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Development and Evaluation of a User Interface for an E-Learning Game

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Bachelorarbeit

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Erklärung

Hiermit versichere ich, dass ich diese Bachelorarbeit selbständig verfasst habe. Ich habe dazu keine anderen als die angegebenen Quellen und Hilfsmittel verwendet.

München, den 15. Oktober 2012

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Zusammenfassung

Termina zählt zu den e-learning Spielen sowie zu den sogenannten "games with a purpose". Das Spielprinzip besteht im Finden von Assoziationen zu einem gegebenen Fachbegriff. Die Implementierung des Spiels ist zwar bereits vollendet, jedoch war die Benutzeroberfläche von Termina nur als temporärer erster Entwurf gedacht. Die Hauptaufgabe dieser Bachelorarbeit ist es, eine neue grafische Benutzeroberfläche für Termina zu erstellen und zu evaluieren. Um diese so intuitiv und leicht bedienbar wie nur möglich zu gestalten, wurde bei dieser Arbeit nach dem Ansatz des User Centred Design vorgegangen, der zwei Nutzerstudien mit Teilnehmern beinhaltet, die aus der zukünftigen Zielgruppe stammen. Die neue Benutzeroberfläche des Spiels scheint benutzerfreundlicher und leichter bedienbar zu sein als die Bisherige und die Resonanz aller Teilnehmer - besonders derer aus der zweiten Studie - war durchwegs positiv.

Abstract

Termina is an e-learning game with a purpose ("GWAP") that asks its users to name associations to a given term. Although the implementation of the game itself was already completed, Termina's first user interface was only meant as a temporary first draft. Designing and evaluating a new graphical interface for Termina is the main task of this bachelor thesis. In order to create a user interface that is as intuitive and easy to use as possible, the User Centred Design approach was applied, including two studies with participants belonging to the future user group of Termina. The new user interface of the game appears to be more user-friendly and easier to use than the previous one and the reactions of all participants - especially in the second study - were very positive.

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1. Introduction

According to the International Organisation for Standardisation, the usability of a product is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [5]. In addition to this, the meaning of the word usability also includes any method that can be applied to improve the ease of use of a product [17].

Thirty years ago, the usability of software was severely neglected as developers were almost solely concentrating on the functionality of their product. Today, ensuring that a product is easy to use has become one of the most important design steps to the success of new software. As computers are becoming more and more powerful and network connections are getting faster, the patience of users is diminishing by the minute. In the 21st century, creating a website that is difficult to navigate is simply out of the question, because as soon as users have to learn how to use a website first, the great majority of them will leave it instantly [23].

Designing an intuitive graphical user interface for the new e-learning platform Termina is the purpose of this bachelor thesis. The basic idea of Termina is to help students prepare for their exams by asking them to find accurate associations to given terms. Players are rewarded with points when they find correct associations and try to collect as many points as possible. All associations given by students are saved and can be reviewed by the lecturer and his assistants helping them to find out whether students have understood the lecture or not. As the implementation of the game itself was already completed, this thesis focuses on improving the usability of the software. In order to accomplish this task, the User Centred Design approach is applied, which includes intense user research during the design process.

This thesis is structured as follows: After this introduction, topics related to this project are discussed. Then, an explanation of the necessary steps that were undertaken before evaluating the new design concept is given as well as a summary of the outcome of the first study. Afterwards the development of the final design of Termina and the results of the second evaluation are described. Finally, the thesis concludes with a summary and future prospects for Termina.

2. Related Work

2.1. Games With a Purpose

Even though a tremendous progress has been made over the years concerning the performance of computers, there are still some problems left that cannot be solved by them. Not only would computers need to be more efficient and much more powerful to be able to find solutions to those problems, but they also lack several skills that the human brain has perfected through thousands of years [28]. Creativity and intuition are just two examples of capabilities that come natural to humans but are very difficult to achieve with computers. A lot of effort has already been made to use the capabilities of the human intellect to solve those large scaled problems rather than waiting for computers to improve significantly. A very popular approach to this is to hide the problem solving aspect behind an online game. These games are called *games with a purpose* and their mentioned purpose is to collect a large amount of data. Thanks to the Internet, millions of people can contribute to this data-gathering without even knowing it [28].

2.1.1. The ESP Game

One of the most popular field of applications for games with a purpose is the collection of labels for images. So far, the results of algorithms used to overcome this problem automatically are less than satisfactory. "The ESP Game accomplishes the same task through a simple online game" [28] and was developed by Luis von Ahn at the Carnegie Mellon University in Pittsburgh [15]. Two players are paired together at random and the same image is presented to both of them. Both players are asked to guess what word their partner would use to describe the given image and have to enter their assumption. As soon as both of them have typed the same term, the next image is presented to them. The partners are rewarded with points for each word they agree on. The aim of the game is - of course - to collect as many points as possible. Some images might have taboo words associated with them which cannot be entered by the players to make it more difficult for them to come up with an identical label. It should be mentioned that both players cannot communicate with each other. The ESP Game appears to be "extremely popular, with many people playing more than 40 hours per week" [28].

2.1.2. ARTigo

ARTigo (www.artigo.org) is a variation on the ESP Game that emerged from the collaboration of the chair of Programming and Modelling Languages with the chair of Art History and the IT Group Humanities at the Ludwig-Maximilians-Universität in Munich [1]. It was developed "as an alternative approach to indexing the art work of a database of more than 30.000 art works" [20]. The labels collected can be used as keywords to enrich the possibilities of searching and browsing the database. Although the basic idea of ARTigo bears a great resemblance to the original ESP Game, a few changes have been made, e.g., there are no taboo words in the original version of ARTigo. The game is also quite successful: "Within 4 years, it collected 4.03 million tags" and "succeeded in attracting an active community of 14.169 registered users" [20].

2.1.3. Duolingo

Games with a purpose are of use in a broad variety of areas, not only in the collection of tags for images. E.g., one could imagine them being extremely helpful in the translation of languages [28]. Duolingo (<http://duolingo.com/>) is an e-learning platform that "helps people learn a foreign language by asking them to translate sentences from that language to their own, starting with simple sentences and advancing to more complex ones as their skills increase" [26]. To help players translate the sentences successfully, Duolingo offers them suggestions for translations of single words and users can view how other players translated the same sentence. Moreover, all learners can rate existing translations on their level of accuracy as well as correct them if needed [2].

2.2. E-Learning

According to Marc J. Rosenberg, author of the book *E-Learning - Strategies for delivering knowledge in the digital age*, the meaning of the word e-learning includes any "use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance" [24]. The author also describes three characteristics that are typical for most e-learning systems. Its inter-connectivity is probably the most important aspect, allowing information to be always up-to-date and the contained knowledge of an e-learning system can be made available to people around the world, who have access to the Internet. The second and most obvious criteria of e-learning is the fact that users access the e-learning content through a computer that is connected to the Internet. Last but not least, e-learning is more than just the delivery of knowledge, but it also provides its users with tools to memorise the delivered content as well as to improve their performance [24].

Today, as the Internet has expanded to almost every corner of the earth, e-learning platforms represent an interesting addition to traditional teaching methods and have a vast field of application [22]. Starting with tools to help Web developers improve their skills [3] to educational games for children [4], the range of e-learning platforms on the Internet is massive. Furthermore, e-learning systems have an important amount of advantages, of which only a few shall be mentioned here. First of all, people can use an e-learning platform any time they want as long as they please and they are not tied to specific dates and times. Also, the scalability of e-learning platforms is significantly higher compared to traditional lectures or classes. As it can be accessed via Internet, people can use the platform at home or any place else, they do not have to sit in a classroom with room for only a limited amount of people. Moreover, compared to traditional teaching methods, e-learning has lower costs, because the instructors do not have to travel and no classroom needs to be booked [24]. Also, routine supervision tasks can be provided by the software.

An example for the latest developments in e-learning are *massive open online courses* ("MOOC"). MOOCs consist of courses that can be accessed via the Internet and are available to everyone. In addition to that, they are free of charge and suitable for any number of participants [16]. A good example for a successful MOOC is Udacity (www.udacity.com) as it counts more than 112.000 students and also caught the attention of "major technology companies who are actively recruiting from the Udacity student body" [6].

2.3. Termina

Termina has been developed at the chair of Programming and Modelling Languages at the Ludwig-Maximilians-Universität in Munich as an e-learning platform that will hopefully be a useful addition to lectures. It is designed to be a game, helping students to prepare for their exams in a playful manner. At the same time, it is intended to be a game with a purpose, meaning that only by playing the game, users automatically contribute to the collection of data that might be of use for educational and scientific purposes later on. So, Termina is beneficial to both the students and the provider of the game. "For the operator the goal of the game Termina is the creation of complex term databases for several important terms from special learning contexts. For the learner one possible goal of the game can be the accumulation of a more comprehensive vocabulary of concepts in a certain matter" [21].

