regularly, once in general and once with special focus on the access to those sites from mobile devices. On the one hand, these questions should provide information about how many users are members of social networks and use them regularly, because users that don't use such network will not take advantage of the community features of the SOMA framework. On the other hand, the answers of these two questions were taken into account in our decision which social network to integrate into the SOMA framework.

   The next two questions ask for the brand of the respondent's mobile phone and the operating system it is running. One the one hand, this is interesting to find out how widespread the use of Android devices is among our target group. On the other hand, the aim of these two questions was to find out which operating systems are most commonly used besides Android.

   Finally, a few additional questions gather information about the typical usage of mobile phones among our target group. This includes general information about which features of current mobile phones are commonly used, followed by two questions focusing on the use of mobile Internet and third party applications on mobile phones. We were especially interested in the last two aspects, since SOMA is such a third party application that needs to be installed by the user and that regularly needs to access the Internet for downloading courses as well as plugins.

6.2.3 Results

We received a total number of 72 responses to our survey. Due to the publication as a web page that prohibited submitting answers, which are not formatted correctly, there were no incomplete responses and all respondents filled in the questionnaire correctly.

This section summarizes the most important findings of the evaluation of the questionnaire. This summary is divided into the three groups of questions defined above.

1. Not all respondents fit exactly in our target group of teenagers, however most of the responses were submitted by pupils and students in the age of 12 to 25. No connection between the type of school and the use of e-learning environments could be identified, for such an exploration a larger number of responses and some kind of predefined classification of schools instead of an open question for the type of school would be needed.

2. The second group of questions showed that approximately two-thirds of the respondents have already worked with e-learning solutions. In almost all cases, the product mentioned was Moodle which strengthened our decision of reviewing the Moodle environment as part of our state-of-the-art research work although it is not a mobile solution. Almost no

responses were given to mobile e-learning environments, which leads to the conclusion that such systems are still not widely known and used.

The question for the most important requirements of mobile e-learning solutions showed some interesting results: According to the respondents, the most important aspects are quality and adequate amount of e-learning content as well as handling and usability. The features that were classified as least important are entertainment (e.g., through small games) and the integration into social networks which was also mentioned as result of the case study.

3. Most of the respondents are members of at least one social network site, and nearly half of them own a Facebook account which they use regularly. This was one of the reasons, besides the ones mentioned in Section 3.2.2, for relying on the Facebook network instead of establishing a new community or using other social networks. Apparently most users still do not access social network sites from mobile devices, but those who do already also mentioned Facebook as the most important network.

   Unfortunately, many respondents were not able to identify the operating system their mobile phone uses. However, the answers that were given show that iPhone OS, Symbian and Microsoft Windows Mobile are still more widely used than Android.

   Finally, the questions concerning mobile phone usage showed some promising results: Approximately one-third of the respondents already access the Internet from their mobile devices regularly, which is a larger number than we would have expected. About one quarter of the respondents use third party software on their mobile phones that needs to be installed by the user.

After we successfully finished the implementation of our prototype we conducted a case study, which is presented in the following section along with the findings retrieved.

6.3 Case study

For the verification of the acceptance of our application among our target group, we conducted a case study as part of the SOMA project. This evaluation was carried out in direct cooperation with the Youth Red Cross Klosterneuburg regarding requirements, content, and final examination. One typical first aid class including 12 students in the age of 10 to 18 have agreed to participate in our case study. We accompanied those students during their preparation for the province camp contest 2010.

In order to show the practicable appliance of SOMA we manually transferred existing first aid learning content into a SOMA course as part of this thesis. The material used can be found in appendix A and consists of 98 multiple choice, single choice, open and associative questions which are intended for preparation for a province wide contest attended by all Youth Red Cross groups. The original document was provided in the Adobe PDF format and the manual trans-

formation was straight forward. We did not encounter any problems except for some missing plugins such as open and associative questions which can be easily added in the future.

The attending groups can get rewards for their performance in a theoretical and a practical part. Because the implementation of plugins other than multiple choice, single choice, and regular expressions would have gone beyond the scope of this thesis we concentrated on the theoretical part of the exam.

Usability and user interface testing have been the central concerns of our analysis. The main users of our example course were children in the age of 10 to 18, which have basic knowledge of first aid. We split the participating students in two groups, one using SOMA and the other one using classical learning methods. After two weeks of preparation an exam had to be carried out which was also available as a SOMA course, besides the traditional printed version. The students were asked to complete a questionnaire about usability and design issues, which can be found in Appendix C. We describe the content of the questionnaire in the following section and evaluate the results in Section 6.3.2.

6.3.1 Content of the questionnaire

The questionnaire, which has been developed in order to support evaluation of the case study, consists of two parts. The first part is basically a rating of the SOMA application regarding usability of the application whereas the second part deals with experiences and feature requests.

Similar to the survey introduced in Section 6.2, the first two questions collect personal data including age and attended school. This information is needed to classify the user according to our target group as already specified for the survey.

The rating concentrates on the respondents' experience with SOMA. The answers should provide an overview on how satisfied the user was with the handling of the SOMA application. All categories can be rated according to school grades reaching from one (best) to five (worst). The first category represents overall handling, followed by intuitivity which showed that usage of the application was straight forward. Besides the handling we included two ratings about design of the application which included displaying of text and multimedia elements. Because we decided on using Java Reflection, which is known for its performance issues, we gave respondents the possibility to rate the performance of the SOMA application. A mobile learning environment should be ready to use at any time, regardless of the situation, therefore we introduced a category for the integration into the mobile operating system. According to our research on learning styles and the design of mobile learning applications, the feedback given to the user is essential for effective learning. The respondent can rate the feedback of the SOMA application in a distinct category. Finally we are also interested in the possibilities of practical appliance and therefore we included two categories to measure them. One of them is the respondents opinion about practical usage and the other one is the quality of our sample first aid course. The respondent may also add critics or suggestions in a separate field.

The second part starts with a question about how the respondent used SOMA for exam preparation and if he or she can imagine to use it for further learning. Interaction with social networks was one of our central ideas when developing the SOMA project. In order to measure

the acceptance of this approach we included three questions in this questionnaire. The first one is about whom the respondent would provide his scores to and he or she would publish the actual score on his or her Facebook profile. Besides that we tried to measure the competition aspects with a question which asks the respondent if he or she would take a course because someone published his or her score online.

Further development of the SOMA framework is a goal of our project and therefore we attached two questions about preferable features, which includes the implementation for other mobile platforms and novel input methods.

In addition to this questionnaire we also evaluated students' learning progress and the actual time spent on learning content within the SOMA application. After the exam we compared the results of the students who used SOMA to learn with those who did not. In the following section we present the outcome of our case study and describe each result in detail.

6.3.2 Results

The results of our case study introduced some new points of view and provided a lot of interesting feedback to our work. We structured the concrete findings in the following listing:

- First we will describe the usability issues which have been criticised by the users of our first aid course. The most serious problem was the fact that the size of text displayed on the screen was too small. This was a major drawback to overall usability because it was hard to differ between answers when using a touchscreen. It was even worse because we decided on removing the radio boxes of multiple choice questions in order to show the advanced possibilities of customisation. Instead of the radio boxes we used enumeration first which was more confusing than helpful to the students. The text size problem was not limited to multiple choice questionnaires, but also existed within the main window of the SOMA application. Another criticised aspect regarding the text was the usage of grey font colour instead of black. If the user reduced the backlight of the mobile device display, content was hard to read.

- The performance issue described in Section 5.5.1.1 has also been mentioned, in particular by those users who worked on older devices with less processing power or Android version 1.6. This was a potential drawback which we accepted when deciding on the use of Java Reflection for the plugin environment.

- Besides the mentioned issues, the students were enthusiastic in using a modern smartphone for learning instead of a book, paper and a pencil. We are convinced that novel input and learning methods can increase learning motivation of students. Unfortunately the implementation of plugins, which are using these methods would have gone beyond the scope of this thesis and so we could not verify our assumptions.

- The teachers involved in the case study were satisfied with the instant feedback, both for the students and themselves but requested a feature for seeing what students are actually doing on their mobile devices. According to the teachers' opinions, there should be some

possibility of controlling a students device if he or she misuses it during the lesson. We noticed that without such a feature the probability of getting distracted is higher, because students are more likely to play around with their mobile phones. Besides that, the teachers liked the instant analysis of students' questionnaires, which saved time that is usually needed for correction and enabled instant reactions to students' needs.

- Students also liked the instant feedback given by the SOMA application and many have been worried about their bad results. The reason for this is that students are apparently more likely to give answers without thinking about them when taking electronic questionnaires.

- Another interesting finding from the results of the case study is the correlation between the scores of students using SOMA for learning and those who did not. We can conclude that there is no difference between using SOMA and traditional learning methods. Those who had never been particularly good students did not perform mentionable better when using SOMA for preparation. Also good students did not perform mentionable better or worse.

- Many of the attending students expected more possibilities of interaction with the mobile device. Some of them were even disappointed about answering the same multiple choice questionnaires on a electronic device. All students interviewed are looking forward to new ways of controlling and interacting with the device to get most out of the SOMA learning experience. The most promising suggestions mentioned by users have been described in Section 5.7.

- According to our point of view, the most interesting result from our case study is the fact that our approach about integrating social networks seamless into the SOMA application was unsuccessful. We wanted to improve the learning motivation of students and introduce a competition to the learning progress. Unfortunately none of the participants in our case study chose to publish their score online. We asked for the reason in our questionnaire and for 90% the response was because of bad performance. We are not satisfied with this result, but without a higher number of attendees it is impossible to retrieve better results.

In the final chapter of our thesis we provide a conclusion about all topics discussed so far and give an outlook to future perspectives.

CHAPTER 7

Conclusions

7.1 Summary

In this thesis, a novel approach of creating e-learning courses to be used on mobile devices was presented. We reviewed and discussed the most interesting literature regarding e-learning. In particular, we focused on the topics of learning styles, learning using mobile devices, game-based learning, and the use of social networks for increasing learners' motivation.

Some existing e-learning environments were presented, focusing on solutions that were developed especially for mobile devices, showing their advantages as well as drawbacks. These reviews were based on the creation of morphological matrices and gave us an in-depth insight into state-of-the-art-solutions. In addition, we learned important aspects about the design and shortcomings of existing projects when talking to the project managers responsible.

Besides that, a survey was conducted in order to learn details about experiences and expectations of potential users. The responses to the questionnaire published in this survey helped us to understand the usage of mobile phones among our target group. In addition, they helped us to identify the most important features that have to be available in a successful mobile learning environment.

