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Education in Emergencies

Designing a mobile solution for the education of refugees

Bachelor of Science Thesis in Computer Science and Engineering and Industrial Design Engineering

Herman Carlström
Erik Jansson
Alice Johansson
Filip Larsson
Magdalena Lindén
Oskar Samuelsson

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF GOTHENBURG
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Supervisor: Jonas Landgren

Chalmers University of Technology
University of Gothenburg
Department of Computer Science and Engineering
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000
Department of Computer Science and Engineering
Göteborg, Sweden June 2017

Abstract

An overwhelming number of people are currently displaced as a result of conflicts and face numerous challenges in accessing education. In order to address this limited access, this project strived to determine the requirements of a mobile e-learning platform which could support the education of refugees in regions with limited internet access. The requirements were established as a result of data collection in the form of interviews with educators and students in the region. The data collection focused on Jordan as this represents both urban and camp environments. A final design concept and software prototype were created with the specification in mind and tested on-site in Amman, Jordan, in order to validate the requirements. These need to consider financial limitations, non-binary internet access and limited English literacy and are presented as a step towards a solution for supporting refugee education.

Sammanfattning

I nuläget befinner sig en överväldigande stor mängd människor på flykt på grund av konflikter i världen. Detta har resulterat i att tillgången till utbildning är ytterst problematisk och begränsad. För att belysa detta ämnar projektet att fastställa de krav som bör ställas på en mobil e-learning plattform vars syfte är att stödja utbildning för flyktingar i områden med begränsad internetuppkoppling. Kraven bestämdes genom analys av data insamlad från intervjuer med lärare och studenter i regionen. Datainsamlingen fokuserade på Jordanien då landet representerar både flyktingsituationer i läger och i stadsområden. Ett designkoncept utvecklades med grund i kravlistan som sedan implementerades för att testas på plats i Amman, Jordanien, och på sätt validera kraven. I processen togs det hänsyn till ekonomiska svårigheter, icke-binär internetuppkoppling samt begränsade engelskakunskaper. Konceptet presenteras som ett steg mot att stödja utbildning för människor på flykt.

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1 Introduction

A vast number of people are currently displaced due to crises and armed conflicts. The Syrian civil war alone has forced approximately 4.9 million people from their home country. 655 000 of these are currently residing in Jordan, and approximately 140 000 are living in the refugee camps Za'atari and Azraq (*Syria Emergency*, 2017). The UN claims that 1% of Syrian refugees attend university, which is abysmally low compared to the global average tertiary education enrollment of 34% (Hannas, 2017). While there are non-governmental organizations providing education to refugee camps, higher education has not been a top priority (Wright & Plasterer, 2010). The low availability of higher-level education complicates the situation for refugees. Those with higher-level qualifications have a greater chance of finding work and contributing to the economy of their host countries. Higher education increases a refugee's self-sufficiency and ability to support their family and relatives (*Aiming Higher*, 2017).

One resource that gives access to practically unlimited information and educational opportunities is the internet. Universities frequently make course content publicly available online. The emergence of these massive online open courses broadcasts education far beyond the finite limitations of the traditional classroom. Online courses also permit a student living far away from a student center or school to access educational content through the use of a computer or mobile phone. Online education is not limited to university courses, but can include other sources of educational content. One such example is Duolingo, a mobile application which provides free software for language learning.

With a large part of the world's population displaced from their home, the access to higher level education can benefit many refugees whether they return to their home country or build a life abroad. The physical access to education is limited for refugees. However, through digital systems, free educational content can be made more accessible.

1.1 Purpose

The purpose of this project is to develop a software solution which aims to improve access to education for people who are displaced as a result of long-term conflict or crises. To determine the demands on the software, a requirements specification will be developed based on the refugee end users' situation. The developed software and concept will be empirically tested to determine the efficacy with which it fulfills the aforementioned requirements and by extension, the accuracy of the requirements themselves.

1.2 Research Question

What requirements should be present in educational software in order to support the education of users living in a refugee situation?

1.3 Scope and Delimitation

The project focuses on creating software to improve access to educational content for adult refugees seeking higher education and does not discuss education for children. The research focuses on

refugees living in Amman and Za'atari, although the findings might be applicable to other unconventional learning environments. Additionally, the software to be created assumes a basic familiarity with technology, such as downloading and installing applications to a smartphone, as well as basic Arabic literacy skills.

One important delimitation is the fact that the software to be created is student-facing. The software required for teachers to create and upload the educational content is not investigated as this is deemed to be beyond the scope of the research question. A further delimitation is that educational content is regarded to be outside the scope of this project. The application to be developed is seen as a vessel that aims to efficiently and flexibly provide education. The research question specifically pertains to the providing of education but the content itself is realized by the pedagogue or teacher.

The report is structured as follows. First, the theories and insights from previous studies are presented which lay the foundation for the design and development decisions made in the project. Secondly, the design methods used are described and related to the particular challenges of this project. These methods are then used in the design and development process, which also encapsulates a prototype validation performed in Jordan. Finally, the results of the study are presented and related to the posed research question as well as other studies performed in the field of refugee education.

2 Related Work

Many studies relating to the spreading of knowledge in crises have been performed. Those specifically dealing with e-learning in such scenarios are described, followed by an account of the current technological basis on which an e-learning platform could be deployed in Jordan. Finally, evidence supporting the feasibility of a smartphone application for learning is highlighted. These related studies lay the groundwork for the development process and serve as a starting point for the initial data collection phase.

2.1 E-Learning In Emergencies

The access to higher education in refugee situations is highly limited. Studies show that education helps people living in refugee situation to cope with their environments (Crea & Mcfarland, 2015) and that teachers in refugee camps are already turning to technology for support in education (Dahya & Dryden-Peterson, 2016). The project JC:HEM was created to provide education to people living in and near Dzaleka Camp in Malawi, Kakuma Camp in Kenya, and urban refugees living in Aleppo, Syria. This education came in the form of university-level coursework made available to students via the internet. In 2012, the program was relocated from Aleppo to Amman, Jordan, due to the outbreak of the civil war in Syria. Students enrolled in the programs spoke of the benefits of receiving education in their current circumstances (Crea & Mcfarland, 2015).

Many universities around the world offer entire courses online which are accessible to anyone with an internet connection (*Aiming Higher*, 2017). Because of the online availability, a student is able to access content via a smartphone or laptop despite not being formally enrolled in a program like JC:HEM. However, the need for an internet connection can make online education difficult for refugees in unconventional living situations. The organization Libraries Without Borders started the Ideas Box project in 2014. Ideas Boxes are batches of equipment that can be quickly set up in order to establish a rudimentary but adequate educational space. Among other things, they contained a server filled with e-learning content that could be accessed via a makeshift Wi-Fi hotspot. These hotspots could then transmit educational content to smartphones and tablets in the vicinity (Hayes, 2016). The presence of educational content and e-learning technologies led to students showing a 23% increase in academic performance compared to students being taught in traditional classroom settings (Peich, 2016).

Another tactic to circumvent the scarcity of network connectivity in refugee situations is to maximize the amount of offline functionality. By allowing users to download and save relevant content to their devices, it is possible to reap the benefits of online education even after losing the active internet connection. It is also possible to trigger an app to download the desired content as soon as the user is within the boundaries of a Wi-Fi hotspot (Mahenge, 2017).

Online learning has previously been proven useful in the JC:HEM and Ideas Box projects, with both projects lending evidence towards increased student performance. Educational content can be made accessible to anyone with an internet connection and the hardware required to harness that internet connection. If that content could be provided in a way that minimizes the reliance on internet, even users with harshly limited internet access could learn through online education.

2.2 Technology in Za'atari

In the refugee camp Za'atari, Jordan, approximately 88% of youth between 15 and 24 possessed mobile phones in the year 2015. Furthermore, mobile devices also served as their primary method of connecting to the internet. Via the mobile devices an internet connection is achieved both through the mobile-network as well as Wi-Fi hotspots supplied by NGOs. The mobile devices used by the population of Za'atari are mainly Samsung, iPhone and Nokia (Maitland et al., 2015), with older Android units like the Samsung Galaxy Series being the dominant majority (Maitland & Xu, 2015).

However, the existing cellular networks provided cannot support the large number of people living in the Za'atari area. As a result, the internet connection must be seen as non-binary; a person may have internet access but limited bandwidth. For example, Zain is one of the most widely used network providers, yet fails to to deliver a dependable internet connection almost one third of the time (Maitland & Xu, 2015).

Despite the limited internet access in Za'atari, a large percentage of the population has access to smartphone technology. The prominence of mobile devices means that the development of a smartphone application will not exclude a significant portion of the population.

2.3 Mobile-Assisted Learning

Mobile-assisted learning refers to the use of mobile platforms, commonly smartphones, as a way of learning. Students can access educational material on demand at any time and location. Because the student is independent of schools at a fixed location, student motivation improves and students can reach educational autonomy (Miangah & Nezarat, 2016). Mobile-assisted learning also has the added advantage of expanding the reach of a single teacher. With mobile-assisted learning, teachers can educate a much larger number of students than would be practical in a traditional classroom environment.

However, mobile-assisted learning can result in certain negative outcomes. For instance, frequent usage may lead to users becoming less socially active. Additionally, the teacher's ability to tailor the mobile-assisted course to an appropriate curriculum may be limited by hardware, software or the platform itself (Behunova et al., 2016). Mobile learning platforms are also susceptible to interruptions and distractions originating from the mobile device itself. These distractions can in many ways impair learning (Chen & Yan, 2016). Another issue with mobile learning are the high costs associated with mobile phone ownership and mobile internet browsing. However, these problems are becoming less of an issue as mobile phone ownership becomes more widespread and web technology becomes more efficient (Dyson et al., 2009).

One branch of mobile-assisted learning uses the smartphone medium in the education of languages. According to Behunova et al. (2016) the main requirements for mobile-assisted language learning software are to be free of charge and easy to use. Being able to repeat and view previously completed tests further ensures efficient language learning with plenty of possibilities to review past concepts and assess one's knowledge level. These attributes are present in the widely-used mobile language learning application Duolingo. Duolingo is a free application where students are challenged by a number of interactive elements in the name of language learning. The presence of these interactive elements can significantly increase knowledge retention (Mclaughlin & Rhoney, 2015). Gamification is frequently used as a rewarding way of furthering the language development of the user (*Learn a*

language for free, 2017). By not overwhelming the user and introducing new concepts with care, Duolingo creates an effective and welcoming e-learning environment (Soad et al., 2016).

Mobile-assisted learning can be an effective way to distribute educational content to a large number of students. A successful mobile learning application strives to be flexible enough to accommodate a wide variety of teaching curriculums. It is also vital to convey the educational material in a way beneficial to the learning process. While this is in large part dependent on how teachers formulate the material, the software itself can help promote an effective teaching style.

Previous studies on software applications as a way of distributing information in emergency situations, as well as the available technology in Za'atari suggests that a smartphone application could aid in providing education in these environments. Moreover, utilizing proper design principles for displaying information and encouragement can ensure that users maximize their learning and choose to continue this learning.

3 Design Theory

The interface design philosophies relevant to the development of the application can be divided into the instructional and motivational design categories. Instructional design is the practice of conveying information in a way that minimizes the effort required from the user. This is highly relevant to the development of an educational application, considering that users should not be unnecessarily stressed by the presentation of this information. By further utilizing motivational design principles, users can be encouraged to return to the application and continue their learning. A number of relevant aspects of these fields are presented below.

3.1 Instructional Design

Current theories center around the idea that learning takes place through adjusting or building upon mental models. Mental models represent a current understanding of a given topic and are stored in the long-term memory. While the capacity of the long-term memory can be thought of as practically infinite, the working memory (or short-term memory) is heavily limited. It is therefore unfortunate that learning occurs primarily in the limited working memory. The process of learning takes place by accessing a mental model of a given topic from the long-term memory and modifying this model in the short-term memory (Sweller, 1998). The working memory is of special interest in the learning of languages, since an increased working memory capacity correlates with an increased reading ability in second language students (Harrington & Sawyer, 1992). When designing for learning it is of paramount importance to minimize the associated cognitive load to avoid the working memory being unnecessarily stressed. This is the goal of instructional design.

One such instructional design principle is the modality effect which utilizes the audial and visual information channels simultaneously. Two units of information that are not understandable in isolation are shown to the student. When these units of information are conveyed in separate mediums, a synergistic effect is achieved improving the student's ability to learn (I.Chen & Chang, 2011). This is closely related to dual-coding theory which states that humans encode memory via separated visual and verbal channels (Chandler & Munday, 2011).

Another important instructional design principle to lessen cognitive load is to avoid redundancy. In addition to increasing cognitive load, redundant material can demotivate students (Wang & Shen, 2011; Sweller, 1998). The process of removing unneeded material to lessen cognitive load is known as weeding (Mayer & Moreno, 2003). Some cognitive load is however unavoidable when designing educational software. When the material is conceptually difficult, the cognitive load increases. In order to mitigate this type of cognitive load it is possible to apply segmenting. With segmenting, the material to be learned is divided into manageable sub-sections, giving the student time to process and mentally organize the learning content (Mayer & Moreno, 2003).

Instructional design strives to minimize the stress placed on the short-term memory during learning to maximize the knowledge absorbed by the student. This can be done by presenting complementary units of information or by dividing complex material into workable chunks. While maximizing the educational impact of one learning session certainly is important, learning is a continuous long-term process and requires students to be incentivized to return to the application and further their education.