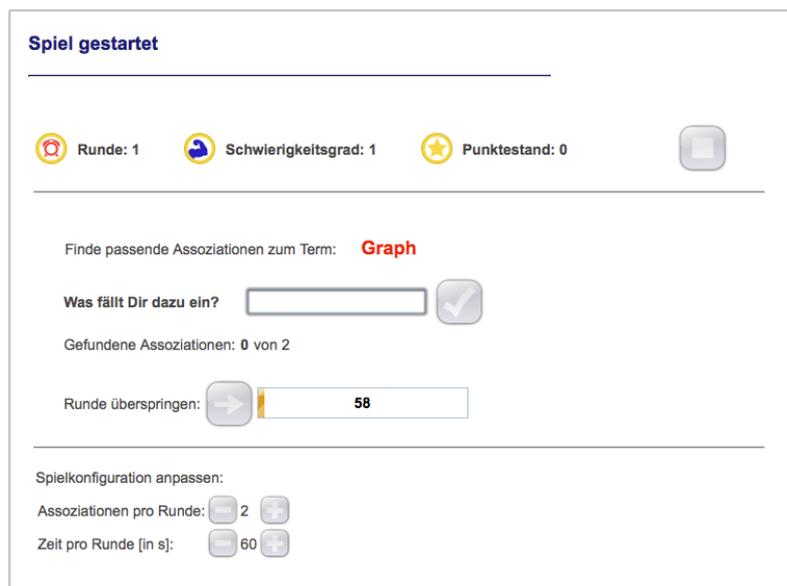


Figure 1: The regular game mode of Termina (new game design)

The basic idea of Termina bears a great resemblance to concept maps. When playing Termina, students basically have to find as many accurate associations as possible for a given term. The game offers users two different modes: the regular game and the free tagging game.

In the regular game which can be seen in Figure 1, the player is given one term per game round. Those terms originate from lectures the player is currently attending and can vary in their degree of difficulty. The player has to name associations either by typing them in an input field or by choosing the correct association(s) among a given list of correct and wrong associations. When the game begins, the player has zero points. For each accurate association they are rewarded with points. However, the amount of points per correct answer depends on the individual configuration of the game which the player can modify as they please. On the one hand they can choose the number of correct associations they have to

find to each term. On the other hand, they can adjust the amount of time they are given per game round. As soon as their number of total points drops below zero, the game is over, but the player can end the game any time they want. Their score is saved and listed among the ones of other players, giving them the opportunity to compare their results to the ones of their fellow students and to get a grasp of how well they did in the game.

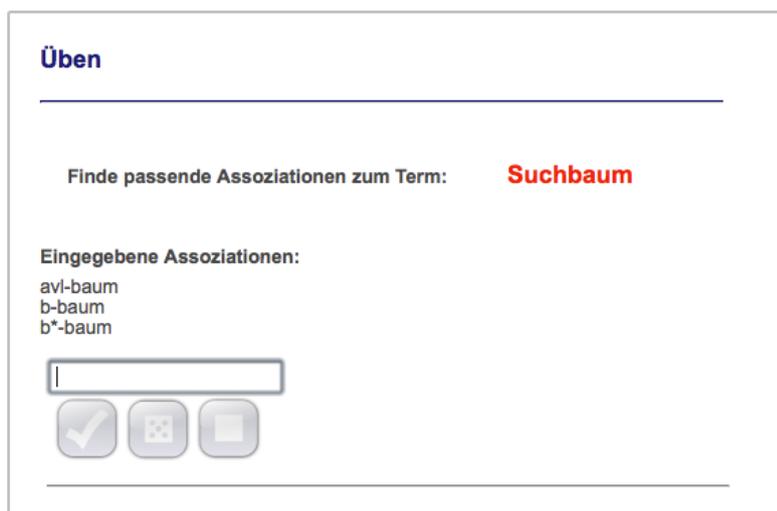


Figure 2: The free tagging mode of Termina (new game design)

In the free tagging game (see Figure 2), no points are awarded. Players have unlimited time for each term and can give as many associations as they wish. They can end the game any time they want, otherwise the game continues until all terms have been played. After the free tagging game is finished, an overview (illustrated in Figure 3) is shown with all correct associations as well as the ones that have not yet been confirmed by the administrators.

2.4. User Centred Design

When it comes to the process of designing a new product or creating a redesign for an already existing one, applying a systematic method that provides step-by-step guidelines for developers is most favourable. Over the years several different approaches have been developed that can be applied during the design process. For this bachelor thesis the User Centred Design was chosen, because compared to other possible approaches it is the one that focuses most on the future users' needs and goals [25]. The User Centred Design describes a set of methods that can be applied to increase the future users' involvement in the development of the product as well as the general idea, that users know best what requirements the product needs to fulfill in order to help the users achieve their goals. "The term 'user-centered design' originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s and became widely used after the publication of a co-authored book entitled: User-Centered System Design: New Perspectives on Human-Computer Interaction (Norman & Draper, 1986)" [17]. However, it took developers

| Deine Assoziationen | Assoziationen aller Nutzer | |
|------------------------------|---|---|
| Runde 1 (Rechnerarchitektur) | | |
| | Bus (12x) Ausgabegerät (5x) CISC (4x) Prozessor (3x) von Neumann (1x) | CPU (4x) register (3x) Boolesche Algebra (2x) ALU (2x) binär (1x) |
| Runde 2 (Boolesche Algebra) | | |
| und oder Gatter | und (7x) DNF (6x) oder (6x) KNF (3x) funktional vollständig (2x) | true (3x) Gatter (2x) false (1x) relation (1x) Vereinfachung (1x) |

Grüne Assoziationen sind bereits vom Dozenten bestätigt, rote Assoziationen noch nicht.

Figure 3: The overview of the game result

a while to discover the benefits from incorporating the User Centred Design in software engineering, probably because compared to the 21st century, in the early years of personal computers the possibilities for interactions with computers were very limited.

The core of this approach consists in the presumption that no one knows better what requirements a product needs to fulfill in order to become a helpful tool in the everyday life of its users than the users themselves [25]. As the satisfaction of customers is crucial for the success of a product, helping designers to meet the users' needs by involving future users along every step of the design process appears to be most profitable. Thanks to the interdisciplinary nature of User Centred Design, it offers a great variety of possibilities to include as much user research as possible. Although the continuous involvement of users during the design process is very beneficial to the efficiency and safety of the product and the users' satisfaction, it has some disadvantages at the same time: much user research is very time consuming and often requires additional human and financial resources [17].

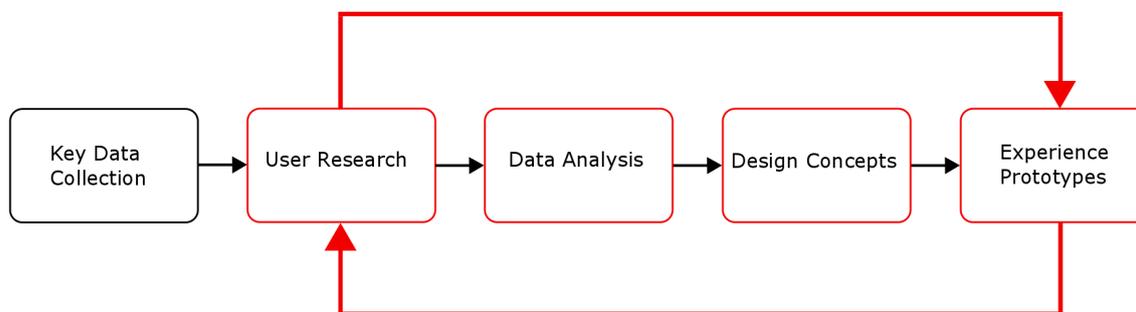


Figure 4: The User Centred Design [18]

The second key feature of User Centred Design is the iterative nature of its procedure (as illustrated in Figure 4). First of all, the design team has to collect important information regarding the users' needs and goals as well as establishing the requirements the product will have to fulfill. Based on the analysis of this key data, the design team starts developing a first design concept and creates several alternative designs. The ones that are worth exploring will be tested by users with experience prototypes that are built especially for this evaluation in order to detect the parts of the design that still need to be worked on. After analysing the results of this user testing, designers go back to the development of concepts, now basing every single decision on the results of the evaluation of the previous design concept until they and most importantly the future users are satisfied. This iterative procedure of User Centred Design sets it apart from any other possible design approach such as Activity Centred Design, Systems Design or Genius Design [25]. For this bachelor thesis however, only two iterations were made due to the limited time available.

2.5. Evaluation Methods

2.5.1. Paper Prototyping

Paper Prototyping is a quick and efficient way to evaluate the design concept of a product in the early stages of its development. The general idea is to draw the interface on paper including every element of it: buttons, forms, graphics, text etc. During the usability testing of a paper prototype, the participant has to interact with it while a member of the development team plays the part of the computer and mimics the system's behaviour by laying down the elements of the interface as they would appear on screen [27]. The participants simulate mouse clicks with their finger and use a pencil whenever they would need the keyboard if they were interacting with a real website or application.

One of the great advantages of this method of evaluating a new design concept is that it helps to avoid wasting time, because a broad variety of problems - big and small - can be found before even a single line of code is written [27]. Furthermore creating a prototype does not take too much time and is very cheap, as it is made out of material that can be found in any office. However, a paper prototype might be considered as unprofessional by the participants and they might not take the evaluation as serious as if they would have been given a more sophisticated prototype to interact with [27]. But, at the same time the simplicity of paper prototypes helps participants to focus on the important aspects of the design rather than to get distracted by minor details such as colours or fonts. Finally, it should be mentioned that some problems cannot be detected using paper prototypes, e.g., performance and speed [27].

