Abstract

Applying to the Technical University of Munich (TUM) presents challenges for many students. Particularly those with foreign university degrees might find it time-consuming to locate and understand information on TUM's respective websites.

In this study, we developed and tested a proposal to improve the clarity of information conveyed through the website designated for applications to the B.Sc Mathematics program. We designed a self-assembled mock-up website to determine whether structural alterations and information displayed in simple language could enhance the process of gathering information for the aforementioned application.

In order to assess the efficacy of the old website versus our new model, we carried out a quantitative study that measured performance - indicated by time taken, tabs opened, success rates - as well as user experience and language comprehension via usability questionnaires. Our participant pool consisted of 11th and 12th grade students with varying levels of German proficiency from Brazil and Germany.

Findings indicated that the existing website layout made finalizing a correct application challenging and often leads to misinterpretations of requirements. Our mock-up website, on the other hand, enhanced the speed of completing a simulated application at TUM and received higher user experience scores (UEQ). Also, we found no correlation between German language proficiency and performance.

These results highlight the necessity of a comprehensive structured content display on informational websites. They also emphasize the need for a balance between condensing information and oversimplifying it, to achieve optimal user understanding.

Moving forward, our mock-up website presents a more user-friendly and efficient alternative to the current website for prospective TUM students.

Background

Conveying written information in a convoluted, intransparent way makes it more likely that the information gets lost than communicating in a simple, straight-forward manner (*Labrador Reveals the Effectiveness of Plain Language Proven by Data*, 2020). The way of transporting information determines whether it will reach the whole target audience or just a fraction of it (Langford et al., 2021). While one can observe this phenomenon in every aspect of daily life, it particularly occurs in universities, where complicated sentences and long reference chains are used constantly (Clayton, 2015). Here, not only the contents of the study programs are difficult for many students to understand, but also the application processes that enable them to enroll in the first place.

While it is clear that application processes require a certain complexity to cover all necessary proofs of qualification, it is not essential that the information about the process has to be delivered complexly as well. Applicants that are patient enough to thoroughly gather all of the information on this process are not necessarily the best fit for their study program, and applicants that get easily frustrated by websites are not necessarily bad students.

One of many examples of a website providing information on a university application process, which is rather difficult to understand, is the website on TUM's bachelor program Mathematics. The way in which information is conveyed here is at least partially imprecise, incomplete and not clearly structured.

In this study, we develop and test a proposal to improve information conveyance using the mentioned website as an example.

The methods for improving the website comprise content personalization (Tam, 2006), the use of simplified language (Hinchliffe & Mummery, 2008) as well as a more transparent navigation (Zhang & Yang, 2009). These principles have been shown to increase user satisfaction in other contexts, hence it is expected that they improve user experience here as well. Together with the results of a small-scale qualitative assessment of the current website regarding users' performance, language comprehension and experience, these methods are the cornerstones of the mock-up website which we developed as an alternative to the current website.

The method we use for the assessment of the websites is usability testing. Website usability tests have their origin in health sciences, where the importance of understandable websites is clear. The before-mentioned characteristics (performance, language comprehension and experience) were proposed by Anetta Hincliffe and William Mummery, who improved a physical activity health promotion website using a self-designed test which captures the users' impressions on the website's design, navigation and terminology. By "performance" Hinchliffe and Mummery mean the time needed for a task or the whole test as well as the number of errors. "Language comprehension" describes the ability of the participants to understand the information in a way that allows them to answer questions about it (TUM language optimization expert Julia Pötzl advised our design of a comprehensibility questionnaire). "Experience" refers to the subjective user experience, which is evaluated with two methods: first, by asking about the difficulty of the just-finished task after each task, i.e. using the so-called "single ease question". The difficulty is evaluated on a 7-point Likert scale ranging from 1 (very difficult) to 7 (very easy). This type of scale is highly correlated

with other measures of user experience and is an established tool in website and product testing (Sauro & Dumas, 2009). The second measure of user experience is the so-called User Experience Questionnaire (UEQ), a widely recognized tool for the assessment of several characteristics in user experience: attractiveness, efficiency, perspicuity, dependability, stimulation and novelty (Laugwitz et al., 2008). These categories are explained as follows:

- Attractiveness: is your experience with the website enjoyable, good, pleasing? Does it send out a friendly vibe?
- Efficiency: do you feel fast, efficient using the website? Is it organized, practical?
- Perspicuity: is the structure and text on the website understandable, clear, easy to learn?
- Dependability: is the website's reaction predictable, does it meet your expectations? Does it feel secure to use the website?
- Stimulation: does using the website feel exciting, motivating, interesting?
- Novelty: does the design and structure of the website feel creative, inventive, leading edge?

