Bachelor‘s Thesis

Current vs. prospective students; attaining their mental models about navigating university websites by means of card sorting to determine the usability of university websites.

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Abstract

The purpose of this research was to establish whether university websites should implement multiple mental models into their information architecture to ensure usability for multiple user groups. This argument was made as previous literature explained that an information architecture based on the mental models of a website's users allows for intuitive searching, and that the ability to seek information intuitively increases a user's perception of the usability of that website. To achieve this goal, the mental models of two different user groups of university websites had to be obtained, enabling the determination of whether the mental models of different user groups vary in relation to the same concept. This study chose the population of current students and the population of prospective students as their target groups, as they represented the main user groups of university websites. To elicit the mental models of these recruited sample groups, the method of card sorting was used, creating an open digital card sorting, and analysing the results using multiple matrix analyses. In general, three main differences were established between the two mental models, indicating that universities indeed must implement two different information architectures to provide both user groups with the required usability. Additionally, this paper highlighted some limitations created by the procedure of this research.

Introduction

The goal of any website, whether it concerns e-commerce, entertainment, social media, or another domain, is to provide information. Moreover, seeing there is a 83% chance users will leave when it takes them to much effort to find what they are looking for (Vila & Kuster, 2011), a website should preferably be able to do that easy and quickly. This view is supported by Morville and Rosenfeld (2002) who write that website users are task oriented and not concerned with the structuring and build of a website itself. Users do not want to spend time figuring out how a website works; they just want their information and go on with their day. In other words, a website should be designed with usability in mind (Lawrence & Tavakol, 2007). Usability being 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" (ISO, 1998)

According to Singla and Aggarwal (2020), an important aspect that influences website usability and is often overlooked, is the ability of users to search for information intuitively. More research by Morville and Rosenfeld (2002) supports this and clarifies that when users manage to find information in the places they expect to find it, they will experience a website as more usable. Therefore, also making them more likely to revisit. To enable intuitive searching, both sources argue that the organisation of a website's content, the manner in which its information is grouped and linked to each other, plays a role. As well as that a website should be designed based on an understanding of what their unique users regard as intuitive. Additionally, a study by Johnson-Laird (2004) explains that these perceptions of intuition are represented in the mental models users have. Coming to the conclusion that a good understanding of the mental models of a website's users enables website developers to facilitate intuitive searching for those users, which in turn contributes to an improvement of usability of the website.

Looking at the domain of university websites, the inability to find information efficiently and effectively (i.e., poor usability) could have quite some substantial consequences. A university provides many services (e.g., education, jobs, research facilities, connecting job markets and future employees) and is involved with a lot of different people (e.g., students, staff, companies, organisations, prospective students). These people all need information about various sorts of topics (e.g., contact details, enrolment procedures, mental health support, facilities, PhD tracks, partner opportunities). Meaning that a university website contains a lot of information in which their multiple user groups could get lost. If those groups were to not reach certain information, it could lead to a multitude of problems. Ranging from students missing classes and exams because they could not find their schedule, to the university missing out on collaborations and possible income because companies could not find the right contact details, to no new students registering because people were not able to find the different studies the university offers. Overall, a university highly benefits from a website that is usable by all parties involved and allows for them to navigate to their wanted information.

Linking the fact that a university website has many different user groups and that an understanding about their mental models could facilitate valuable website usability, the question arises whether these groups also have different mental models. Since, if so, multiple mental models are to be implemented to ensure the website's usability. To provide universities with a deeper insight into the usability of their websites, this study will investigate two of the main user groups of university websites and their respective mental models. In order to fully understand the process of this study, more background information will be provided in the next paragraphs. As well as a more detailed formulation of the research question.

Information architecture and navigation structure

As mentioned before, website usability is influenced by the degree to which intuitive searching is possible. Which in turn is caused by the organisation of a website's content. To clarify what this exactly entails, literature uses two terms. Schall (2014) and Fang and Holsapple (2007) employ the concept of navigation structure. While Carter (1999), Morville and Rosenfeld (2002), and Singla and Aggarwal (2020) explain it using the term information architecture (IA). Both views describe the organisation of a website's content as the layout of different paths through which pages and information can be accessed (i.e., syntax) and the language used to label that information (i.e., semantics). It does not entail the graphical aspects of a website, such as the use of colours or pictures. Nor does it involve the software development behind a website. It solely focuses on the labelling and structural design of an information infrastructure. Comparison of the two leads to the conclusion that both terms have the same meaning. To avoid confusion, this study will use the term information architecture in the rest of this paper. Additionally, Fang and Holsapple (2007) and Lazar (2001) refer to the importance of understanding the mental models of a website's users in order to establish the information architecture (IA) that suits them the best. Meaning that information is located on pages that are logical to the users and the names used to describe topics are not misleading. Overall enabling them to search for information naturally. Which also implies that when an IA is not based on the mental models of users, it negatively influences the user's ability to achieve that goal of intuitive searching and thereby diminishes the usability of a website.