2.5.2. Product Reaction Cards

When Joey Benedek and Trish Miner, both working for the Microsoft Corporation, were looking for a way to evaluate a product's desirability, one of the methods they developed are product reaction cards. Basically, this tool consists of a set of 118 adjectives, most of them can be interpreted both in a positive and negative way. Each word is written on a separate card and presented to the participant at the end of a study. Now, all they have to do is

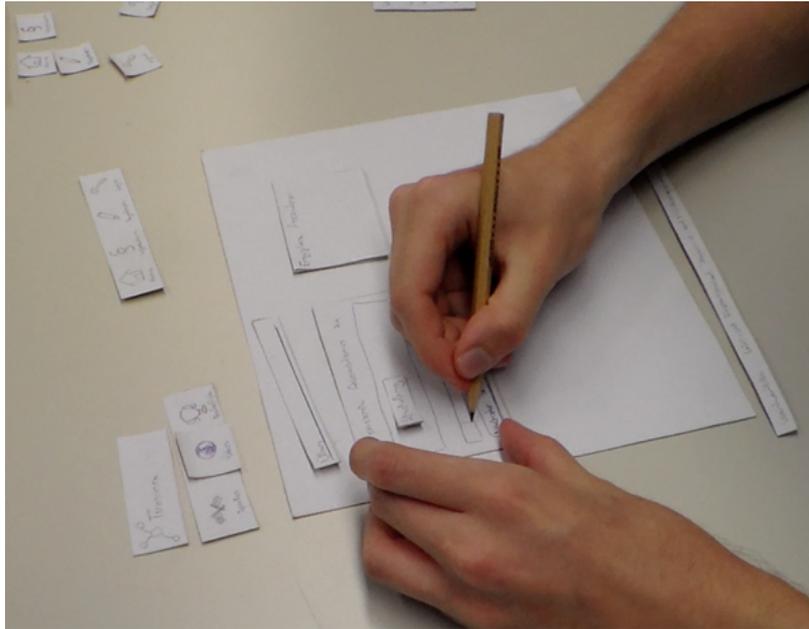


Figure 5: A participant interacting with the paper prototype of Termina

to choose three to five cards that - according to them - best describe the product currently evaluated. Then, the practitioner will ask the participant to explain why they selected those words, forcing them to give away more details on their reaction to the product [19].

This method has become quite popular due to some significant advantages. First of all, product reaction cards is a quick and money-saving tool for usability testers to get a useful insight on how the evaluated product is perceived. Another important aspect of this method is that it encourages participants to give positive and more importantly negative feedback. Usually users prefer to only mention what they liked about the product rather than to criticise it. Product reaction cards also help to find out if the designer's perception of the product corresponds to the one of the future users and to discover possible discrepancies between them [19].

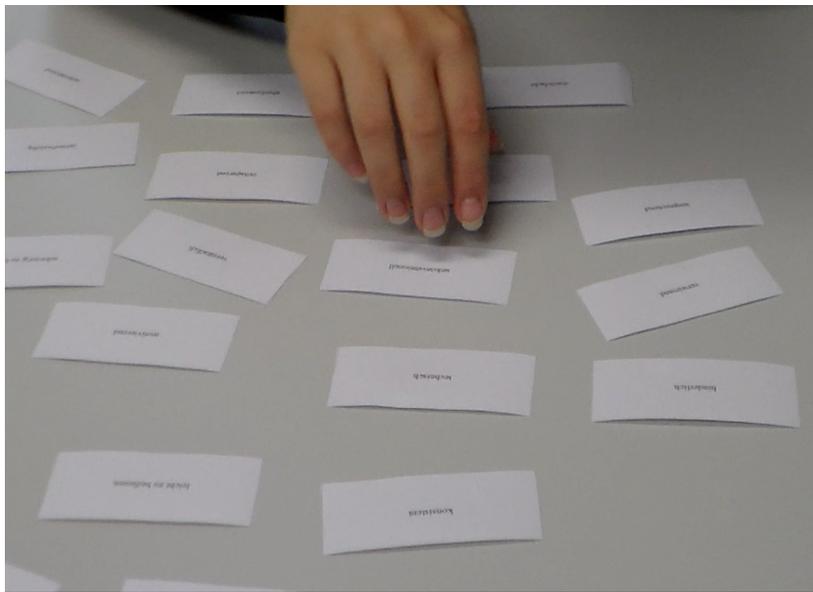


Figure 6: A participant choosing among several product reaction cards

3. Evaluation and Refinement of the Existing Design

3.1. Analysis of the Existing Design

3.1.1. The General Website

Before developing a new design concept for Termina, it was essential to find the majority of all existing problems of the first design draft. To save some time and effort, this was not done with a study, but only by a single person. During the process, the person looked at every page on the website and tested it critically. In the following, the problems that were found will be discussed.

Before looking at the two game modes or the administrative section, the general website and its design were examined. The first draft of Termina's design (as illustrated in Figure 7) had too many unnecessary white spaces in it and on some pages weird graphical artefacts could be found. The logo of the game was partly overlapped by the website's content, which resulted in the effect that the overlapping elements of the website were not legible anymore. Also, the logo itself was very unimaginative and boring. Moreover, the colour scheme used contained some colours that did not match as they did not offer enough contrast. Finally, the buttons were quite boring, as they only consisted of a rectangle with its label. Sometimes they could not even be recognised as buttons and might have been overseen easily.



Figure 7: The old welcoming page of Termina

Termina lacked a consistent and reasonable navigation, also the menu items did not attract enough attention and might not have been recognised as such. Furthermore, there were some information and links given at the bottom of the page, that clearly belong to the debug mode used by developers. Those might be highly confusing for ordinary users and should be hidden from them. As for the registration form, the symbol marking mandatory input fields was not explained at all. Moreover inconsistencies could be found when submitting without having given all necessary information: sometimes the error message came up once, at times even twice. Also the error messages were not really meaningful: e.g., instead of giving details on why the login might have failed (unknown username, password incorrect etc.), all the message said was that the login was not successful. Some buttons were not visibly disabled even if clicking on them was futile.

Not only the technical aspects of the website needed some improvements, but also its content. E.g., the welcoming text on the home page was very scarce and did not hold enough information. The website's imprint was highly incomplete, almost every standard information usually given in this division of a website was missing. Moreover, no section answering frequently asked questions was available. The page containing the saved highscores was very minimalistic, only giving away the name and score of each player. It might be interesting to enumerate each entry, because as soon as the highscore consists of more than fifteen players, it gets difficult for users to estimate which place they currently hold. Another addition would be to not only save the name, the number of points and the placement of each entry, but also the date it was made. In the free tagging mode no feedback is given when all saved associations have been given and neither is the total number of saved associations revealed to the player.



Figure 8: The first interface of the regular game mode

As for the regular game Termina, which can be seen in Figure 8, the formula (see (1)) used to calculate the amount of points rewarded after each round is not explained or even given anywhere.

$$(found\ associations - missing\ associations) \cdot level\ of\ difficulty \cdot time\ coefficient \quad (1)$$

So, users cannot know increasing the required number of associations or decreasing the amount of time available will help them to achieve a higher score. In addition to that, it might have been helpful to specify the unit in which the time is measured. During the game, it might be quite confusing to users when they are suddenly asked to select the correct associations in a list of possible answers, after they have been asked to type the associations in an input field for several rounds. Maybe it would be better to explain the two input methods to them beforehand. Finally, after the game has ended the amount of received points can be overseen easily.

3.1.2. The Administrative Section

After looking at the part of the website that is relevant to students, the administration section was analysed. As the design of the administration panel was identical to the one of the general website, the following paragraph contains solely problems concerning the content of the administrative section.

The screenshot shows the administration panel with a navigation menu on the left containing 'IMPRESSUM', 'REGISTRIEREN', 'LOGIN', 'TERMLISTE', 'TOPIC LISTE', and 'GAMECONFIGURATION LISTE'. A success message in the top right reads: 'Successfully created', 'Neuen Term hinzufügen', and 'Term Prozesszustand wurde erfolgreich geändert!'. Below this is a table with the following data:

| | Id | Term | Level | Bestätigte Assoziationen |
|----------------------------|----|--------------------|-------|---|
| bearbeiten | 7 | Sortieralgorithmus | 1 | Quicksort, Bubblesort, Mergesort, externes Sortieren, internes Sortieren, |
| bearbeiten | 12 | Suchbaum | 1 | AVL-Baum, B-Baum, B*-Baum, |
| bearbeiten | 17 | Scheduling | 1 | First Come First Serve, Round Robin, Shortest Job First, |
| bearbeiten | 23 | Datentyp | 1 | Integer, Boolean, Float, String, |
| bearbeiten | 30 | Graphen | 1 | Knoten, Kanten, gerichteter Graph, ungerichteter Graph, Pfad, |
| bearbeiten | 36 | Objektorientierung | 1 | Klasse, Objekt, Vererbung, Attribut, |
| bearbeiten | 43 | Prozesszustand | 1 | ready, running, suspend, blocked, new, |

Figure 9: The old administration panel

First of all, not a single explanation is given that would help future administrators understand what terms, topics and game configurations might be. Moreover, there were some inconsistencies concerning the chosen language: the website is probably more legible when all texts are written in one language and the use of foreign words is avoided. The capitalisation of some table labels was inconsistent. Furthermore the positioning of error messages was not really thought through as all messages were simply listed below the form instead of positioning them directly beside the corresponding input field. In addition to that, some

technical problems were discovered concerning the import of new terms. There were no restrictions on the accepted file formats. When trying to upload, e.g., a pdf file, the administrator finds himself on the debug page. It should be made impossible to upload files that do not correspond to a readable file format. On top of that, there is no link to the term upload in the navigation of the administrative section. Finally, some essential features still need to be implemented as it is not possible to delete existing terms, topics or game configurations neither can new associations be confirmed or denied.

3.2. Development of a New Design Concept

Based on the results of the extensive analysis of the existing design of Termina, a first attempt was made to improve it. However, the changes made were only implemented after being tested during the first user study. At first, the website was divided into three different areas as it is commonly done on the Internet (see Figure 10): a header containing Termina’s logo and the main navigation, a section for any content and finally a footer with links to the university as well as to the chair of Programming and Modelling Languages.

