About usability of mobile e-learning applications on an example of an UML-Quiz

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Abstract: *In this paper we investigate the challenges of interaction design of mobile e-learning applications on an example of a quiz. Starting with the evaluation results of a previous application (UML-Quiz^{iOS}) to facilitate mobile e-learning for our students at our university and based on related research and technology in this area, we re-designed, re-developed, and re-evaluated a new version of the same quiz by optimizing its usability and interaction mechanisms. The resulting UML-Quiz^{Android} supports the learning process in a lecture of the computer science bachelor program at our university, called object oriented modelling techniques. It facilitates a playful way of understanding and implicit learning of differences between diverse modelling techniques. Our first evaluation with students and some other users show very promising results that we present and discuss in this paper.*

Key words: *e-learning, usability, evaluation, mobile e-learning.*

INTRODUCTION

Mobile devices became an important technology for everyday life. These devices also found their way into classrooms. There are many applications, which promote the learning of different types of users by helping them to understand difficult contents in a playful way. Besides different ways of classroom assessment [16], students at universities need to assess their knowledge before the exams. Many students have still the problem of easily losing motivation for learning.

At our university we use an e-learning environment based on Moodle, called TUWEL (TUW E-Learning, tuwel.tuwien.ac.at). The most courses we offer in computer science programs are organized in TUWEL. Time schedules, documents we provide for our students, work assignments, marking, etc. are the main components we use for the administration and management of our courses. We also use the community functionality and communication channels that Moodle facilitates. Unfortunately, how we use TUWEL is not enough to call its application "blended learning". TUWEL only offers additional support for the communication between the lecturers and students by being mainly a document management system and organiser at the same time.

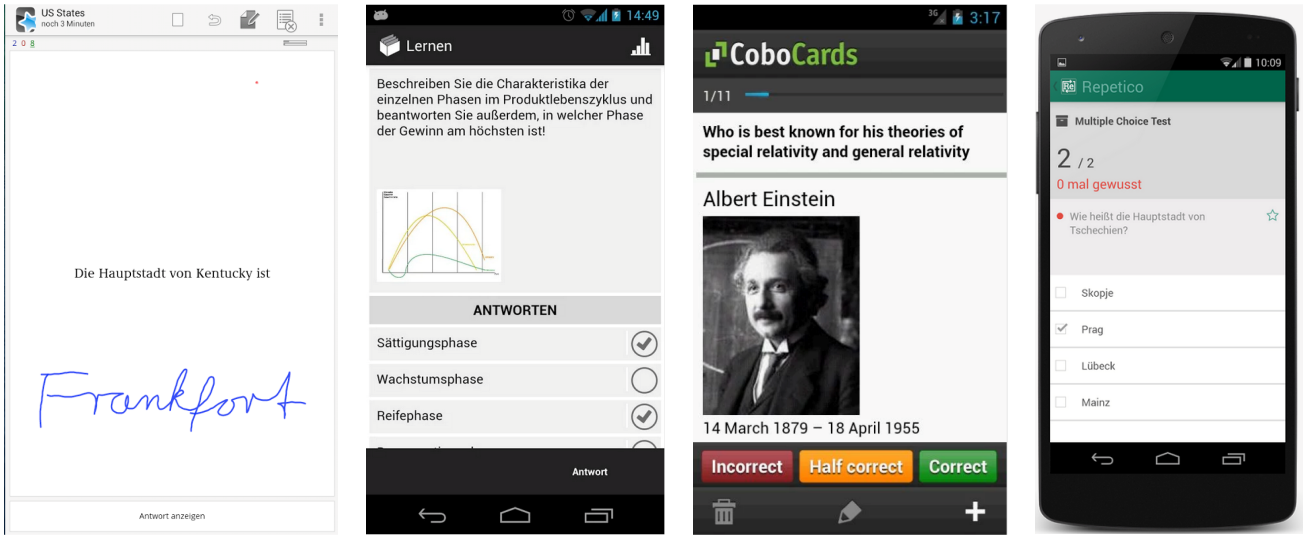
To improve the learning success of our students, especially in the computer science bachelor studies, we want to explore new ways of supporting learning. Some used quiz as an effective way to engage students in the classroom. Even using a simple true/false quiz to motivate students to react immediately and to share their viewpoints and opinion with others can support the participation of students in a course and the success in learning [5, p.197]. Considering quiz as a possibility to "engage students in fundamental play and enjoy a challenge while teaching them" [6, p.428], one of our students has already designed and developed a quiz, called UML-Quiz^{iOS}, to facilitate learning unified modelling language (UML) in a specific course, called object oriented modelling techniques [17] [18]. This quiz is based on Apple's iOS. The evaluation of this application resulted in several factors that needed to be improved in future work. We continued in developing UML-Quiz^{iOS} by mainly focusing on the usability issues of its interaction mechanisms and improved it in several ways. We re-designed, re-developed, and re-evaluated it and the result is UML-Quiz^{Android}. We studied usability issues of UML-Quiz^{Android} interaction mechanisms. This paper is about the analysis and presentation of our results.