The participants of the usability tests should at least partially represent the demographic which is using the application information website. The typical applicant for a bachelor's degree in mathematics at TUM is a high school student in their last year of school or briefly afterwards, and with a likelihood of 42% they did not go to school in Germany. The five most prominent countries of origin of foreign TUM students are China, India, Turkey, Austria and Italy (*TUM in Zahlen 2020*, 2021). When widening the context to all German universities, with a probability of 16% the potential applicant has a study-relevant disability (*Wissenswertes Rund Um Das Studium Mit Behinderung Und Chronischer Erkrankung*, n.d.).

Eventually, we use the testing methods to answer the question whether structural changes and language simplifications can improve the information-seeking process in the application for the TUM bachelor's program Mathematics.

Goals & Methods

This section explains the choice of study participants as well as the testing procedure.

Participants

The testing consists of two rounds, the pre-tests and the comparative tests. As mentioned in the introduction, the most important target group of the website are high-school students in their last year who attend school in Germany, China, India, Turkey, Austria or Italy.

For usability pre-tests, especially China and Italy are of interest since these countries require additional documents which require a bit of searching on the TUM website.

Performing the pre-tests in Munich, age and education are the easier criteria from this list. However, we are unable to find willing participants from the last (12th) year of high school due to collision with their Abitur exams, hence we recruit students from the second-to-last (11th) year of high school, assuming that their ability to find written information on a website would not differ too much from their one-year older colleagues. This of course implies that these students visit school in Germany, not in China or Italy. To also gather information on the experiences of those demographics, some of the participants receive the instruction to search for information that is relevant for an applicant who completed high school in one of these countries. One of the participants was diagnosed with a learning disability, making it possible to cover this perspective at least to some extent in the pre-tests.

Eventually, we invited six participants to the TUMJA office to complete the tasks of the usability pre-testing round.

After finishing the development of the mock-up website using the results from these first tests, the second round of Usability Testing starts. This second round comprises more participants and is of quantitative nature, helping us to spot the statistical differences between the old and the new website. We group the participants into one group working with the new website and a control working with the old one. All 76 participants are in 11th grade of high school, 69 of them attend a German school in Brazil, 6 go to school in Germany. A large part of the Brazilian participants are non-native German speakers.

Study Design

While we use the testing guideline by Hinchliffe and Mummery as an orientation, our methodology differs at several points. Hinchliffe and Mummery have two rounds of Usability Testing, where the only changing variable is the website. They use the results of the first round to improve the website, and then test for significant differences in the second round with the improved version. The number and demographics of the participants is similar for both rounds. Due to logistic constraints, we decide to split the two rounds differently.

Our first round is a purely qualitative test using only the old website, with a small sample and a broad demographic. The idea behind this is to gather insights into the information-finding process from several different backgrounds and for as many aspects of the website as possible. Since this is a considerable effort for the participants, as it requires them to work

very intensely with the website, we expected that recruitment would not be easy and therefore designed the tests for only a small number of participants.

We printed the tasks on paper. These had to be answered by either collecting information on the website and filling in blanks or selecting multiple-choice options on the task-sheet, or by denoting subjective experiences on the sheet. Also, before the test, we invited the participants to voluntarily declare their German language proficiency and whether they have a diagnosed learning disability. The tasks of the questionnaire included:

1. Simulating the application information finding process by researching the necessary documents for the application and the enrollment, depending on a role the participants were assigned to before the test. This was a person that either received their diploma in Germany, Italy or China and has the respective citizenship. There were two probands per role.

2. Describing the application evaluation process and finding out how to know whether one's application was successful.

3. Researching the maximum number of semesters one's studies are allowed to take.

4. Gathering information about the enrollment and researching the specialties of studying Mathematics at TUM.

5. Filling out a standardized questionnaire on user experience.

We gave the tasks to the participants in the form of a multipage paper sheet. The participants brought their own computers to perform the research.

