Making TeleTOP usable for mobile devices

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ABSTRACT
This paper presents research on the topic of the usability of digital learning environments aimed at desktops on mobile devices. In particular the digital learning environment called TeleTOP from the company TeleTOP e-Learning B.V. This product is used throughout The Netherlands in various educational institutes. People are travelling more and more, requesting information as they go through mobile devices. These devices differ from a desktop in screen size, processing capability and storage. That raises the question if the interface initially intended for desktops is still usable on a mobile device. This paper presents a solution to this problem. A heuristic inspection of the desktop interface of TeleTOP is conducted. For this inspection guidelines and heuristics for designing interfaces with mobile interfaces in particular are researched and presented. The inspection shows the shortcomings of the TeleTOP interface on mobile devices. These shortcomings provide the basis for the decision to design a new interface specially for mobile devices. The new design is then inspected with the same guidelines showing encouraging improvements and a very good way of making the current TeleTOP functionality accessible on mobile devices in a usable fashion.

Keywords
Usability, TeleTOP, mobile devices, website, digital learning environment, e-learning, learn, guidelines, heuristics, inspection

1. INTRODUCTION
On the university of Twente students and (assistant) professors use a digital learning environment (in form of a web application) to communicate and exchange information with each other about courses and other educational related matters. In this digital learning environment, titled TeleTOP, they are registered as users. By authenticating over the local network or internet with corresponding account details, access is provided to a personal environment containing the user’s courses and communication details.

Given the rapid developments on the market of mobile devices, information is increasingly becoming available anywhere at any time. This provides new opportunities to efficiently use ones time, for example checking your e-mail while traveling by public transit and checking location details for the next class while at the university. However, to be able to do these tasks information has to be accessible for mobile devices. Assuming that a reasonable percentage of students at Twente university own an internet enabled mobile device and would like to check course details ‘on-the-go’, TeleTOP should be accessible and usable for these types of devices. In the past TeleTOP has primarily been developed for desktop computers and laptops, this could mean that it is inaccessible on mobile devices or has a poorer usability. The former is the case when using the default browser on my own mobile device and the latter is the case when using an alternative browser. So based on own observations, either the course information is inaccessible on mobile devices or the web application is practically unusable.

This poses a problem in fulfilling the goal of having the TeleTOP functionality accessible on mobile devices in a usable fashion. Thus creating an area for research, which is the subject of this paper.

2. PROPOSED RESEARCH
Provided that there is a need for using TeleTOP on mobile devices as argumented in the introduction, how can the current TeleTOP functionality be made accessible on mobile devices in a usable fashion? Important keywords in this question are, ‘current functionality’ which means that it is assumed that the users need all of TeleTOP’s functionality to be accessible on their mobile device. No separate research is conducted into what part of the current functionality users actually need and want to be accessible. With ‘accessible’ is meant that it should be available on mobile devices not stating anything about its usability. By ‘mobile devices’, one should think of smart phones (standard cell phone with internet capability, PDAs and PDA phones, which are PDAs with cell phone functionality) having screens with a minimum resolution of 320x240 pixels. However, the leading mobile device during the research will be the Qtek 9100 [3] a.k.a. the T-Mobile MDA Vario, because I use it personally, thus being available at all times. The keyword ‘usable’ is meant in respect to the usability of interfaces as mentioned in [11].

A great deal of literature is available on the subject of us-
ability and interfaces. Several books are available [11], [8], [6] covering the subject of how to create an interface with high usability from the ground up. In all of the books above it is mentioned that it is more than good practice to design interfaces by well-established guidelines and heuristics. Guidelines and heuristics concerning the flow of an interface, its layout and behaviour, fitting the target group, the platform of the interface and the application context. Relating the above to the context of this paper several questions arise. First, all of the books mentioned above primarily focus on interfaces for the desktop platform, so what guidelines and/or heuristics are available in existing literature for designing interfaces for mobile devices? There are numerous contexts for which applications and interfaces are developed. The application in this paper is TeleTOP and its context is the digital learning environment. Therefore are there guidelines and/or heuristics available in existing literature for designing interfaces in this particular context?