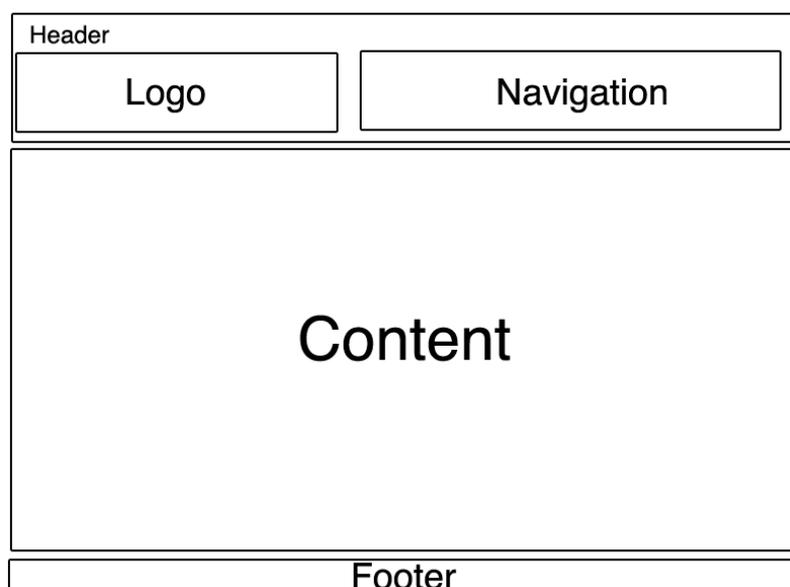


Figure 10: The layout of the new design concept for Termina

The navigation links were put in a reasonable order and missing links were added (e.g., the link to the import of terms). After browsing some popular websites, the idea came to mind to enrich the navigation through playful icons. This would also help to make the website’s navigation more visible. The first improvement of the design concept mainly contained changes concerning the general layout and navigation of the website, the content as well as details such as colours and fonts would be modified after the new design concept was tested by a first study using a paper prototype.

4. User Study for the First Design Concept

4.1. Conceptual Design of the Evaluation

The purpose of this study was to evaluate the new layout and navigation of Termina using a paper prototype that was built based on the results of the first analysis of the already existing design. The participants were asked to perform certain tasks by interacting with the paper prototype. First, they had to register on the website. After that, their task was to try the free tagging mode of the game during two rounds. Finally, they were asked to play the regular game for two rounds as well, allowing the practitioner to test the two input methods used in the game. The second part of the study consisted of choosing three out of 24 product reaction cards and explain why each card was picked. Last but not least, the participants were asked to complete a questionnaire. Five students (three were male) aged between 21 and 27 were willing to participate in this study, three of them are studying media informatics, one has already his diploma in informatics and one is studying informatics for a teaching profession.

4.2. Quantitative Results

The questionnaire at the end of the study contained several questions that had to be answered using a Likert scale ranging from 1 ("I strongly disagree") to 6 ("I strongly agree"). The number of possible answers was even on purpose as to deprive the participants of the possibility to always choose the neutral centre whenever they were not sure on how to answer a question. An overview of the results can be viewed in Table 1. For further details, the boxplot of each question can be found in appendix A.1.

| ID | Question | Mean | Lowest | Highest |
|----|---|------|--------|---------|
| 1 | <i>I could easily navigate within the prototype right from the beginning.</i> | 5.8 | 5 | 6 |
| 2 | <i>The prototype was clearly structured.</i> | 5.2 | 5 | 6 |
| 3 | <i>The given explanations of the game were sufficient enough.</i> | 4.2 | 2 | 6 |
| 4 | <i>The design of the prototype was consistent.</i> | 5.4 | 4 | 6 |
| 5 | <i>I liked the idea of using icons in the menu.</i> | 5.8 | 5 | 6 |
| 6 | <i>Would you appreciate it, if Termina was used in lectures?</i> | 4.4 | 3 | 6 |
| 7 | <i>Do you think, Termina might help you to prepare for an exam?</i> | 4 | 2 | 6 |

Table 1: Overview of the answers to the rating questions in the first study

The two questions with the highest arithmetic mean (question 1 and 5) were both relating to the navigation of the paper prototype. The results of the questionnaire show that Termina's new navigation is easy to use and did not cause the participants any problems. Moreover,

the idea of using icons was very much appreciated. So, the graphical icons are going to be incorporated in the final version of Termina.

Not only the new navigation but also the general layout of the paper prototype was perceived quite positively. All participants agreed on the fact that the prototype was clearly structured (question 2). Furthermore, the statement asking whether or not the layout of the prototype was consistent (question 4) was confirmed by all five participants as well.

As the explanation of the game on the original website was pretty scarce, it was very interesting to find out whether it was sufficient enough or if it needed to be more detailed. The answer to question 3 was more diverse compared to the two previous ones. This probably results from the fact, that the practitioner explained what Termina was all about beforehand. Some participants might have misunderstood the question and referred their answer to the explanation given by the practitioner during the study.

After answering those five questions concerning the paper prototype, the participants were asked whether or not they would appreciate it if Termina was used in lectures (question 6) and if they think that Termina might help them when preparing for an exam (question 7). The range of the given answers was quite diverse again, indicating that the participants might still have some doubts regarding the usefulness of Termina. However, it should be considered that they were only interacting with a paper prototype, which might be the reason for this insecurity.

4.3. Qualitative Results

During the first part of the user study, all participants were asked to use the think aloud method, meaning that they should speak out any thought they had concerning the prototype. The following paragraph discusses all comments given by the participants during the interaction with the paper prototype.

The first participant found some grammar errors in the welcoming message and said, that the landing page after logging in was too empty as it did not show any content with the exception of a short "welcome back". Also, she would prefer if the error messages appeared at the bottom of the form rather than above it. Concerning the free tagging mode the participant thought that it would be more beneficial to the learning process, if the solution was presented to the user after every single term not just after ending the game. Last but not least, she noticed that the website's imprint was incomplete. The second participant emphasised that the colour scheme used to differentiate correct associations from the ones that might be wrong was easy to understand. During the regular game, the second input method (a given list of correct and wrong associations) surprised her and she seemed to be confused at first. The next participant really liked the fact that the active menu item is coloured while the rest are only greyscaled. She mentioned that in her opinion the "welcome back" message did not make any sense as it was the first time she ever logged herself in. Finally, the participant thought it was a good idea to instantly show already typed associations in the free tagging mode rather than to hide them from the user. The fourth participant described the prototype as "cool" and also said that it was kind of "cute". She also liked the overview given after the end of the game. However, she did not realise that she could end the game any time she wanted. The last participant was the only one to

| | | | |
|---------------|-----------------|---------------|----------------|
| appealing | easy to use | intuitive | time-consuming |
| boring | familiar | motivating | time-saving |
| complex | frustrating | overwhelming | too technical |
| comprehensive | gets in the way | supportive | unconventional |
| confusing | hard to use | predictable | unpredictable |
| consistent | inconsistent | sophisticated | useful |

Table 2: Product reaction cards given in the first study. The words were translated into German as all participants were German students.

think, that she could enter more than just one association at the same time. Also, she was quite surprised when an overview of her performance was presented to her at the end of the game. There, the participant did not understand that the colour red did not necessarily mean that the association was wrong but only that it might be wrong. Last but not least, she was confused by the fact that it was possible to achieve a much higher score than she had as it was not explained anywhere that increasing the number of required associations or decreasing the available time would help to improve the score.

After interacting with the paper prototype, 24 product reaction cards (see Table 2) were given to the participants from which they were asked to choose at least three adjectives that they found best suited to describe the prototype.

All five participants selected at least three cards as they were asked to, two even picked four and five adjectives. It should be mentioned that the participants often had difficulties to differentiate between similar adjectives, e.g., comprehensive and intuitive. With three out of five participants, the most popular word to describe the paper prototype, was **intuitive**. When asked about why they thought Termina was intuitive, the participants explained that they automatically knew what buttons to click and that the buttons did what they expected them to do. Furthermore, every element of the prototype was labelled and the prototype contained enough explanations. Last but not least, it was said that the paper prototype itself was pretty self-explanatory. Other commonly selected cards were predictable, easy to use, consistent, sophisticated and useful (two out of five participants). On the one hand, the adjective **predictable** was referred to the system’s behaviour regarding clicks. On the other hand, it was said that the concept of the prototype was clear and the navigation consistent. The navigation of the paper prototype was considered as **easy to use**, because the menu bar was always present and not too overcrowded as well as the navigation was not complex but rather insightful. The word **consistent** was already mentioned to describe the system’s predictability, but was also selected by another participant to compare the interfaces of the free tagging mode and the regular game. She was pleased to see that after first playing the free tagging game, the interface of the second game mode was rather similar and she did not have to learn how to use it, but instantly knew how to operate the game. The other participant who described the prototype as consistent liked the division between the free tagging game and the regular game. Not only the separation between the two game modes was quite popular, but also the fact that the game itself offers some variety in the way students have to answer the questions: the alternation between an input field and a given list of alternatives was considered quite **sophisticated** by one of the participants.

The visualisation of the results in both game modes was described as sophisticated as well. Last but not least, two out of five participants could imagine that Termina will be **useful** to them when preparing for their exams or revise a lecture's content. One of them also mentioned that she liked the idea that Termina might encourage the communication between students and the lecturer. The first participant thought that some button labels were rather **technical**, e.g., the button used to enter an association was labelled with "send". She worries that although computer science students will probably not have any problems with that, people taking other courses of studies might misunderstand the meaning of the label. The same participant also thought that the navigation was a bit **time-consuming** regarding the amount of avoidable clicks she had to make. The layout of Termina was considered quite **understandable** by the last participant. She did not have any trouble discovering all possibilities Termina offered her, although when asked if she would still feel that way if she had not been informed about the game beforehand by the practitioner, the participant admitted that the explanations given on the paper prototype were rather scarce. The second participant said that she perceived the layout of the paper prototype as pretty **familiar** and that Termina did not surprise her with elements she would not have expected (which was meant in a positive way). One participant selected the adjective **appealing** to describe the general layout of the prototype, although she would have preferred the menu item logout to be on the right of the menu bar as this would be the place where she would expect the logout button to be.