In accordance with the test by Hinchliffe and Mummery, the pre-tests measure the three characteristics: performance, language comprehension, and user experience. We measured the performance by stopping the time for task 1 and evaluating whether the students selected correct documents, deadlines and submission forms. A correct answer yields +1 point, a wrong answer -1 point, and no answer 0 points. Also we evaluated the answers of tasks 2 and 3 for performance measure. We evaluated language comprehension with task 4. Task 5 generated data on the user experience. We analyzed the results of the pre-tests to find out about the most outstanding issues with the old website such that the new website can be developed targeting precisely these problems.

As soon as we finished the mock-up, the second round of usability tests started with substantially more participants. More participants also mean less tasks to save time, requiring a new test sheet. However, still the same three characteristics are supposed to be captured: performance, language comprehension and user experience. The test sheet for the comparison tests consists of the following tasks:

1. Simulating the application information finding process by researching the necessary documents for the application alone, without the choice of a role. We asked the participants to perform all tasks using their own (prospective) backgrounds as high school alumni.

2. Gather information about the enrollment, describing the application evaluation process and find out how to know whether one's application was successful.

3. Filling out the User Experience Questionnaire (UEQ).

The participants measured the time to complete tasks 1 and 2 respectively by themselves. Also, we asked them to denote the number of browser tabs which they needed to open for the research. This number is of interest as participants of the pre-tests stated that they would have liked it if they had not needed to keep so many tabs open to find all the information. Less tabs means less transferring between websites which provides a feeling of overview and could help to save time.

Similar to the pre-tests, we measured performance using the duration of tasks 1 and 2 and by evaluating the answers to task 1. Task 2 aimed at language comprehension, and task 3 provided insight into the students' opinions on the websites. As in the pre-tests, tasks 1 and 2 were followed by the single ease question to collect as many subjective impressions as possible.

We concluded the tests with the UEQ as it was the case with the pre-tests.

All questionnaires included a comment section in the end, and participants were encouraged to remark any thoughts they considered important during the test.

Materials

In the following, we describe the original website and how we constructed the mock-up website.

Status-quo

The main reference point for the testing is the application website of TUM bachelor's program Mathematics as of November 2023. In this section we describe the structure and the content of the website.

The main website consists of four parts - description of the course, information about the application process ("Bewerbung"), information about the admission process ("Einschreibung") and the course of studies ("Im Studium"). Each section is accompanied by expandable subsections (Fig. 1).

The most relevant information for the decided applicants can be found in the section "Bewerbung". Application deadline, required documents and the description of the application process can be found here. There are also subsections explaining two important aspects of the application process - letter of motivation and essay.

The information stated in this section is, however, imprecise, incomplete and not properly structured.

One example of imprecision are language requirements. The subsection "Was muss ich beachten, wenn ich aus dem Ausland komme" ("What do I have to consider if I come from

abroad") states all applicants are "usually" ("in der Regel") required to submit a sufficient proof of language proficiency if their classroom language was not German. This is specified only in the corresponding statute (*Satzung über Das Studienorientierungsverfahren Für Den Bachelorstudiengang Mathematik an der Technischen Universität München*, 2018), which for example excludes German nationals who attended a German-speaking high school for less than two years and do not have German Abitur from this exception.

Additionally, this statute is linked in the website under the section about the course of studies, subsection examination regulations. Both the section and the subsection are not directly related to the application process.

Subsection "Was muss ich beachten, wenn ich aus dem Ausland komme" also contains information about German nationals whose classroom language was not German. This is also relevant to some German nationals born and living in Germany, despite the title suggesting otherwise.

In the subsection regarding the required documents, some documents are listed as relevant in some cases ("ggf."). These are mostly required for international students. This, however, is not stated anywhere in the subsection. German nationals might find the information irrelevant or even confusing, as they have to make sure they do not need to get some of the documents. On the other hand, some international students might find the information also confusing as not all documents are listed here. This is the case for students from countries such as China, Vietnam or Georgia, where the applicants have to meet special criteria. All international students are guided to a link below the list to find out if and which special criteria might apply in their case.
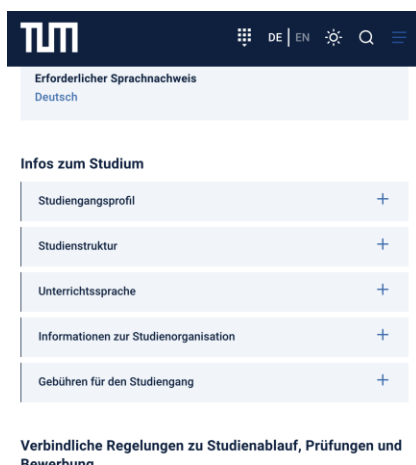