Next to the guidelines and heuristics there is TeleTOP itself, which is a well-established application. It has proven its worth throughout the last years at various educational institutes. Although it has an interface for the desktop platform, can it not be modified for the mobile platform instead of designing a separate interface? In this way all advantageous interface elements are preserved while filtering out the ones disadvantageous for the mobile platform.

To find answers to all of these questions, research has been done into these topics. In the subsequent sections of this paper the results of this research are shown. Starting with the third section, the method of research is explained and more details are given on guidelines, heuristics and inspections. The fourth section shows a user profile analysis characterizing the target group for the TeleTOP interface on mobile devices. Sections five through eight show the results of the research done into the previously formulated questions. The following list gives a per section overview in terms of tasks and results of what results can be found.

**Section 5**
**Task:** Research into guidelines and/or heuristics for designing mobile interfaces in general and digital learning environments in particular. Solutions which implement these guidelines and/or heuristics is searched for in parallel.
**Result:** List of guidelines and/or heuristics.

**Section 6**
**Task:** Heuristic evaluation of the current TeleTOP interface [11] on a mobile device.
**Result:** List of TeleTOP interface elements which need adaptation for mobile devices.

**Section 7**
**Task:** Designing a new interface or adapting the current design.
**Results:** Low and high fidelity prototypes [11] of the new or adapted design including argumentation on design decisions.

**Section 8**
**Task:** Inspecting the prototypes on the leading mobile device.
**Results:** Inspection results showing if a designed adaptati

As last, this paper is closed with a concluding section and acknowledgements.

**3. METHOD**
To guide the research and development of an interface for TeleTOP on mobile devices, a combination of two methods has been chosen, namely literature study and experimental design. This combination is chosen because a thorough literature study forms a solid foundation to create a first design of an interface, which is later on perfected through experimental inspections.

**3.1 Literature study and design**
After doing a thorough literature study in which a set of guidelines, heuristics and possible applications of these was compiled, the new design was created. It was implemented in a high-fidelity prototype. This form was chosen for its advantages as listed by Stone et. al [11]. It is interactive, it can show complete functionality as well as the look and feel, layout and behaviour of the final interface. However the disadvantages according to Stone et. al [11] are that they are more time consuming to create in comparison to low-fidelity prototypes and they can look so professional and finished that users are less willing to comment. In the case of this interface the time consumption of creating a high-fidelity prototype is reduced by the technologies which are used. Technologies like HTML and designing in Photoshop integrated with PHP have made it easier to produce high-fidelity prototypes. The fact that users could have been less willing to comment is negligible, because they were inspectors not real or representative users. They are familiar with the heuristic inspection procedure (also known as heuristic evaluation) and experienced in commenting on elements of interfaces.

**3.2 Experimental inspections**
To inspect the current and new design of TeleTOP on a mobile device the method of heuristic evaluation as described by Stone et. al [11] is chosen. With a heuristic evaluation a set of guidelines or heuristics for interface design is chosen according to which the interface is checked thoroughly by inspectors. These inspectors are experienced in the fields of Human Computer Interaction, Interface and/or interaction design. Next to that, they are also experienced in the domain of the system, because they are fellow students using TeleTOP themselves. To give equal attention to all the heuristics, two inspectors were found. The results of the heuristic inspections conducted by these two formed the foundation for a new or modified interface design.

Although usability testing with scenarios and use cases would probably give more detailed results when testing the new design, it is already time consuming to measure and process quantitative and qualitative data, besides from finding the necessary amount of real or representative users. Doing heuristic inspections may provide less detailed but adequate results with the benefit that it is less time consuming. Due to the limited time available for this project, the choice was made to use heuristic inspections also for checking the new design. For both inspecting the current and new design the
same set of heuristics were used. This has the advantage of inspecting the new design against the same set of heuristics with which it was designed.

To conduct a heuristic inspection the inspector received the set of heuristics and a form on which errors were reported. While monitored by the researcher the inspector has gone through the complete design of the interface and check interface elements against the set of heuristics writing down any defects or deviations on the form. The defect reporting form has four columns, namely 'Location in the interface', 'Heuristic violated', 'Defect description' and 'Inspector's comments regarding the defect', so as to have a structured way to administer possible defects.