After selecting three product reaction cards, the participants were asked to complete a survey that contained three open questions. The first one asked the participants if they could think of features that they would like to add to Termina. Three out of five participants stated that they would appreciate it, if more detailed explanations of the game were added to the website. Another suggestion made, was to include examples of possible associations to both game modes as well as a notification on whether or not a player is placed among the highest scores. Finally, it was also said that a more detailed welcoming page of the login area would be most favourable. The next question asking whether or not Termina contained any features that could be considered as unnecessary or that the participants did not like, was only answered by the first participant. She repeated that there were some unnecessary clicks she was annoyed by as she had already mentioned during the second part of the study. Last but not least, participants were asked if they had any suggestions to improve Termina. Again, only one participant answered and stated that she would appreciate it, if suggestions for correct associations were given in the free tagging mode.

5. Development of the Final Version of Termina

5.1. Employed Technologies

After the first user study, Termina's user interface was modified and improved based on the results of the study. During the process, several programmes were employed: all graphics for the new design were originally made using the open source vector graphics editor Inkscape [10]. Sometimes the generated vector graphics needed to be converted to png files and their resolution adjusted, which was done using the open source image manipulation program GIMP [9]. Termina's source code was modified using Eclipse [7], an open source project providing a powerful editor that can be used to create small projects as well as complex applications. The user interface is formatted in XHTML and CSS, but basic HTML was used as well. Firebug [8] - a free plugin for the browser Mozilla Firefox - offered a useful insight in the website's final source code and was very helpful when testing Termina's website. The implementation of Termina is based on the Java Enterprise Edition [13] and uses the web application framework JBoss Seam [12] as well as the JBoss Application Server [11]. The database containing all the necessary data of Termina is managed using PostgreSQL [14].

5.2. Graphics Design Decisions

The graphics design of Termina's website is crucial to the usability of the game. Furthermore, it probably has a great influence on whether or not Termina will be accepted by students once it is ready to launch. As the website's first design was only a rough first draft, Termina's new look turns out to be a complete redesign rather than just a modification of the already existing design.

The first design decision made, was to keep the background colour white and at the same time the text colour dark in order to guarantee a high contrast as this is very beneficial to the legibility of the website. However, the black font colour was swapped to a dark grey because this softens the general look of the website. The layout of the website was changed to the one tested during the preceding user study since all participants strongly agreed on the fact that the prototype presented to them was clearly structured. The different parts of the website were visually set apart through lines coloured in a light grey. Another significant change to the website was the removal of any background colour in forms and table headers as the colours originally chosen did not match the new design of the website. Also, the colour of their borders was swapped to a light grey.

The logo was the first graphic designed for the website and can be seen in Figure 11. It contains the word Termina and four ellipses that are connected to each other and shall remind the user of concept maps. In order to avoid making the logo look too crowded, only three colours were chosen to design it: blue, yellow and red. It was important to transmit the fact that Termina is a game to the logo, so no predefined font was used to write the word Termina but each letter was given a unique look. Last but not least a dropshadow and a gloss effect were added to the logo to make it appear more modern.



Figure 11: The new logo of Termina

One important aim was to keep the design of Termina as minimalistic as possible in order to avoid users getting distracted by irrelevant details. So, the colours used for the logo determined the look of all other graphics that still needed to be designed. The idea of using graphical icons for the navigation links was incorporated in the new design of Termina as it had already been tested during the first user study and all participants reacted very positively to the presented navigation. A great effort was made to find symbols that would be as suitable and self-explanatory as possible for the individual menu items. The new navigation for Termina consists of seven links and can be viewed in Figure 12. The icon belonging to the currently active page is coloured while all others are greyscaled, so two versions of each icon were needed. This effect gives additional visual feedback to the user on his whereabouts. Finally, Termina needed new and better looking buttons. The set of buttons used in the new design of Termina contains seventeen different buttons in two versions: a greyscaled one and a blue one. The two different versions are needed to implement a mouse-over effect giving the user visual feedback on what button he is about to click on. The shape of the buttons was strongly influenced by the popular "app-symbol" used by operating systems for most smartphones and lately also by the ones for computers. Text was only used to label the individual menu items, however the graphics of all buttons do not contain any label in order to maintain the possibility for translations later on, meaning that the symbols presented on the buttons had to be designed as self-explanatory as possible. In addition to that simple HTML tooltips were employed.



Figure 12: The new navigation of the website

Last but not least, some new icons were included in the regular game to make it look more "playfully". For each of the three parameters (game round, score and level of difficulty) an icon was made consisting of a golden ring surrounding a symbol on the inside. For the game round a clock was chosen, the level of difficulty was visualised by a muscular arm and the score by a golden star (see Figure 1).

5.3. Changes to the Content

Not only the design of Termina was in need of a makeover but also the content itself as well as its presentation had to be modified significantly. All changes made to the content of the website will be discussed in the following paragraphs.

The previous welcoming message on the home page was replaced by a new one that offers a more detailed explanation of Termina. At the same time it is kept as short as possible encouraging visitors to actually read it. So far, the website's imprint only contained the information that the chair of Programming and Modelling Languages of the Ludwig-Maximilians-Universität is responsible for Termina. Now, all standard information are given on the website's imprint, including the complete address of the institute of informatics, an e-mail address of the person responsible for Termina, a short disclaimer as well as a list of all contributors. A new addition to Termina's website is the section for frequently asked questions. This page mainly contains information on the game and explains how Termina is played. However, this section only covers the basic questions users might ask themselves when they play Termina for the first time and new explanations should be added each time the game is expanded.

The next part of the website that needed to be modified was the registration form. The form was not changed, but an explanation for the symbol marking mandatory input fields was added. Also, the font weight of the labels of these input fields was changed to bold to make it even more obvious that those were information that had to be given. Furthermore, visitors are given a reason on why they should register on the website in the first place (a user's name can only appear in the highscore section if they are registered). Before users can play the game, they land on a page asking them whether they want to start the game at once or if they prefer to configure it first. In the previous version of Termina the two parameters that can be modified by the player were hardly explained. Now, the page offers more detailed information on them, e.g., the metric in which the time is measured is given. The game interface itself also got a complete makeover, which can be seen in Figure 1. First of all, three of the relevant parameters of the game (number of game rounds, level of difficulty and score) are given at the top of the page and are clearly visible thanks to individual icons next to them. The button allowing to end the game, is now positioned in the same row on the right. Directly below that row, the term is given to which the player is asked to find accurate associations. The red font colour as well as the bold font weight and the bigger font size help to set the term apart from the rest of the interface to make it as visible as possible. The input field (or the list of correct and wrong suggestions) is positioned directly below the given term. Furthermore, when giving the users a list of possible answers, each element now has a checkbox to make it clearer to the user that more than just one suggestion can be selected at the same time. Finally, the buttons allowing to configure the next game rounds are placed at the bottom of the interface, because they are not as essential to the game as the rest of the elements of the game interface.

Not only the regular game but also the free tagging game was rearranged and can be viewed in Figure 2. However, the changes to the second game mode were less extensive: the term is highlighted in the same manner as it is already done in the regular game and the already given associations now appear in between the current term and the input field. Moreover, all buttons (send association, swap term and end game) are positioned below the input

field in a single row. Finally, a short text explaining the free tagging mode is given at the bottom of the page. The page presenting the results of a player counts among the sections where the least changes were made. In fact, only the old button to restart the game was replaced by the new graphical one and the score is made more visible thanks to an icon next to it. The highscore section is another part of Termina's website that did not need extensive modification as it only consists of a simple table. Besides changing the background colour of the table header, the individual scores are placed at the centre of their table cell. Finally, the content of the login page itself has hardly changed, only the presentation of it was modified consistently to the rest of the website and the login button was replaced by a new one.

In the course of the complete redesign of Termina, not only the sections relevant to students were modified but also the administration panel. First of all, a welcoming page was added including a very short introduction to the administrative section. Administrators can modify terms, topics and game configurations of the game. Each of these three elements has its own section. To each of them a short text was added, explaining what either terms, topics or game configurations are. Furthermore, any foreign word (in this case, any English word as German is the only language currently available) was translated to increase the legibility of the administrative section.

All three sections of the administration panel were barely modified: each section now contains a short information on its content and all hyperlinks were replaced by the new buttons. An additional column was inserted to the table containing a list of all existing terms, indicating whether a term is active and appears in the game or not. Also, a link to the page containing the import function for new terms was included at the bottom of that table.

5.4. Browser Compatibility and Adjustments to Different Screen Resolutions

After creating the new design of Termina the remaining step was to make sure that the website looks exactly the same regardless of the used Web browser or the resolution of the screen. During the development of Termina's new look the Web browser Mozilla Firefox was used. In addition to that, Termina's website was tested using the majority of Web browsers that are currently very popular: Google Chrome, Safari and Opera. The website almost looked the same in every Web browser mentioned, however Chrome and Safari do have some issues showing the logo, probably because it is a vector graphic: in Chrome an aliasing effect can be seen around the edges and in Safari the dropshadow only consists of a simple grey line. Opera does not have any problems and shows the website exactly as Mozilla Firefox does.