Fig. 1: Status quo website for TUM B. Sc. Mathematics applicants

Mock-Up

As a part of the research question we provide an alternative information website where students can get information about their desired study course. For the model we again

choose the TUM bachelor's program Mathematics.

To create an alternative model, we had to consider two strong constraints:

- New model can use only the same content as found on the status-quo website or in the attached or publicly accessible documents.
- The language used in the new model has to be precise.

These constraints ensure that we improve only the model's structure and wording, not the content itself.

Additionally, there were several principles we followed to improve the current website, mainly:

1. <u>Use simple language throughout the text wherever possible</u>. We used a popular large language model GPT3.5 to iteratively simplify the text until we achieved equivalent content in the result. Multiple iterations were often necessary because GPT3.5 has a tendency to leave out important information. In cases where no further simplification was possible, we added additional explanation. GPT3.5 also helped us to identify advanced words such as *"Hochschulzugangsberechtigung"* (university entrance qualification), which are not easily understandable especially to the international applicants. Some other methods for simplifying the language included using the second person in the text such, i.e "du"-form (you-form) and using active voice (Naji, 2022).
2. <u>Show relevant information only.</u> Instead of trying to fit every piece of information in one webpage, we show step by step relevant information only. This is important because students have different backgrounds and it's practically impossible that they need to know how the process works for other students, e.g. German nationals will find it irrelevant what Chinese nationals are required to submit and vice versa.
3. <u>Allow simple navigation.</u> It is reasonable to assume that people need different information throughout their application process instead of having everything at once. We split the information in blocks, where more details are shown on request. It is important to note this principle is already partially present on the status-quo website.
4. <u>All information in one system.</u> There should be no need to search for information outside one system regarding the application process.

Design and user Journey

We demonstrate the principles on a model of a web application. After opening our web application, the user sees three buttons - *"Important terms"*, which serves as a glossary with additional explanations, *"What do you need for your application?"* with requirements assessment and *"Key data and contacts"*. The structure ensures we follow principles 3 and 4.

"Important terms" were mostly inspired by the glossary on the status-quo website. The biggest change consists of wording as described in principle 1. We focused on some existing downsides of the status-quo glossary, e.g. missing explanations of some difficult words such as "*Hochschulzugangsberechtigung"* or using multiple terms for the same concept, e.g. *"Einschreibung"* and *"Immatrikulation"* both mean *"Enrollment"*, despite the equivalence not being stressed enough.

"What do you need for your application?" demonstrates principle 2. In this section, the user gets multiple questions about his background (Fig. 2) to assess, whether and under which circumstances can they study the given course. The output of this section is a list of required documents with their respective forms and deadlines to be submitted (Fig. 3). This eliminates unnecessary information and reduces the need to search for more information for special cases.

As the name suggests, *"Key data and contacts"* provides simple information such as the application deadline, contact partners and the link to the official website.

Technical Implementation

We implement the given design as a Flutter web application. We chose Flutter because it can be used to implement the design and the logic of the application using one codebase. We then uploaded the built website content to our hosting, so it is accessible for the survey participants with ease. The web application did not collect any information, including personal information.
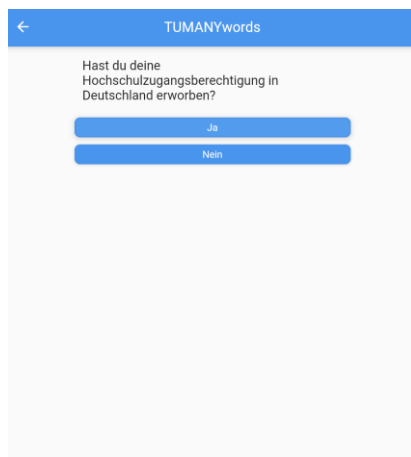