4. THE USERS

In the process of developing an interface, its users play an important role. Although an interface already exists for TeleTOP from which the functionality can be derived, that does not have to mean that the target group can be copied as well. Therefore it is good to reevaluate the target group and its characteristics.

The current TeleTOP interface is used by students, (assistant) professors and administrative personnel, so the target group for that interface comprises at least of users from these three categories. All use different parts of the interface. The question is if users from these three categories use a mobile device and use TeleTOP with it. Because of time constraints only the category of users who would most likely have a mobile device and use TeleTOP with it is focused on and that is the category of students. So, the group to which the new interface is targeted is the group of university students.

Studying this group of users reveals several characteristics which were put together in a user profile shown in table 1.

5. GUIDELINES AND HEURISTICS

In this project guidelines and heuristics were used for two inspections. The first inspection had as goal to evaluate if the current interface of TeleTOP is suitable for mobile devices and if not list the parts which are not suitable. The goal of the second inspection was to evaluate the new design specifically targeted at mobile devices. Therefore some guidelines and heuristics mentioned hereafter are applicable to both inspections and some just to one of them. As mentioned before the current interface is targeted at desktop users. This platform has different properties in comparison with mobile devices. Key areas to inspect are therefore those differing properties. This gives an important source for guidelines and heuristics. The following is a list of differing properties:

- **Screen size** - Mobile devices have smaller screens, which poses challenges for the layout of the interface.
- **Input methods** - The mobile devices which are targeted in this research do not always have the luxury of a keyboard or a pointing device, which makes input of data more difficult and probably more laborious.
- **Processing capability** - In comparison with desktops, mobile devices have less processing capability in terms of CPU speed.
- **Storage capability** - Although permanent storage capabilities are not posing that many challenges nowadays (i.e. memory cards etc.), internal memory is still limited.
- **Connection throughput** - Considering the mobile devices aimed in this project, both low and high throughputs are possible. Low throughput speeds of typically around 12 to 56 Kbps and high speeds provided by WiFi technology around 11 Mbps are variably available.

Both uservision.co.uk [12] and Seong [7] verify these findings. Knowing that the TeleTOP interface for mobile devices will be a web application, the question rises if the same guidelines and heuristics apply as with web applications designed for desktops, albeit slightly modified in respect to the properties mentioned above.

A very well-known list of guidelines and heuristics for user interfaces including web applications are the ten heuristics of Nielsen [5]. Both Stone et al. [11] and Sharp [8] reference them in unmodified form. In Seong’s paper [7], which is about developing a framework for guidelines for designing mobile learning portals, they can also be found, albeit in a different context. Gong and Tarasewich [2], explicitly discuss the application of Shneiderman’s [9] version of Nielsen’s guidelines. In other words, the common denominator of all these papers is still Nielsen’s set of guidelines.

The following listing summarizes those guidelines. For a full listing of the guidelines including corresponding heuristics and examples, see the first subsection of appendix A.

- **Visibility of system status**

<table>
<thead>
<tr>
<th>User characteristics</th>
<th>TeleTOP user characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Ranges between 18 to about 28</td>
</tr>
<tr>
<td>Sex</td>
<td>Male and female</td>
</tr>
<tr>
<td>Physical limitations</td>
<td>May be fully able-bodied or may have some physical limitations in relation to hearing and sight</td>
</tr>
<tr>
<td>Educational background</td>
<td>Has at least six years of high school or five years and one year at a university for professional education</td>
</tr>
<tr>
<td>Computer/IT use</td>
<td>May have none, little or much experience with use of TeleTOP, but moderate experience in using computers and their mobile devices</td>
</tr>
<tr>
<td>Motivation</td>
<td>May be very motivated to use TeleTOP on mobile devices for quick info. on courses regardless of the current location</td>
</tr>
<tr>
<td>Attitude</td>
<td>The attitude of use is in general positive, because mobile devices are popular, but what may have influence is the speed with which information is retrieved</td>
</tr>
</tbody>
</table>

Table 1: User profile for target group of TeleTOP interface for mobile devices.
• Match between system and the real world
• User control and freedom
• Consistency and standards
• Error prevention
• Recognition rather than recall
• Flexibility and efficiency of use
• Aesthetic and minimalist design
• Help users recognize, diagnose, and recover from errors
• Help and documentation

Although these guidelines have proven to be useful in general user interface design and apply to mobile web design, several guidelines were also identified which are specifically targeted at mobile web design. Most of these guidelines have come out of the fact that mobile devices have constraints on hardware capabilities as described previously. The following guidelines are taken from Stone et al. [11], Seong [7] and Gong [2]. For a full listing of the guidelines including corresponding heuristics and examples, see appendix A subsection two.