3.2 Motivational Design

To ensure that first-time users are motivated to return to the application, a number of visual and functional design patterns can be implemented. The most obvious attributes to influence the return of users to software are those pertaining to user encouragement. Encouragement functions as an incentive for continued use and leaves the user feeling rewarded and appreciated. For instance, it is important to serve the user with visual gratification upon the completion of tasks. Similarly, scores and collected points can function as encouragement and entice users into returning to the application (Lewis, 2014). High scores, achievements and other features commonly associated with gamification can enhance the user experience and engagement even outside the realm of video games (Deterding et al., 2011).

Another important attribute to motivate users is predictability. Predictability makes the user comfortable, while an unpredictable application causes users to feel apprehensive and unsure of what results to expect from a given action. One way to create a predictable application is to ensure that application state is preserved. The user must feel comfortable aimlessly browsing the app, knowing that no action will lead to work being lost. If the user makes an error or faulty action, it should be simple to undo this action and return to a previous state. Without the option to step back, users will refrain from spontaneous actions for fear of making irreversible mistakes (Lewis, 2014).

Curiosity and the yearning for knowledge can be a deciding factor in motivating users. To keep the user interested but not overwhelmed, the user should be able to explore and branch out according to their interests. These interests should be acknowledged by the application and the content shown should be customizable by the user. By presenting the content according to these personal preferences, the interest of the user can be piqued. To maintain this curiosity, the software should present a list of the content yet to be shown, foreshadowing what the user can expect (Lewis, 2014).

Introducing social elements in an application can additionally increase the motivation of users (and by extension the number of returning users). By letting users interact with each other, the users become more invested in the network and are therefore more likely to return to the application. Letting users form groups or identify with a community permits a sense of belonging and further suggests that social companionship can positively impact the likelihood of returning users (Lewis, 2014).

By encouraging continued use of the software with gamification patterns as well as permitting an explorative and forgiving browsing experience, an application can greatly increase the number of returning users. Keeping the users of educational software motivated is necessary to ensure that users return and that the continuous practice required for learning actually takes place.

4 Research Approach and Method

In order to ensure the aptness of the final prototype, it is vital to adapt the software to the distinct characteristics of the intended end users. This view of product development is known as Human-Centered Design (Oviatt, 2006) and encompasses a number of different methods for data collection and concept generation. The data collection encompassed seven interviews with domain experts on education for refugees in Jordan, technology in refugee camps and a refugee student. The collected data was used to extract product requirements relevant to the development of an educational application. Because these requirements are used to generate concepts with an additional set of methods, it is highly important that they are unambiguous, solution-dependent and verifiable (Bligård, 2015). The generated concepts were then evaluated with respect to usability standards and the characteristics of the users in order to guarantee the usefulness of the product to as high a degree as possible. This chapter describes these methods and relates their strengths and weaknesses to the specific difficulties in this project. The research was heavily influenced by the inaccessibility of the intended end users.

4.1 Interviews

Interviews are a method generally used for collecting qualitative data. One type of interview is the semi-structured interview which uses an approximative interview guideline complete with a checklist of topics that are to be covered. This rough outline encourages the interviewer to deviate from the guidelines towards relevant topics that arise naturally. The interviewee can be exhorted into providing important information previously unknown to the interviewer by probing the subject's answers to the prepared questions. This type of interview is suitable when the interviewer has limited knowledge of the domain. Utilizing an interview guide also allows for reliable and comparable qualitative data between interviews (Bernard, 2015). This explorative interview technique ensures that a wide range of topics can be covered and is highly applicable to the project due to the complexity of the refugee situation.

Finding perfectly suited interview subjects who are both refugees and potential end users can be a difficult standard to attain. As such, the requirements for interview subjects were slackened to include third parties. The sample group from which data was collected should have knowledge of either the intended end users or the context in which they operate. The non-stochastic selection of interview subjects sets the lower limit for gaining a sufficient domain understanding at six interviews (Bernard, 2015).

While interviews are an efficient way of gaining a qualitative understanding of the domain, they inherently imply uncertainties. An ideal interview is conducted in the environment related to the actual interview. The environment itself can convey information which is not made readily apparent by the interview subject (Wikberg-Nilsson et al., 2015). The remoteness of the end users, makes these ideal interviews extremely difficult to organize. Additional information can be lost through the language barrier. Interviews are not an exact science and are highly dependent on interpretation. Many of the finer aspects of communication can be lost when conveyed through a second language or an interpreter. Another issue with interviews which cannot be overstated is the fact that subjects may have a view that differs from reality. Interviews are a data collection method highly susceptible to individual experiences and interpretations of reality. These individual aspects can however be somewhat mitigated through an adequate sample size.

4.2 The KJ Method

The KJ method is used to organize research data in clusters based on affinity. The KJ method can be used in conjunction with interviews by extracting relevant quotes and comments. These quotes and comments are grouped together based on their underlying themes which makes comprehensive data more manageable and helps to capture its true essence and implications (Hannington & Martin, 2012). Another advantage of this method is the fact that it starts at the detail level from which a bigger picture then emerges. Thus, there is no need to define the affinities prior to the analysis as they emerge naturally in this process (Bligård, 2015).

4.3 Persona and User Scenarios

A persona is a fictional creation of the typical user of the product or service being designed (Bligård, 2015). The persona is generated as a direct result of the data collection and serves as a manifestation of the collected data. The purpose of the persona is to help the designers meet the user's needs instead of their own personal preferences and thus avoid feature creep (Laurel, 2003). In the same way the creation of a persona aims at making the intended user more realistic, a user scenario functions as a concrete expression of the user situation (Bligård, 2015). This is done by describing a typical situation in which a hypothetical user would utilize the product.

The persona and user scenario are important when dealing with a situation as foreign to the designers as the refugee crisis. These two techniques attempt to make the unconventional situations and environments more tangible in the design process.

4.4 Brainstorming and Braindrawing

Brainstorming is a method used for generating a large number of ideas in a group setting. The idea is to influence each other's creativity, creating an ideation environment that is greater than the sum of its parts. The method focuses on quantity rather than quality by disallowing criticism and encouraging unconventional thinking. It is therefore preferably used early in the ideation phase (Wikberg-Nilsson et al., 2015). There are countless brainstorming variations but these generally begin with the establishing of a theme. Ideas surrounding this theme are generated for a short period of time before the ideas are evaluated. Braindrawing is a similar method in the sense that it focuses on quantity instead of quality. However, braindrawing is done individually, where half-finished concepts are passed around to other members of the braindrawing session in order to breathe new life into the process.

4.5 Workshops

A workshop is a creative meeting where the possible participants can include anyone from the end users, to domain experts or even people with no prior connection to the project. The purpose of the workshop is to join forces to creatively discuss different aspects of a given theme. Workshops typically start by discussing the current state of development and lead on to speculate about possible future developmental directions (Wikberg-Nilsson et al., 2015).

4.6 Focus Groups

A focus group is a theme-specific discussion group which can be beneficial throughout the design process. In later stages, focus groups are generally used to receive feedback on a design concept. The advantage of conducting focus groups is that participants share opinions with each other, which potentially highlight concerns that are otherwise difficult to discover (Wikberg-Nilsson et al., 2015).

Focus groups are usually overseen by a moderator whose job is to steer discussions towards relevant topics and should also be mindful that all participants get a chance to speak their mind. The success of focus groups is largely determined by the moderator (Wikberg-Nilsson et al., 2015). Culturally diverse focus groups can imply an even greater difficulty for moderators. Gender-specific aspects of the focus group as well as information being lost in the language barrier have to be taken into account in these special settings (Bobeth et al., 2013).

4.7 Usability Evaluation

Cognitive Walkthrough (CW) is a theoretical, task-specific method used for evaluating the usability of an interface. A CW can be used to question assumptions of user thinking, note inadequate feedback from the interface as well as identify shortcomings in the requirements specification. Due to the remoteness of the end users this evaluation method, which can be used without the need of actual users, is highly valuable (Bligård, 2015). One disadvantage of this method is that it is tedious and that a lengthy analysis may be sloppily executed (Lewis & Rieman, 1993). This often causes certain aspects of software functionality to be neglected in the analysis. Therefore, the tasks evaluated with this method have to be prioritized.

Predictive Human Error Analysis (PHEA) is another theoretical method used to explore possible errors that may occur when a user interacts with an interface, why they occur, the consequences these errors result in and the possibilities for recovery (Bligård, 2015). The advantage of PHEA is that it can be used in the early stages of the design process. Additionally, it not only describes what the error is, but also gives an underlying explanation to why it occurs, its severity and how it can be avoided.

4.8 Empirical User Evaluation

While theoretical methods have the advantage of being easily applicable early in the design process, they rely on assumptions of how the user thinks and acts. Empirical methods such as user tests are therefore of high importance to fully understand the users. User tests are conducted by studying users performing given tasks with the product (or an adequate representation) to detect issues in the interaction between user and interface (Bligård, 2015). When conducting user tests, encouraging the test subject to verbalize their thoughts while performing specific tasks with the interface is key to gaining valuable information. This allows the designer to realize the user's misinterpretations of the interface (Holzinger, 2005). However, the think-aloud scenarios imply a somewhat unrealistic user scenario as most users do not talk to themselves when using a product. The think-aloud scenarios may further jeopardize the usefulness of the evaluation as the user may fear that exposing one's confusion would be interpreted as stupidity (*Nielsen Norman Group*, 2017).

A highly relevant disadvantage of empirical user evaluations are the difficulties associated with organizing tests with relevant users. To perform fully representative user tests with users in the

actual context would involve travelling to a refugee camp. Additionally, the involvement of users is preferably not done prior to the development of an actually usable prototype. This prevents empirical user evaluations from being done in the beginning of the development process where they are perhaps most needed.

5 Design and Development Process

The development process was divided into six phases which are described in this chapter. Phase one consisted of an initial data collection which resulted in product requirements. The requirements led to cyclical, gradual refinements of an application concept in phases two through four. Each of these cycles began with an ideation stage, led to a prototyping stage and concluded with an evaluation stage. Phase five consisted of the software development of a prototype and was concurrent with phases three and four. Finally, in phase six, the final design concept and software prototype were validated in Jordan. The diagram below provides an overview of the process, displaying each phase and its associated methods, as well as illustrating the parallelism of phases 3 and 4 with phase 5.

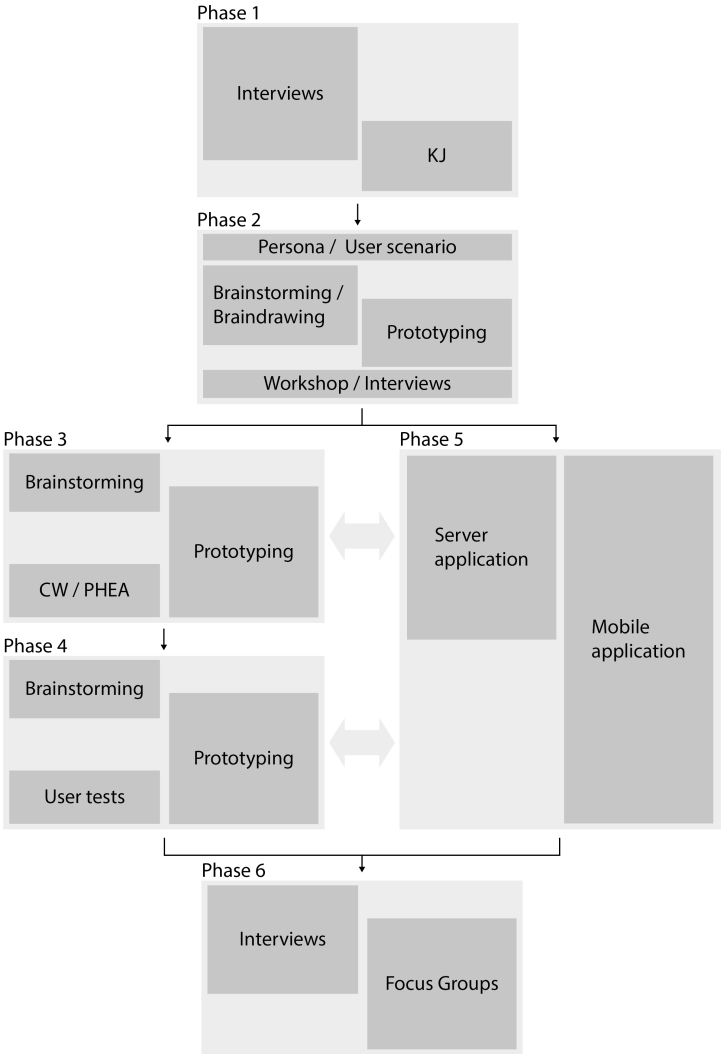

Figure 1: The phases and methods used in the design and development process.

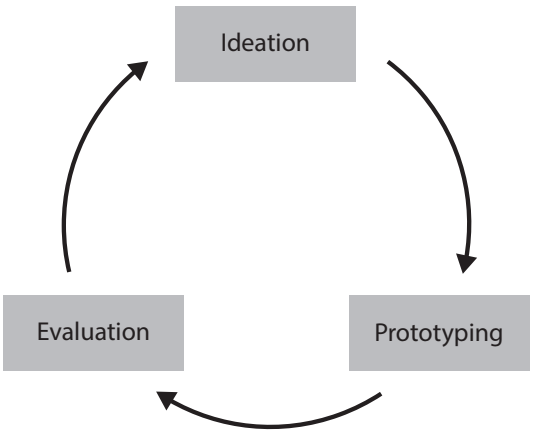

Figure 2: The iterative stages of phases two to four.