A prototypical version of the SOMA framework was developed as part of this thesis, including several sample plugins and a sample e-learning course. A case study was conducted to test the prototype of the SOMA framework, using this sample course and the sample plugins.

We can conclude that most of the goals defined at the beginning of this thesis have been reached successfully. Besides the predefined goals, many new features have been added. One of these features is the security component which has become a very central aspect of the SOMA framework. Using asymmetric encryption for content protection is a unique approach in mobile learning environments. We are convinced that this approach can increase content security in many fields of application and are looking forward to see similar implementations for other solutions.

After implementation of the first prototype, we decided on using a different learning style model than stated first. We found out that Sabine Graf's approach was not designed for mobile applications and is not sufficient for our purposes. With the Dunn and Dunn learning style model we extended the user model with various additional properties, which enables better responses and more individual design of courses.

We further have to conclude that SOMA was not designed for multiple choice or single choice questionnaires. This can also be identified on the basis of the results of our case study. Students criticised design, handling, and the lack of intuitivity of the current prototype of the SOMA application. It is desirable to implement more interactive plugins which make use of the novel input methods described within this thesis.

The same applies to the game-based learning aspects of SOMA. The SOMA application itself provides only a framework for creating game-based e-learning courses, however the features offered by this framework must be used by plugin developers and course suppliers in order to create interesting, multimedia-based, playful courses.

The plugin environment has been developed using the Java Reflection technology as planned, but is one of the most critical aspects of our prototype. Java Reflection is well known for its performance issues, which could be a bottleneck on mobile devices with limited processing

power. It was sufficient for our sample plugins and the course developed for our case study, but may reach its limit when running more complex plugins.

Finally we have determined the following limitations which were disadvantageous for our proceedings.

7.2 Limitations

A limitation of this thesis is the limited number of test persons who participated in our case study. All participants were students from the same first aid class of the Youth Red Cross Klosterneuburg. Although they are all among our target group and therefore suitable test persons, they all have the same background knowledge. It would be interesting to interview more students, both inside and outside of our target group, in order to retrieve more representative results.

For this reason, also more Android devices would be needed for providing each participant with a testing device. During the execution of the case study, mobile phones had to be exchanged among students because of the lack of a sufficient number of testing devices.

Besides that we are still looking forward to future fields of application and adding more advanced features to the SOMA framework. Finally we describe two interesting features intended for future work in the last section of this thesis.

7.3 Future work

As part of this thesis, a prototype of the SOMA application was developed to be used in the case study in order to find out how novel e-learning techniques can enhance the learning process. However, for publishing a final version of SOMA that can be efficiently used in real-life learning environments, several of the software modules the SOMA application contains need to be adapted or refined. This section lists some of these modules and explains which features could be improved.

7.3.1 Graphical content editor

In order to make SOMA even more interesting for content providers, a graphical content editor should be implemented. We created an illustration of such an editor which is shown in Figure 7.1. It should provide the most important aspects of creating a course and result in a compressed package containing an XML course file and any multimedia elements, which can be processed by the SOMA server. The editor should be capable of loading existing and creating new courses for the SOMA application. This functionality will be accessible through the main file menu on the top, together with an option to create a new exercise at any time a course is loaded. The

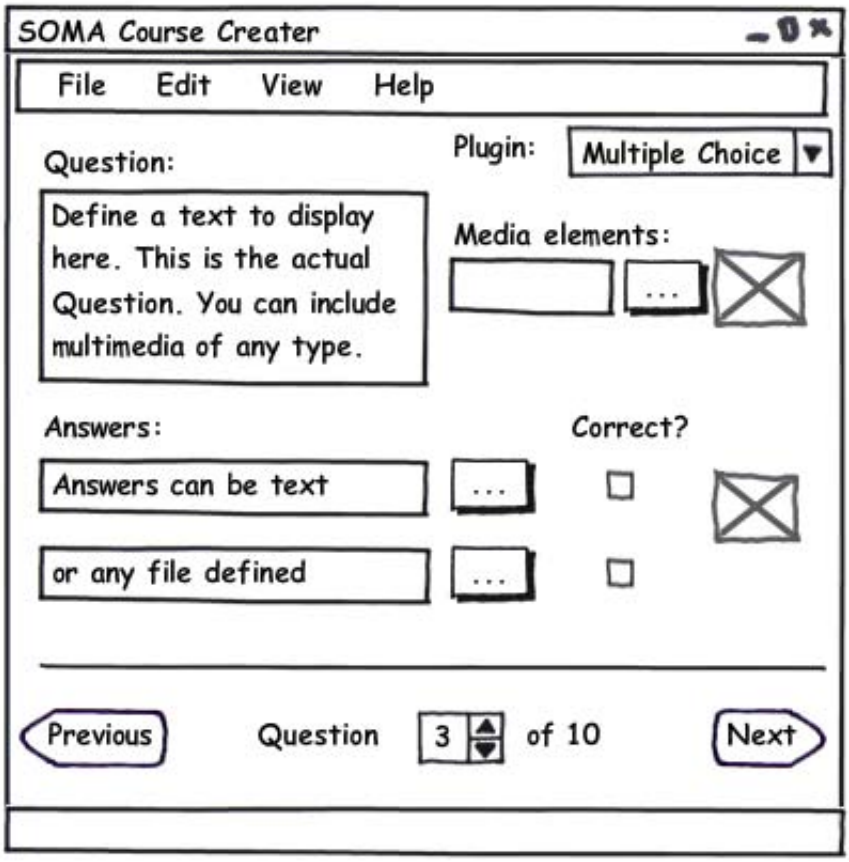

Figure 7.1: A basic mockup of a course editor

edit menu should provide advanced editing features like moving questions to specific positions or formating text. Also the configuration values will be accessible through this menu. The view menu could provide different views, for example when plugins are used which cannot be displayed in the default view. It is desirable to provide configuration of each view in a very flexible way to support all imaginable input methods. An example would be the accelerometer input which would be rather uncomfortable with the proposed default view because it would mean to write numbers into most of the fields shown.

The default view enables the selection of a plugin used to process the exercise. The list of available plugins should be automatically downloaded from the SOMA server to ensure compatibility with all clients. When a plugin is selected, a different view may be created automatically by the plugin developer. We believe most of the exercises will contain a textual question or any media like pictures or videos to introduce the student to his objective within the current exercise. If a media element is added, the editor should create a little preview of the file or just display the icon if it is not able to render the data correctly. Whenever an element is selected, a new file choose dialog should be added automatically to enable multiple media elements in a single question statement. Most of the usage scenarios we thought of needed multiple answers in any

way, either to provide multiple choices with incorrect answers or multiple solutions to a single problem. Therefore it is possible to define an unlimited amount of answers and choose whether they are correct or not. This feature should work like the media elements mentioned before, it should show a preview if possible and add new file chooser dialogs when needed. At the bottom of the editor a navigator offers the possibility to switch between questions. The user can either navigate through the set of questions using the previous and next buttons or directly go to a specific question by entering its number in the current set.

7.3.2 Automatic detection of learning styles

In Section 3.3 we gave an introduction to learning styles and their importance for the design of and interaction with e-learning applications. In the current version of the SOMA framework we have no possibility to detect the learning style of a user. If we want to know something about the preferences of a user we have to ask him to fill in a questionnaire and classify the results afterwards. This is both stressful and vulnerable to errors because the student taking the questionnaire could get bored and fake his answers.

A much better solution would be the automatic detection of a user's learning style by monitoring his or her behaviour and analyzing his or her solutions to provided exercises. We will use Sabine Graf's approach for this process and extend it to support the new input methods available on smartphones. For example we would like to integrate the captured accelerometer values to determine the emotional state of a learner. Within our case study we figured out that students who are bored of the content tend to shake their mobile phone while interacting with the application. We believe this can be used to determine the learning style of a user. However, further research work and larger case studies would be needed to proof this concept.

After implementing automatic detection of learning styles, the next step would be the integration of adaptive courses. Because students do not always stick to the same learning style, but switch between several and the content provider does not know the preferred learning style of a user when creating a course, it would be reasonable to enable a course to support multiple learning styles. The course would start with default contents and can adapt to the user needs according to his or her learning style while working on. At best the user would not even know about the adaptation that runs in the background.

Up to our knowledge there is currently no adaptive mobile learning environment available. This would make it a very interesting and novel project in the sector of mobile learning applications. We already provided the basic structure needed for building an adaptive system to enable the implementation in future projects. Some changes remain to be applied to the current architecture, the client as well as the server application and the content structure. Because the content structure is based on XML this changes can be achieved easily. Most extensions have to be done in the client application, where the detection has to be implemented.