Mental models

As early as 1983, mental models have been a known term within psychology. Being explained in diverse ways. However, the collective understanding is that they represent the cognitive knowledge schemes a person has about all sorts of matters they have come into contact with (e.g., objects, animals, people). Ultimately guiding their thinking and reasoning in relation to everything they do (Johnson-Laird, 2004). Concerning the origin of these mental models, there is no exact method to determine how these models are precisely formed. However, the majority of existing research suggests that they are created over the years and are based on the experiences and interactions people have with all that is around them (Staggers & Norcio, 1993; Johnson-Laird, 2001). Relating to the use of websites, mental models able to clarify what expectations a user might have about where to find certain common website features. E.g., the search bar, a home button, a log-in page, or the navigation. Which enables website designers to implement the most suitable information architecture. A paper from Roth, Schmutz, Pauwels, Bargas-Avila, & Opwis (2010) that investigated three types of web pages (online web shops, news portals, and company web pages) also noted that users of the internet have different mental models regarding different types of websites and their features. Their study established that the topic ‘about us’ was not intuitively included on the pages representing web shops or news outlets. It was however included on the pages that represented a company. Similarly, the inclusion and positioning of the ‘search field’ was different between the three types of web pages they investigated. Additionally, the study proposed that these mental models were congruent over time and not influenced by gender. Overall, they advised that implementing the mental models of users could improve the perception and usability of websites.

Card sorting

Previous work by Shall (2014) determined that card sorting is a good method to investigate navigation structures and uncover the mental models users might have that directs their navigation. Previous research by Fang and Holsapple (2007) and Wood and Wood (2008) also confirm this. They concluded that card sorting can be used to document the different ways people organise their knowledge. Creating an external reflection of a person's internal mental process (Fincher & Tannenberg, 2005). Concerning the experiment itself, it consists of a selected group of test subjects that is generalisable to the main target group performing a task in which they are given a list of concepts and are asked to organise them into piles that make sense to them. Ultimately reflecting their ways of thinking. After the sorting, the participants are asked to put a label on the created piles. This specific method is also called open card sorting. The other form of card sorting is called closed card sorting and involves participants assigning concepts to already labelled piles. For this research, a sample of each target group (current students and prospective students) will perform an open card sorting.

This research

The scope of this research is to learn more about the usability of university websites based on the mental models of two of their main user groups. More precisely, this study will investigate the usability of the website pages regarding education related topics. Researching the usability of an entire university website would require a card sorting experiment too extensive for the available resources. Furthermore, registration statistics of 2021 for the University of Twente imply that there are approximately 3 times more students than employees and other partners engaged with the university ("Feiten En Cijfers (5 Jaar) | Organisatie," n.d., "Feiten En Cijfers (5 Jaar) | Onderwijs," n.d.). Suggesting that education is still the primary objective of the UT, which supports the choice

to specify on the educational pages, and suggesting that current students are a probable first user group of university websites to research.

Looking into a possible second user group of the educational pages of a university website, prospective students comes to mind. Defining prospective students as adolescents at the age of 18 years who in their final year of high school and in the process of choosing a university to attend after graduating. At first glance, these two groups have a lot in common. However, they could possibly differ in their familiarity with the UT website. Enabling the possibility that current students have a different mental model about navigating the website due to more previous experiences with it. Suggesting that website familiarity might be an important factor to include in this study. Besides this possible difference in website familiarity, previous literature also suggests that these two groups are likely to differ in what topics they find relevant (Yadamsuren et al., 2009). Current students are for example more interested in information regarding their classes (such as homework, schedule, exams) or in information about studying abroad in their academic career. Whereas prospective students more often to look for information about the university itself (such as its history or graduation rate) or for information about the tuition and fees. Which in turn may suggest another possible difference in mental models.

To summarise, this research paper intends to obtain the mental models that current and prospective student have about navigating the educational pages of university websites. Aiming to analyse them for differences and/or similarities and determine whether the two sample groups have different mental models about the same subject. Consequently establishing whether two different mental models are to be implemented to ensure intuitive searching by the two user groups and therefore good usability of those web pages.

Methods

Participants

As this study aimed to investigate the mental models of both current students and prospective students, two different sample groups were obtained. The sizes of these sample groups were determined as prior research by Wood and Wood (2008) suggested that a larger sample would very likely display the same results.

This study was approved by the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente, and all respondents gave their informed consent prior to participating. In order to participate individuals had to be 18 years of age or older.

Upon first look at the data, one participant was excluded from the dataset due to two reasons. One being the fact that they did not disclose their level of education (current of prospective). Resulting in the inability to assign them to one of the two sample groups. Second, they also did not perform the card sorting as asked. Instead of creating multiple lists, they assigned all items to one and the same list. After this first exclusion, the groups were separated to be further analysed with regard to their demographics and the exclusion criteria.

Current students.