5.1 Phase One: Determining Product Requirements

The purpose of this phase was to derive a specification of requirements for the software being developed. To do this, understanding the context in which the software is intended to be used is a vital component. This includes understanding the user, the user's situation as well as the limitations and possibilities imposed by the surrounding environment. In this phase, empirical data was collected and analyzed. This resulted in six problem areas from which the product requirements were determined. These requirements are presented in detail in Section 6.

Four interviews were conducted in this phase in order to gain a better understanding of the educational situation for refugees. The interviews were held via Skype and lasted around an hour. The first interview was held with the academic officer at the Jesuit Refugee Service (JRS), located in Amman. This organization aims to bring education to refugees living in the city of Amman. The academic officer at JRS brought forth valuable information concerning the educational situation in the area, as well as rough insight into the daily lives of the refugees. In the interview it was stated that the refugees living in Amman often lack work permits, resulting in an excess of free time. Many of them apply to courses offered by the JRS, but the applicants vastly outnumber the available spots.

The next interview was conducted with a volunteer educator with the Jamiya education project which strives to educate Syrian refugees. The volunteer educator contributed to the Jamiya project by translating course material and acted as a course supervisor for an introductory programming course. He voiced the interest in language courses among students and emphasized that some refugees living in the camp were forced to complete tedious tasks throughout the day. As a result they could have limited free time in comparison to those living in Amman. Both the academic officer and the volunteer stated the scarce access to internet outside of NGO centers which contrasted previous studies described in Section 2.2. One author of the aforementioned study was contacted in order to get an updated view of the connectivity in the Za'atari refugee camp. In the interview, he stated that much has changed since the study was performed in 2015. The government is now much more

restrictive of the publicly accessed networks. In order to hinder malicious content like terrorist propaganda from reaching Za'atari, the government blocks the internet connection. There has also been a vast reduction in the number of Wi-Fi hotspots being offered by NGOs due to the large amounts of pornographic content being accessed by the population.

In order to gain a student perspective on education for refugees, an interview was conducted with a student at the Jesuit Refugee Service. The student currently lives in the city of Amman and has the possibility to attend class twice a week. He regularly skips classes if he feels that he has understood the coursework and indicated that the courses were generally quite easy. The entire coursework is available online and it is possible to complete all assignments at home. He expressed that the desire for education stems from not wanting the unfortunate refugee circumstances to cause a stagnation in personal development.

The student told of personal acquaintances that were not as fortunate as to be able to attend courses at the learning center. Transportation between living quarters and the learning center can cause unreasonable costs forcing students to drop out. Some students' work schedules also interfere with their studies. The limited internet access can also be a significant challenge to students. Furthermore, many of the student's friends are not granted admission to courses due to the limited capacity of the learning center.

The data gathered from related studies and interviews was extensive and was therefore organized with the KJ method. The data was divided into six themes corresponding to the major obstacles preventing refugees from receiving education. These problem areas lead to the construction of product requirements in order to provide a framework for the remainder of the design process.

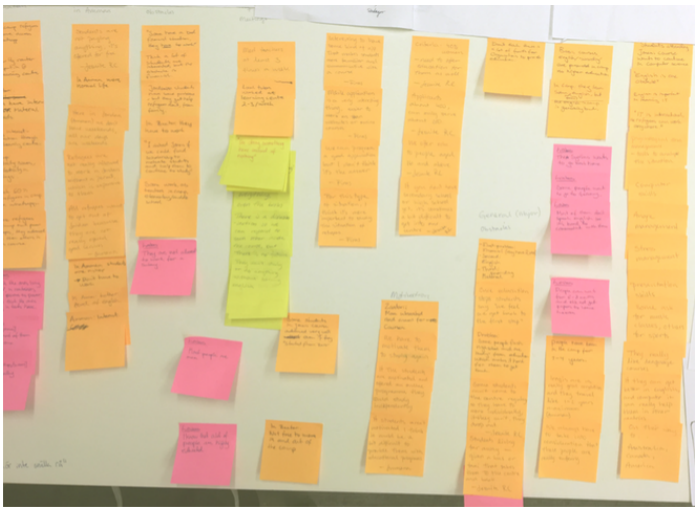

Figure 3: Picture showing a KJ-analysis

5.2 Phase Two: Application Mock-Up

The purpose of this phase was to create and evaluate a basic application mock-up with the product requirements in mind. To create an application that meets the needs of the end-user, a persona as well as a user scenario were constructed (see Appendix A). During this phase, functionalities aimed

at fulfilling aspects of the product requirements were suggested. Brainstorming and braindrawing sessions were held, resulting in a multitude of solutions aimed at evading the limited internet access, encouraging application usage, maximizing the education efficiency and many other detected problem areas.

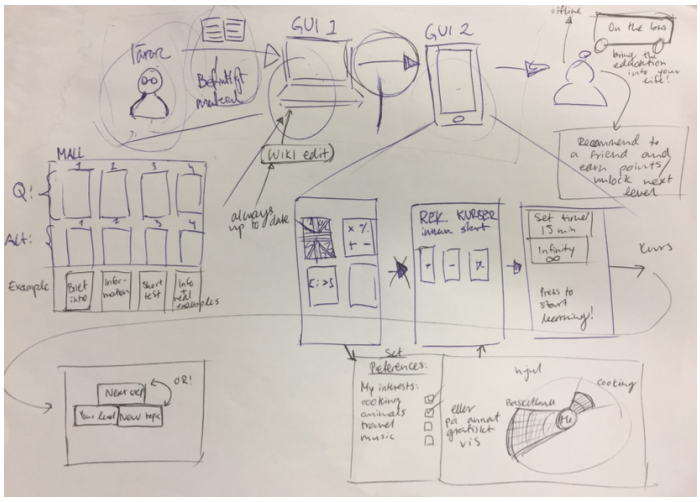

Figure 4: An example brainstorming session

The next step in this phase was to combine these single approaches into complete application concepts that met several of the requirements. Some of them emerged by combining ideas at random whilst others were created by considering which ideas would work well together. They were evaluated by assessing how many requirements were fulfilled and to what extent. In addition, they were also evaluated with regards to how well they fit the persona and the scenario. Based on the outcome of these evaluations, one of them was selected for further development. At this point, the concept was not an actual interface but a series of sketches. This loosely defined concept was concretized in the form of a wireframe mock-up and used as a communication tool in conjunction with the workshop.

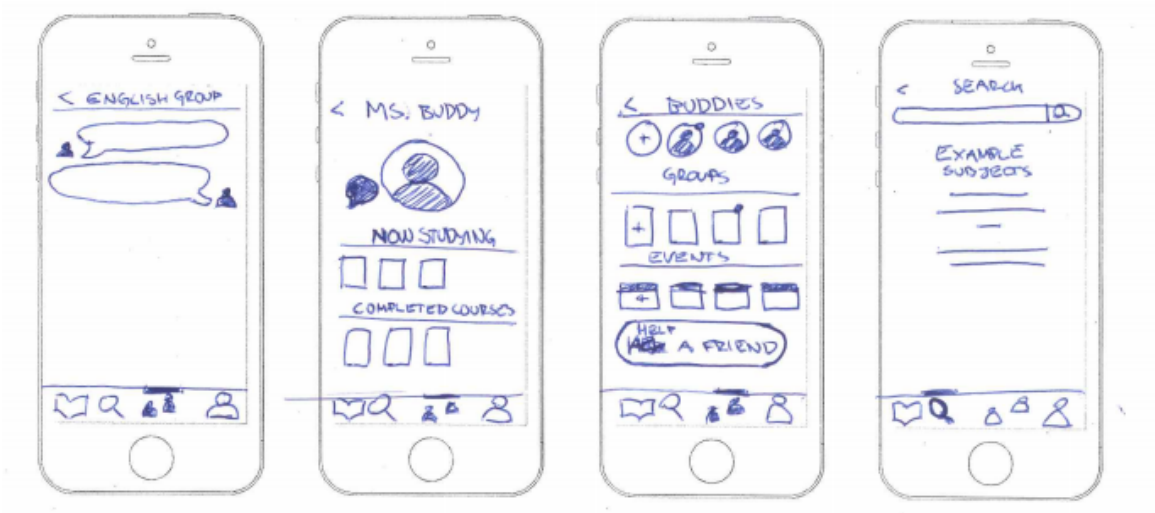

Figure 5: First mock-up sketch

The workshop was held with the academic officer of the non-governmental education organization Jamiya and its founder. The purpose of the workshop was to confirm the problems associated with the education of refugees and to perform an informal user test of the application mock-up. During the workshop, discussions and semi-structured interviews were held with both participants. The workshop resulted in additional data regarding the refugee situation in Jordan. All parts of the problem areas were confirmed. Moreover, feedback was received on the mock-up and the design ideas. For example, introducing functionality to help users gather and create study groups could be prohibited by the intelligence service in Za'atari and was therefore discarded. Once again, the unpredictability of the internet access was confirmed. However, it was revealed that low-bandwidth applications such as WhatsApp were usable on the public network. Additionally, the problem of an equally unpredictable electrical grid was highlighted. The academic officer also confirmed the issue of a high dropout rate. According to her, the high number of dropouts was due to the difficulties in travelling to the learning center. This additional data served to refine the sketched mock-up into a digital mock-up interface.

An additional interview was held with the education officer at UNHCR in Jordan which further suggested that the surveyed problem areas were valid. The three additional interviews meant a total of seven interviews performed in the first two phases of the development. Given the non-stochastic sampling and the fact that many aspects were confirmed by a majority of the interview subjects, a sample of this size was considered sufficient for meaningful data (Bernard, 2015).

5.3 Phase Three: Digital Mock-Up

The purpose of phase three was to refine the wireframe mock-up and increase the quality and level of detail. This phase consisted of ideation methods for changing and adding functionality to the concept as well as creating a digital mock-up for usability evaluation.

The ideation consisted of more brainstorming sessions where early design ideas and deliverables from the previous phases were considered together with new design ideas in order to improve or add functionality to the concept. The concepts were generated with motivational and instructional design principles (described in Section 3) in mind. The application was to allow the transmission of educational content via very low bandwidth network usage. Additionally, the only social aspects of the application were to be between teacher and student due to the risk associated with the organization of study groups. Educational content would be organized into courses to allow users to study according to preference. This content would be divided into manageable subdivisions in order to lend a sense of progression. With these attributes determined, wireframes were constructed in Adobe Illustrator and linked together in Marvel. This mock-up had a higher level of detail and displayed icons and buttons. The structure and flow of the application concept was constructed. Functionalities such as achievements and user interactions were also added.

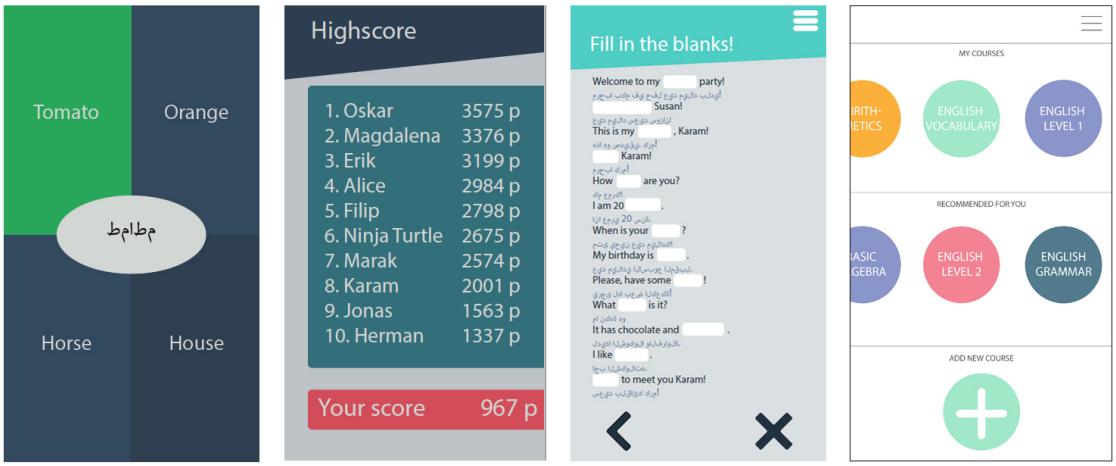

Figure 6: A number of examples of digital mock-ups

As a first step in ensuring that the application would exhibit sufficient levels of usability, theoretical usability testing was performed on the mock-up. Theoretical testing is done without the involvement of users. A Cognitive Walkthrough (CW) and a Predictive Human Error Analysis (PHEA) was performed on the most relevant use cases. The template used during these evaluations can be viewed in Appendix B. The CW highlighted interface deficiencies caused by incorrect assumptions of the user's mental models. One such example is the realization that users must be able to ask for hints during tough quizzes and tests. From the PHEA, possible errors, the consequences and severity of these and the possibilities for recovery were evaluated. For example, the option to cancel certain actions, navigating out from an active course and additional feedback after performing tasks had to be implemented.

5.4 Phase Four: Final Concept

The purpose of phase four was to create a final application concept and establish the definitive functionality and interface. This phase consisted of modifications resulting from the theoretical usability

evaluations, applying aesthetic expression, empirical usability evaluation and final modifications.