APPENDIX A

Case study sample course

```
- <course guid="EHFragenkatalog2010" title="Erste Hilfe Fragenkatalog 2010"
    description="Fragenkatalog zur Vorbereitung für die theoretische Prüfung des
    JRK Landeslager 2010 (Multiple Choice)">
  - <chapter id="1" name="Kapitel 1">
    - <topic id="1" plugin="soma.PLUGIN.MultipleChoice">
        <Info text="Vorbereitung für die theoretische Prüfung am
          Landeslager 2010" />
        <Info text="Hinweis: Es können immer mehrere/keine Antworten
          richtig sein!" />
        <Pause duration="3000" />
      </topic>
    - <exercise id="1" plugin="soma.PLUGIN.MultipleChoice">
        <Question text="Wie heißen die Grundsätze des Roten Kreuzes?" />
        <Answer text="Neutralität" correct="true" />
        <Answer text="Unabhängigkeit" correct="true" />
        <Answer text="Mitgefühl" correct="false" />
        <Answer text="Freiwilligkeit" correct="true" />
        <Answer text="Menschlichkeit" correct="true" />
        <Answer text="Demokratie" correct="false" />
        <Answer text="Universalität" correct="true" />
        <Answer text="Tapferkeit" correct="false" />
        <Answer text="Einheit" correct="true" />
        <Answer text="Opferbereitschaft" correct="false" />
        <Answer text="Unparteilichkeit" correct="true" />
      </exercise>
    - <exercise id="2" plugin="soma.PLUGIN.MultipleChoice">
        <Question text="Der Leistungsbeitrag des Jugendrotkreuzes wird
          verwendet für:" />
        <Answer text="Therapielager" correct="true" />
        <Answer text="Ankauf von Grundstücken" correct="false" />
        <Answer text="Erste Hilfe- und Schwimmkurse" correct="true" />
        <Answer text="Kurse für ELKI sowie Betreuung und Pflege in der
          Familie" correct="true" />
        <Answer text="Ausflugsfahrten" correct="false" />
      </exercise>
    - <exercise id="3" plugin="soma.PLUGIN.MultipleChoice">
        <Question text="Wer war der Gründer des Roten Kreuzes?" />
        <Answer text="Henry Dunant" correct="true" />
        <Answer text="Albert Schweitzer" correct="false" />
        <Answer text="Theodor Körner" correct="false" />
        <Answer text="Florence Nightingale" correct="false" />
      </exercise>
    - <exercise id="4" plugin="soma.PLUGIN.MultipleChoice">
        <Question text="Welche beiden Maßnahmen sind in Notfällen als erste
          durchzuführen?" />
        <Answer text="Notruf" correct="true" />
        <Answer text="Hilferuf" correct="false" />
        <Answer text="Unfallursache feststellen" correct="false" />
        <Answer text="Lebensrettende Sofortmaßnahmen" correct="true" />
        <Answer text="Polizei verständigen" correct="false" />
      </exercise>
    - <exercise id="5" plugin="soma.PLUGIN.MultipleChoice">
        <Question text="Welche Maßnahmen gehören zu den Pflichten von
          Ersthelfer/innen?" />
        <Answer text="Unfallursache feststellen" correct="false" />
        <Answer text="Zumutbare Erste-Hilfe-Leistung (körperliche und
```

```
    geistige Fähigkeit)" correct="true" />
      <Answer text="Arzt oder Rettung verständigen" correct="true" />
      <Answer text="Verletzte/n nicht alleine lassen und Trost zusprechen"
        correct="true" />
      <Answer text="Medikamente verabreichen" correct="false" />
      <Answer text="Verletzten/r zu essen, trinken oder rauchen gebe"
        correct="false" />
    </exercise>
  - <exercise id="6" plugin="soma.PLUGIN.MultipleChoice">
      <Question text="Was versteht man unter lebensrettenden
        Sofortmaßnahmen?" />
      <Answer text="Alle Maßnahmen, die Verletzte vor zusätzlichen
        Schädigungen bewahren" correct="false" />
      <Answer text="Alle Hilfeleistungen, die unmittelbar der Erhaltung des
        Lebens dienen" correct="true" />
      <Answer text="Alle Maßnahmen, die sofort am Unfallort ergriffen
        werden" correct="false" />
      <Answer text="Alle Maßnahmen, die sofort am Unfallort ergriffen
        werden, damit schnell die Rettung verständigt werden kann"
        correct="false" />
    </exercise>
  - <exercise id="7" plugin="soma.PLUGIN.MultipleChoice">
      <Question text="Die Glieder der Rettungskette heißen:" />
      <Answer text="Hilferuf" correct="false" />
      <Answer text="Rettungsdienst" correct="true" />
      <Answer text="Ärztliche Versorgung" correct="false" />
      <Answer text="Lebensrettende Sofortmaßnahmen" correct="true" />
      <Answer text="Sanitätshilfe" correct="false" />
      <Answer text="Notruf" correct="true" />
      <Answer text="Weitere Erste Hilfe" correct="true" />
      <Answer text="Transport" correct="false" />
      <Answer text="Weitere Versorgung" correct="true" />
    </exercise>
  - <exercise id="8" plugin="soma.PLUGIN.MultipleChoice">
      <Question text="Der Hilferuf „Hilfe! Kann mir jemand helfen?“ soll zu
        welchem Zeitpunkt erfolgen?" />
      <Answer text="Wenn man zum/r Verletzten kommt" correct="false" />
      <Answer text="Wenn keine Reaktion auf Ansprechen, Berühren und
        Schmerzreiz festgestellt wird" correct="true" />
      <Answer text="Wenn ich daran denke" correct="false" />
      <Answer text="Wenn die Notfalldiagnose Atem-Kreislaufstillstand
        vorlieg" correct="false" />
    </exercise>
  - <exercise id="9" plugin="soma.PLUGIN.MultipleChoice">
      <Question text="Wann muss eine Unfallstelle abgesichert werden?" />
      <Answer text="Nur bei schlechter Sicht" correct="false" />
      <Answer text="Wenn Verletzte sich in einer Gefahrenzone befinden"
        correct="true" />
      <Answer text="Wenn dem/r Helfer/in Gefahr droht" correct="true" />
      <Answer text="Wenn noch Zeit bleibt" correct="false" />
    </exercise>
  - <exercise id="10" plugin="soma.PLUGIN.MultipleChoice">
      <Question text="In welchem Abstand vom Unfallgeschehen wird bei
        einem Verkehrsunfall das Warndreieck im Ortsgebiet (ggfs. in
        beiden Richtungen) aufgestellt?" />
      <Answer text="10 m" correct="false" />
      <Answer text="50 m" correct="true" />
```

```
    <Answer text="100 m" correct="false" />
  </exercise>
- <exercise id="11" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="In welchem Abstand vom Unfallgeschehen wird bei
      einem Verkehrsunfall das Warndreieck auf einer Landstraße (ggfs.
      in beiden Richtungen) aufgestellt?" />
    <Answer text="50 m" correct="false" />
    <Answer text="100 m" correct="false" />
    <Answer text="150 m" correct="true" />
  </exercise>
- <exercise id="12" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="In welchem Abstand vom Unfallgeschehen wird bei
      einem Verkehrsunfall das Warndreieck auf der Autobahn
      aufgestellt?" />
    <Answer text="100 m" correct="false" />
    <Answer text="250 m" correct="true" />
    <Answer text="500 m" correct="false" />
  </exercise>
- <exercise id="13" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie verhältst du dich bei einem Unfall mit
      gefährlichen Gütern?" />
    <Answer text="Annäherung höchstens auf 30 m, Absicherung mind.
      60 m" correct="false" />
    <Answer text="Gefahrgut einsammeln, sodass keine weiteren
      Menschen damit in Kontakt kommen" correct="false" />
    <Answer text="Mindestabstand von 60 m einhalten, Annäherung nur
      in der Windrichtung, absichern mind. 100 – 200 m, Notruf
      durchführen, dabei die spezielle Kennzahl angeben"
      correct="true" />
    <Answer text="Zündquellen ausschalten bzw. vermeiden und
      ausweichen, wenn das Gefahrgut durch Wind vertragen wird."
      correct="true" />
  </exercise>
- <exercise id="14" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Farben haben die Warntafeln bei
      Gefahrguttransporten?" />
    <Answer text="Blau mit oranger Umrandung" correct="false" />
    <Answer text="Orange mit schwarzer Umrandung" correct="true" />
    <Answer text="Rot mit schwarzer Umrandung" correct="false" />
    <Answer text="Gelb mit grüner Umrandung" correct="false" />
  </exercise>
- <exercise id="15" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Bei einem Strommast hängt eine Starkstromleitung
      herab. Daneben liegt eine reglose Person. Du..." />
    <Answer text="versuchst sofort zu bergen" correct="false" />
    <Answer text="versuchst die Bergung nur mit trockenen Schuhen"
      correct="false" />
    <Answer text="verständigst über die Polizei (Notruf 133) das
      zuständige Stromversorgungsunternehmen" correct="true" />
    <Answer text="gehst nicht zum/r Reglosen und achtest auf den
      Eigenschutz" correct="true" />
  </exercise>
- <exercise id="16" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Dein/e Freund/in ist in den Stromkreis geraten. Da
      du das Gebäude nicht kennst, kannst du den Strom nicht
      abschalten. Welche Vorsichtsmaßnahmen triffst du vor der
      Bergung?" />
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    <Answer text="Notruf absetzen" correct="true" />
    <Answer text="Hände und Füße isolieren" correct="true" />
    <Answer text="Verletzte/n mit einer Hand an der trockenen Kleidung
      fassen und wegziehen" correct="true" />
    <Answer text="Verletzte/n an den Händen fassen und wegziehen"
      correct="false" />
  </exercise>
- <exercise id="17" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie verhältst du dich bei einem Brand? Du..." />
    <Answer text="suchst den Brandherd" correct="false" />
    <Answer text="befolgst die Anweisungen der Feuerwehr"
      correct="true" />
    <Answer text="lässt dich bei einer möglichen Bergung nicht vom
      Feuer einschließen" correct="true" />
    <Answer text="beachtest die Vergiftungsgefahr durch Rauch- und
      Giftgase" correct="false" />
  </exercise>
- <exercise id="18" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie verhältst du dich bei Gasunfällen?" />
    <Answer text="Kein offenes Licht und keine Taschenlampen
      verwenden" correct="true" />
    <Answer text="GAS - Regel beachten" correct="true" />
    <Answer text="Keine Betätigung elektrischer Anlagen (Schalter)"
      correct="true" />
    <Answer text="Mit einem Feuerzeug prüfen, ob Gas vorhanden ist"
      correct="false" />
  </exercise>
- <exercise id="19" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wo kommt Kohlendioxid vor? In..." />
    <Answer text="Stollen und Brunnenschächten" correct="true" />
    <Answer text="geschlossenen Garagen" correct="false" />
    <Answer text="Gärkellern (von Wein- und Mostkellereien)"
      correct="true" />
    <Answer text="Jauchegruben" correct="true" />
  </exercise>
- <exercise id="20" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie muss sich ein/e Ersthelfer/in verhalten, wenn
      eine Person ins Eis eingebrochen ist?" />
    <Answer text="Verunglückte/n bitten, beide Arme auf die Eisfläche zu
      legen und sich möglichst wenig zu bewegen" correct="true" />