• Select versus type form of input
• Consistency between platforms in addition to general consistency
• Design stability
• Design for “top-down” interaction
• Design for speed
• Design for small screen display
• Pay extra attention to designing navigation

6. HEURISTIC EVALUATION RESULTS

The heuristic evaluation of the current TeleTOP interface on the leading mobile device was conducted by two inspectors. Both have followed an education in which Human Computer Interaction was an integral part. The inspectors were familiar with design guidelines / heuristics and inspections. So, as mentioned in the ‘Method’ section, the inspectors received the list of heuristics and several forms on which they could write their comments. They were asked to ‘surf’ through the complete web application and write at least that down that was in violation with the heuristics provided. Both inspectors took about an hour for the task and wrote down various violations. Although not requested inspector B also wrote down several observations which are in accord with the heuristics. These are also useful as they state what should be maintained in the new or modified design.

6.1 The violations

The most important / critical violations the inspectors found were those violating guidelines 14 through 17. In various locations of the interface these violations were found. For example in the login screen, main screen and course screen. Many of these violations are concerning guideline 16 which can also be found at these locations. Heuristic 16 is about the design for small screen display (see Appendix A.2). It was to be expected that this heuristic would be in violation, then the current TeleTOP interface is designed for the desktop platform. In general this platform has larger resolutions and bigger screens. In most of the violation descriptions the inspectors have written down that there is too much white space between elements or elements are unnecessarily large in dimensions, causing a lot of horizontal or sometimes even vertical scrolling. Because of the smaller display and the large elements it often happens that the layout cannot be maintained and elements start to obscure one another. This disables their intended function. For instance, general news messages are displayed in the main screen of TeleTOP on the desktop platform. On the leading mobile device these are obscured by layout elements, which cannot be resized properly so that the news messages are displayed also. Figure 1 demonstrates this by showing the current design on desktop and the target platform.

Figure 1: Two images showing TeleTOP on the desktop (A) and the desktop design fully skewed on the target platform (B).

Additionally, the inspectors also came across several pages which did not function due to diminished capabilities of the browser. Because the leading mobile platform has less processing capabilities as an ordinary desktop platform, many of the mobile application counterparts are therefore ‘stripped’ of process intensive functionality. This is also the case with browsing. The mobile browser used (i.e. Pocket Internet Explorer as part of Windows Mobile 5) clearly has less Javascript processing capabilities. Both inspectors were therefore unable to see anything on the ‘Berichten’ screen (i.e. message inbox screen).

Inspector A also wrote down a comment about the loading times of pages. The opinion of this inspector was that all pages browsed were slow in loading. This was also one of the heuristics, then mobile devices do not always have a broadband or better internet connection available (at least not in The Netherlands as of yet), which the desktop platform usually has. During the inspections a GPRS connection of 64 kbps down (in theory, with full reception) was used. Therefore it was important to qualitatively inspect the loading times of pages. In general a page in TeleTOP has a lot of elements which need to be loaded and processed. In addition, several of these elements are large in size and take a
short amount of time to download. When these are optimized for the mobile platform, performance would increase and possible irritation of users would be minimized.

6.2 The best option for a solution
As the previous subsection shows, almost every page of the web application suffers of one or more of the above mentioned problems. So how could these problems be tackled? Well, two options exist. As the third subquestion in section ‘Proposed research’ already denotes, the existing design could either be modified or a new design especially for mobile devices could be created. The important question here is, what is the best option? To answer this question the heuristic evaluation results from the previous subsection and the specific mobile user interface design guidelines (Appendix A.2) are taken into consideration. According to the latter extra attention needs to be payed to the navigation of the mobile user interface. In the case of the current TeleTOP interface, maintaining the same navigation in modified form will prove difficult. Most of the navigation is set out horizontally making it too wide for the mobile display. Modifying it so that it is set out vertically, but keeping its form and style would increase the necessity for vertical scrolling greatly. Therefore it is better to redesign the navigation, thus opting for the second option.