An expression board was created in order to summarize the aesthetic direction of the application interface. The expression board consisted of color schemes and graphics that were selected to match the persona's preferences. The aesthetic expression of the application strived to be modern, simplistic and serious, yet warm and inviting. Different themes were applied to the application interface and evaluated in comparison to the expression board.

Figure 7: A few examples of different aesthetic expressions

To assess the concept's level of usability, user testing was conducted with four participants. The only criterion for the participants was that they were students. It was hypothesized that young adult students had similar smartphone experience as the intended end users. The ethnicity and cultural background of the participants were not considered at this stage in the evaluation.

The user test consisted of three parts. The first part tested the understanding of icons and gathered information of previous smartphone app experience and digital learning tools. The second part was a practical test of the concept. The test subject was asked to complete six different tasks, ranging from navigating through educational content to interacting with quizzes and tests inside the lessons. The tasks and interview questions can be viewed in Appendix C. During this portion of the test, thinking out loud was encouraged to understand the test subjects' thought processes and their reasoning when performing certain actions. The last part of the user test consisted of an interview with questions about their experience using the application mock-up, as well as their likes and dislikes concerning the application. User input about the structure, coloring, text size, graphics and course sections was collected. The resulting data consisted of comments and observations which were used to further refine the concept.

5.5 Phase Five: Software Implementation

In order to enable validation of the concept's technical aspects, a functioning software prototype was built. The development of this prototype was initiated in the beginning of phase three with the

goal of providing a testable proof-of-concept. Development began with a basic mobile application capable of retrieving dummy data from a remote central database. The functionality of this basic core application was expanded as the design process steadily yielded a more clearly defined goal application. The application was built with the framework React Native with a backend application housing the educational content deployed on a Heroku server.

The project was divided into two separate development processes, namely the development of the mobile application and the development of a RESTful server application. Git was used for version control and the two applications were divided into two separate repositories. The addition of a new application feature would entail branching away from the development branch and then merging back to the development branch upon completion of the feature. Merging was done via a pull request which had to be approved by another developer. This forced a code review of each feature and gave rise to a shared familiarity with the different parts of the codebase. The design team was consulted to ensure the quality of the software and its compliance with the functionality present in the concept prior to each merging of the development branch into the stable master branch. During the development phases this was roughly once or twice per week, with a higher frequency during the final stages of the project.

A set of flexible development tools was needed in order to accommodate an exploratory development process. JavaScript is a high-level dynamically typed scripting language which lends itself well to the "quick-and-dirty" programming potentially required. Using JavaScript also allows for usage of the cross-platform development library React Native. With React Native it is possible to develop for both Android and iOS systems on the same codebase, with only a bare minimum written specifically in Java or Objective-C for Android and iOS respectively. This is preferable with a non-linear development process as changes to the app need only be made in one codebase.

The most significant software development challenges were all related to the refugees' unreliable internet connections. Two major application functionalities were developed to tackle these challenges. The first strived to minimize the size of the downloaded educational content in order to make the most out of the limited internet bandwidth. This was done by expressing educational content in a highly condensed form. Since all lessons shared a common structure, many of the graphical aspects common to all content were factored out and expressed in a short text format. The second functionality aiming to tackle the connectivity challenges took advantage of mobile background downloading. This meant that the application waited for the presence of an internet connection before automatically downloading the requested content.

A JavaScript codebase written with the React Native library fit the exploratory nature of the development well and enabled the software to quickly respond to design changes. The mobile application also provided two connectivity-related functionalities to be tested in Amman.

5.6 Phase Six: Validation

The purpose of the validation phase was to ascertain whether a solution fulfilling the product requirements would improve access to education among refugees living in Za'atari and Amman. With the product requirements in mind, such a solution should

1. Expose the users to relevant learning material
2. Maintain long-term use
3. Contribute to an increase in the knowledge of the user

The validation phase was conducted over a four day period on-site in Amman, Jordan. Access to the Za'atari refugee camp was not granted and therefore validation could not be conducted with the possibly critical users residing in the refugee camp. Due to the short duration of the validation it was difficult to discern long-term effects of the application. However, interviews focusing on the application's place in the daily life of the refugee were held in order to speculate on the long-term usage patterns. The interviews also served to assess the need for an educational application in refugee situations and if this need exists, how this application would preferably be used. This aimed to investigate points one and two in the list above.

Interviews and focus groups were conducted with six potential application users as well as the educational officer at JRS (see Appendix E) whose students could benefit from the application. These interviews were held with potential end users to determine the likelihood that the application would be used and understood. They were also used in order to gauge if users could learn through the application's lesson format which corresponds to point three in the above list. The interview questions and tasks can be viewed in Appendix D. The pilot courses were short courses in English and the diagnosis and treatment of fever. The learning material for the course in English came from a language education website. The borrowed material tested intermediate English concepts such as sentence structure and the use of questioning words. These intermediate concepts were seen as more appropriate for the testing users who themselves were not beginner learners of the English language. The course about fever was borrowed from Health Translation since the page provided material in both English and Arabic which therefore eliminated the critical translation procedure. The courses strived to demonstrate the fact that learning via a mobile phone could be useful and relevant to the users and led to active discussions.

Figure 8: User testing in Amman

The interviews at JRS shed new light on the uniqueness of each individual refugee situation. For some students in Amman, internet accessibility is not an obstacle. Their smartphones are used frequently, Wi-Fi is available in their apartments and they live within walking distance of the learning center. However, other refugees living in Amman do not own a smartphone and access the internet when visiting a learning center. There are also refugees who are able to borrow a device from a family

member which may have a limited data plan. The offline functionality of the application may therefore be less important for some and indispensable to others. This means that exposing users to relevant learning material (item 1 in the list above), is variably difficult for different user groups.

Early data collection showed that internet access was an obstacle for many refugees resulting in development focusing on minimizing the file size of downloaded courses. However, the validation process unveiled that students asked for content of different mediums than solely text, such as photos, videos and audio files. Students argued that a broader spectrum of content, especially visual content, would increase motivation and maintain engagement. Seeing as the internet access is not harshly limited for all students, the application should allow for multimedia rendering. Requirements should therefore reflect that motivation is more important than minimal file sizes, bearing in mind that some students still experience difficulties in accessing internet.

Another motivational aspect which was underestimated was the value of social learning. The possibility of meeting new and old friends at the learning center was a deciding factor in maintaining the engagement of the students. One student expressed this as,

"You need some motivation. You need to see people talking with you. It's not all about working. The social part. That makes everything easier."

A cultural aspect that had been overlooked was the interpretation of colors. In order to avoid affecting the users' choice of courses, the color scheme should be kept neutral. During a user test one student asked,

"[You chose pink] because you're a girl, right?"

The educational officer suggested that the app could connect not only teachers and students but also connect students who are studying the same course. This is a time-consuming process that is currently performed manually by the teachers at JRS. Long-term use of the application could be furthered by taking these social aspects into consideration.

The educational officer at JRS also expressed the need for the application content to connect to the actual material being taught at the center. This would allow the application to be used as a complementary study method and help students review the material covered in the physical classroom sessions rather than to be a stand-alone application for education. While exclusively providing this type of functionality would likely help enrolled students, it would do little to aid students who are turned away from the learning center.

An acceptable application solution would allow users to access educational content during a long-term period and positively affect the user's knowledge level. The efficacy with which the software fulfills these conditions was investigated through interviews in Jordan. Successfully fulfilling these conditions would imply that the application (and by extension the product requirements) adequately accommodate the education of refugees. The interviewed education officer and students showed interest in the application and saw its potential as a learning tool. Certain aspects surrounding motivation and social integration had however been deprioritized in previous development phases. By revising the product requirements, an application could possibly be developed that is designed to further maintain long-term use.

6 Results

This study has led to requirements that a software application should fulfill in order to support education in an unconventional learning environment. These requirements are the result of an empirical data collection with students living under these conditions as well as experts on the domain. To investigate the validity of the found requirements, a design concept and a software prototype were built and tested in Amman, Jordan. This chapter opens with the result of the data collection presented as six problem areas that hinder adult refugees from receiving education. Secondly, the product requirements attempting to tackle these problem areas are shown. In closing, the final design concept and software prototype used for validating these requirements are presented.

6.1 Contextual Challenges and Product Requirements

Data collected in interviews suggest that people displaced by armed conflicts and other catastrophes retain the ambition for education and personal development. The challenges preventing them from attaining these goals concern many different areas and are highlighted in this section. Thereafter, a set of product requirements for educational software to overcome these challenges are presented. These requirements are then examined with the data from the validation phase in mind.

The issues standing between refugees and their access to education can be divided into six main categories. These are displayed in the table below, along with quotes from the data collection phase which summarize the respective challenges.

Table 1: Problem areas derived from data collection.

Problem Area	Analysis	Quote
1. Financial	Refugees may face difficulties finding employment.	*"Refugees are not really allowed to work in Jordan without a permit, which is expensive to them" - Academic officer, JRS*
	Refugees may find education financially unfeasible.	*"If Jordanians pay one dollar per hour of education, we pay ten." - Student, JRS*
2. Distance and Transportation	Students living far away from learning centers rely on expensive transportation such as buses and taxis.	*"Students living far away can study, given a bus or taxi that takes them to the centre and back." - Academic officer, JRS*
3. Time	Refugees may have an excess of spare time	*"Its really a bit boring [...] Here in Jordan we don't have weekends as all our days are weekends" - Academic officer, JRS*
	Refugees in camps may be preoccupied with time-consuming tasks which can be made mutually non-exclusive with education.	*"They fill their day with uninteresting activities, so they might not have enough time to study. They perhaps need to stay in a queue to get food…" - Academic officer, Jamiya*
4. Resources	With the available resources, learning centers can not meet the demand of refugees wanting to receive education.	*"Applicants about 400, we can only serve about 200." - Academic officer, JRS*
5. Educational Level	Refugees that have been outside the education system for a prolonged period may experience knowledge regression.	*"Once education stops, students say they feel as if they get back to the first step." - Academic officer, Jamiya*
	It is difficult to create courses that accomodate different knowledge levels.	*"I think it's quite simple to be like for a university objects or something, but I'm doing something here, instead of doing nothing." - Student, JRS*
	English can not be considered general knowledge.	*"English is one obstacle we have. This course was provided in arabic." - Volunteer teacher*
6. Technology	Many users seem to have older mobile phones with limited performance and storage capacities.	*"No, of course not the newest, since they don't even have internet access [...] I don't know any name or model but they are from 2011 or 2012 or something." - Student, JRS*
	Internet access can be heavily limited for the refugees	*"The internet problem is not binary, not 0 or 1, but instead something in between." - Founder, Jamiya*

A number of product requirements were derived to tackle these problem areas. These requirements were divided up into main requirements and eligible requirements. The main requirements were seen as absolutely necessary while presence of the eligible requirements was merely favorable. Requirements one through 12 are present in both the final design concept and the prototype application and the additional requirements 14 through 17 are covered only by the design concept. The reason for the omission of requirement 13 was the practical difficulty with implementing course work which adapted to the knowledge of the user. The majority of the requirements are derived from the discovered problem areas, however some requirements relate to the previous studies in the field.

Table 2: Requirements derived from problem areas.

	No.	Requirment	Description	Problem Area
Main Requirements	1	Should enable the viewing of teacher created content	-	-
	2	Be compatible with older smartphone versions	iOS 8.0, Android 4.1.	5
	3	Enable studying without internet connection	The user should be able to finish a complete course without wi-fi or internet connection.	2 & 6
	4	Content should not contain superfluous material	Content should be expressed in a text-based format to minimize data traffic and storage capacity.	1 & 5
	5	Adding content should not require access to the local device	A teacher should not require physical or local access to a student's device to add new educational content.	2
	6	Should not place additional stress on teachers	The teacher workload should not be affected by an increased number of enrolled students.	4
	7	Should not require English knowledge	An Arabic-speaking user without English proficiency should be able to utilize all features of the application.	5
Eligible Requirements	8	Should be compatible with Arabic interface	The interface should support the right-alignment of the arabic language.	5
	9	Content should allow user interaction	The software must provide the ability to actively participate in education through quizzes and tests.	-
	10	Enable studying during shorter time periods	A level-adapted course should at most take 15 minutes to complete.	3
	11	Enable maintenance of knowledge	Finished courses should be repeatable.	5
	12	Quick resumption of latest session	The current lesson should be resumable by a maximum of two presses after the app has started.	3
	13	Allow level-adapted education	Users with differing levels of knowledge should be able to study at an appropriate level.	5
	14	Encourage continuous studying	The application should encourage the user to keep studying.	-
	15	Enable the user to see their improvement	The application should contain information about the user's performance over time.	-
	16	Enable educational help without internet connection	The user should be able to get help to continue studying without wi-fi or internet connection	5
	17	Enable communication with teachers	The application should enable the student to contact the course teacher	-

The validation phase yielded a new view of educational software for use in Amman. Certain requirements in the specification were revised as a result of this validation phase. For instance, requirement 2 was removed from the list of main requirements and appended to the list of eligible requirements as all potential end users that were interviewed in Amman had access to reasonably recent smartphone models. The validity of this reprioritization should however be further investigated with a larger sample size. Similarly, requirement 4 was removed from the specification for Amman in Table 2.