    <Answer text="Verunglückte/n bitten, beide Arme auf die Eisfläche zu
      legen und sich möglichst viel zu bewegen, um nicht auszukühlen"
      correct="false" />
    <Answer text="Verunglückte/n bitten, beide Arme auf die Eisfläche zu
      legen und sich möglichst viel zu bewegen, um nicht unterzugehen"
      correct="false" />
    <Answer text="Notruf" correct="true" />
    <Answer text="Eine Sicherung ist nicht nötig, weil zuviel Gewicht
      nicht gut ist" correct="false" />
    <Answer text="Seilsicherung oder Sicherung durch zweite/n
      Helfer/in" correct="true" />
    <Answer text="Hilfsmittel verwenden (Bretter, Leiter, Stangen,...)"
      correct="true" />
    <Answer text="Tragfähigkeit des Eises prüfen" correct="true" />
    <Answer text="Bedenken, dass die Eisfläche bei der Bergung Helfer/in
      und Verunglückte/n tragen muss." correct="true" />
    <Answer text="Auf breiter Unterlage sich liegend dem/der
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Eingebrochenen nähern." correct="true" />
    <Answer text="Auf breiter Unterlage sich gehend dem/der
      Eingebrochenen nähern, um Gewicht zu sparen." correct="false" />
  </exercise>
- <exercise id="21" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie muss sich ein/e Ersthelfer/in bei einem
      Badeunfall verhalten?" />
    <Answer text="Bei Umklammerung entweder abtauchen oder sich mit
      Befreiungsgriffen lösen" correct="true" />
    <Answer text="Gefährlichkeit des Gewässers beachten (Untiefen,
      große Entfernung, starke Strömung, Wellengang,
      Uferbeschaffenheit,...)" correct="true" />
    <Answer text="Mit einem Hechtsprung ins Wasser springen"
      correct="false" />
    <Answer text="Rettungsring und Leine dem/der Ertrinkenden
      zuwerfen" correct="true" />
    <Answer text="Notruf" correct="true" />
  </exercise>
- <exercise id="22" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Warum muss bei einer verunfallten Person ohne
      Bewusstsein der Sturzhelm abgenommen werden?" />
    <Answer text="Zur besseren Lagerung" correct="false" />
    <Answer text="Zur Atemkontrolle" correct="true" />
    <Answer text="Zur besseren Fixierung des Kopfes" correct="false" />
    <Answer text="Um Erstickungsgefahr zu verhindern" correct="false" />
    <Answer text="Zum Erkennen von Gesichtsverletzungen"
      correct="false" />
  </exercise>
- <exercise id="23" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Warum soll ein/e Ersthelfer/in Einmalhandschuhe
      verwenden? Zum Schutz vor ..." />
    <Answer text="nassen Händen" correct="false" />
    <Answer text="Körpersekreten" correct="true" />
    <Answer text="kalten Händen" correct="false" />
    <Answer text="Hepatitis" correct="true" />
    <Answer text="Fingerabdrücken" correct="false" />
    <Answer text="HIV" correct="true" />
  </exercise>
- <exercise id="24" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie erfolgt die Kontrolle des Bewusstseins?" />
    <Answer text="Ansprechen" correct="true" />
    <Answer text="Kniereflex testen" correct="false" />
    <Answer text="Starken Schmerzreiz zufügen" correct="false" />
    <Answer text="Berühren" correct="true" />
    <Answer text="Augenlid anheben und Pupillenreflex kontrollieren"
      correct="false" />
    <Answer text="Schmerzreiz am Handrücken zufügen" correct="true" />
    <Answer text="Schütteln und rütteln" correct="false" />
  </exercise>
- <exercise id="25" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Ein Unfallopfer reagiert auf äußere Reize nicht
      situationsgerecht. Was sind die nächsten Schritte?" />
    <Answer text="Erfragen der möglichen Ursache dieses Zustandes"
      correct="false" />
    <Answer text="Suche nach Zusatzverletzungen" correct="false" />
    <Answer text="Hilferuf, Atemkontrolle" correct="true" />
    <Answer text="Sofort in die stabile Seitenlage bringen"
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  correct="false" />
  </exercise>
- <exercise id="26" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie kann man kontrollieren, ob normale Atmung
      vorhanden ist?" />
    <Answer text="Hören auf Ein- und Aus- Atemgeräusche"
      correct="true" />
    <Answer text="Schauen auf Brustkorbbewegungen" correct="true" />
    <Answer text="Ansprechen, berühren und einen leichten Schmerzreiz
      zufügen" correct="false" />
    <Answer text="Fühlen der Ausatemluft" correct="true" />
  </exercise>
- <exercise id="27" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was ist notwendig, um die Atemwege frei zu
      machen?" />
    <Answer text="Öffnen beengender Kleidungsstücke" correct="false" />
    <Answer text="Sofort Inspektion der Mundhöhle in vorgefundener
      Lage des Kopfes" correct="false" />
    <Answer text="Kopf nackenwärts überstrecken, damit die Zunge
      angehoben wird" correct="true" />
    <Answer text="Einblasen von Luft in den Mund oder die Nase"
      correct="false" />
    <Answer text="Wenn sich nach der ersten Beatmung der Brustkorb
      nicht bewegt hat, Mundhöhle inspizieren und gegebenenfalls
      ausräumen" correct="true" />
  </exercise>
- <exercise id="28" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Bei welchen Gegebenheiten spricht man von einer
      bewusstlosen Person?" />
    <Answer text="Bewusstsein fehlt, Atmung fehlt" correct="false" />
    <Answer text="Bewusstsein fehlt, normale Atmung erhalten"
      correct="true" />
    <Answer text="Atmung fehlt, Bewusstsein erhalten" correct="false" />
  </exercise>
- <exercise id="29" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Gefahren drohen einem/r auf dem Rücken
      liegenden Bewusstlosen?" />
    <Answer text="Ersticken durch Zurücksinken der Zunge"
      correct="true" />
    <Answer text="Rückenverletzungen" correct="false" />
    <Answer text="Unterkühlung" correct="false" />
    <Answer text="Ersticken durch Fremdkörper, Erbrochenes oder Blut"
      correct="true" />
    <Answer text="Epileptischer Anfall" correct="false" />
  </exercise>
- <exercise id="30" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="In welche Lage ist ein/e Bewusstlose/r zu
      bringen?" />
    <Answer text="Stabile Seitenlage zum Freihalten der Atemwege"
      correct="true" />
    <Answer text="Rückenlage mit überstrecktem Kopf zur Erleichterung
      der Atmung" correct="false" />
    <Answer text="Flache Rückenlage, damit die Person auf der Trage
      weniger Platz braucht" correct="false" />
    <Answer text="Flache Rückenlage mit erhöhten Beinen zur besseren
      Blutzirkulation" correct="false" />
  </exercise>
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- <exercise id="31" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Maßnahmen müssen nach der Lagerung der
      bewusstlosen Person noch durchgeführt werden?" />
    <Answer text="Alle 10 Minuten Atem- und Kreislaufzeichen
      kontrollieren" correct="false" />
    <Answer text="Schockbekämpfungsmaßnahmen wie Wärmeerhaltung,
      Frischluftzufuhr, usw." correct="true" />
    <Answer text="Nach jeweils einer Minute Atemkontrolle"
      correct="true" />
    <Answer text="Person zu tiefer und langsamer Atmung anregen"
      correct="false" />
  </exercise>
- <exercise id="32" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Woran erkennt man einen Atem-
      Kreislaufstillstand?" />
    <Answer text="Kalter Schweiß auf der Stirn" correct="false" />
    <Answer text="Blaue Lippen" correct="false" />
    <Answer text="Keine Atmung, aber Bewusstsein vorhanden"
      correct="false" />
    <Answer text="Kein Bewusstsein und keine normale Atmung
      feststellbar" correct="true" />
  </exercise>
- <exercise id="33" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Erste-Hilfe-Maßnahmen sind bei einem
      Menschen mit Atem-Kreislaufstillstand durchzuführen?" />
    <Answer text="Herzdruckmassage und Beatmung" correct="true" />
    <Answer text="Stabile Seitenlage" correct="false" />
    <Answer text="Frühdefibrillation" correct="true" />
    <Answer text="Notruf" correct="true" />
    <Answer text="Nur Beatmung" correct="false" />
  </exercise>
- <exercise id="34" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Worauf muss bei der Beatmung geachtet werden?" />
    <Answer text="Überstrecken des Kopfes nackenwärts"
      correct="true" />
    <Answer text="Farbe der Lippen" correct="false" />
    <Answer text="Heben und Senken des Brustkorbs" correct="true" />
    <Answer text="Alter der betroffenen Person" correct="false" />
    <Answer text="Freie Atemwege" correct="true" />
  </exercise>
- <exercise id="35" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie oft pro Minute soll die Herzdruckmassage beim
      Erwachsenen mindestens durchgeführt werden?" />
    <Answer text="80 Mal" correct="false" />
    <Answer text="100 Mal" correct="true" />
    <Answer text="160 Mal" correct="false" />
  </exercise>
- <exercise id="36" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Beschreibe die Technik der Herzdruckmassage beim
      Erwachsenen:" />
    <Answer text="Be- und Entlastungsphase sollen gleich lang sein,
      rhythmischer Druck" correct="true" />
    <Answer text="Möglichst kurze und kräftige Kompressionen zur
      Erzielung hoher Blutdruckwerte" correct="false" />
    <Answer text="Reglose/n auf eine harte flache Unterlage legen,
      Druckpunkt in der Mitte des Brustkorbes, Handballen auf das
      Brustbein auflegen" correct="true" />
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<Answer text="**Finger abspreizen, Brustbein ca. 4 – 5 cm eindrücken, Druck senkrecht von oben**" correct="**true**" />
</exercise>
- <exercise id="**37**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**In welchem Rhythmus erfolgen Herzdruckmassage und Beatmung?**" />
<Answer text="**5 Herzdruckmassagen, 1 Beatmung**" correct="**false**" />
<Answer text="**5 Beatmungen,1 Herzdruckmassage**" correct="**false**" />
<Answer text="**30 Herzdruckmassagen, 2 Beatmungen**" correct="**true**" />
<Answer text="**30 Beatmungen, 2 Herzdruckmassagen**" correct="**false**" />
<Answer text="**15 Herzdruckmassagen, 2 Beatmungen**" correct="**false**" />
<Answer text="**15 Beatmungen, 2 Herzdruckmassagen**" correct="**false**" />
</exercise>
- <exercise id="**38**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Wie lange soll bei einer reglosen Person Herzdruckmassage und Beatmung durchgeführt werden?**" />
<Answer text="**Mindestens 15 Minuten**" correct="**false**" />
<Answer text="**Bis normale Atmung einsetzt**" correct="**true**" />
<Answer text="**Bis die Rettung /das Rote Kreuz eintrifft**" correct="**true**" />
<Answer text="**Bis alle Nachbar/innen versammelt sind**" correct="**false**" />
<Answer text="**Bis der Helfer/die Helferin von jemanden abgelöst wird**" correct="**true**" />
<Answer text="**Solange die Familie es wünscht**" correct="**false**" />
<Answer text="**Bis der Helfer/die Helferin nicht mehr kann**" correct="**true**" />