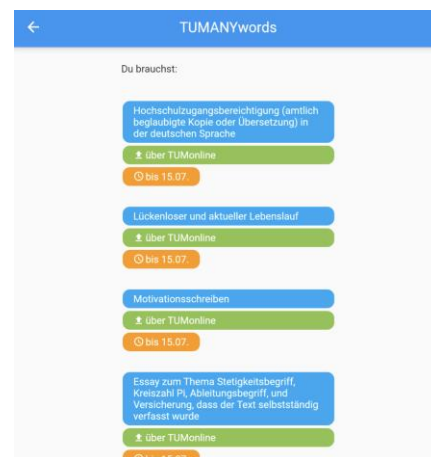Fig. 2: Mock-up with an question to assess applicant requirements

Fig. 3: Mock-up showing personalised requirements

Outcome

We evaluated the pre-tests qualitatively, leading to the following main results: the document search (task 1) took the longest for the students who were assigned the Italian and the Chinese roles. It was rated most difficult by the students with the Italian role, which was also the role with the most errors. For all participants, the choice of language certificates as well as the deadlines were the tasks which yielded the most errors. Even the students who had the role of German citizens with a German high school graduation selected various German language certificates necessary. The participants performed the other tasks with less difficulties. Since task 1 was the largest of all tasks, its difficulty had the largest influence on the UEQ results, which were neutral to negative in all categories. The category with the most extreme negative score was perspicuity. This is not surprising given the results of task 1 and our observations on the status quo. Regarding the comments of the participants, most concerned minor technical difficulties. One comment however noted how it would be nice to have a more interactive website which returns a custom-made document list.

We used these findings to develop the mock-up, as it is described in the respective section.

We evaluated the comparative tests quantitatively. They reveal significant performance improvements with the mock-up website in both tasks. Using the mock-up, task 1 is completed faster (mean time original website (version A): 36.07 +/- 11.69 min versus mock-up (version B): 18.19 +/- 10.31 min; p-value = 0.00000005) and with less errors (mean points version A: 3.43 +/- 3.97 points versus B: 6.69 +/- 5.40 points of a range of -15 to 15 points, p-value = 0.002) than when using the original website. Task 2 is also completed faster (A: 29.20 +/- 14.12 min versus B: 14.18 +/- 8.63 min; p-value = 0.0004), but the number of errors does not decrease (A: -0.14 +/- 1.51 points versus B: -0.66 +/- 1.72 points of a range of -6 to 6 points, p-value = 0.16). See the results of task 1 and 2 in Fig. 4, 5, 6 and 7.
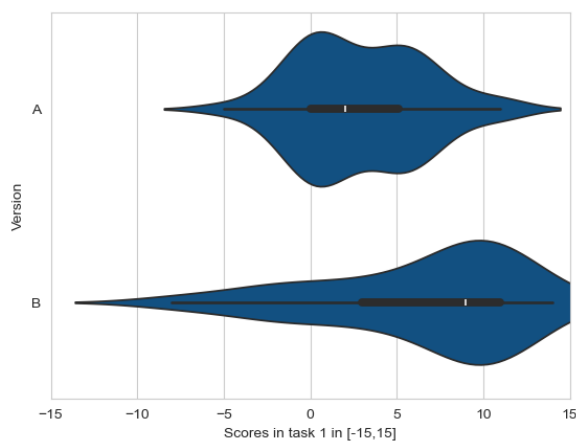

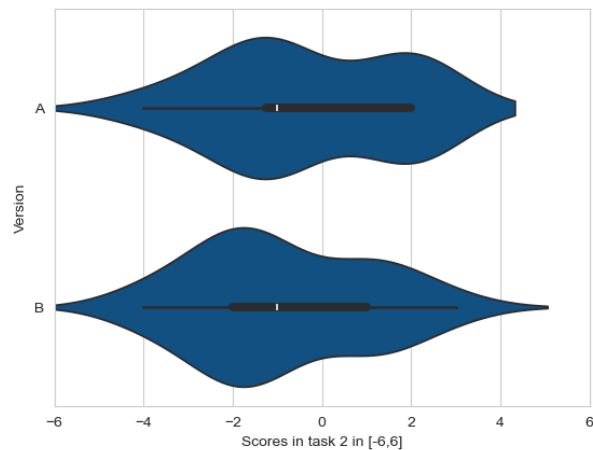Fig. 4: distribution of the scores of task 1, grouped by website version.