The students interviewed in the validation phase expressed the need for multimedia for reasons of motivation. They argued that the presence of visual and audial stimulation would make lesson content more engaging. While this would increase file sizes and contradict requirement 4, all of the interviewed students had regular access to Wi-Fi. As such, file sizes were not deemed to be a critical factor. A requirement was also added to reflect the desire for multimedial content. A cultural interpretation of the color scheme was also noticed and resulted in an additional requirement. Lastly, the students adamantly expressed the need for educational software to support the social aspects of learning. This is also reflected as an eligible requirement in the new specification for Amman.

Table 3: The revised list of requirements specific to Amman. Note the decreased priority of backwards compatibility as well as the addition of requirements 17 - 19

	No.	Requirment	Description
Main Requirements	1	Should enable the viewing of teacher created content	-
	2	Enable studying without internet connection	The user should be able to finish a complete course without wi-fi or internet connection.
	3	Adding content should not require access to the local device	A teacher should not require physical or local access to a student's device to add new educational content.
	4	Should not place additional stress on teachers	The teacher workload should not be affected by an increased number of enrolled students.
	5	Should not require English knowledge	An Arabic-speaking user without English proficiency should be able to utilize all features of the application.
Eligible Requirements	6	Should be compatible with Arabic interface	The interface should support the right-alignment of the arabic language.
	7	Content should allow user interaction	The software must provide the ability to actively participate in education through quizzes and tests.
	8	Enable studying during shorter time periods	A level-adapted course should at most take 15 minutes to complete.
	9	Enable maintenance of knowledge	Finished courses should be repeatable.
	10	Quick resumption of latest session	The current lesson should be resumable by a maximum of two presses after the app has started.
	11	Allow level-adapted education	Users with differing levels of knowledge should be able to study at an appropriate level.
	12	Encourage continuous studying	The application should encourage the user to keep studying.
	13	Enable the user to see their improvement	The application should contain information about the user's performance over time.
	14	Enable educational help without internet connection	The user should be able to get help to continue studying without wi-fi or internet connection
	15	Enable communication with teachers	The application should enable the student to contact the course teacher
	16	Be compatible with older smartphone versions	iOS 8.0, Android 4.1.
	17	Support multimedia content	The application should be capable of displaying incorporated multimedia content
	18	Encourage student-to-student interaction	The application should support and foster the social aspects of learning
	19	Use gender neutral colors	The application should not influence course choices by way of esthetic expression

Note that all data from the validation is applicable only to the situation in Amman. Educational software to be used in Za'atari may well still be susceptible to the harsh restrictions of low-bandwidth internet and other limiting factors.

6.2 Final Design Concept

The resulting application design concept was created with the requirements and relevant problem areas in mind. The functionalities of the application directly correspond to the requirements specification shown in Table 2. The concept provides education to refugees by acting as a platform for teacher-created learning material. This material can then be accessed by users in an environment which is far away from the nearest classroom. The application itself comes completely devoid of educational content. Users can download courses on topics of interest. The courses screen lists the courses currently saved to the device, the user's progress on these courses, as well as courses queued for download. Completed courses are also shown in this screen, should the user feel the need to repeat a course (which corresponds to requirement 11).

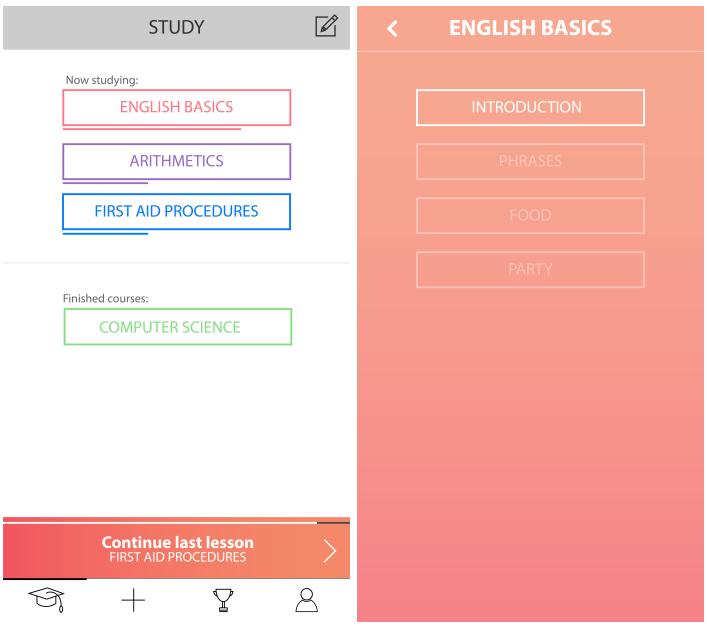

Figure 9: The main course list (left) as well as the lessons contained in a course (right).

To download additional courses the user can click the plus icon in the bottom bar. This takes the user to the course download page which shows the latest updated list of available courses. Upon clicking a course, the user is shown a course summary and is presented with the option to download. By clicking the download button, the user places this course in the download queue. The next time the application detects available Wi-Fi, the course is downloaded and persistently saved for offline use. This opportunistic downloading ensures that the user does not waste valuable data bandwidth by downloading while connected to the public network. This functionality addresses requirements

1, 3 and 5 as the downloading allows remote addition of educational content which can be perused offline.

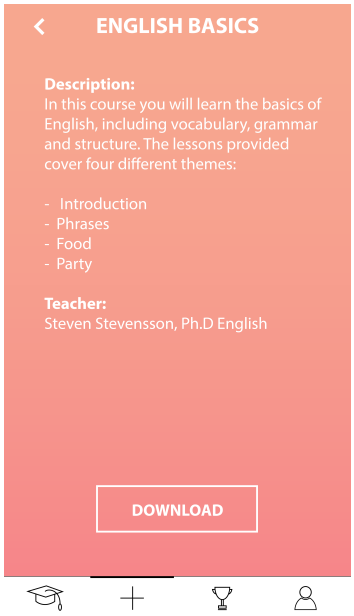

Figure 10: Detailed course information shown prior to download

The courses themselves are divided into a number of coherent subdivisions of content called lessons. These clear divisions of content give the user a frequent sense of completion and therefore correspond to requirements 10 and 14. Requirement 10 specifically states that the application should allow for interruptible learning. The irregular schedules of the user can be peppered with breaks too short to properly make use of. Users can find themselves spending long durations of time standing in lines. These types of everyday situations are perfectly suited to combine with education. In order to fit into the users' uneven schedules and allow for interruptible learning, the application saves the progress of the user at all times. The application should not punish the user for diverting their attention to a more pressing matter or putting their phone in their pocket. Upon return to the application, the user can immediately return to their position in the last active lesson corresponding to requirement 12. In addition, the division of courses into short lessons and the presentation of lesson summaries upon finishing lessons give frequent rise to a sense of completion. This makes the user feel comfortable in interrupting their learning and studying in short sessions.

Figure 11: The button to resume the last active session

The lessons are comprised of slides containing text and interactive elements that display information and test the user's understanding. These interactions answer to requirement 9. During a focus group at JRS in Amman, a student expressed his thoughts on the sectioning of the learning material, first presenting informational content followed by an interactive quiz.

"It's a good way. It's teaching me immediately, like the information you get, it sticks in your mind immediately."

It is important to note that the exact shape and content of the lessons are determined by the teacher responsible for the course. The application itself merely contains the functionality to display the course material created with the possible lesson elements. Should the student require assistance with any part of the course, it is possible to contact the responsible teacher via WhatsApp according to requirement 17. Offline hints are also present within the lessons if the user is unable to find a network connection. The figures below represents the final concept of a quiz, a lesson- as well as a course summary.

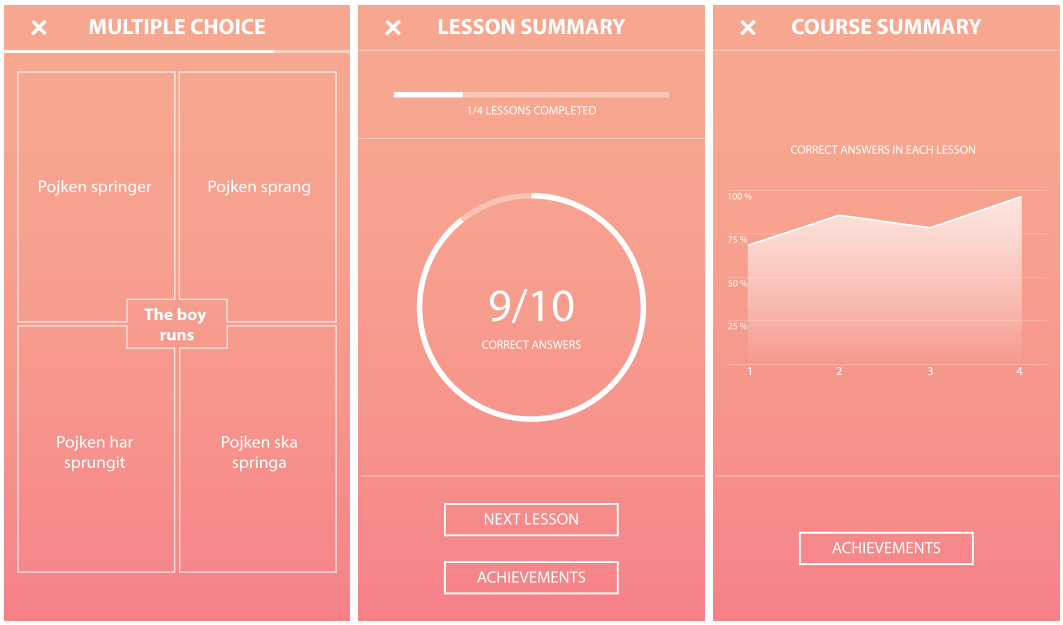

Figure 12: An example of an interactive quiz (left), a lesson summary (center) and a course summary (right).

Recurring use of the application is essential for drawing the full benefits of education. The application has motivational features in the shape of achievements to motivate users to return to their learning. The user can earn achievements by studying for prolonged periods of time or showing academic diligence and act as viewable user statistics. Achievements seek to further motivate the users by fulfilling requirements 15 and 16. The achievements are viewable by clicking on the icon in the bottom bar. During a focus group at JRS in Amman, a student expressed his opinions on the achievements feature.

"I prefer every time you do a test and you get an award or achieve something. This keeps you move on, step by step, to achieve."

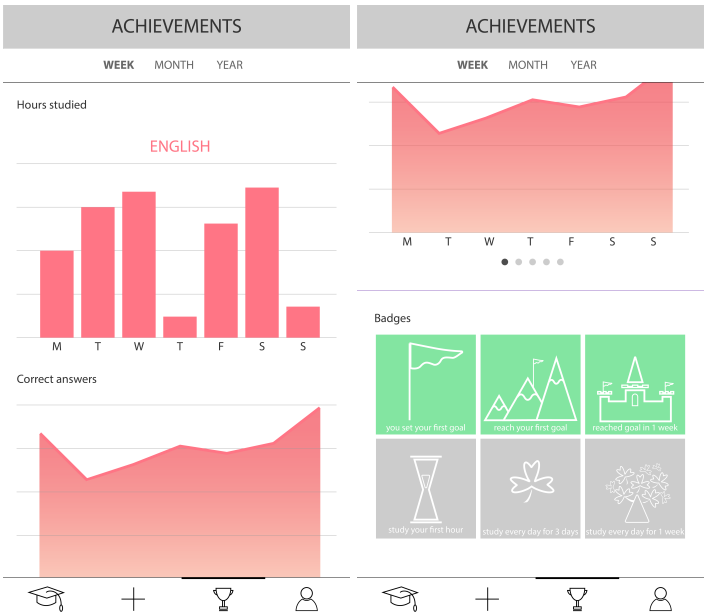

Figure 13: Achievements view in the final design concept.

The last icon in the bottom bar takes the user to the profile view. This presents the user with his or her personal information as well as the teachers responsible for the users' courses. The user can also toggle the language of the application between English and Arabic which is expressed in requirement 8 in order to make Arabic users feel at home. Apart from translating the text in the application, selecting Arabic language settings causes the application to flip from the western left-to-right alignment to an Arabic-friendly right-to-left alignment.

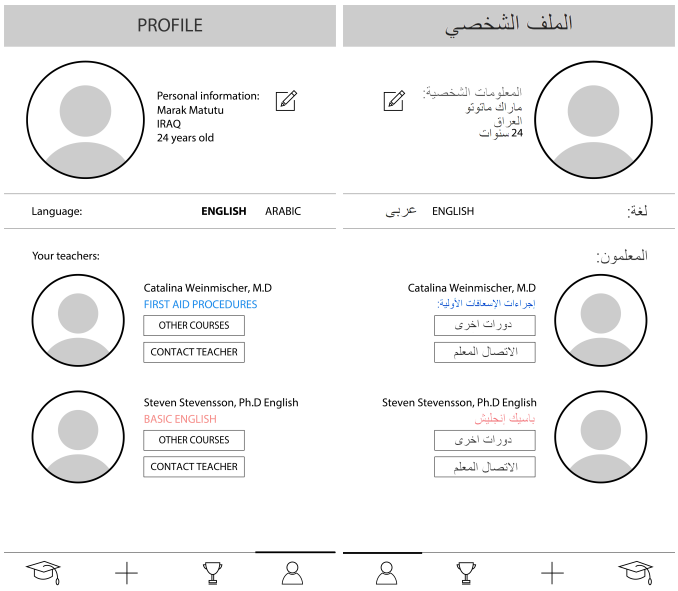

Figure 14: Left-to-right and right-to-left alignment as well as language settings

6.3 Software Prototype

The prototype application was not equipped with all the functionality of the design concept. Functionalities such as Achievements and the ability to contact teachers were not present. Instead, development focused on functionalities pertaining to internet access as these are impossible to test with design mock-ups. Special importance was placed in the offline availability of educational content. Content should be downloadable as needed and should be persistently stored for offline use. Functionality pertaining to the profile and achievements screens was deemed to be efficiently testable with the design concept. The developed software focuses on the various aspects of course rendering and interaction. The application permits Arabic alignment, offline accessibility and interuptible learning. The screens of the developed application prototype can be seen in Appendix F.