In the next section we present the related work on mobile e-learning applications on different platforms and with different features. Then we briefly present the UML-Quiz^{Android} before we show the evaluation results. Finally we discuss the usability issues we found in our analysis and conclude our paper.

RELATED WORK

In this section, we first want to compare four other mobile e-learning applications for the Android platform we selected from the Google Play Store (Figure 1). Our focus is on there interaction design used for implementing a quiz. From layout design and content points of view these four applications are the most relevant ones for our study. Our goal for the comparison was to find out the best interaction mechanism for an e-learning quiz application: 1) to display mixed content on a small device like mobile phones, and 2) to motivate end users to use their mobile devices to access the quiz because they find it highly usable and flexible. The latter should build the base for the improvement of our users' learning process.

- "Ankidroid" [2] is an application for learning flashcards. Its design is simple and flat. It uses ActionBar on the top. The layout design provides enough space to show the question and answers of a quiz item.
- "Brainyoo" [3] has been found as one of the best applications for displaying a quiz with a question and an image as well as displaying answers with text and images. On the top there is an ActionBar. The question can be shown with an image. It is possible to click on the image and switch it to full screen and back. The possible answers are displayed below the image.
- "CoboCards" [4] is very similar to Brainyoo. There are only two differences. On the top of the content area there is a progress bar, which shows the current card number and the number of cards left. In the content area there is a line between the question area and the answer area.
- "Repetico" [11] shows perfectly the combination of grey scales inside the content area to divide the question and the answer area.



Ankidroid [2] **Brainyoo [3]** **CoboCards [4]** **Repetico [11]**

Figure 11. Four e-learning quiz applications selected as examples from the Google Play Store to study the user interface and interaction mechanisms

The user interface of an application and its interaction design are very much defined by the platform the system is implemented for. There are several libraries for GUI (graphical user interface) elements, usability guidelines to follow, conventions established for interaction mechanisms, and best practice examples for different platforms, what we of course considered in our study. Comparing iOS and Android platforms informs us for our design. We found out that the following two factors play an important role in this matter:

- One major difference between the two platforms is the Back-Button [15]. In

Android the Back-Button is used to navigate backwards in an application. If one application interacts with another application it is possible to switch back to the main application with this additional button. This is very useful if you quickly want to change something on the screen or read something in another application and go back to the controller of this event. Many users miss the Back-Button in iOS applications. A Back-Button has an essential place in the architecture of such applications. That is why developers have to consider including a Back-Button from the beginning of the design process. To integrate a Back-Button into an application from scratch it is necessary to create an activity diagram because it is crucial to configure and administer the access of each activity onto the App-BackStack. This means that if one presses the Back-Button to switch to the application's main menu, the App-BackStack has to know which activity was the previous one in order to load it again.

- Another difference is the so-called ActionBar. The ActionBar is a small menu on the top of a screen of a mobile application. It can be used to place an individual help for the displayed activity or a menu to switch back to a specific previous activity.

These two major differences between iOS and Android applications and the ways how the compared four applications (Figure 1) implemented a quiz with respect to layout and display options inspired us to improve the interaction design of the existing UML-Quiz^{iOS} [18]. By using the functionalities of Back-Button and ActionBar and by considering the display alternatives shown in the studied systems we built a new application with better interaction mechanisms and with more space for displaying the important things of a quiz, namely the questions and answers.

UML-Quiz^{Android}: THE APPLICATION

The new version of the UML-Quiz^{Android} is an Android application as an e-learning quiz. It supports the learning process of students in the course object oriented modelling techniques. It helps to learn differences between diverse modelling techniques. It is playful and very informative at the same time. We ported the main content and business logic of the UML-Quiz^{iOS} and improved its usability based on presentation and interaction mechanisms. Figure 2 shows the main interfaces of the UML-Quiz^{Android}.