Fig. 5: distribution of the scores of task 2, grouped by website version.

The number of tabs being opened for task 1 and 2 is significantly lower for the users of the mock-up compared to the users of the original website, supporting the claim that the mock-up website reduces the need for outside research to gather all necessary information (A: 7.4 +/- 3.5 tabs versus B: 4.1 +/- 1.7 tabs, p-value = 0.0002).
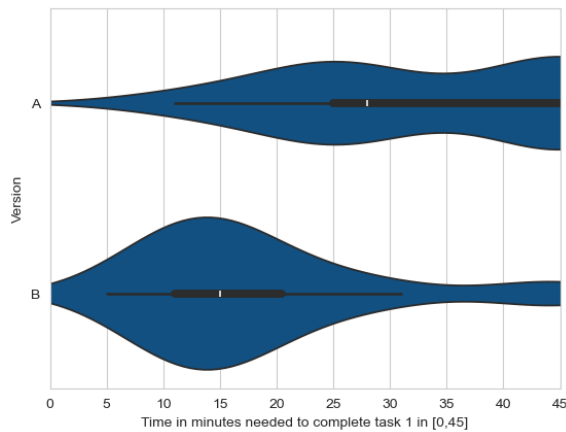
Fig. 6: distribution of the needed time for task 1, grouped by website version.
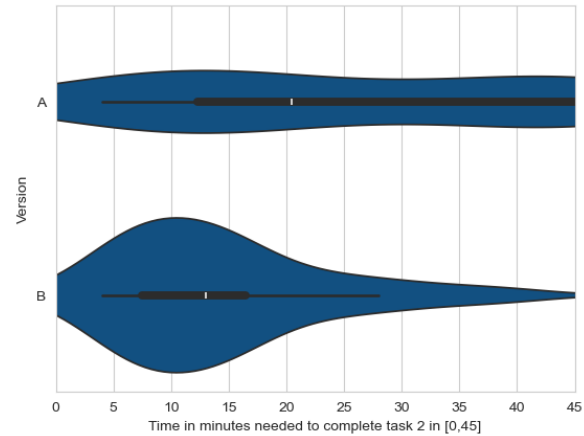

Fig. 7: distribution of the needed time for task 2, grouped by website version.

As task 1 is the most important one of the questionnaires as it comes close to the procedure necessary for a real university application process, it is investigated in more detail. Four students have indicated that they have a diagnosed learning disability, and all of them worked with the original website in the comparative tests. In mean, they reached a higher score than the non-disabled cohort: 5.00 +/- 3.65 points (learning-disabled, version A) versus 2.76 +/- 3.60 points (non-disabled, version A). This difference is insignificant (p-value = 0.209).

Another finding regarding task 1 is that the self-assessed German proficiency does not correlate with the performance. While a small trend is observable for the mock-up website, where a higher level of German language skill can be associated with fewer errors, no trend is detectable for the original website.

The results of the UEQs speak a clear language: improvements are visible in each category, see Fig. 8. As in the pre-tests, missing perspicuity is the most prominent flaw of the original website, which is cured with the mock-up. Novelty is the only category which did not overcome the good-usability-threshold, yet it now has a neutral-to-positive rating instead of a negative one.
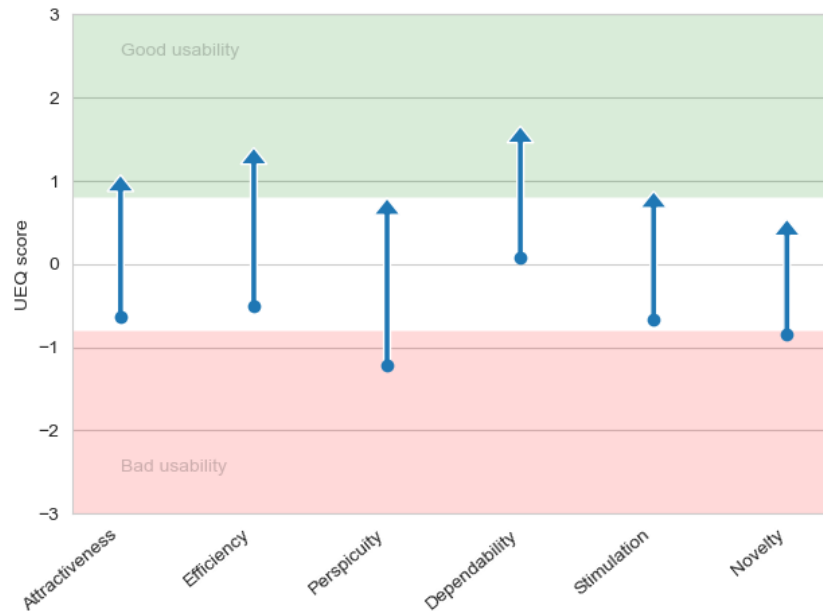
Fig. 8: evolution of the UEQ scores. The origin point of each arrow describes the score
obtained with version A, and the arrow head indicates the score obtained with version B.