In this chapter, a structural overview of the smartphone application is given before discussing problems and solutions associated with the sporadic availability of internet bandwidth.

The codebase for the backend[1] as well as the frontend[2] can be found at GitHub.

6.3.1 Architectural Overview

The mobile application has been developed with the Redux-framework which encourages the use of an amalgamation of package-by-feature and MVC structures. The application is roughly divided into reducers (which change the global app state and correspond somewhat to the "M" in MVC), components and containers (the rendered segments of the user interface, corresponding to "V" in MVC)

[1] `https://github.com/iyor/dbEDU`
[2] `https://github.com/iyor/packEDU`

and action creators (which respond to user input to evoke changes in the state, corresponding to the "C" in MVC). The reducers and action creators are divided into different areas of responsibility and are connected in a pair-wise fashion. For instance, the reducer in `active_course_reducer.js` responds to the actions in `active_course_actions.js` which are in turn produced by users interacting with the currently active course. These systematic subdivisions of application functionality make it simple to add new features and limits the amount of code to be understood in order to completely grasp a given feature.

As with any React-flavored framework, the user interface is divided into self-contained components. When using React and Redux together, these components retrieve any data they require from a central global state object known as a store. Components emit simple actions when reacting to user input. The logic handling these actions is located in a reducer which is connected to the store. The separation of the app state and logic from the UI components allow for creation of so-called dumb components. These dumb components contain no internal state themselves and only reference the store. When the app state changes, the components automatically re-render.

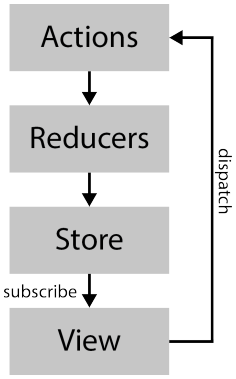

Figure 15: Uni-directional flow of a Redux application

The app state in the store is an immutable map-like data structure where every change to the state returns a new copy of the state. In order to further align the application with the security associated with immutability, the JavaScript library Immutable.js was used to handle all properties of the state connected to the components.

The mobile application uses a number of utility functions in order to make network requests, convert the replies of said requests into renderable lesson content, and to persistently store content to the smartphone's internal storage. This code is located in `lib/` and is accessed by both actions and reducers.

The application backend was built using the JavaScript runtime Node.js. The Node.js backend allows for a homogeneous development environment, with both the frontend and backend applications written in JavaScript. A major advantage of using a Node environment is the ability to easily dispatch asynchronous events. This is highly convenient when developing server applications that are to be concurrently accessed by a number of users (Vaddineni, 2014). The server is built with the Express framework and provides a RESTful API to the mobile application. The mobile application can make requests to the server which the server then routes to the appropriate mongoDB database function in order to retrieve the requested information.

The server application is hosted on the Heroku platform which allows for easy deployment from git. Heruko offers the possibility to push to the Heroku-cloud directly from the project repository. Heroku then automates the building of the project, according to the dependencies and instructions listed in package.json.

6.3.2 Non-Binary Internet Access

A hugely difficult aspect of development concerned the refugee students' non-optimal internet connections. In order to avoid preloading the app with lesson content and to allow students to access new courses, the app requires some sort of connection to a central database. Beyond this, the app should not rely heavily upon an internet connection. The information received concerning conditions in the refugee camps suggest that internet access is sporadic and unreliable, but not nonexistent. As such, the application relies on the internet solely for course downloading. Courses can be downloaded at Wi-Fi hotspots or NGO buildings and are persistently saved on the local device. These downloaded courses can then be accessed offline at any time. The downloading for persistent storage concerns product requirements 3 and 5.

When the application is running in the background of an android unit, it will be periodically woken up by the operating system. During this brief wake-up period, the application checks the internet connection's status and if a connection is available, proceeds to fetch courses queued for download. For iOS devices however, the operating system does not allow applications to be run in the background if they are not related to e.g audio playback or geolocation tracking. Instead, the operating system lends requesting applications roughly 30 seconds of activity to perform background fetches, which can be used for the same purpose as the Android device. Download behaviour will differ slightly between operating systems, as the fetches occur sporadically for iOS devices and periodically for Android devices.

6.3.3 Lesson Markup Language

The courses are downloaded from the central database formatted in a human-readable markup language. The markup language contains the building blocks used to create lesson content similar to the way HTML is used to build websites. This markup dialect is adapted for displaying interactive lesson content and is locally parsed and rendered to JSX components. Sending the lessons in a markup language allows for smaller file sizes transmitted across the web as well as smaller save files on the local device. For an arbitrary lesson consisting of two text slides and a quiz, a side-by-side comparison shows that the markup language has an estimated file size of roughly 30-40% of the raw JSX-elements (see Appendix G). This reduction in size corresponds to product requirement 4.

The currently available markup tags are:

`<slide>`
The root element in which all elements of the current lesson screen are contained. Each lesson consists of a number of slides which the user swipes between.

`<text>`
The basic text paragraph element comparable to the `<p>` element in HTML.

`<bullet>`
Similar to the text element, but is preceded by a bullet point.

`<heading>`
Larger and bolder text. This element is comparable to `<h1>` in HTML.

`<interaction>`
An element which awaits user interaction. The element requires the attributes type (to tell what type of interaction is expected), answer (which functions as an answer key), and an evaluator id (which specifies which evaluator script is to be used to grade the interaction). An example of a fully functional interaction element tag is:
```
<interaction type="multiple_choice_quiz" answer="Isaac Newton"
evaluator="58edd59af36d2878e4382daf">
```

`<choice>`
A choice element for multiple choice-style interactions.

The parsing and conversion of these markup language elements is done in `lib/slideCompile/`. The markup is converted from a long string into fully functional JSX components that can be rendered by React Native. The available components are located in `containers/elements/`.

6.3.4 Interactive Course Elements

An additional space-saving feature of the lesson markup language and the onboard parser is the handling of interactive course elements. The current interactive elements are quite simple and the app currently offers multiple choice quizzes, flash cards and fill-in-the-blank type quizzes.

Quizzes and tests require an evaluation script to correct and grade small assignments. A downloaded course payload carries a list of the required evaluation scripts. If these evaluation scripts have not been previously saved, they are downloaded and saved to the local device for future use. All interactive quiz elements extend the abstract base class `Interaction`, which states that an interactive element checks the user's answer against an answer key with the specified evaluation script. By clearly defining the behaviour of the application and its use of evaluators, future development can include more advanced evaluators for pronunciation practice, oral quizzes or handwriting practice. These more advanced quizzes can be fully supported by the app in its current state as long as they in some way check user input against an answer key.

6.3.5 Supporting Older Devices

React Native is compatible with an overwhelming majority of smartphones. Older Android units are prevalent in refugee camps and to ensure a responsive performance on these devices, the navigation between screens had to be as efficient as possible. Most mobile applications store the navigation history allowing a user to step backwards to previously visited screens. This causes performance hits in React Native and significantly slows the application. To remain compliant with older and slower devices, the application does not save the history when switching between the four tabs of the bottom bar. Furthermore, all animations during screen switches have been removed to enable a swifter navigation through the application. These optimizations for older smartphones are in line with product requirement 2 in Table 2.

It is of particular importance to ensure compatibility with a wide variety of mobile devices in order to reach as many people as possible. React Native is supported by Android 4.1+ and iOS 8.0+ (*facebook/react-native*, 2017). This gives coverage to 98% of Android devices and more than 95% of

devices running iOS (*Dashboards*, 2017; *App Store*, 2017). In particular, this means that many of the phones present in Za'atari are compatible with the developed application. The validation phase presented the modernity of the mobile phones of most students enrolled in the JRS learning center in Amman. This suggests that the smartphones belonging to refugees in Amman do not impose critical restrictions on the software solution.

7 Discussion

The prototype application and final design concepts draw heavily from work previously done in the areas described in section 2. The connection between these various fields of study and the software prototype, final design concept and validation results are discussed. Additionally, design and developmental choices which compromise the legitimacy of the validation are touched upon. Because the project resulted in an exploratory prototype, further development should be done before a functioning software solution can be released to the public. As a final note, possible steps to further this development are suggested.

7.1 Relation to Existing Studies

In order to provide education to people living in unconventional conditions it was first required to decide a medium with which to do so. Previous studies suggested that e-learning both improved student performance and that teachers were already turning to technology for educational support. The decision to develop a mobile application was based on the wide availability of smartphones among young adults living in the Za'atari refugee camp. The main technological obstacle for the application is the unpredictable internet connection. The interview with the technology domain expert shed new light on the connectivity in the Za'atari refugee camp and contrasted the study from 2015. Access to internet has become much more restricted in the past two years. In order to overcome this hindrance, two technical tactics were employed. A markup language was created to minimize file sizes during download and secondly, downloads were scheduled to only be performed in the presence of an adequate internet connection. While these functionalities somewhat lessen the reliance on the internet, they do not completely remove the need for an internet connection. It is also worth mentioning that the internet detection functionality is a potential source of significant battery drainage because the application needs to be periodically awoken. Interviews during the data collection phase mentioned frequent power outages in the refugee camp. The application could therefore possibly reduce battery time in an environment where recharging can be a challenging task.

The network connectivity obstacle also affects the style of the lessons. In section 3.1, it is mentioned that the modality effect benefits learning. The modality effect arises when both audial and visual perceptions are involved in the learning process. It would therefore have been favorable to include both pictures and sound files in lesson content. However, the ability to view educational content containing these types of multimedia was cut out of the application as they would have greatly increased file sizes. Suboptimal learning material was deemed more useful than optimal content which would be unreachable by the user.

The mobile format does however come with certain instructional design benefits. Design principles like segmenting (the division of complex content into smaller, manageable chunks) and weeding (the exclusion of unnecessary, redundant material) promote user-friendly learning and are intrinsic to the mobile platform. Due to the small screen sizes, teachers will be forced to partition and prioritize the content to be presented. The application itself might therefore promote proper instructional and educational design principles and avoid overwhelming the student.

A number of different strategies are employed to encourage users and achieve long-term usage. Gamification elements such as achievements are present in the final design concept to give users a sense of progression which is vital for motivation. The division of courses into separate lessons is

done to lend a sense of progression as well. The lesson and course progress bars further underline the user's accomplishments. The user experiences instant gratification when answering correct questions. These gamification factors all contribute to a long term usage.

One feature which could have further ensured long-term usage, is the enabling of social networking interactions as stated in section 3.2. The ability to interact with other users to form study groups was proposed but rejected as a result of the workshop with Jamiya officials. In this workshop it was brought to light that the formation of unsanctioned groups was restricted in the Za'atari refugee camp. Even benign groupings could make authorities suspicious of illicit activities. A certain level of social interactivity is however present in the student-teacher relation. The design concept incorporates the possibility to contact a teacher via WhatsApp or similar chat clients to ask for assistance.

7.2 Sources of Error

The design process that shaped the final concept and software prototype was dependent on data collection and user tests. These methods greatly influenced the decisions made during the development process. However, the methods used contain a number of possible error sources which could have led to a suboptimal prototype and design concept. For instance, the remoteness of the end-users was an ever-present difficulty in the development.

The optimal source of information would have been a theoretically representative sample (Bernard, 2015). A theoretically representative sample is a non-stochastic sample where each subject has to meet certain criterias that are regarded specific for the user and the user context that it is meant to represent. In this project, such a sample would consist of people living in a context similar to Za'atari and Amman. However, because of the singular user situation and large geographical distances such a sample was not realistic during phases 1 and 2. Although the data gathered from interviews cannot be regarded as a theoretically representative sample, it is still a non-stochastic sampling. Hence, the sample size of seven can be considered adequate according to Bernard (2015). This indicates that the reliability of the data collection is high, while the validity can be questioned due to the gap between the interview subjects and the actual end users. The validity of the on-site tests in Amman can similarly be questioned. The user tests were conducted only with students that had been admitted and enrolled in courses at the Jesuit Refugee Service. This could be an example of a biased selection and might have contributed to a skewed view of the end users in Amman.

The remoteness of users similarly affected many of the evaluation methods used. User tests were not conducted with Arabic speakers. Therefore the user testing needed to assume a great deal of similarity between the way western and middle-eastern ethnicities perceive interfaces. This can be seen as rather presumptuous due to the two user groups reading from opposite directions. However, data collection suggests that Arabic users are well-adapted to western-oriented interfaces as these are often shipped as default in applications and operating systems. A related issue was that the data collection phase suffered from a lack of field studies and observational tests. These data collection methods would have been an invaluable source of information to quickly gain insight into the lives of the inhabitants of Amman and Za'atari as there can be gaps between reality and what is said in an interview. Possible errors in the interpretations of the interview data could have led the ideation phases astray.