Furthermore designing for top-down interaction is another guideline from Appendix A.2. Top-down interaction as in showing the user a small part of the information as he or she would know what to expect. Additionally, the user can choose to see more when clicking on it. For instance, a summary of a text and after clicking it the user gets the full text. The current TeleTOP interface does this with news messages and the like by adding a checkbox. When checked it shows the full text, but only a clickable title when not checked. For the mobile interface of TeleTOP it is in accordance with the guideline that this checkbox should be checked by default. Unfortunately the checkbox does not function on the mobile browser. However the current TeleTOP interface could be modified to display titles only in the case a mobile browser is detected. Therefore the implementation of the top-down interaction guideline opts for modification of the current TeleTOP interface.

Continuing with a third guideline from Appendix A.2, design for small screen display. As argued before the complete layout is designed with a desktop platform in mind. Leaving out several elements to make it fit better on a small screen display would marginally improve the usability of the current interface on a mobile device at best. Images and other elements would be resized to such an extent making them unreadable not being able to fulfill their function. Therefore a new layout needs to be designed especially for the small screen display, hence opting for a new interface for mobile devices.

However when considering the guideline ‘Consistency between platforms in addition to general consistency’, one would tend to opt for modification of the current interface. In this case the interface is modified without touching the current style and recognizable features easing possible transitions from desktop to mobile interface and vice versa. On the other hand when carefully observing the style of the desktop interface it is not that hard to apply it to a new interface wherever possible. So this is not really a convincing argument opting for modification of the current interface.

To conclude, let us take the above arguments into consideration. When talking about the navigation of the current interface, modifying it so it is also suitable for mobile devices proves difficult. The layout of the current interface is also difficult to modify. The argument about consistency between platforms is also not a strong argument to opt for modification of the current interface. The only argument that does is that of top-down interaction. However implementing top-down interaction in a new design should not prove that difficult either. Hence, the option to design a new interface specifically for mobile platforms is the better option. This is reinforced by the trend seen with Dutch public services websites, which also have an interface specifically for mobile devices. See NS Mobiel [10] and 9292OV Mobiel [1]. A popular website for social communication also has a separate interface for mobile devices, see Hyves [4]. Although it would be preferable to put all functionality of the desktop interface into the mobile interface in a usable fashion, time is limited. The following pages and corresponding functionality are intended to be implemented for the mobile interface (sorted on priority):

- Login screen
- Main screen showing general news messages
- Course catalog screen for course enrollment
- Course screen
  - ‘Nieuws’ screen
  - ‘Studiewijzer’ screen
  - ‘Informatie’ screen
  - ‘Deelnemers’ screen
  - ‘Resultaten’ screen
- Help screen

This list has been chosen on the assumption that users while underway in most situations just like to ‘check’ particular information. Therefore not many editing functions are on it. Then again, editing on a mobile device (e.g. text processing) is not done that much.

7. THE DESIGN FOR MOBILE DEVICES
Now that it has become clear that a new design is the better option, it is important to pay close attention to those design guidelines which have been violated in the heuristic inspection. Then the pages that contain these violations are problematic for a mobile device to display. Most of the violations are related to guidelines 14 through 16 (see appendix A), as described in the previous section. Additionally guideline 17 is also vital for the success of the new design, because the navigation for a mobile web application simply needs to be different in comparison with navigation for a desktop one. This is due to constraints like a smaller screen, other (less conventional) input mechanisms and less processing capability. So to have a resulting design which does not violate the above guidelines, solutions for the violations in the current desktop need to be found. Afterwards these solutions need to be checked in the inspection of the new design.

In the search for solutions to the violations, sources of the World Wide Web Consortium (W3C) provided useful and practical design information. The Mobile Web Best Practices, [14] is especially written to assist in making web content available on mobile devices. Additionally this document refers to the Web Content Accessibility Guidelines 1.0, [13] written to assist in making web sites accessible for users
who have a disability. Many of these guidelines also apply to mobile web sites.