<Answer text="**Maximal 30 Minuten**" correct="**false**" />
</exercise>
- <exercise id="**39**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Was bewirkt ein Defibrillator-Schock bei Atem-Kreislaufstillstand?**" />
<Answer text="**Sofortiges Einsetzen der Atmung durch Stimulation der Lungengefäße**" correct="**false**" />
<Answer text="**Vom Kammerflimmern zum regelmäßigen Herzrhythmus**" correct="**true**" />
<Answer text="**Durch Herzerwärmung zu erneutem regelmäßigen Schlagen**" correct="**false**" />
</exercise>
- <exercise id="**40**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Bei wem und wo darfst du einen Defibrillator verwenden?**" />
<Answer text="**Bei Erwachsenen**" correct="**true**" />
<Answer text="**Bei Kindern**" correct="**true**" />
<Answer text="**Bei Säuglingen (0-1 Jahr)**" correct="**false**" />
<Answer text="**Bei Nässe**" correct="**false**" />
<Answer text="**Auf Metallteilen**" correct="**false**" />
<Answer text="**Auf Beton**" correct="**true**" />
<Answer text="**Gar nicht, da es ein medizinisches Gerät ist**" correct="**false**" />
</exercise>
- <exercise id="**41**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Wann spricht man von einer starken Blutung?**

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Wenn ..." />
    <Answer text="die Person ein blutverschmiertes Gesicht hat"
      correct="false" />
    <Answer text="das Blut dunkelrot ist" correct="true" />
    <Answer text="Blut aus einer Wunde spritzt oder stark fließt"
      correct="true" />
    <Answer text="das Blut hellrot ist" correct="false" />
    <Answer text="innerhalb kurzer Zeit eine erhebliche Menge Blut
      verloren geht" correct="false" />
    <Answer text="die Wunde länger als 5 cm ist" correct="false" />
  </exercise>
- <exercise id="42" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was sind die ersten Maßnahmen bei einer stark
      blutenden Wunde?" />
    <Answer text="Tieflagerung, wenn möglich" correct="false" />
    <Answer text="Hochhalten, wenn möglich" correct="true" />
    <Answer text="Fingerdruck" correct="true" />
    <Answer text="Druckverband" correct="false" />
    <Answer text="Guter Zuspruch" correct="false" />
  </exercise>
- <exercise id="43" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie erfolgt die Blutstillung durch Fingerdruck?" />
    <Answer text="Verletzte/n hinsetzen oder hinlegen und wenn möglich
      verletzten Körperteil hochhalten" correct="true" />
    <Answer text="Keimfreie Wundauflage auf die stark blutende Wunde
      pressen" correct="true" />
    <Answer text="Fingerdruck bis zum Eintreffen der Rettung
      beibehalten" correct="true" />
    <Answer text="Durch andere blutstillende Maßnahmen ersetzen (z.B.:
      Druckverband)" correct="false" />
    <Answer text="Auf keinen Fall Handschuhe verwenden (rutschen von
      Wunde ab)" correct="false" />
  </exercise>
- <exercise id="44" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was ist zu tun, wenn es durch den Druckverband
      durchblutet?" />
    <Answer text="Sofort mit den Fingern draufdrücken" correct="true" />
    <Answer text="Sofort den Druckverband entfernen und einen neuen,
      festeren anlegen" correct="false" />
    <Answer text="Einen zweiten Druckverband darüber anlegen"
      correct="true" />
    <Answer text="Eine Abbindung durchführen" correct="false" />
  </exercise>
- <exercise id="45" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was ist mit abgetrennten Körperteilen (Amputaten)
      zu tun?" />
    <Answer text="Immer in das Krankenhaus mitgeben" correct="true" />
    <Answer text="Nur dann mitgeben, wenn der/die Verletzte das
      Annähen wünscht" correct="false" />
    <Answer text="Einfrieren, damit sie haltbar bleiben" correct="false" />
    <Answer text="In Plastikbeutel mit Eiswürfeln legen"
      correct="false" />
    <Answer text="Keimfrei versorgen, vor Nässe, Kälte und Hitze
      (Sonne) schützen und den Sanitäter/innen mitgeben"
      correct="true" />
  </exercise>
- <exercise id="46" plugin="soma.PLUGIN.MultipleChoice">
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    <Question text="Was versteht man unter einem Schock?" />
    <Answer text="Schwere Störung des Kreislaufs" correct="true" />
    <Answer text="Erschrecken" correct="false" />
    <Answer text="Starrer Gesichtsausdruck" correct="false" />
    <Answer text="Blasses Gesicht" correct="false" />
  </exercise>
- <exercise id="47" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Kennzeichen des Schocks:" />
    <Answer text="Teilnahmslosigkeit oder auffallende Unruhe"
      correct="true" />
    <Answer text="Blässe und feuchte, kalte Haut" correct="true" />
    <Answer text="Langsamer, gut tastbarer Puls" correct="false" />
    <Answer text="Muskelzittern" correct="true" />
    <Answer text="Stark beschleunigter, schlecht tastbarer Puls"
      correct="true" />
  </exercise>
- <exercise id="48" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was soll die Schockbekämpfung bewirken?" />
    <Answer text="Zusatzverletzungen vermeiden" correct="false" />
    <Answer text="Die lebenswichtigen Funktionen (Atmung, Kreislauf)
      begünstigen und aufrechterhalten" correct="true" />
    <Answer text="Vermeidung von Unterkühlung und Hirnschädigung"
      correct="false" />
    <Answer text="Erhaltung der Darm- und Nierenfunktion"
      correct="false" />
  </exercise>
- <exercise id="49" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Maßnahmen dienen der
      Schockbekämpfung?" />
    <Answer text="Rasche, exakte Blutstillung" correct="true" />
    <Answer text="Warme Getränke verabreichen" correct="false" />
    <Answer text="Beruhigen und guter Zuspruch" correct="true" />
    <Answer text="Dem Zustand entsprechende Lagerung"
      correct="true" />
    <Answer text="Schutz vor Wärmeverlust, Zudecken" correct="true" />
    <Answer text="Verabreichen von schmerzstillenden Medikamenten"
      correct="false" />
    <Answer text="Öffnen beengender Kleidungsstücke" correct="true" />
    <Answer text="Wundversorgung" correct="true" />
    <Answer text="Zu tiefer, langsamer Atmung anhalten"
      correct="true" />
  </exercise>
- <exercise id="50" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wann muss man auch mit einer geringfügigen
      Verletzung zum Arzt oder zur Ärztin?" />
    <Answer text="Wunde ist rot" correct="false" />
    <Answer text="Wunde schmerzt" correct="false" />
    <Answer text="Keine Tetanusimpfung" correct="true" />
    <Answer text="Gegenstand ist weniger als 1,5 mm eingedrungen"
      correct="false" />
  </exercise>
- <exercise id="51" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie wird eine Wunde mit einem herausragenden
      Fremdkörper versorgt?" />
    <Answer text="Muss vor dem Transport entfernt werden"
      correct="false" />
    <Answer text="Darf nicht entfernt werden" correct="true" />
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    <Answer text="Wird immer zur Wundversorgung entfernt"
      correct="false" />
    <Answer text="Keimfreie Wundauflage – Ringpolster - fixieren"
      correct="true" />
  </exercise>
- <exercise id="52" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Erste-Hilfe-Maßnahmen bei Nasenbluten?" />
    <Answer text="Blutendes Nasenloch zudrücken" correct="true" />
    <Answer text="Die Nase mit Watte tamponieren" correct="false" />
    <Answer text="Kopf in den Nacken legen lassen" correct="false" />
    <Answer text="Kopf nach vorne beugen" correct="true" />
    <Answer text="Trösten" correct="true" />
    <Answer text="Warme Umschläge in den Nacken" correct="false" />
    <Answer text="Kalte Umschläge in den Nacken" correct="true" />
  </exercise>
- <exercise id="53" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei einem
      Insektenstich im Mund-Rachenraum:" />
    <Answer text="Warme Umschläge um den Hals legen"
      correct="false" />
    <Answer text="Bei allergischen Reaktionen: weitere Reaktionen
      abwarten" correct="false" />
    <Answer text="Kalte Umschläge um den Hals legen" correct="true" />
    <Answer text="Bei allergischen Reaktionen: Arzt/Ärztin oder
      Krankenhaus aufsuchen" correct="true" />
    <Answer text="Ständig Eis lutschen lassen" correct="true" />
    <Answer text="Schockbekämpfun" correct="true" />
    <Answer text="Notruf" correct="true" />
    <Answer text="Luftröhrenschnitt" correct="false" />
    <Answer text="Warme Getränke geben" correct="false" />
  </exercise>
- <exercise id="54" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen, die nach einem Biss
      einer heimischen Giftschlange durchzuführen sind:" />
    <Answer text="Verletzten Körperteil ruhig stellen" correct="true" />
    <Answer text="Warme Umschläge auf die Bissstelle" correct="false" />
    <Answer text="Schockbekämpfung" correct="true" />
    <Answer text="Kalte Umschläge auf die Bissstelle" correct="true" />
    <Answer text="Notruf" correct="true" />
    <Answer text="Verletzten Körperteil bewegen lassen"
      correct="false" />
    <Answer text="Transport durchführen" correct="false" />
    <Answer text="Bisswunde aussaugen" correct="false" />
    <Answer text="Gliedmaße abbinden" correct="false" />
  </exercise>
- <exercise id="55" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Warum kann ein Zeckenbiss gefährlich sein?" />
    <Answer text="Übertragung von Tollwut" correct="false" />
    <Answer text="Übertragung von anderen Krankheiten (z. B.
      Borreliose)" correct="true" />
    <Answer text="Übertragung von Hirnhautentzündung (FSME)"
      correct="true" />
    <Answer text="Übertragung von Wundstarrkrampf" correct="false" />
  </exercise>
- <exercise id="56" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen nach einem
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Zeckenbiss:" />
    <Answer text="Ungeimpfte sollen nach einem Zeckenbiss auf jeden
      Fall eine/n Arzt/Ärztin aufsuchen" correct="true" />
    <Answer text="Öl auftropfen, durch kreisende Bewegung Zecke
      lockern und entfernen" correct="false" />
    <Answer text="Bei späteren Rötungen bzw. Entzündungen ist ein/e
      Arzt/Ärztin aufzusuchen" correct="true" />
    <Answer text="Mit einer Pinzette ganz vorne fassen und ohne Drehen
      gerade abziehen" correct="true" />
  </exercise>
- <exercise id="57" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Erste Hilfe nach einem Tierbiss" />
    <Answer text="Wunde mit erträglich heißem Seifenwasser
      auswaschen" correct="true" />
    <Answer text="Wunde desinfizieren" correct="true" />
    <Answer text="Wunde aussaugen" correct="false" />
    <Answer text="Keine Wundversorgung durchführen" correct="false" />
    <Answer text="Keimfrei verbinden" correct="true" />
    <Answer text="Sofort Arzt/Ärztin oder Krankenhaus aufsuchen"
      correct="true" />
    <Answer text="Tierbesitzer ermitteln" correct="true" />