Another potential source of error in the project was that it was difficult to evaluate the application and concepts in complete isolation from the coursework. The application functions as a vessel for

content. Thus, it is challenging to test the application without also implicitly testing the educational content. Results from the user tests which touched upon the lessons could easily be muddled by content itself. Users had to be consciously steered away from focusing of the content presented as the creation of content lay outside the scope of the project. It was also difficult to convey the limitations of the design mock-up when performing the user tests in Amman. Test users stressed that the "app" should be faster and display real educational content. Due to the polished representation of the concept, much of the feedback was directed towards small graphic details and the performance of the mock-up rather than the functionality provided. Simple sketches or wireframes might have created a better platform for discussion, opening up for ideas on a higher level of abstraction. However, the polished representation of the application might have enabled users to see themselves actually using the software and therefore contributed to more realistically grounded feedback.

In summary, the main challenges of the project surrounded the inaccessibility of the end users. Certain measures were taken to minimize the potential pitfalls of a remote user base, such as using a non-stochastic sample group when interviewing. Nevertheless, the fact that the interview subjects were non-representative of the target group could very well have contributed to a skewed domain understanding and a suboptimal solution. However, field studies and interviews with refugees held in Amman contributed with a nuanced understanding of different situations among refugees. In an optimal scenario, this visit should have been conducted in an earlier phase.

7.3 Further Development

The largest undertaking required to publicly release this application is related to the teachers who must supply the platform with educational content. The educators would play a vital role in a platform that aims to provide education to refugee environments as it is their learning material which is presented to the end user. The current state of the application requires learning material to be written in dense, albeit readable, markup language format. While it is completely possible to create this lesson content by writing the markup by hand, it would be a cumbersome process for teachers. A further development would entail an online editing application that could allow for simple graphical editing of lesson slides. A teacher could drag-and-drop slide elements to easily build lesson content. This graphical representation of course content could then be translated into the markup language in a process which would simply be a reversal of the markup-to-graphics translation currently present in the application. While the technical basis of this second application is already enabled, its development would imply the need to perform a second teacher-focused data collection phase. It would need to be known what tools are required by teachers to create effective educational content.

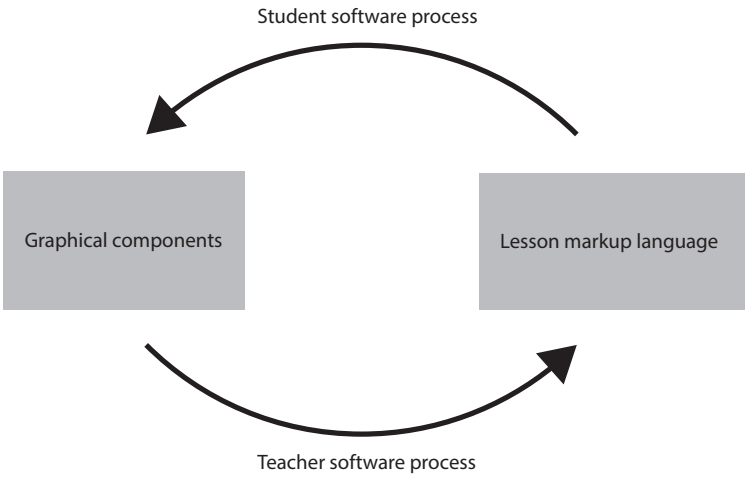

Figure 16: Schematic picture of the conversion between the lesson markup language and graphical components.

An equally important part of developing a full-scale education platform would be to ensure proper distribution of the application. There is an unfortunate circular dependency between teachers not willing to devote time to create content for a platform devoid of students and students not willing to use a platform which is devoid of content. A possible way to tackle this issue is to perform small-scale pilot projects to hopefully act as convincing evidence of the viability of mobile-learning in refugee crises. It might be possible to collaborate with the learning centers of Amman and Za'atari, to incorporate the application into the education of enrolled students and students turned away as a result of the capacity issues of learning centers. If usage of the application positively affects their level of knowledge, the evidence in favor of educational software in refugee situations could be strengthened and possibly convince more educators to partake in the creation of educational content. The application would have the chance to be distributed on a larger scale and could hopefully contribute positively to the education of refugees.

A further distributive measure in Za'atari could be to enable spreading the application via bluetooth peer-to-peer sharing. Students could easily pass the application executable to their friends and family and as such completely bypass the need for internet. The bluetooth solution could be further developed to encompass the transmission of courses between users living in camp.

The internet bandwidth required by the application could be further minimized. The predictive and repetitive structure of the markup language is ideal for compression. According to Shannon's information theory, information which is of low entropy (or randomness) permits a high loss-less compression ratio. In other words, the predictable structure of the course content lends itself well to data compression (Lombardi et al., 2015). This could allow for even smaller file sizes being transmitted and could truly allow for minimal network usage when downloading courses. Educational content could be compressed by the server application, transmitted across the internet, and then decompressed by the mobile application, thus significantly decreasing the internet bandwidth required.

Early research and data collection resulted in the requirement that content should not contain superfluous material in order to minimize file sizes. This was based on research in Za'atari which described the limited internet connection and restricted data plans of the residents. In contrast, the validation in Amman showed that refugees in the city who own smartphones access the internet easily through both Wi-Fi hotspots and personal data plans. The application requirements could be divided into two parts, adapting each part to the circumstances of the users in both Amman and Za'atari. All students who participated in user tests at JRS, stressed that the motivation would increase if content was displayed in multimedia formats. Students also suggested competitive gamification functionality such as a scoreboard visible to students enrolled in the same course and the possibility to advance to higher levels when studying. Further development should look into how content could be viewed in order to increase chances of long-term usage of the application by introducing different medias to display content to the users in Amman.

This study was focused solely towards Amman and Za'atari in Jordan. User tests, interviews and focus groups were however only performed with potential end users in Amman. In order to determine whether the product requirements are feasible in Za'atari as well as in other emergency situations, further validation of these should be performed in the relevant environments.

To perform similar studies in the future one must take the complexity and diversity of refugee crises into account. For instance, adult refugees in Jordan come from various different countries in the Middle East and Africa. This means that they have differing cultural backgrounds, religion and experiences, leading to a wide variety of educational backgrounds, experience levels with technology and financial situations. These factors need to be taken into consideration when designing for the user group. There are currently non-governmental organizations working to provide education to refugees. Rather than reinventing the wheel, it is important to realize that the actors already involved in the education of refugees have a plethora of knowledge that they are often more than willing to share. These organizations maintain regular contact with members of the relevant user group and can act as middlemen for contacting end users. Initiating collaborations with these organizations can maximize the efficiency of further projects.

Additional factors to bear in mind are related to the field testing with actual end users. It can be difficult to prepare field studies with users who are inaccessible to the engineer. One might have minimal knowledge of the end user prior to the field study which can lead to a diffuse planning stage and test users inappropriate to the study. Moreover, displaced people waiting for asylum are equally likely to stay in the same place for years as they are to suddenly leave if their asylum application is approved. As such, there is an uncertainty inherent to field studies performed in refugee situations. To more thoroughly understand the user situation, time should be spent outside test environments to reduce the stress that a test can put on the user. If possible, casual and conversational interviews can be held in the user's own environment, visiting their workplace, favorite café or a casual walk in the city.

The furtherment of the application is highly dependent on the inclusion of teachers into the educational platform. In order to develop a complete application, the creation of course content by teachers would have to be optimized. The distribution of the application is also an important challenge. Devising a strategy to increase the spread of the application among both students and teachers is a decisive step in improving education for refugees. By launching pilot projects with the help of a small number of learning centers, adequate evidence of the usefulness of the software could be found. With a well-grounded solution and a solid kernel of users, the application could possibly gain enough traction to make a sizeable impact in the educational situations of people living in refugee conditions.

8 Conclusion

The project aimed to find requirements for software supporting the education of displaced people. This resulted in a series of 19 verified product requirements that were used to develop a design concept as well as a software prototype. These were then used to validate the product requirements through interviews and focus groups in Amman, Jordan. The challenges when designing for inaccessible users became apparent during the validation stage and cannot be overstated. When collecting data pertaining to inaccessible users, it is possible that details and finer nuances will be lost in the distance between engineer and user. It is worth bearing in mind that there is no average refugee and that the situations of all displaced people are unique.

Investigations unearthed new connectivity conditions in the Za'atari refugee camp, revealing that internet access has been starkly restricted in the past two years. This strongly affected the requirements specification and the application prototype, which itself can act as a starting point for further software development. The software is fully capable of supporting a sister-application to be used by teachers to create educational content to be made available by the developed platform. The study also found that although the social aspects of learning can greatly motivate and benefit a student, the formation of study groups is highly restricted inside refugee camps. Social learning software should therefore be developed with utmost care.

The requirements were adapted solely for the student-facing software and further developments should be directed towards data collection focusing on teachers and pedagogues. Teachers are a vital facet of the overall solution as they are the providers of educational content. In addition, a plan for distribution to the end users should be formulated to maximize the impact of the learning software.

The education of refugees is an important part of increasing the quality of life for displaced people. By utilizing modern e-learning principles, the scarcity of teaching resources in such environments can be bypassed. With a human-centered design approach the suitability of a possible education solution can be ensured. The results of this report offer a starting point in the creation of such a solution.

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Appendix

A Persona and Scenario

A.1 Persona

Marak is 23 years and was born in Syria. For the past two years, Marak has been living together with his family 40 minutes outside central Amman, Jordan. Back in Syria, Marak attended university in order to become a dentist but after he and his family were forced to leave Syria for Jordan he has not been able to continue his studies as planned. This is mainly due to the high enrollment costs at the universities in Jordan. Moreover, transportation costs from the suburbs into central Amman are an expense that Marak's family cannot afford on a daily basis. Marak's family do not have access to internet and therefore taking online courses on a regular basis are not an option either. Even if they did have internet, Marak's English skills are not particularly strong which limits the range of online courses he could potentially enroll in. Instead of studying, Marak spends his days playing football with his friends and helping his family with chores.

A.2 Scenario

Every Saturday Marak's family goes to the city center to run errands. In Amman, Marak seizes the opportunity to use internet on his phone to contact friends through social media. Last week Marak found out via a facebook ad that there is a learning center in the city that provides English courses to refugees. Marak thinks that learning English would be valuable to him, especially since his family is thinking about moving to another country in the future. This Saturday there is a placement test at the learning centre and when Marak arrives, he realizes that he is not the only one taking the test. There are approximately 100 people taking the test. Marak does his best, but after the test he is told that his results were not good enough to garner a spot at the learning center. "Maybe it's best this way", Marak thinks to himself on the bus back home. "Either way, I couldn't afford going to the center three times a week".

B Usability Evaluation

Table 4: This table shows the template used for cognitive walkthroughs and predictive human error analysis

CW and PHEA		YES/ NO	WHY?	PROBLEM	NOTES
1.	Will the user try to reach the right goal?				
2.	Will the user notice that the right action (to reach the goal) is available?				
3.	Will the user associate the right action with the corresponding effect?				
4.	If the action is carried out, will the user register that it brought her/him closer to the goal?				
	What action can the user do wrong in the right moment? What action can the user do right in the wrong moment? What happens if the user doesn't complete an action or excludes and action? What happens if the user completes the actions in the wrong order?				

Misstake	Reason	Consequence	Detection	Recovery

C User Tests

C.1 Tasks

These are the tasks preformed by the test users in phase four. The test began with a short introduction to the project and followed by the tasks below:

1. You've been studying for a while during the morning and are now keen to continue your studies from where you last ended. How would you do that?
2. That session was quite quick. You were planning on studying english for a bit longer, how would you do that?
3. It seems like the level of this course is too low for you and therefore you decide to delete it from your course library to make room for other, new courses. How would you do that?
4. You feel curious about how your studies have been going lately and want to check the statistics in the app. Please do so.
5. You're out walking with a friend who recommends a course for you, called Linear Algebra. You want to add it to your course library immediately but you're out of internet data. How do you cope with that?
6. Now, you want to repeat a course in First Aid Procedures that you finished last week. How do you proceed with that?

C.2 Interview

The following questions were asked after the test person had performed the tasks in the user test:

1. How easy/hard did you find the tasks? Why?
2. Was there any task that was particularly hard? Which one and why?
3. How did you experience the course elements? Hard to understand - easy to understand. Why?
4. Was there anything about the interaction with the app that you found nice? Please specify.
5. Was there anything about the interaction with the app that you think could be improved? Please specify.
6. Where there any functions that were good in your opinion? Why?
7. Where there any functions that wasn't very good in your opinion? Why?
8. Please describe the app with 3 words.
9. How did you experience the interaction with the app? Intuitive - hard to understand.
10. How did you experience the coloring of the app? Appealing - not appealing
11. How did you experience the size of the text? Too big - just right - too small.
12. How did you experience the contrast of the test? Very good - Very bad

13. What are your opinions about the achievement page? Was there anything you would've like to add?
14. Further comments.

D User Tests - Validation in Jordan

D.1 Pre-Test Interview

Note: the text written in italic are probing questions that were asked when appropriate.

1. Please tell us a little bit about your background and how your experience with education has been.
2. What does your daily life look like? Please tell us about a regular week.
3. Did you study before you came to Jordan?
4. Why do you want to study?
5. What makes you feel motivated to study?
6. What makes you continue your studies?
7. Is there anything that you find especially problematic when it comes to your educational situation? *Level of education, course offering, practical obstacles such as transportation to the learning centre?*
8. How would you like your educational situation to be like? Feel free to dream big.
9. Do your friends in similar situation (refugees) study?
10. If no, why do you think they don't study?
11. What do you think would make your friends study?
12. Do you think they would like to study with a mobile application?
13. How much time would you like to spend studying every day?