One of the biggest challenges to design was the general layout of every page in respect to guideline 16, design for small screen display. Because of the mobile device test platform (Windows Mobile 5 (WM 5) with Pocket Internet Explorer (IE)), the layout and all elements needed to be kept simple. Pocket IE is equivalent with the desktop Internet Explorer 4.01, thus supporting equal HTML and CSS standards, the technologies used for the design. This was also a factor in keeping the design simple, then IE 4.01 does not support advanced CSS 2.0 features for example.

To prevent the need for horizontal scrolling the layout of the pages was chosen to be in one column. For recognizability, every page has the same header containing a smaller version of the TeleTOP logo and the header image. Location information is also included on a separate line underneath. The content section follows thereafter, preceded by a text header. The navigation section follows at the bottom of every page. For this particular layout is chosen because the content is shown after a small header, but before the navigation. One of the Mobile Web Best Practices is to show the content as early on the pages as possible. This way the user can quickly judge the relevance of the content and skip to the navigation if necessary as opposed to having to scroll past the navigation first, judging the relevance of the content and scrolling back to the navigation. Figure 2 shows the new designed layout as described above. Designing for “top-down inter-

Figure 2: Screenshot of the new design, demonstrating the layout used on every page.

action” as mentioned by guideline 14 is also incorporated in the new design. Although this was partially available in the desktop design it did not suffice. Every message or larger text in the new design is either summarized or only its title is displayed by default. A special case of this was tabular data. In every occurrence the table from the desktop website could be reduced to show the most important data columns and providing a link to the remaining information. This was done to reduce the screen space needed. It also provides easy scanning of the text on relevance after which the user can click on an additional link to continue to the full data or text.

Guideline 15 is about designing for speed. In concreto this results in small page sizes and images. Small pages are incorporated in the design by using as less information elements as possible. This does not only reduce the page size in Kilobytes, but also in elements to be processed / rendered by the browser. The images are kept small by reducing their resolution and save them in the maximum number of colours the platform can handle (which is 128 colours for WM 5). Paying extra attention to the design of the navigation as mentioned by guideline 17 is also important, because not all navigational elements of the desktop design were available on the mobile device. Furthermore, multiple navigational elements (e.g. main menu, submenu) were positioned differently on pages in the desktop design (see figure 3). Although this might be effective for the desktop, for mobile devices it is not. Therefore the navigation needed to be completely redesigned. Important hereby according to the Mobile Web Best Practices was that it is consistently positioned on every page and uses a simple structure. The consistent positioning is achieved in the new design by always putting the navigation after the content section under a textual heading. As for the structure, the Mobile Web Best Practices recommended to use simple text-based links which have access keys assigned. By using a number at the beginning of the link to indicate the access key, the user can press the corresponding key on their mobile device to follow the link. Furthermore two groups of links are used separated by a white line. The ‘always-available-link’ group for example ‘Logout’, ‘Help’, ‘My courses’ (when logged in) etc. are placed under the group of links which vary per page.

After this design was made a second heuristic inspection was held to evaluate the new design especially on the guidelines mentioned in this section. The results of this inspection are described in the next section.

8. INSPECTING THE DESIGN

A second heuristic inspection was held after the new design of the TeleTOP website for mobile devices was complete. It had the goal to evaluate the new design on its usability and especially if the guideline violations found in the first heuristic inspection were solved. The inspection was conducted in the same manner as the first. Two different experts inspected the designs using the same guidelines, but paying special attention to guidelines 14 through 17. Those were violated the most as the first inspection showed. Also as in the first inspection, both inspectors did the inspection
on the target platform to simulate normal user conditions as much as possible. The results of this inspection are very encouraging. Only one or two comments were made by the inspectors about guidelines 14 through 17. One of the comments was that the access keys do not function at all. That could be because of the Windows Mobile 5 target platform. How the HTML definition of access keys is implemented on this platform could not be found. The access key functionality is possibly meant for ordinary mobile phones or smart phones which have internet access, but not for 'PDA-like' devices like the target platform.