  </exercise>
- <exercise id="58" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie wird HIV übertragen? Durch ..." />
    <Answer text="Besuche im Schwimmbad, in der Sauna etc"
      correct="false" />
    <Answer text="Blutabnahmen, Blutspenden mit sterilem Besteck"
      correct="false" />
    <Answer text="Sexualkontakt mit infiziertem/r Partner/in"
      correct="true" />
    <Answer text="gemeinsames Benutzen von Sanitäranlagen"
      correct="false" />
    <Answer text="Schwangerschaft / Geburt von Kindern infizierter
      Mütter" correct="true" />
    <Answer text="gemeinsamen Gebrauch von Injektionsspritzen (z.B.
      Drogenabhängige/r)" correct="true" />
    <Answer text="gemeinsamen Gebrauch von Geschirr, Gläsern, Besteck
      und Handtüchern" correct="false" />
  </exercise>
- <exercise id="59" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Erste-Hilfe-Maßnahmen bei Verätzungen
      der Haut:" />
    <Answer text="Kleider nicht entfernen, um nicht die bereits
      geschädigte Haut weiter zu verletzen, sondern intensiv mit kaltem
      Wasser spülen" correct="false" />
    <Answer text="Einmalhandschuhe verwenden, metallisierten Verband
      anlegen, weitere Schockbekämpfung und Notruf" correct="true" />
    <Answer text="Einmalhandschuhe verwenden, sofort mit reinem
      Wasser intensiv spülen, darauf achten, dass das abfließende
      Wasser den kürzesten Weg über die Haut nimmt, um unverletzte
      Körperstellen zu schützen" correct="true" />
    <Answer text="Einmalhandschuhe verwenden, sofort die mit ätzender
      Substanz getränkte Kleidung entfernen (Selbstschutz beachten!)"
      correct="true" />
  </exercise>
- <exercise id="60" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Erste-Hilfe-Maßnahmen bei Verätzung der Augen:" />
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<Answer text="**Auge 10 - 15 Minuten mit reinem Wasser von innen nach außen spülen**" correct="**true**" />
<Answer text="**Schockbekämpfung und Notruf absetzen**" correct="**true**" />
<Answer text="**Auge nicht ausspülen**" correct="**false**" />
<Answer text="**Auge keimfrei bedecken und Ruhigstellung beider Augen**" correct="**true**" />
</exercise>
- <exercise id="**61**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Warum werden bei Schädigung eines Auges beide Augen bedeckt?**" />
<Answer text="**Um die Lichtstärke zu vermindern**" correct="**false**" />
<Answer text="**Ohne Bedeckung würde das verletzte Auge den Bewegungen des unverletzten Auges folgen**" correct="**true**" />
<Answer text="**Damit die Schädigung nicht auf das unverletzte Auge übergreifen kann**" correct="**false**" />
<Answer text="**Um bleibendes Schielen zu verhindern**" correct="**false**" />
</exercise>
- <exercise id="**62**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Nenne die Erste-Hilfe-Maßnahmen bei Verätzungen des Verdauungstraktes:**" />
<Answer text="**Sofort Wasser in kleinen Schlucken zu trinken geben, um die Substanz zu verdünnen**" correct="**false**" />
<Answer text="**Mit Salzwasser zum Erbrechen bringen, um die Substanz zu entfernen**" correct="**false**" />
<Answer text="**Milch trinken lassen, um die Substanz zu binden**" correct="**false**" />
<Answer text="**Mund ausspülen**" correct="**true**" />
<Answer text="**Wenn die Substanz bekannt ist, die Vergiftungsinformationszentrale (VIZ) unter der Telefonnummer 01/ 406 43 43 anrufen und deren Anordnungen durchführen**" correct="**true**" />
<Answer text="**Weitere Schockbekämpfung**" correct="**true**" />
<Answer text="**Notruf**" correct="**true**" />
</exercise>
- <exercise id="**63**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Was ist zu tun, wenn die Kleidung einer Person Feuer gefangen hat?**" />
<Answer text="**Brennende Person am Boden wälzen**" correct="**true**" />
<Answer text="**Flammen mit Decke, Tüchern oder Kleidungsstücken ersticken**" correct="**true**" />
<Answer text="**Brennende Person am Weglaufen hindern**" correct="**true**" />
<Answer text="**Angeklebte Kleidungsstücke herunterreißen, damit man die Haut kühlen kann**" correct="**false**" />
</exercise>
- <exercise id="**64**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Erste-Hilfe-Maßnahmen bei Verbrennungen:**" />
<Answer text="**Salbe, Puder oder Gelee auf die Wunde geben**" correct="**false**" />
<Answer text="**Olivenöl auf die Wunde gießen**" correct="**false**" />
<Answer text="**Mindestens 10 - 15 Minuten mit kühlem Wasser spülen**" correct="**true**" />
<Answer text="**Bedeckung mit metallisiertem Verband**" correct="**true**" />
<Answer text="**Schockbekämpfung und Notruf**" correct="**true**" />

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  </exercise>
- <exercise id="65" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Vorteile hat die Kaltwasseranwendung nach
      einer Verbrennung?" />
    <Answer text="Nachbrennen wird vermindert" correct="true" />
    <Answer text="Körperhygiene" correct="false" />
    <Answer text="Schmerzlinderung" correct="true" />
    <Answer text="Schockbekämpfung" correct="true" />
    <Answer text="Blutdrucksenkung" correct="false" />
  </exercise>
- <exercise id="66" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Womit soll die keimfreie Bedeckung von
      Brandwunden erfolgen?" />
    <Answer text="Notfalls mit frischen Leintüchern" correct="true" />
    <Answer text="Mit Brandwundenverbandstüchern oder
      Brandwundenpäckchen" correct="true" />
    <Answer text="Notfalls mit feuchten Papiertaschentüchern"
      correct="false" />
    <Answer text="Mit metallisierten Tüchern" correct="true" />
  </exercise>
- <exercise id="67" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Körperstellen sind besonders
      erfrierungsgefährdet?" />
    <Answer text="Körperstellen, die von zu enger Bekleidung umgeben
      sind (z. B. Schuhwerk)" correct="true" />
    <Answer text="Rücken" correct="false" />
    <Answer text="Körperstellen, die von weiter Bekleidung umgeben
      sind, da diese wenig Kälteschutz bietet" correct="false" />
    <Answer text="Besonders gefährdet sind Körperstellen, die wenig
      Schutz durch Muskulatur und Gewebe haben (Zehen, Finger,
      Wangen, Nase und Ohren)" correct="true" />
  </exercise>
- <exercise id="68" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Beschreibe Erste-Hilfe-Maßnahmen bei einer
      ansprechbaren Person mit einer Erfrierung:" />
    <Answer text="Keimfreien Verband anlegen, Körper durch zusätzliche
      Kleider oder Decken erwärmen, Arzt/Ärztin oder Krankenhaus
      aufsuchen" correct="true" />
    <Answer text="Die Durchblutung durch Einreiben mit Schnee oder
      durch Frottieren wieder anregen" correct="false" />
    <Answer text="Beengende Bekleidung öffnen und heiße, gezuckerte
      Getränke verabreichen" correct="true" />
    <Answer text="Alkohol zu trinken geben, dadurch werden die Gefäße
      erweitert und wärmendes Blut kann besser zu den kalten
      Gliedmaßen gelangen" correct="false" />
  </exercise>
- <exercise id="69" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Zeichen einer Unterkühlung:" />
    <Answer text="Anfangs heftige Schmerzen, später zunehmende
      Teilnahmslosigkeit und Müdigkeit mit Beschleunigung von Puls und
      Atmung" correct="false" />
    <Answer text="Unterkühlte/r fühlt sich beschwerdefrei und schläft
      ein" correct="true" />
    <Answer text="Anfangs heftige Schmerzen, später zunehmende
      Teilnahmslosigkeit und Müdigkeit mit Verlangsamung von Puls und
      Atmung" correct="true" />
    <Answer text="Rascher Puls und niedriger Blutdruck"
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  correct="false" />
  </exercise>
- <exercise id="70" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Maßnahmen musst du bei einem/r
      Unterkühlten durchführen?" />
    <Answer text="Warme Getränke verabreichen" correct="true" />
    <Answer text="Warme, trockene Umschläge auf Brust und Bauch
      legen" correct="true" />
    <Answer text="Alkohol verabreichen" correct="false" />
    <Answer text="Körper massieren und frottieren, damit er warm wird"
      correct="false" />
    <Answer text="Kalte, nasse Kleidung vorsichtig entfernen"
      correct="true" />
    <Answer text="In angewärmte Decken hüllen" correct="true" />
    <Answer text="Erfrierungen keimfrei verbinden" correct="true" />
    <Answer text="Den/die Unterkühlte/n ständig bewegen"
      correct="false" />
  </exercise>
- <exercise id="71" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie versorgt man eine Quetschung?" />
    <Answer text="Kalte Umschläge" correct="true" />
    <Answer text="Verabreichung von Schmerzmitteln" correct="false" />
    <Answer text="Ruhigstellung" correct="true" />
    <Answer text="Hochlagerung des verletzten Körperteils"
      correct="true" />
    <Answer text="Warme Umschläge" correct="false" />
  </exercise>
- <exercise id="72" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Kennzeichen einer Verstauchung:" />
    <Answer text="Stufenbildung" correct="false" />
    <Answer text="Abnorme Stellung" correct="false" />
    <Answer text="Schwellung, Blaufärbung, die oft von einem Bluterguss
      herrührt" correct="true" />
    <Answer text="Schmerzen, vor allem bei entsprechender Bewegung"
      correct="true" />
  </exercise>
- <exercise id="73" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Woran erkennt man eine Verrenkung? An..." />
    <Answer text="abnormer Beweglichkeit" correct="false" />
    <Answer text="Schmerzen" correct="false" />
    <Answer text="sichtbaren Knochenstücken" correct="false" />
    <Answer text="abnormer Gelenksstellung bzw.
      Bewegungsunfähigkeit" correct="true" />
  </exercise>
- <exercise id="74" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Gefahren bestehen bei Knochenbrüchen?" />
    <Answer text="Bei offenen Brüchen Infektionsgefahr"
      correct="true" />
    <Answer text="Bei geschlossenen Brüchen Infektionsgefahr"
      correct="false" />
    <Answer text="Mögliche Verletzungen von Nerven, Blutgefäßen und
      inneren Organen" correct="true" />
    <Answer text="Schock durch Blutverlust und Schmerzen"
      correct="true" />
  </exercise>
- <exercise id="75" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Erste-Hilfe-Maßnahmen bei offenen
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Knochenbrüchen:" />
    <Answer text="Sofortige keimfreie Bedeckung" correct="true" />
    <Answer text="Druckverband" correct="false" />
    <Answer text="Kalte Umschläge" correct="false" />
    <Answer text="Ruhigstellung, Notruf, Schockbekämpfung"
      correct="true" />
  </exercise>
- <exercise id="76" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei Beinbrüchen:" />
    <Answer text="Schuh ausziehen" correct="false" />
    <Answer text="Ruhigstellung durch unterstützende Lagerung,
      Schockbekämpfung und Notruf" correct="true" />