D.2 Test of Application

"We have built a concept which gives an idea of what a study app could look like. We would like to show it to you and hear your ideas and input on how to make it better. To test the app we will ask you to try different functions. It would be great if you tell us what you think, positive and negative thoughts and especially if you have ideas on how to make it better."

1. **Add course** - So if you would like to study a course, what would you do to add it?
2. **Remove course** - If you would like to take it away? What would you do?
3. **Study an English course** - We have prepared some simple courses to show how the application could be used. Let's try it out.
4. **Understanding of summary achievements** - This page shows how the course went. What is it that you see? Does this kind of information motivate you to keep studying?
5. **Understanding of general achievements** - This page shows your progress. What is it that you see? How would you like to follow your progress? What do you think of this page? *Does it motivate you to keep studying?*

D.3 Post-Test Interview

1. What are your thoughts when you see this app?
2. What kind of apps do you use today? Western or Arabic? Is the flow different?
3. How could an app like this help you in your studies? *Distance Transportation, lack of internet access?*
4. What kind of educational content/courses do you think would be suitable in this kind of application?
5. If you were to use an app like this, would you like to keep contact with the teacher?
6. If yes, how would you like that contact to be? *When would you like to contact? How often? Through WhatsApp?*
7. What would make you feel motivated to study with a mobile application?

E Interview with Academic Officer at Jesuit Refugee Service in Amman, Jordan

Note: the text written in italic are probing questions asks if necessary.

1. Last time we spoke you told us that the interest of your English courses were very high. How has the interest evolved since?
2. The students that apply for your English courses, have they any previous experience with learning English? *E-learning or classroom based.*
3. What happens to the students who don't pass the placement test?
4. What are your thoughts on e-learning?
5. How do your students respond to the MOOCs that JRS provide from Georgetown?
6. Do the students have any other alternatives to study if they don't get accepted to Georgetown?
7. How are the MOOCs/English material distributed? Does the studying demand internet access?
8. Do you have any ideas about what would be helpful for you as a teacher to ease the study situation of your students?
9. Could a mobile application be used as a complement in your current courses?

   Show application

10. What are your thoughts when you see this application?
11. What kind of educational content/courses do you think would be suitable in this kind of application?
12. If you were to use an app like this, would you like to keep contact with the students through the app?
13. If yes, how would you like that contact to be? *When would you like to contact? How often? Through Whatsapp? What is the contact like now?*

F Software Application Screens

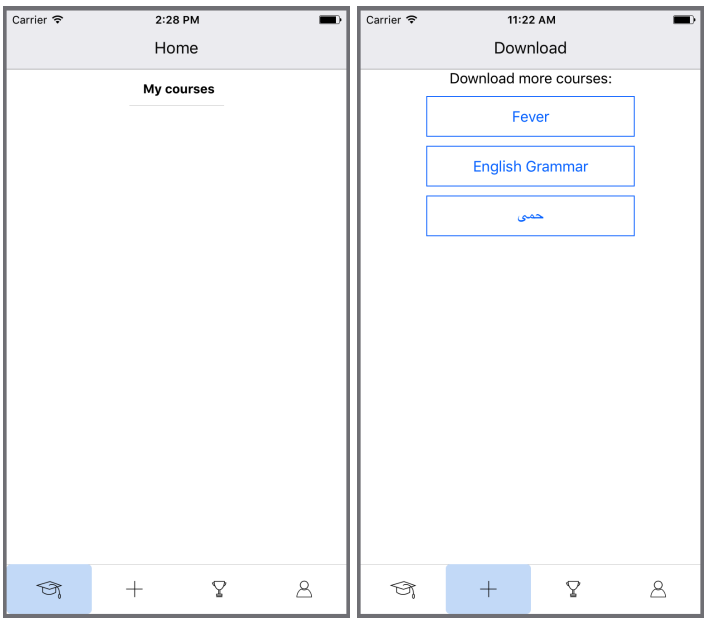

Figure 17: The view of all local courses as well as remote courses available

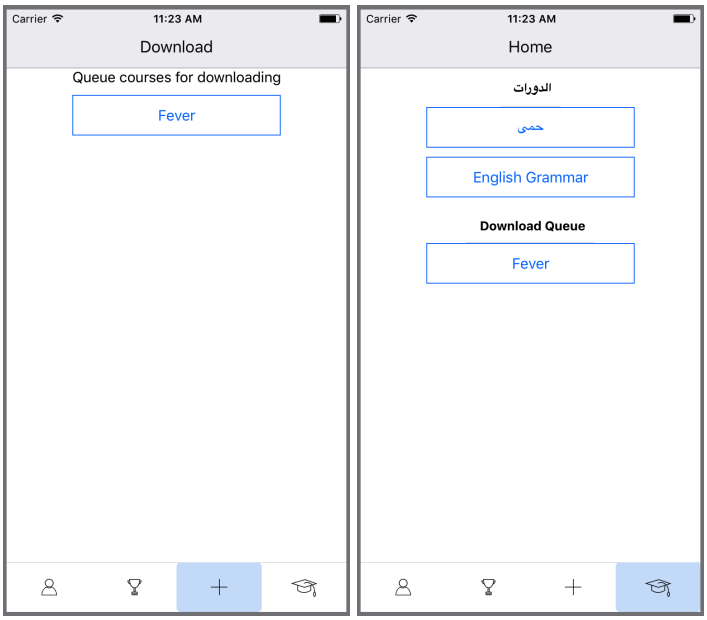

Figure 18: The view for the available courses (left) as well as the download queue (right). Note that the alignment is set to Arabic alignment

Figure 19: English-to-Arabic and Arabic-to-English alignment conversion

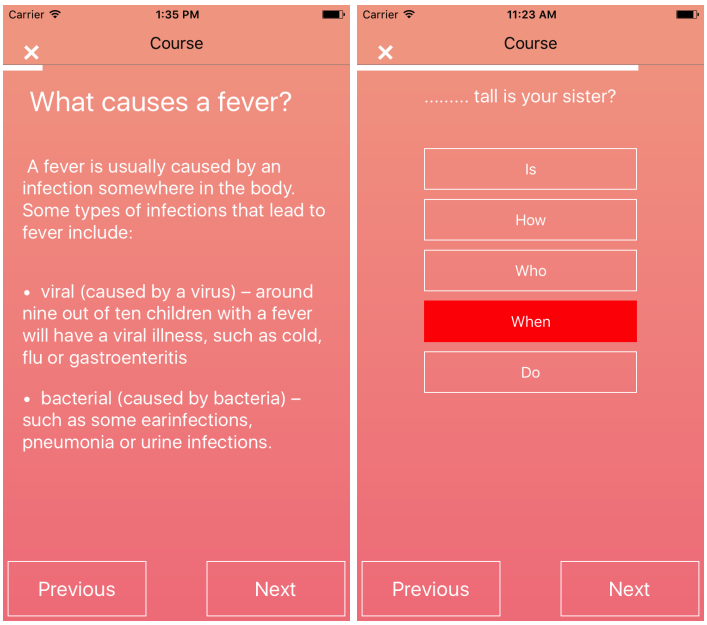

Figure 20: Text slide as well as a multiple choice quiz for a lesson

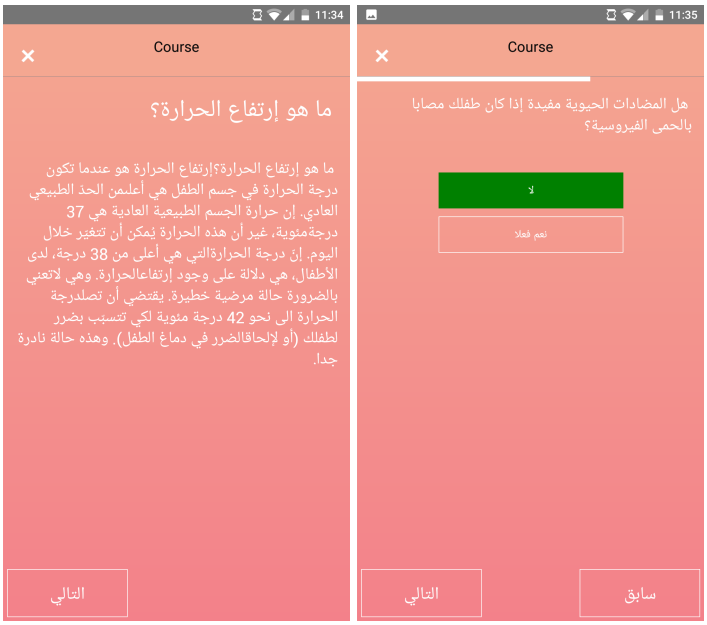

Figure 21: Arabic course with Arabic alignment. The "Next" button is now placed on the left side, and the "Previous" button is on the right

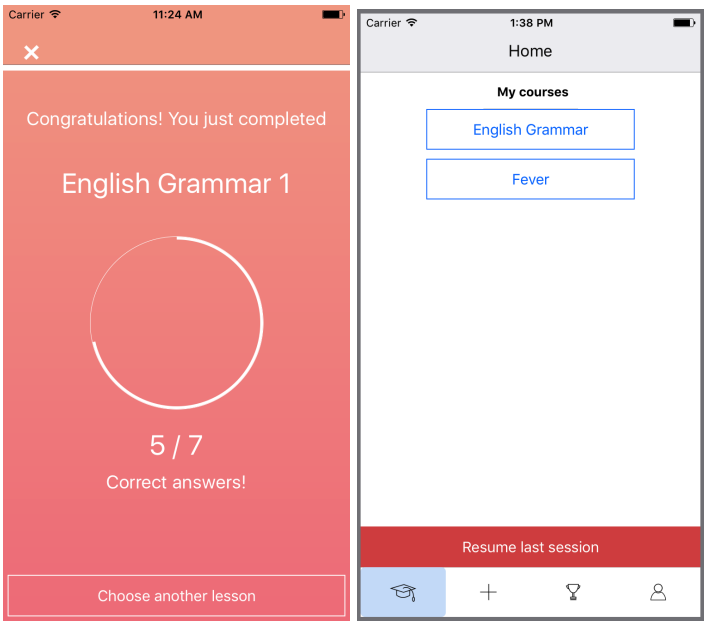

Figure 22: A completed lesson as well as the resume last session option

G Lesson Markup Language and JSX Comparison

```
<slide>
    <heading>What is a fever?</heading>
    <text>
        A fever is when your child's body temperature is higher than normal.
        A normal body temperature is about 37º Celsius but this can vary during the day.
        In children, a temperature over 38ºC indicates a fever.
        It does not indicate a serious illness. A fever needs to reach about 42ºC
        to cause harm to your child (or damage their brain). This is very rare.
    </text>
</slide>
<slide>
    <text>What is normal body temperature?</text>
    <interaction type=\"multiple_choice_quiz\" answer=\"38\" evaluator=\"58edd59af36d2878e4382daf\">
       <choice>37</choice>
       <choice>38</choice>
       <choice>40</choice>
       <choice>42</choice>
    </interaction>
</slide>
```

```
<Content>
   <Header><View style={{flex:1, alignItems: 'center', padding:15}}>
      <Text style={{fontSize:20, color:'white'}}> What is a fever? </Text>
   </View></Header>
      <View style = {{flex:2, padding:15, marginTop:15}}>
         <Text style = {{fontSize: 20, color:'white'}}>
         A fever is when your child's body temperature is higher than normal. A normal body temperature is
         about 37ºCelsius but this can vary during the day. In children, a temperature over 38ºC indicates a fever.
         It does not indicate a serious illness. A fever needs to reach about 42ºC
         to cause harmto your child (or damage their brain). This is very rare.
         </Text>
      </View>
</Content>
<Content>
   <Header><View style={{flex:1, alignItems: 'center', padding:15}}>
      <Text style={{fontSize:20, color:'white'}}> What is normal body tempertature?</Text>
    </View></Header>
   <View style={{marginTop:20, flexItems:1>
      <Button bordered style={{borderColor:white}} onPress = {() =>
         {evaluateAnswer(37) ? style={{borderColor:green, backgroundColor:green}}:
            style={{borderColor:red, backgroundColor:red}}}}>>
         <Text>
          37
         <Text>
      </Button>
      <Button bordered style={{borderColor:white}} onPress = {() =>
         {evaluateAnswer(38) ? style={{borderColor:green, backgroundColor:green}}:
            style={{borderColor:red, backgroundColor:red}}}>
         <Text>
          38
         <Text>
      </Button>
      <Button bordered style={{borderColor:white}} onPress = {() =>
         {evaluateAnswer(40) ? style={{borderColor:green, backgroundColor:green}}:
            style={{borderColor:red, backgroundColor:red}}}}>
         <Text>
          40
         <Text>
      </Button>
      <Button bordered style={{borderColor:white}} onPress = {() =>
         {evaluateAnswer(42) ? style={{borderColor:green, backgroundColor:green}}:
            style={{borderColor:red, backgroundColor:red}}}>
         <Text>
          42
         <Text>
      </Button>
   </View>
</Content>
```

Figure 23: The lesson markup language (top) and JSX graphical components (bottom). Note the difference in length between the lesson markup language and graphical components.