Another comment on this matter is that the numbers in front of the text links change per page. For the dynamic section of the navigation this is logical. However the 'always-available-links' section also varies the numbers, which should actually be static. That is to facilitate the speed of navigation by having the same access keys under the corresponding links on every page. Additionally, the links were numbered in descending order. One of the inspectors commented that one would naturally expect an ascending order. Although this is true, the descending order was chosen because of the division of the navigation into two sections. The 'always-available-links' section was placed under the dynamic links section and can then use the same numbers for the corresponding links on every page. The dynamic links section then holds the links the user most likely wants to use next and varies per page.

Furthermore, one of the inspectors also commented about the space the header takes up on every page. Although it makes the page recognizable and provides location information it does take up a considerable amount of space at the top of the page. The inspector suggested to only use the top line of the header on the index page and remove it from the remaining pages. Being a legitimate comment the design was changed to accommodate this. Additionally a modified version of the TeleTOP logo was positioned in the background to the right of the textual header. However the textual header overlapped the logo already at the length of just a few words. In addition, the second inspector also commented that the first line of the header was only on the index page and not all other pages, impeding recognizability. Therefore, the first line of the header was reinserted on every page, but its image was made smaller so it would take up less space.

Other comments by the inspectors were on a functional and usability level not part of the main goal of this project. For example, the functionality for sorting table columns was not implemented yet or the form for searching for courses to subscribe to did not mention the fact that no input was given, but said that no courses could be found instead. These are things which should be ironed out in a detailed design.

9. CONCLUSIONS
This paper touched on the topic of the usability of web applications aimed at desktop computers on mobile devices. More specifically, the interface of the digital learning environment web application called TeleTOP. TeleTOP is used throughout The Netherlands in different kinds of educational institutes. Nowadays people are more and more on the move, making the request for information come from mobile devices. Mobile devices which differ in screen size, processing capabilities and storage in comparison with desktop systems. In a lot of cases other types of interfaces are needed to request and input information on such devices. Practical experience with TeleTOP has also shown this. Not all functionality of the current TeleTOP works on mobile devices, so how can this be made accessible on these devices in a usable fashion? Searching current literature for guidelines and/or heuristics available on designing mobile interfaces resulted in a list of practical guidelines as shown in Appendix A. However a similar search for interfaces in the context of digital learning environments came up with nothing of relevance. With the list of practical guidelines and heuristics the desktop interface of TeleTOP was evaluated in a heuristic inspection. Based on the results the decision was made to design a separate interface for mobile devices. To prove this was the right course to take, a new design was made in the form of a high-fidelity prototype in accordance with the list of guidelines. This design was then inspected by third party inspectors again on the list of guidelines. These final results proved encouraging. Most, if not all problems identified in the first inspection were solved and both inspectors of the second inspection found in their expert opinion the new design very usable. Although two experts are positive about this design, this does not provide significant assurance. So to conclude it can be stated that the new design has good potential to make the current TeleTOP functionality accessible on mobile devices in a usable fashion.

10. FUTURE WORK
A lot of research has been done to make the current functionality of TeleTOP available on mobile devices as this paper shows. However the research was started under a few assumptions. In the future these assumptions need to be further explored to see how it effects the final goal. Depending on the possibilities and available resources, usability tests should be conducted with real users at the least. This would give a more accurate assessment of the new design’s usability. In order to do so the new design should be extended and improved to also hold the functionality which now can only be seen visually. Making more test data available would also be required.

When more time and resources are available a user study can be conducted on a larger scale. This user study should then additionally include research into the assumption that the target group described in this paper indeed has the need to request information through a mobile device. Furthermore, what kind of information users need while being mobile (i.e. travelling) should also be included, because the subset of functionality selected for the new design is only based on a single person’s view and experience on this matter. As described above many interesting open topics of research remain. In other words this paper has laid a solid foundation for future research to build on.

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12. REFERENCES
APPENDIX

A. USED GUIDELINES AND HEURISTICS

Full listing of all guidelines used in the heuristic evaluations, including the corresponding heuristics and examples. Wherein ‘G’ stands for guideline, ‘H’ for heuristic and ‘E’ for examples.

A.1 General user interface design guidelines
Nielsen’s general set of user interface design guidelines [5] which were found applicable in this paper’s context.