On the one hand we applied Back-Button [15]. On the other, we used the ActionBar feature to display a tutorial for the current quiz or to switch to a settings menu for changing default settings of the displayed round of the quiz.

We chose participatory design as the software process model in this work [10]. The process was evaluated by a group of students as well as by several persons with no university degree as potential users of the application. We had in total 12 users: They were people between 25 and 55 years old, some used similar applications on their own mobile devices, and some with the aim to learn certain content in a very efficient way. These users evaluated the different interaction possibilities and helped the development team to make decisions in critical moments. After this evaluation phase several functions and display options have been updated. Some parts of the final version are presented in Figure 2.

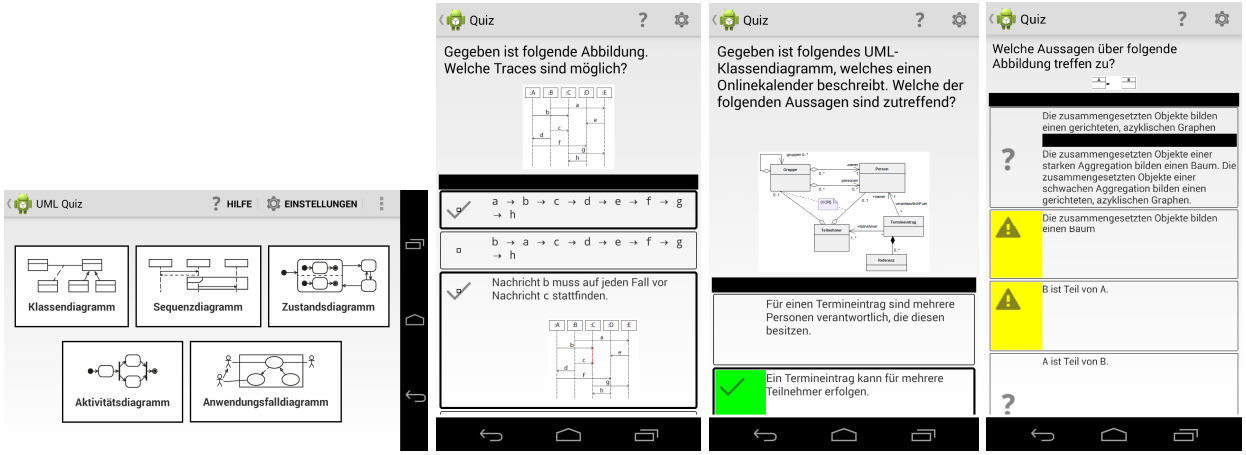


Figure 12. UML-QuizAndroid: The main menu to choose between different UML diagrams to start a quiz (left), the question page showing the question and options for answers (middle), the feedback page showing the correct answer (with the colour green), and the explanations to each wrong answer (with the colour yellow) (right)

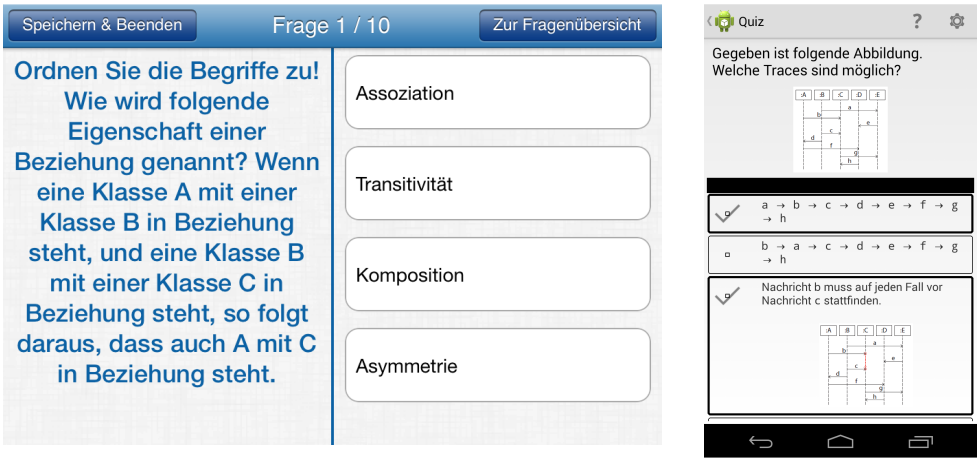
EVALUATION RESULTS

After having several evaluation sessions with our users, we modified our application UML-Quiz^{Android} and the result is shown in Figure 2.