Regarding the comments by the participants, the original website received a lot of negative
feedback due to its complexity and detailedness. However, the mock-up website received
the opposite criticism: some participants found it to be not detailed enough.
Some participants also mentioned that the mock-up website did not make statements about
necessary language certificates. The issue seems to be that if no certificates are necessary,
the mock-up does not list any certificates which causes confusion.

Discussion

Being in contact with TUM authorities, such as the Language Center and the Website
Design Team, our ultimate goal is to share the results of our study with them and have a
voice in the future design of TUM web pages that are concerned with application processes.

As stated in the „Results" section, those students that took on the role of a foreign student
(meaning non-German) took longer, as this is usually more complex due to country-specific
language and high school diploma guidelines.

The errors with respect to deadlines and language certificates can be likely traced back to
the confusing layout of information on the original website, as well as the overwhelming
number of available options of language certificates. The Brazilian students with German
Abitur often fell for the 'trick question', asking them to list necessary certificates if applicable
when in reality there were no additional certificates needed.

It is rather telling that, out of all UEQ results, perspicuity had the worst score. This strongly
indicates that the (old) website design strongly lacks the structural and linguistic adequacy to
make it understandable to users across the board.

For both tasks, the students were able to solve the tasks more quickly and (for task 1) with higher scores, proving that the mockup fundamentally improved the students' ability to understand the requirements for the application process. As previously described, the central goal of the mockup was to provide the students with all the necessary information to complete the application process, but as little information as possible to make it easily digestible. We reached this goal.

For similar reasons, the mockup consequently made it possible for students to complete the tasks with a lower number of additionally opened tabs.

Interestingly enough, the self-assessed German proficiency does not correlate with the performance. A very likely reason for the absence of a (stronger) correlation is that the students assessed their skills inadequately. Some might not have been familiar with the European reference system (A1-C2) or might have simply overstated/understated their skills.

The UEQ have demonstrated that a positive change is possible. Meaning that the correct display of information in a structured, legible manner is essential to the applicants' understanding of the application process. This is why the mock-up scored higher in all relevant categories.

Nevertheless, it is important to note that an oversimplification can indeed occur, as some students noted that the mock-up was, in fact, too reductive. There seems to be a sweet spot between showering a user with information and reducing it to a minimum that has to be found in order for websites to convey their content most efficiently. At times, users might welcome some additional information, even if it is not necessary, to gain a better sense of understanding of the entire application procedure. At the same time, the status quo seems to indicate that the most relevant group for application processes (high school students) seems to have severe issues getting an understanding of said process and subsequently having the ability to complete it, without a significant amount of additional research.

Summary

In conclusion, our study aimed to enhance the user experience, as well as simplify the information available on the TUM websites regarding the application process.

We identified that the current layout makes a successful completion of an application more difficult and often leads to misinterpretations of requirements.

Our mock-up website led to improvements in completion speed of a simulated application at TUM and higher UEQ scores. However, we did not find a correlation between German proficiency and performance.

These findings evidence the importance of a comprehensive structured content display on informative websites. They also underline that for optimal user comprehension there must be a balance between information reduction and oversimplification.

In the end, our mock-up website proves to be an alternative to the current website with enhanced user-friendliness and efficiency for prospective students at TUM.

The team hopes to have a lasting effect on how TUM application procedures are presented on their respective websites. A prospective goal is that forwarding the results and ideas for a better website design that emerged from this project will be taken into the account by TUM authorities and that there will be a continuous improvement process of the university's internet presence. We are open to further discussing our results and developing our concept in cooperation with the coordinators of the TUM website design.

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