Finally, the website needed to be tested for various screen resolutions. The monitor used during the development has a resolution of 1920 x 1200 pixels. Using this resolution, the layout of the website is displayed perfectly and no horizontal scrolling is needed. As soon as the screen resolution was decreased significantly (e.g., 1280 x 1024), a horizontal scrollbar appeared, which should be avoided in any case. Horizontal scrolling is most commonly perceived as very unpleasant and interferes with the usability of a website. As many people use netbooks that might only have a resolution of 1024 x 768 pixels, horizontal scrollbars should be made unnecessary at least down to this resolution. The first measure that was

taken to optimise the website regarding the screen resolution, was to decrease the size of the logo and the menu icons. This resulted in the effect that Termina is now displayed correctly on screens with a resolution of 1280 x 960 pixels and higher. However, this still was not enough for screens with a resolution of only 1024 x 768 pixels. For those, an additional stylesheet was generated that decreases the width of the logo even further until no horizontal scrolling is needed anymore.

6. Evaluation of the Final Version of Termina

6.1. User Study

6.1.1. Conceptual Design of the Evaluation

The structure of the second user study bears a great resemblance to the first one, except that instead of testing a paper prototype, the participants were asked to interact with the actual website of Termina. During the interaction their assignment was to register on the website, find associations to four terms in the free tagging mode and play the regular game until it ends. Concerning the administrative section, the participants were asked to either edit an existing term, topic or game configuration or to create a new one. Then, 41 different product reaction cards were presented to them from which they each had to choose at least five. Finally, all participants completed a questionnaire containing 15 questions. During the study both parts of the website, the one relevant to students as well as the administration panel were evaluated using the Web browser Mozilla Firefox on a MacBook Pro equipped with an Intel Core i5 with 2.53 GHz and 4 GB RAM as well as the operating system Mac OS X 10.6 Snow Leopard. In addition to that, a ThinkPad Bluetooth mouse was provided for participants who might not be familiar with Apple's Multi-Touch Trackpad. In this study 12 people (seven were male) aged between 20 and 34 participated: eight of them are studying media informatics, three are computer science students and one is studying arts and multimedia.

6.1.2. Quantitative Results

After choosing five product reaction cards, the participants were asked to complete a survey containing ten questions that had to be answered using a Likert scale. Just as in the first user study the scale ranged from 1 ("I strongly disagree") to 6 ("I strongly agree"). This chapter discusses how these questions were answered. All related boxplots can be found in Appendix A.2.

After testing the sections of the website that are relevant to students, the administration panel was evaluated by all participants as well. Question 2 asked if this section of the website offered enough possibilities to administrate Termina. Surprisingly, a great majority of all participants agreed that the possibilities were sufficient, even though it was not possible to confirm or deny new associations given by students while playing the game. Furthermore, the participants were asked whether or not they had problems administrating Termina (question 3). All of them agreed to the statement that, indeed, the administration did not cause them any problem at all.

A lot of effort was made to improve the explanations of Termina given on the website. Thus, it was interesting to find out whether or not they were understood by the participants (question 1). Also, this question can be compared to a very similar one that was included in the first survey asking whether or not the given explanations were sufficient enough. When comparing the arithmetic mean of the both questions (first study: 4.2, second study: 5.5) as well as the lowest given answer (first study: 2, second study: 4) it can be seen, that the improvements made were quite significant.

| ID | Question | Mean | Lowest | Highest |
|----|---|------|--------|---------|
| 1 | <i>The explanation of Termina was understandable.</i> | 5.5 | 4 | 6 |
| 2 | <i>The possibilities to administrate Termina were sufficient.</i> | 5.2 | 3 | 6 |
| 3 | <i>I had no problems with the administration.</i> | 5.7 | 4 | 6 |
| 4 | <i>The website was clearly structured.</i> | 5.9 | 5 | 6 |
| 5 | <i>The design of the website was consistent.</i> | 4.9 | 1 | 6 |
| 6 | <i>I liked the graphical design of the website.</i> | 5.5 | 4 | 6 |
| 7 | <i>I had no problems with the navigation.</i> | 5.3 | 5 | 6 |
| 8 | <i>I always knew exactly where I was on the website.</i> | 5.8 | 4 | 6 |
| 9 | <i>Would you appreciate it, if Termina was used in lectures?</i> | 5.2 | 2 | 6 |
| 10 | <i>Do you think, Termina might help you to prepare for an exam?</i> | 5.3 | 1 | 6 |

Table 3: Overview of the answers to the questions in the second study

Another comparison can be made between the question whether or not the website (or the paper prototype in the case of the first study) was clearly structured (question 4). As the layout of the website is almost identical to the one of the paper prototype, it is not surprising that the answers to both questions are very similar. The arithmetic mean of the second question is even slightly higher (5.9) than the one of the first question (5.2), meaning that a great majority of the participants strongly agreed to the statement that the website was clearly structured, indeed.

Question 5, asking whether or not the design of the website was consistent, was already asked during the first user study as well, although then it was referring to the paper prototype. Here, the arithmetic mean of the second question is lower (4.9) compared to the first study (5.4).

The answers to question 6 indicate that the graphical design of the website was perceived very positively. This was not surprising as most of the participants had already commended the general design of the website during the preceding parts of this study.

Also, the question saying that one always knew where one was on the website, was confirmed (question 8). This was expected as well, because it had already been mentioned quite a lot during the second part of the study.

The last two questions concerning Termina in general were already included in the first user study. They were asked again in the second study as to allow a comparison between the response to the paper prototype and the website. First of all, the participants were asked whether or not they would appreciate it if Termina was used in lectures (question 9). The arithmetic mean of this question increased quite significantly (from 4.4 to 5.2). The mean of the last question asking whether or not the participants think that Termina might help them to prepare for an exam increased even more (from 4.0 to 5.3). As the game was not

modified at all, the reason for this growth might be that the participants of the first study were only interacting with a paper prototype whereas the ones of the second study were already able to try out the final product.

6.1.3. Qualitative Results

In the course of the second user study qualitative feedback was gained during the interaction with the website, through product reaction cards as well as through the questionnaire at the end of the study. Again, the participants were asked to apply the already mentioned think aloud method while they were interacting with Termina. In the following, all qualitative feedback given in the course of the second study is discussed, starting with the comments given during the interaction with the website, continuing with the results of the product reaction cards and finally ending with the analysis of all answers given to the open questions of the survey.

6.1.3.1. Interaction With the Website First of all, most participants said that it would be better to place the explanation of the colours used for the overview of the game result above the table, because as soon as the number of game rounds played is too long to fit onto the screen, the explanation can only be seen after scrolling down to the bottom of the page. Furthermore, a great majority of the participants did not realise that associations could be transmitted to the game by pressing enter. Also, some of them thought they could submit multiple associations at the same time. Concerning the administrative section several participants did not understand the purpose of the checkbox indicating whether or not a term appears in the game. Moreover, some did not clearly understand the meaning of the level of difficulty. Finally, the fact that Termina does neither accept different spellings of the same word, e.g., "Quick Sort" and "Quicksort" nor understand that a word can be written in singular or plural and still have the same meaning, caused problems for all participants.

The first participant was quite surprised during the regular game, when she was asked to choose the correct associations among a given list of possible associations rather than typing them in an input field as she had done so far. But all in all she mentioned that most of the time she knew instantly where she had to click on and did not have to think a lot while navigating on the website. The next participant noticed that no restrictions concerning the spelling of the username were given on the registration page resulting in the effect that users cannot know whether or not they are allowed to use special characters or not. Moreover, the participant suggested that the button submitting the registration shall be activated automatically as soon as all necessary information have been given enabling the new user to submit the registration by pressing enter. Concerning the free tagging mode, she thought that it would be beneficial to the usability of the game if a short explanation of the three buttons contained would be added. She also got confused by the fact, that the highscore section contains two highscore lists as it is not explained that one of them lists the daily highscores and the other one the highscores over all time. In the administration panel, the participant missed the possibility to delete existing terms as well as an indication, that topics can be generated even without associating any term with them. Furthermore, the

participant suggested that the possibility to relate topics to other topics would give the opportunity to create hierarchies of connected topics. Last but not least, she said it was too easy to detect the correct associations among the given list of possible associations in the regular game and that she would prefer if for each term an array was saved, containing wrong associations that seem to be correct. The next participant had troubles to differentiate the administrative section from the regular website as both have the same design. Also, when adding a new topic she did not understand that the list of terms on the left represents the terms that can still be added to a topic. The fourth participant really liked the graphics used in the new design of Termina, especially the logo. However, she would use a coloured version of the registration button to make it more visible. Finally, she was not sure whether or not the changes she made when editing an existing topic were really saved and in addition to that the participant would have liked a warning before leaving the editing view of terms, topics or game configurations without saving. The next participant commended the tooltips given for each button because it made the navigation of the website pretty self-explanatory. However, at first she oversaw the button to swap terms in the free tagging mode and did not realise that she could end this game mode by clicking on the corresponding button. Also, the participant had troubles understanding what game configurations were all about. The following participant could imagine Termina being very suitable for a mobile application. She appreciated the visual countdown during the regular game as well as the fact that no google analytics were included in the website's imprint. However, she discovered some details that she was not particularly fond of: in the profile editing section, the e-mail address of the user should be entered automatically in the corresponding input field. Also, in her opinion the page containing the frequently asked questions was not appealing enough as it did not contain any screenshots. Concerning the regular game, the participant thought that changes to the current score as well as the button to end the game were not visible enough. Moreover, the participant would place the configurations of the number of required associations and the amount of time available next to each other rather than positioning one below the other. Also, regarding the second input method of the game (list of correct and wrong associations) she would have preferred the submit button to be positioned at the bottom of the list. Finally, she was disturbed by the mouse-over effect added to the buttons. Compared to all the other participants the next one focused more intense on the graphical aspect of Termina as she studies arts and multimedia. Unlike the previous participant she really appreciated the mouse-over effect added to the buttons and was very fond of the logo and the menu icons. Only the fact, that some of them moved when hovering over them and some did not, disturbed the participant a little bit. Furthermore, she found the administration of Termina very easy to use and she really liked the general idea of Termina, especially the fact that it helps to get an overview of a lecture's content. The following participant did not realise that her chosen password had to be at least six letters long. Furthermore, she did not understand that she could select more than one association in the second input method of the regular game at the same time. Also, she first thought that associations that were marked red in the overview of her result were wrong. Concerning the administrative section, the participant was the second one that did not fully understand the purpose of the left and right list of terms presented when editing a topic. Finally, in her opinion the navigation of the website was very easy to use. The next participant basically had only positive things to say about Termina: she also stated that the website is easy to use and thought that the menu bar as well as the regular game were clearly arranged. The

| | | | |
|------------|--------------|------------|----------------|
| connected | flexible | inviting | slow |
| efficient | fun | organised | stimulating |
| effortless | inflexible | reliable | trustworthy |
| exciting | intimidating | simplistic | uncontrollable |
| fast | | | |