The most important change we made is the orientation of the screen that shows the question and answers (Figure 2, middle and right image). There are several reasons for that: This quiz is available on a mobile device. Our users want mainly use it while they are traveling in the city whenever they have time, e.g., while waiting for public transportation or being in a bus or tram traveling from one place to another. One wants to keep one hand free while moving in a city. The UML-Quiz^{iOS} was only usable horizontally and that is why two hands were always occupied. This means that one had to hold the device with one hand and answer the questions with the other. We solved this restriction in UML-Quiz^{Android}. For one hand usage of the quiz, we had to layout it vertically.

The consequence of having the layout vertical than horizontal, we had to think about the layout of the questions and answers (Figure 3). In UML-Quiz^{iOS} the screen was divided into two parts. The left side was the area for questions and the right side for answers. Questions contained normally a question text and an image illustrating the context of the question. Answers displayed the options to choose from. Both areas were vertically scrollable, which was after a while very confusing for the users because they easily lost the overview of current questions and answers. Additionally the application was not usable for left-hander because questions could only be answered on the right side by putting almost the whole arm all over the device. At the same time the users found that the horizontal view of the quiz was not "natural". They expected to have the questions on the top and the answers below the question. They also required a scrollbar to scroll the view vertically. The scrollable view enables even using long text for questions and several options for answers.

Usability in terms of accessibility was improved by enabling zooming into the images displayed both in questions and answers. It is possible to display an image bigger on the screen of a smart phone by tapping on it. This is very often necessary to see the details in the images before answering the question. In UML-Quiz^{iOS} magnifying was only provided for images in questions and not in answers.

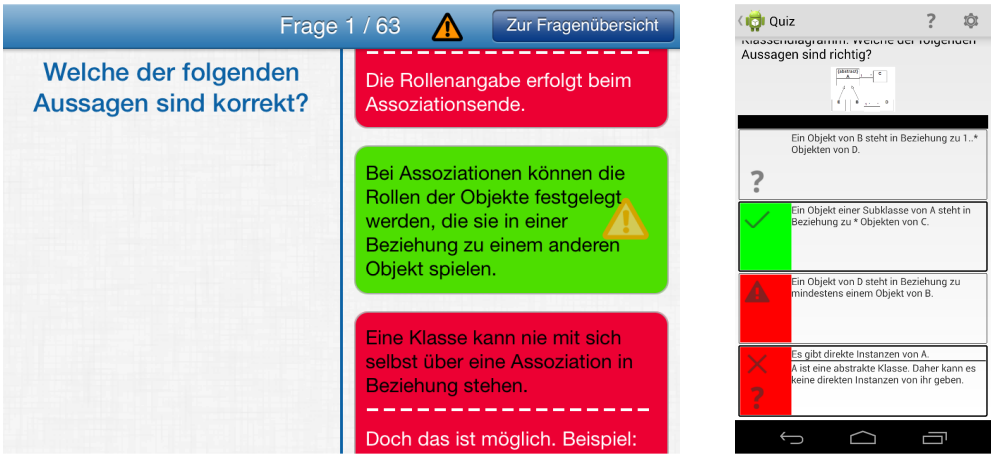


UML-Quiz^{iOS} **UML-Quiz^{Android}**

Figure 13. The question/answer interface of the UML-QuiziOS (left), the same of the UML-QuizAndroid (right)

Feedback to the user has also been improved. First, we modified the feedback for interaction: In UML-Quiz^{Android} checked answers are displayed with a bigger border and a checkmark on the left side (Figure 3, right image) while in the UML-Quiz^{iOS} only a check mark was displayed on the right side. Second, we considered additional learning support in the feedback mechanisms of the quiz: We developed a new view for showing the result of an answered question. Not only showing what answer is the correct one, we also tried to explain why is an answer a correct one and the others are wrong. This helps the user to understand the reasons for answers and this way it helps learning by answering quiz questions.

The arrangement of a feedback page is of course a very delicate issue. Details about the single answer options fill in normally the whole space available on the screen, and one can easily loose the overview of the overall content of the quiz item. We used colours and symbols to make this easy for the users (Figure 4).