1. G: Visibility of system status
   H: Is the user given feedback on the status of the system? Is this in a timely fashion?
   E: If a system operation takes some time, can the user see that the operation is running and is an indication given of how long it will take?

2. G: Match between system and the real world
   H: Are words, phrases and concepts used which are familiar to the user? Are no system-oriented terms used?
   E: Is the information displayed in natural and logical order?
   E: Is everything readable from left to right and top to bottom?

3. G: User control and freedom
   H: Is context and orientation information provided?
   E: Are there no images on which the text is unreadable or are they greyed out and really disabled?

4. G: Consistency and standards
   H: Are used terms, icons unambiguous? Is the navigation and information design of the web application consistent?
   E: Are no icons used for two different actions? Are the navigation not positioned left on one page and right on the next? Are platform conventions and accepted standards followed?

5. G: Error prevention
   H: Are error-prone conditions prevented? If not, is confirmation asked of the user?
   E: Are interface elements for adding, editing and deleting clearly distinguishable? Is the deletion of information entries confirmed? Are actions which become impossible made invisible or are they greyed out and really disabled?

6. G: Recognition rather than recall
   H: Are all important objects made visible / detectable? Does the user have to remember previously entered information from one part of the web application to another?
   E: Are the actions and commands visible which are possible? Is the most important part of the desired content on the page visible? Are help instructions when needed easily accessible?

7. G: Flexibility and efficiency of use
   H: Are shortcuts provided to cater frequent users? Are infrequent users not inhibited by them? Can users tailor frequent actions?
   E: Does the interface navigation put frequent selected navigation elements at the top? Can collection elements (i.e. lists, tables etc.) be given a default ordering?

8. G: Aesthetic and minimalist design
   H: Is every information element relevant to the user? Is every information element relevant to the user?
   E: Are there no banner ads taking up a lot of space? Are there no images on which the text is unreadable after resizing?

9. G: Help users recognize, diagnose, and recover from errors
   H: Are error messages given in plain language? Is the precise problem indicated to the user? Is a solution
suggested constructively?
E: Are there no error pages given saying just '404'?

10. G: Help and documentation
H: Is the help and documentation easy to search? Does it focus on the user’s task? Does it list concrete steps to be carried out?
E: Is an index provided, giving links to relevant pages concerning corresponding topics? Are step-by-step instructions given to execute a certain task?

A.2 Mobile user interface design guidelines
User interface design guidelines specifically targeted at mobile web design. The following guidelines are taken from Stone et al. [11], Seong [7] and Gong [2].

11. G: Select versus type form of input
H: Is a selection option offered instead of text input wherever this is possible to prevent laborious input?
E: Are drop down boxes given instead of typing a date into three text fields (i.e. date, month, year)?

12. G: Consistency between platforms in addition to general consistency
H: Is the same terminology applicable between platforms? Is the same look and feel used to aid recognition wherever possible?
E: Do the same words used in the navigation elements for the platforms denote the same functionality? Is the same colour scheme used for the platforms?

13. G: Design stability
H: Is the user able to pick up where he or she left off in the event of a connection failure?
E: When returning to a form which was already filled with data, is the data automatically entered to prevent repetitive input?

14. G: Design for “top-down” interaction
H: Are long texts summarized and the user given the option to read the full text?
E: An assignment description is shown by its title and a summary text. By clicking on the title the full assignment is given.

15. G: Design for speed
H: Does a page not have too many information elements which need to be retrieved? Are information elements not too large in size?
E: Are images to be retrieved not 100 kb large or even larger? Does a page refrain from horizontal scrolling?

16. G: Design for small screen display
H: Is refrained from horizontal scrolling? Is there not too much vertical scrolling? Are information elements in proportion to the available screen size?
E: Are long pages segmented into chunks between which can be easily navigated? Are images not too big in screen size?

17. G: Pay extra attention to designing navigation
H: Has the navigation got a simple structure? Is the navigation always available after loading a page? Is the navigation consistently positioned throughout pages?
E: Does the navigation consist of a list of simple text links? Is it always visible at the top of a page?

B. TESTING SCENARIOS
Full description of all the test scenarios used during the test of the new or changed design.