Table 4: Product reaction cards added for the second user study. The words were translated into German as all participants were German students.

next participant had troubles understanding the function of each button in the free tagging mode. Also, she was not sure whether or not the game was case-sensitive. Concerning the regular game, she would have appreciated it if the game had notified her that she was placed among the highest scores. The only additional comment the last participant made that has not been already mentioned by previous participants, was that she would have liked the possibility to name the different game configurations.

6.1.3.2. Product Reaction Cards For the second study some new product reaction cards were added to the ones that were already used in the previous one. A list of all new adjectives can be found in Table 4.

The card that was chosen the most was **intuitive** (nine out of twelve). On the one hand, the word was used to describe the basic idea of the game as it bears a great resemblance to index cards and mind maps. But most of the time participants related to the website itself. They thought its layout was very clear and not overloaded. Also, they stated that thanks to the self-explanatory menu items they instantly knew how to navigate the website and they were always aware of their whereabouts. Finally, the navigation as well as the buttons appeared to be familiar. The second most popular cards were easy to use and effortless as eight out of twelve participants selected them. The adjective **easy to use** was not only associated with the navigation and the general layout of the website but also with the minimalistic nature of Termina as it only contains two game modes which are easy to distinguish from one another. The fact that associations can be submitted by pressing enter was also very popular. Moreover, it was commended that in every form all necessary information were clearly highlighted. Other elements of the website that were considered to significantly influence its ease of use, were all additional texts on the individual pages explaining for instance how the free tagging mode works. In addition to that, the administration panel was described with that card as well as the participants could very well imagine Termina to be of use not only in computer science but in all kinds of courses of studies, e.g., biology, medicine and arts. However, it was said that an additional explanation of some buttons, especially those in the free tagging mode, would be most favourable. The other card - **effortless** - was chosen because of the minimalistic design of the website as well as the game itself. As long as the player has a certain amount of knowledge regarding the content of the lecture, the regular game is really easy to play at the latest when the free tagging mode has been played before. **Understandable** was another card commonly picked. Most of the time the participants referred to all the explanations given in the frequently asked

questions section as well as on each page individually. But also the buttons were considered as understandable thanks to the implemented tooltips. Furthermore, it was commended that the explaining texts were short. Last but not least, the general structure of the website was described as understandable as it was divided into three common areas. The following cards were selected by four out of twelve participants: appealing, flexible and simplistic. When describing Termina as **appealing**, the participants were either referring to the graphics or the general layout of the website. One participant particularly liked the buttons because of their modern look. Another one commended the minimalistic design of the website. The division of the layout into three areas was also considered appealing. The next word used to describe Termina was **flexible**, especially because administrators can put topics together as they please. Also, thanks to the easy administration Termina might be of use not only for computer science students as it has already been mentioned before. In addition to that, two participants made suggestions to improve Termina: one of them would like a notification each time the score changes during the regular game. The other said, that she thinks it might be quite beneficial to the learning process if a short informative text was given with each term. When asked about why Termina could be considered as **simplistic**, some participants said, that the word could be used to describe the website's layout as it is very minimalistic and not overloaded. Also, another participant referred to the basic idea of the game as she had no problems at all playing the game after one or two rounds. Finally, the navigation was also mentioned when this particular card was being explained. The next three game cards were chosen by three participants. The first contains the word **organised**. Participants explained that they thought the layout of the website was quite structured which resulted in the effect that they always knew exactly where they were on the website. Also, it was said that a central theme was recognised throughout Termina's website. The second card that was picked by three participants was **supportive**. Participants stated that they could imagine Termina being a really helpful tool to revise already learned knowledge and that they would appreciate the game as an addition to lectures. Also, one participant thought that students who have trouble memorising terms in particular could really benefit from Termina. Finally, participants stated that Termina was also **time-saving** for two reasons: explanations were given on the same page and not only collected in a single help section and as soon as Termina's database will be filled with terms, students will not have to create index cards themselves for the related lectures anymore. The following product reaction cards were each picked by two participants: useful, fun, consistent, fast and connected. One of the participants stated that in her opinion Termina might not only be a **useful** tool for students but also for the lecturer, because Termina can help him to find out whether or not students have understood his lecture. Another explanation given was the fact that Termina could very well be used in other courses of studies not only in computer science. The word **fun** was used to describe the interface as well as the idea of Termina. The fact that Termina is kept quite simple was very much appreciated by one participant as well as the minimalistic design. The other participant who picked that card also said that she particularly liked that during the regular game, feedback is given at once. Both participants who selected the card **consistent** were referring to the general design of the website. E.g., the fact that the navigation bar is always present was particularly popular. Also, the content on every page is always structured in the same way. The card **fast** was solely used to describe the runtime performance of the website. It was commended that the participants never had to wait as the website reacted very quickly. Last but not least, the word **connected** was used to

characterise the connection between terms and topics as well as the general design of the game.

All the following product reaction cards were only chosen by one participant. The new imprint of Termina as well as the registration form were considered **inviting** by one participant. Another one commended the straightforwardness of the game as very efficient. Also, Termina appeared to be **trustworthy** and was described as being quite **predictable**. However, one participant described Termina as being a bit **inconsistent** at the same time regarding the fact that when editing a term sometimes the save button has to be clicked sometimes it does not. Last but not least, another participant said that she could imagine Termina being quite **frustrating** for students who have difficulties finding correct associations.

6.1.3.3. Questionnaire Most of the feedback given in the questionnaire was already mentioned, however some interesting suggestions were made.

First of all, one participant would appreciate it, if the number of remaining terms was given during the regular game. Furthermore, it was suggested that the colour of buttons submitting the registration form and associations during the game was swapped to a more visible colour, e.g., green. As it had been expected by the practitioner the possibility to confirm new associations was missed by several participants. Last but not least one participant stated that she would have preferred it, if both input methods of the regular game were explained before starting the game.

6.2. Expert Review

In addition to the user study, the new design concept of Termina was tested by Sebastian Löhmann, a media computer scientist currently working at the chair of Media Informatics at the Ludwig-Maximilians-Universität in Munich. In the following the results of this expert review are being discussed.

First of all, he really liked the new layout of Termina because of its minimalistic nature. He was particularly fond of the graphics used and appreciated that the website's content is not expanded over the whole width of the screen. Furthermore, he commended that the layout is stable regarding any resizing of the Web browser's window and stated that he was always aware of his whereabouts on the website. Another aspect of Termina he really did appreciate was the overview of the game results given after the game has ended.

He also made some suggestions to improve Termina even further: first of all, he would add a to-do list to the welcome page of the administrative section. He also said that it would probably be beneficial to the usability of the administration panel if all new associations that have not been confirmed yet would be collected in a single list as to enable the administrator to confirm all of them by only a single click. Finally, listing all associations of one term in their alphabetic order might make it easier for administrators to find a specific association. Sebastian also found several details on the website that still needed to be worked on. E.g., players are not warned when they risk leaving the game by clicking on the logo or any menu item. Also, both picklists in the topic editing section should be made longer to avoid

unnecessary scrolling.

A great effort was made to include the majority of all suggestions given by the participants of the second study to improve Termina. However, due to the limited time available the following problems remain to be solved. First of all, when playing either the regular or the free tagging mode, players should be warned whenever they risk leaving the game unintentionally by clicking on the logo or any menu item. Regarding the regular game, players could be notified when they manage to be placed within the highest scores. Also, enabling the submit button automatically as soon as all necessary information is given during the registration would be a nice feature, because new users could submit their registration by pressing enter. Regarding the administrative section of Termina, the possibility to confirm or deny new associations given by players is absolutely necessary and still needs to be implemented. Moreover, it should be made possible to delete existing terms, topics and game configurations. Furthermore, enabling administrators to name game configurations could be a nice feature. The import function for new terms needs to be worked on as well. It should be made impossible to upload files that do not correspond to a readable file format. Last but not least, Termina needs to be translated in English.

7. Conclusion and Outlook

7.1. Summary

In this thesis the process of the development of a new graphical user interface for the e-learning game Termina is described. This includes all the steps that were necessary before starting to work on a new design concept, e.g., the analysis of the existing design of Termina. In addition to that, the results of the two user studies that were conducted to evaluate the new interface are presented. The first study was done using a paper prototype based on the new design concept while the second user study already tested the final version of Termina's new layout. To conclude this thesis, some of the most promising ideas on how Termina could be improved and expanded are being discussed.