UML-Quiz^{iOS} **UML-Quiz^{Android}**

Figure 14. The feedback page of the UML-QuiziOS (left), the same of the UML-QuizAndroid (right)

In the UML-Quiz^{iOS} correct answers were green and false answers were red. If there was a feedback text to the answers this was displayed in the area of the corresponding answer. This caused naturally much more text in the little half sided area and less overview of the whole content. Moreover if an answer was tapped as true there were check marks and warning symbols. These were sometimes irritating, if a red

highlighted answer had a check mark.

In addition users with a dyschromatopsia (red-green blindness) had problems to understand this way presented feedback. In our solution we combined the feedback mode with a settings menu. In the settings menu it is possible to select a colour scheme, which should be used for displaying right and wrong answers. This means that people with dyschromatopsia can choose their own colours that they can differentiate. Moreover it is possible to select if the whole answer is highlighted with the chosen colour or only the left side of the answer.

We changed the symbols used in UML-Quiz^{iOS}. If an answer is true a check mark is displayed on the left side. If an answer is false a cross is displayed on the left side and the answer is displayed in another colour than the colour used for true answers. Furthermore if there is a false answer, which is not checked by the user, the feedback view puts a call sign in front of it and colours it as a wrong answer to make this explicit for the user. In case there is a feedback text for an answer available, a question mark is displayed on the left side of the answer. If the user taps on the answer the feedback text is displayed. Tapping again closes the feedback text. This means that the user has the possibility to gradually learn why an answer is false.

DISCUSSION

It is important to consider the well-known usability guidelines in mobile applications, especially if these contain different types of data like in a quiz. Besides presenting the data user-friendly the navigation throughout the system needs to be designed properly.

The first important thing is how to display text on mobile devices. The text needs to be formatted in a way that users can easily capture the whole text and all other related data presented in the same context. A technical text with formulas can be read slowly than any other type of text. It is reduced to 75 words per minute [1]. Reading a text on a screen decreases the reading speed additionally by one third [7]. The length of a text like in a question or answer of a quiz is an important criterion for acceptance and usage of the application.

Second, the layout of the displayed text is significant. In the whole application only three different fonts should be used [8]. These fonts could be used to construct a layout that emphasizes specific information and helps to understand the process when information is displayed differently. Though reading is easier if the text is justified, but this is a problem in Android applications. So, left adjustment is the convention established in this matter.

Third, we need to concentrate on emoticons and symbols. These elements help users to understand the context of displayed information faster and guide them in navigation in a page in a certain way. Symbols help users with colour blindness. However, not everyone knows the meaning of a specific icon. That implies that there must be an information site, which describes the used icons.

Using emoticons is positive for interpersonal communication but does not improve the learning itself [9]. In fact a happy or a bad looking emoticon is not interpreted on the same way in different cultures [12]. This means that the use of symbols and emoticons should be tested for usability to find out the perception and interpretation of these symbols by different persons [14]. This helps to find the perfect balance in choosing the symbols or emoticons for an application.

Combined with the appropriate colours the positive impact of symbols increases. The EVADIS II Standards declares that only four colours should be implemented in an application [13]. Our choice of colours for UML-Quiz^{Android} has been corrected several times during the user evaluation. Partly we removed colours and used stronger borders to highlight selected items. Finally, we ended up in a homogenous design including the colours and layout parameters.

An introductory activity helps users to get familiar with an application and its interaction possibilities if displayed the first time the application has been started. Users are guided through an introduction to the application. This should be not repeated too often.

Our application can be configured by its users. A live preview of the settings becomes important, e.g., if a user changes the colour schema of the feedback view a preview of the feedback display must be available. Users then can adjust their choices.

Navigation is the last topic we want to mention. There must be a clear path through the application that is communicated with the user. In our application, first the user must select an UML diagram, then the learning box, following the number of questions of the quiz. Users have to go through these steps if they start with a new quiz. So, they learn how to proceed with the application. If this interaction is not designed well, users do not remember next time what to do, and are easily confused and furthermore demotivated to use the system.

CONCLUSION

In this paper we have shown that elements of usability and interaction are particularly important for an Android application. We presented the second version of the UML-Quiz, UML-Quiz^{Android}, a mobile quiz on Android to support learning of UML modelling. Usability and acceptance by the users are very important factors for our design work. We tried to present these issues in detail, by giving several examples and design implications. Our main goal is to support learners with a mobile quiz which is easy to produce and easy to access from anywhere. We analysed content, layout, and navigational elements of such a system from usability point of view, and presented our findings.

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The paper has been reviewed.