    <Answer text="Bein bandagieren" correct="false" />
    <Answer text="Verletztes Bein bewegen, um zu sehen, ob es
      gebrochen ist" correct="false" />
    <Answer text="Verletztes Bein nicht bewegen, offene Wunden sofort
      keimfrei bedecken" correct="true" />
    <Answer text="Wegen der Gefahr einer Schwellung beengende
      Kleidung lockern und Schuhriemen lösen" correct="true" />
    <Answer text="Ruhigstellung durch unterstützende Lagerung, weitere
      Schockbekämpfungsmaßnahmen, Notruf" correct="true" />
  </exercise>
- <exercise id="77" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Erste-Hilfe-Maßnahmen bei einem
      Schultergürtel- oder Armbruch:" />
    <Answer text="Verletzten Arm nicht bewegen, beengende
      Kleidungsstücke öffnen, Armbanduhr und Ringe entfernen, bei
      offenen Knochenbrüchen sofort keimfreien Verband anlegen und
      gegebenenfalls Ruhigstellen" correct="true" />
    <Answer text="Bei offenen Knochenbrüchen sofort einen
      Druckverband anlegen, um die Blutung zu stillen" correct="false" />
    <Answer text="Ruhigstellung mit Armtragetuch, als Fixierung kann
      eine Dreiecktuchkrawatte oder ein zweites offenes Dreiecktuch
      verwendet werden, Schockbekämpfung, Notruf" correct="true" />
    <Answer text="Beengende Kleidungsstücke nicht öffnen, um nicht
      zusätzlich an der gebrochenen Gliedmaße zu manipulieren"
      correct="false" />
  </exercise>
- <exercise id="78" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei
      Beckenbrüchen:" />
    <Answer text="Mit erhöhtem Oberkörper lagern" correct="false" />
    <Answer text="Zur Schmerzlinderung Knierolle unterlegen"
      correct="false" />
    <Answer text="Lage der verletzten Person nicht ändern"
      correct="true" />
    <Answer text="Bergung durch Wegziehen nur aus dem unmittelbaren
      Gefahrenbereich" correct="true" />
    <Answer text="Schockbekämpfung und Notruf" correct="true" />
  </exercise>
- <exercise id="79" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die möglichen Kennzeichen einer
      Wirbelsäulenverletzung:" />
    <Answer text="Kribbeln oder Gefühllosigkeit in Armen und Beinen"
      correct="true" />
    <Answer text="Krampfanfälle" correct="false" />
    <Answer text="Schmerzen im Rückenbereich, gegebenenfalls
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    Unvermögen, sich aufzurichten bzw. die Beine zu bewegen"
      correct="true" />
    <Answer text="Unfallhergang" correct="true" />
  </exercise>
- <exercise id="80" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne die Erste-Hilfe-Maßnahmen bei Verdacht auf
      Wirbelsäulenverletzung:" />
    <Answer text="Bei Bewusstsein: Lage des/r Verletzten nicht
      verändern bis Rettungspersonal am Unfallort eintrifft. Ausnahme:
      Bergung aus einer Gefahrenzone" correct="true" />
    <Answer text="Die verletzte Person animieren, sich aufzusetzen, um
      zu überprüfen, ob sie sich normal bewegen kann" correct="false" />
    <Answer text="Bei Sturzhelmträger/innen den Sturzhelm nicht
      abnehmen, um die Wirbelsäule nicht noch mehr zu belasten"
      correct="false" />
    <Answer text="Bei Bewusstlosigkeit stabile Seitenlage, wenn möglich
      unterstützt ein/e zweite/r Helfer/in den Kopf" correct="true" />
  </exercise>
- <exercise id="81" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Gefahren bestehen bei einer Schädel-Hirn-
      Verletzung?" />
    <Answer text="Krämpfe" correct="true" />
    <Answer text="Verbluten" correct="false" />
    <Answer text="Erhöhter Hirndruck durch Hirnschwellung"
      correct="true" />
    <Answer text="Infektionsgefahr bei offener Schädelverletzung"
      correct="true" />
  </exercise>
- <exercise id="82" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Anzeichen lassen auf eine
      Gehirnerschütterung schließen?" />
    <Answer text="Kopfschmerzen" correct="true" />
    <Answer text="Erbrechen, Schwindel" correct="true" />
    <Answer text="Kurze Bewusstlosigkeit, Erinnerungslücken"
      correct="true" />
    <Answer text="Wunde am Kopf" correct="false" />
  </exercise>
- <exercise id="83" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei offenen
      Brustkorbverletzungen, die Person ist bei Bewusstsein:" />
    <Answer text="Schockbekämpfung, Notruf" correct="true" />
    <Answer text="Auch wenn die verletzte Person bei Bewusstsein ist,
      sofort beatmen" correct="false" />
    <Answer text="Wunde keimfrei bedecken" correct="true" />
    <Answer text="Mit erhöhtem Oberkörper möglichst auf die verletzte
      Seite lagern" correct="true" />
  </exercise>
- <exercise id="84" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Kennzeichen deuten auf eine stumpfe
      Bauchverletzung hin?" />
    <Answer text="Prellmarken, Bluterguss" correct="true" />
    <Answer text="Starke Bauchschmerzen, gespannte Bauchdecke"
      correct="true" />
    <Answer text="Ausstrahlende Schmerzen im linken Arm"
      correct="false" />
    <Answer text="Austritt von Darmschlingen" correct="false" />
  </exercise>
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- <exercise id="85" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei stumpfen
      Bauchverletzungen:" />
    <Answer text="Schockbekämpfung, Notruf" correct="true" />
    <Answer text="Wärmflasche auflegen" correct="false" />
    <Answer text="Zu essen oder trinken geben" correct="false" />
    <Answer text="Verletzte/n mit angezogenen Beinen und Knierolle
      lagern" correct="true" />
    <Answer text="Verletzte/n mit erhöhten Beinen lagern"
      correct="false" />
    <Answer text="Rauchen lassen, das beruhigt und entspannt"
      correct="false" />
  </exercise>
- <exercise id="86" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Nenne Erste-Hilfe-Maßnahmen bei offenen
      Bauchverletzungen:" />
    <Answer text="Schockbekämpfung und Notruf" correct="true" />
    <Answer text="Druckverband anlegen" correct="false" />
    <Answer text="Verletzte/n mit angezogenen Beinen und Knierolle
      lagern" correct="true" />
    <Answer text="Wunde mit keimfreier, metallisierter Wundauflage
      locker bedecken" correct="true" />
  </exercise>
- <exercise id="87" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Worauf ist bei Personen mit akuten Herzschmerzen
      und erhaltenem Bewusstsein zu achten?" />
    <Answer text="Absolutes Bewegungsverbot, Beruhigen"
      correct="true" />
    <Answer text="Lagerung mit erhöhtem Oberkörper" correct="true" />
    <Answer text="Flache Rückenlagerung" correct="false" />
    <Answer text="Schockbekämpfung, Notruf" correct="true" />
  </exercise>
- <exercise id="88" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="An einen Herzinfarkt muss man denken, wenn die
      Person ..." />
    <Answer text="über Brustschmerzen mit Ausstrahlung in den linken
      Arm und Atemnot klagt" correct="true" />
    <Answer text="Kopfschmerzen und Todesangst hat" correct="false" />
    <Answer text="über Übelkeit, Atemnot und Sehstörungen klagt"
      correct="false" />
    <Answer text="plötzlich umfällt" correct="false" />
  </exercise>
- <exercise id="89" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Man erkennt einen Schlaganfall an..." />
    <Answer text="Halbseitenlähmung oder Gesichtslähmung (hängender
      Mundwinkel), Sprachstörung, Benommenheit" correct="true" />
    <Answer text="Bewusstlosigkeit, ungleich großen Pupillen"
      correct="false" />
    <Answer text="Blutaustritt aus Nase und Augen" correct="false" />
    <Answer text="Orientierungslosigkeit, Übelkeit und Schwindel"
      correct="true" />
  </exercise>
- <exercise id="90" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Erste Hilfe bei einer Person mit akuter Atemnot:" />
    <Answer text="Den Asthmaspray der Tochter verabreichen"
      correct="false" />
    <Answer text="Schockbekämpfung" correct="true" />
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<Answer text="**Zur Gymnastik anhalten**" correct="**false**" />
<Answer text="**Absolutes Bewegungsverbot**" correct="**true**" />
<Answer text="**Lagerung mit erhöhtem Oberkörper**" correct="**true**" />
<Answer text="**Notruf, Defibrillator holen**" correct="**true**" />
<Answer text="**Flache Rückenlagerung**" correct="**false**" />
</exercise>
- <exercise id="**91**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Erste Hilfe bei Zusammenbruch eines Menschen mit Diabetes bei erhaltenem Bewusstsein:**" />
<Answer text="**Traubenzucker, Saft oder anderes Süßes verabreichen**" correct="**true**" />
<Answer text="**Nichts zu essen oder trinken geben**" correct="**false**" />
<Answer text="**VIZ anrufen**" correct="**false**" />
<Answer text="**Notruf und lebensrettende Sofortmaßnahmen**" correct="**true**" />
</exercise>
- <exercise id="**92**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Erste Hilfe bei bzw. nach einem epileptischen Anfall:**" />
<Answer text="**Die Person festhalten, damit sie sich nicht verletzt**" correct="**false**" />
<Answer text="**Den Anfall einfach abwarten**" correct="**true**" />
<Answer text="**Notfallcheck durchführen, lebensrettende Sofortmaßnahmen, Notruf**" correct="**true**" />
</exercise>
- <exercise id="**93**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Erste Hilfe bei Sonnenstich und Hitzschlag:**" />
<Answer text="**Person an einen kühlen, schattigen Ort bringen**" correct="**true**" />
<Answer text="**Lagerung mit erhöhtem Oberkörper**" correct="**true**" />
<Answer text="**Kopf in eine kalte Waschschüssel stecken**" correct="**false**" />
<Answer text="**Beengende Kleidung öffnen**" correct="**true**" />
<Answer text="**Notruf**" correct="**true**" />
<Answer text="**Mit kalten, feuchten Tüchern kühlen**" correct="**true**" />
<Answer text="**Fieber messen**" correct="**false**" />
</exercise>
- <exercise id="**94**" plugin="**soma.PLUGIN.MultipleChoice**">
<Question text="**Welche Erste-Hilfe-Maßnahmen sind bei Vergifteten, die bei Bewusstsein sind, durchzuführen?**" />
<Answer text="**Gift unbekannt: Vergiftungsinformationszentrale (VIZ), Tel. 01/ 43 43 43, anrufen und deren Anordnungen durchführen**" correct="**false**" />
<Answer text="**Vorgefundene Giftreste und Giftbehältnisse sicherstellen und fachgerecht entsorgen**" correct="**false**" />
<Answer text="**Sofort schluckweise Wasser zum Trinken geben, um das Gift zu verdünnen**" correct="**false**" />
<Answer text="**Gift bekannt: Vergiftungsinformationszentrale (VIZ), Tel. 01/ 406 43 43, anrufen und deren Anordnungen durchführen**" correct="**true**" />
<Answer text="**Schockbekämpfung**" correct="**true**" />
<Answer text="**Notruf**" correct="**true**" />
<Answer text="**Vorgefundene Giftreste und Giftbehältnisse sicherstellen und ins Krankenhaus mitgeben**" correct="**true**" />
<Answer text="**Person sofort zum Erbrechen bringen, um das Gift zu entfernen**" correct="**false**" />
</exercise>