7.2. Possible Improvements to Termina

The area reserved for registered users of Termina is probably the part of the website holding the most opportunities for improvements to the game. So far, it only contains the possibility for users to edit their profile. To make it more worthwhile for students to register, an analysis of all their previous game results could be included, offering them a helpful insight on their improvement over time. Also, it might be interesting for students if they were notified each time a new term or topic is added to the game or whether new associations have been confirmed by the administrators since the user's last visit.

Regarding the regular game of Termina, students could also be given the opportunity to not only configure the amount of time available and the number of required associations but they might also want to select the level of difficulty. Furthermore, it would probably be most beneficial to the learning process if players were enabled to choose certain topics they want to practise. So far, when playing Termina users are given all existing terms in the database. Users probably will get annoyed if they are constantly asked to find associations to every single term even though they only want to practise just a small subset of terms. Adding informative texts (e.g., a definition) for each term to the overview at the end of the game might also be helpful. Students could refresh their knowledge on terms they were not able to find any associations to.

Concerning the administrative section of the website, the possibility to accept or deny new associations to existing terms is absolutely necessary and still needs to be implemented. In combination to that, a to-do list is imaginable, notifying administrators on the welcoming page whether or not there are new associations they still need to look over. Also, introducing a priority system for new associations that still need to be confirmed might be most useful as students could be given the opportunity to increase an association's priority whenever they are absolutely sure that their association is correct even if it has not yet been confirmed.

Another necessary improvement to Termina that still needs to be implemented is the acceptance of different spellings of the same word. The results of the second user study indicate that a great majority of the users will have problems with the fact that Termina does not recognise words such as "Quicksort" and "Quick Sort" as equal. Furthermore, Termina does not recognise the singular and the plural form of one word as equal. Finding an efficient way

to solve these problems is probably crucial to the success of Termina, because saving every version of one word is too time-consuming and tedious. A solution to this problem should be found as soon as possible, since most of the users will probably stop playing Termina after encountering these problems for only a few times.

Last but not least, Termina is now designed to be easily translated as every word and text is saved in a special file. Adding new languages, for instance English, to the platform would probably be really helpful for students whose native language is not German.

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A. Appendix

A.1. Boxplots of Answers to Questions of the First User Study

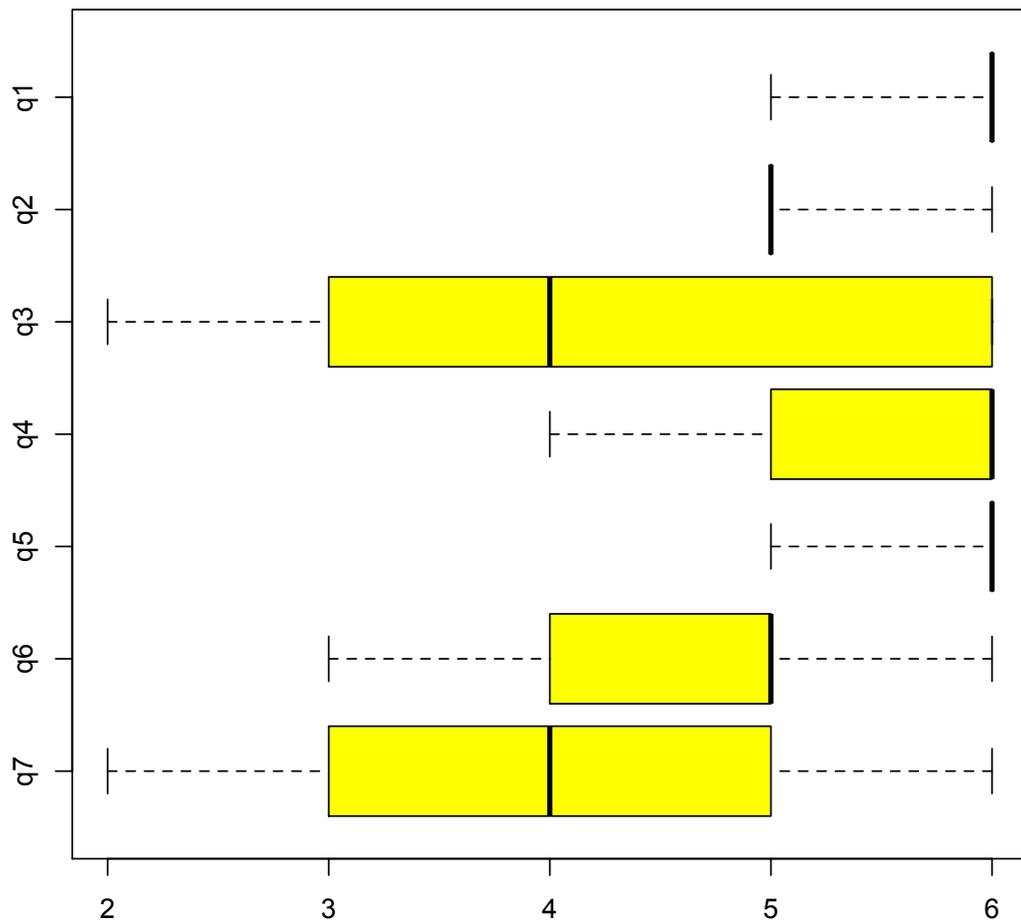


Figure 13: Boxplots to the questions asked in the first survey

| Id | Question |
|-----------|---|
| q1 | <i>I could easily navigate within the prototype right from the beginning.</i> |
| q2 | <i>The prototype was clearly structured.</i> |
| q3 | <i>The given explanations of the game were sufficient enough.</i> |
| q4 | <i>The design of the prototype was consistent.</i> |
| q5 | <i>I liked the idea of using icons in the menu.</i> |
| q6 | <i>Would you appreciate it, if Termina was used in lectures?</i> |
| q7 | <i>Do you think, Termina might help you to prepare for an exam?</i> |

Table 5: Questions belonging to the boxplots in Figure 13

A.2. Boxplots of Answers to Questions of the Second User Study

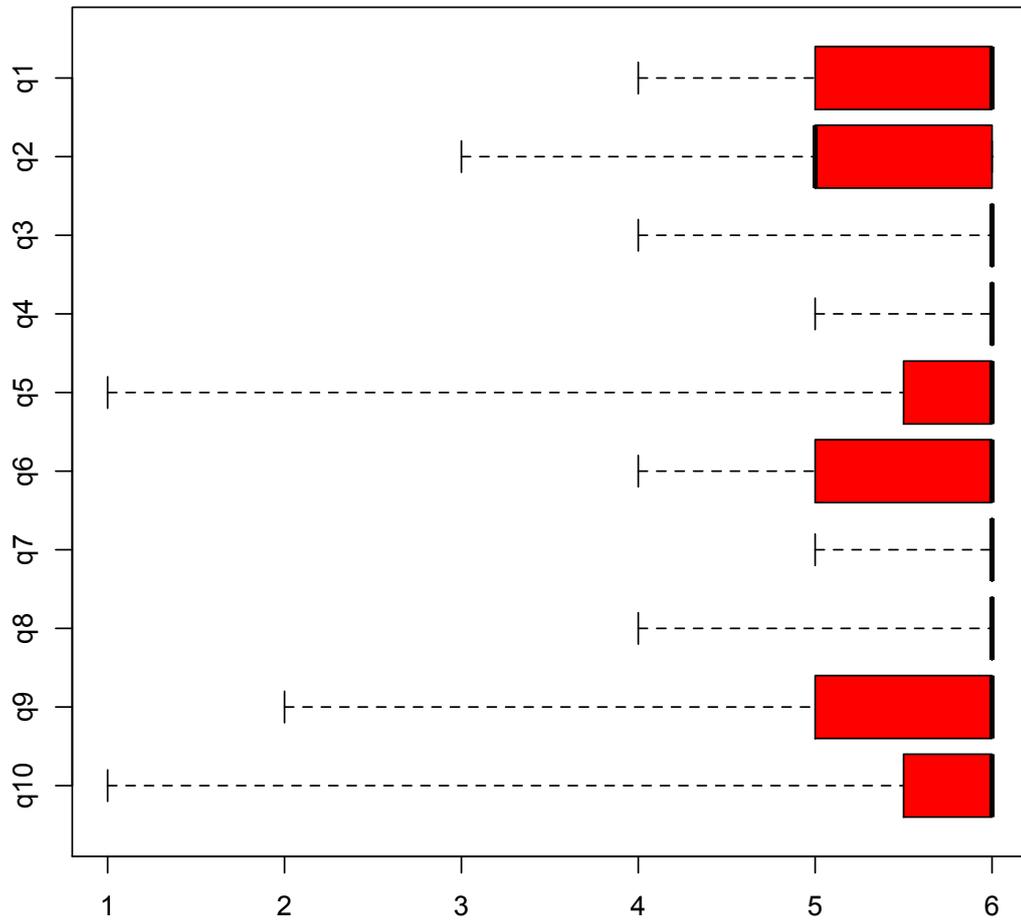


Figure 14: Boxplots to the questions asked in the second survey

| Id | Question |
|-----------|---|
| q1 | <i>The explanation of Termina was understandable.</i> |
| q2 | <i>The possibilities to administrate Termina were sufficient.</i> |
| q3 | <i>I had no problems with the administration.</i> |
| q4 | <i>The website was clearly structured.</i> |
| q5 | <i>The design of the website was consistent.</i> |
| q6 | <i>I liked the graphical design of the website.</i> |
| q7 | <i>I had no problems with the navigation.</i> |
| q8 | <i>I always knew exactly where I was on the website.</i> |
| q9 | <i>Would you appreciate it, if Termina was used in lectures?</i> |
| q10 | <i>Do you think, Termina might help you to prepare for an exam?</i> |

Table 6: Questions belonging to the boxplots in Figure 14