```
- <exercise id="95" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Worauf beziehen sich die Genfer Abkommen? Auf die
      Verbesserung der Situation / den Schutz von..." />
    <Answer text="Zivilpersonen in Friedenszeiten" correct="false" />
    <Answer text="verwundeten und kranken Soldat/innen"
      correct="true" />
    <Answer text="verwahrlosten Obdachlosen" correct="false" />
    <Answer text="verwundeten, kranken und schiffbrüchigen
      Marinesoldat/innen" correct="true" />
    <Answer text="Kriegsgefangenen" correct="true" />
    <Answer text="Zivilpersonen in Kriegszeiten" correct="true" />
    <Answer text="misshandelten Kindern" correct="false" />
    <Answer text="armutsgefährdeten Menschen" correct="false" />
  </exercise>
- <exercise id="96" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Was bedeutet HVR ?" />
    <Answer text="Hilfe durch das Verfassungsrecht" correct="false" />
    <Answer text="Humane Virus Registrierung" correct="false" />
    <Answer text="Humanitäres Völkerrecht" correct="true" />
    <Answer text="Heimatliches Vereinsrecht" correct="false" />
    <Answer text="Holländische Verordnungsrichtlinie" correct="false" />
    <Answer text="Hauptsache vernünftige Regeln" correct="false" />
  </exercise>
- <exercise id="97" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Welche Zeichen gewähren in Konfliktzeiten
      Schutz ?" />
    <Answer text="Weißes Kreuz" correct="false" />
    <Answer text="Rotes Kreuz" correct="true" />
    <Answer text="Weiße Lilie" correct="false" />
    <Answer text="Roter Halbmond" correct="true" />
    <Answer text="Weiße Taube" correct="false" />
    <Answer text="Roter Kristall" correct="true" />
    <Answer text="Roter Hammer und Sichel" correct="false" />
    <Answer text="Rot-weiß-rote Fahne (Neutralität)" correct="false" />
  </exercise>
- <exercise id="98" plugin="soma.PLUGIN.MultipleChoice">
    <Question text="Wie heißen die vier Österreichischen
      Schwimmabzeichen (ÖSA) ?" />
    <Answer text="Oktopus" correct="false" />
    <Answer text="Allroundschwimmer" correct="true" />
    <Answer text="Wassernixe" correct="false" />
    <Answer text="Frühschwimmer" correct="true" />
    <Answer text="Retter" correct="false" />
    <Answer text="Fahrtenschwimmer" correct="true" />
    <Answer text="Freischwimmer" correct="true" />
    <Answer text="Baywatcher" correct="false" />
  </exercise>
</chapter>
</course>
```

APPENDIX B

Pre-implementation questionnaire

SOMA

Service-Oriented Mobile learning Architecture

Case Study Questionaire:

Alter: _____

Schulrichtung: _____

Was sind deine Erwartungen an eine mobile Lernplattform?

	Egal	Unwichtig	Wichtig
Multimedialer Inhalt (Bilder, Videos, etc.)	O	O	O
Einfache Bedienung (Übersichtlich, Verständlich)	O	O	O
Viele Eingabemöglichkeiten (Bewegung, Sprache, etc.)	O	O	O
Verbindung mit sozialen Netzwerken (Facebook, Netlog, etc.)	O	O	O
Vielzahl an (Lern-) Inhalten	O	O	O
Kompatibilität mit verschiedenen Systemen (iPhone, Symbian, Android)	O	O	O
Feedback zu meiner Leistung	O	O	O
Unterhaltungswert (Mini-Spiele, etc.)	O	O	O
Qualität der Lerninhalte	O	O	O

Zusätzliche Anmerkungen:

SOMA

Service-Oriented Mobile learning Architecture

Welche Lernplattformen kennst du?

Welche der folgenden Lernplattformen sind dir bekannt?

- ○ Moodle
- ○ Claroline (classroom online)
- ○ KEWL
- ○ WeLearn
- ○ CLIX
- ○ Keine

Hast du schon einmal eine Lernplattform verwendet? Wenn ja, welche?

- ○ Ja: _____
- ○ Nein

Welche der folgenden mobilen Lernplattformen sind dir bekannt?

- ○ KnowledgePulse
- ○ Linguamo
- ○ mGBL
- ○ Keine

Hast du schon einmal eine mobile Lernplattformen verwendet? Wenn ja, welche?

- ○ Ja: _____
- ○ Nein

Welche der folgenden sozialen Netzwerke verwendest du regelmäßig?

- ○ Twitter
- ○ Netlog
- ○ Facebook
- ○ Studi/SchülerVZ
- ○ MySpace
- ○ Keines

Verwendest du soziale Netzwerke unterwegs (über mobiles Internet)? Falls ja, welche?

- ○ Ja: _____
- ○ Nein

SOMA

Service-Oriented Mobile learning Architecture

Was für ein Handy verwendest du zur Zeit?

Von welchem Hersteller ist dein Handy?

- ○ Apple
- ○ HTC
- ○ Samsung
- ○ Sony Ericsson
- ○ Nokia
- ○ Andere: _____

Welches Betriebssytem läuft auf deinem Handy?

- ○ Android
- ○ iPhone OS
- ○ Symbian < S60
- ○ Symbian > S60
- ○ Maemo
- ○ Proprietäres Betreibersystem (zb. viele Samsung und Sony)
- ○ Andere: _____
- ○ Betriebsystem was ist das?!

Welche Funktionen deines Handy verwendest du regelmäßig?

- ○ Telefonieren
- ○ SMS
- ○ MMS
- ○ Kalender
- ○ Internet
- ○ Kamera
- ○ MP3 Player
- ○ Andere: _____

Verfügst du über mobiles Internet auf deinem Handy? Falls ja, welche Datenmenge ist inkludiert?

- ○ Ja, es sind ca. _____ MB inkludiert.
- ○ Nein

Verwendest du nachträglich installierte Programme (zb.: iPhone Apps) auf deinem Handy? Falls ja, wieviel ca.?

- ○ Ja, ungefähr _____
- ○ Nein

APPENDIX C

After-implementation questionnaire

SOMA

Service-Oriented Mobile learning Architecture

Case Study Questionaire:

Alter: _____

Schulrichtung: _____

Bitte bewerte SOMA nach den folgenden Kriterien (Schulnoten)

	1	2	3	4	5
Bedienung der Oberfläche	O	O	O	O	O
Verständlichkeit der Applikation	O	O	O	O	O
Design (Darstellung)	O	O	O	O	O
Lesbarkeit (Schrift- größe & art bei Text)	O	O	O	O	O
Performance (Startzeit, Ladezeiten)	O	O	O	O	O
Integration in das Betriebssystem	O	O	O	O	O
Feedback zu meiner Leistung (Punkte)	O	O	O	O	O
Praxis Tauglichkeit	O	O	O	O	O
Qualität des Demo Kurses „Erste Hilfe“	O	O	O	O	O

Zusätzliche Anmerkungen und Kritik:

SOMA

Service-Oriented Mobile learning Architecture

Zufriedenheit mit dem SOMA Lernerlebnis:

Könntest du dir vorstellen SOMA zum Vorbereiten für eine Prüfung zu verwenden?

- ○ Ja, als Lernplattform (Lernen+ Leistungsüberprüfung)
- ○ Ja, zum Überprüfen meines Lernfortschrittes
- ○ Nein

Wem würdest du deine Lernergebnisse online zur Verfügung stellen?

- ○ Eltern
- ○ Freunde
- ○ Lehrer
- ○ Verwandte
- ○ Bekannte
- ○ Niemandem
- ○ Andere: _____

Würdest du dein heute erzieltes Ergebnis auf deinem Facebook Profil veröffentlichen?

- ○ Ja
- ○ Nein, weil:

Wenn eine/r deiner Freunde auf Facebook ein Kursergebnis postet, würdest du diesen Kurs auch absolvieren?

- ○ Ja, ich schneide bestimmt besser ab!
- ○ Vielleicht, kommt auf das Thema des Kurses an
- ○ Nein

Für welche Betriebssysteme sollte SOMA noch entwickelt werden?

- ○ iPhone OS
- ○ Symbian <S60
- ○ Symbian >S60

Welche Eingabemethoden würdest du in SOMA gerne verwenden?

- ○ Bild-Eingabe (Kamera)
- ○ Sprachsteuerung
- ○ Bewegung (Beschleunigungssensor)
- ○ Andere: _____
- ○ Keine

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