The final amount of participants recruited for the sample of current students was 44. Of these participants, 38 were reached with the use of the UT BMS faculty's Test Subject Pool system SONA, and they received 0.25 credits for their participation. All others were recruited though the personal social circles of the researchers, using the word-of-mouth method. After further assessment of the responses no other participants were excluded as there were no more missing

participant statistics nor card sorting results with all items assigned to one list. Therefore, the final sample used for further analysis consisted of 44 students.

Concerning the demographics of this sample, 10 students identified as male, 33 as female, and 1 as other. Age wise, 43.18% were between 18-20 years old, 40.90% between 20-22 years, 13.64% between 22-24 years, and 1 participant (2.27%) was 25 years or older. Of these 44, 18 were Dutch, 19 were German and 7 had another nationality. In order to participate all participants understood English even though their native languages varied (Dutch: 40,90%, English: 6,82%, German: 40,90%, Other: 11,36%). To account for any error, participants were also asked about their familiarity with the card sorting method. However, the majority (75.00%) did not know the procedure. Only a few (13.64%) knew how it worked, but they had not used it themselves. The rest (11.36%) had only heard about it before participating.

Prospective students.

For this sample, 8 participants were attained. They were all in their senior year of pre-university education, therefore being prospective students. All of them were recruited via a teacher at the high school in Enschede at which this researcher is employed. Participants were removed from the data set when they were under the age of 18, and if they assigned all cards to one singular group. Resulting in a sample group of 5 prospective students. Of these 5, 2 were male (40%), 3 were female (60%). Their age all between 18 and 20 years old. All 5 had the Dutch nationality, although one of them did have another native language. Also, only 1 participant had heard of card sorting previous to this study, whereas the rest (80.00%) did not know it.

Materials

To execute the objective of this study a digital environment was created using the premium version of the program kardSort. A program that allows one to create an online card sorting experiment and export the data. This environment consisted of a landing page which displayed information about the current study and the informed consent form, a second page with a questionnaire, a third with the participant instructions, and a final page with the open card sorting itself. The exact content of these 4 pages can be found in Appendices A, B, C and D.

As visible in appendix B, the survey contained questions regarding the demographics of the participants (gender, age, nationality, native language). As well as the questions (1) “What level of education are you currently following?”, (2) “How often do you use University websites on average?” and (3) “How familiar are you with ‘Card Sorting’?”. The first one was to enable separating the two sample groups. The second to account for the possibility that current students might have a different mental model than prospective students due to more experience with the website of the UT. And the third made it possible to establish whether there was a considerable difference in familiarity with the procedure between the groups that could also possibly cause different mental models. All questions were multiple choice, requiring the participants to choose the answer that was most applicable. However, all questions also included the option to not disclose the answer to the question. Additionally, all questions were mandatory to answer to be able to proceed to the next page.

With regard to the instructions of the experiment (see appendix C), the decision was made to write them in a directive sense. Being non-directive in the instruction for the participants with the intention to avoid bias seemed right at first. However, Wood and Wood (2008) argued that it is more important to be as clear as possible about the reason a card sorting is performed.

Item selection

Concerning the digital card sorting (see appendix D), it was decided to create an open card sorting using the 34 items that would best represent the webpages of a university that concerned education. To decide which items that were, this research studied the websites from 8 Dutch universities and made a list of all the topics that the education related pages would mention. Next, the presence of each topic was checked for all 8 websites. Creating the matrix shown in appendix E. Looking at frequency that each item was present, the 34 most common items were identified. Creating the list as shown in appendix F. Ultimately, these items were selected and implemented in card sorting. The 8 universities of which their website was used to determine the value of these items were University of Twente, the University of Groningen, the Radboud University in Nijmegen, the Eindhoven University of Technology, the University of Amsterdam, Leiden University, Delft University of Technology, and Maastricht University.

To account for the possibility that the understanding of the concepts by participants was overestimated, literature advised to provide a clear description of the different concepts (Wood & Wood, 2008). However, because this research aimed to be as accurate as possible in regard to the navigation on the described domain, it was decided to not follow this suggestion. The websites of universities also do not provide more information about a concept when navigating.

The data gathered with kardSort was exported into multiple .csv files. Separating the questionnaire responses from the card sorting data. The first was analysed using Microsoft Excel, the latter was uploaded into SynCapsV3 to be further analysed.

Procedure

Participants were able to access the kardSort digital environment via a website link that was provided via SONA or via WhatsApp message. When they opened the link, participants would arrive on the landing page. Which welcomed them, explained the goal of the study, and gave a first idea of what the concluding experiment would be. In addition, the benefits and risks of participating were mentioned, as well as their ability to voluntarily withdraw from the study at any given moment. The contact details of the researchers were listed, some information about the data confidentiality was added, and a few sentences made respondents aware that students participating via SONA had the possibility to receive reimbursement. Moreover, the page also mentioned that if any participant would have questions regarding their rights as a research subject, they would be able to contact the ethics committee of the University of Twente. Providing their contact information. Finally, it was stated that by continuing to the next page participants would agree to statements of the informed consent form. Going to the second page by clicking on “next”, participants would reach the demographical questionnaire. After filling in the survey and clicking on “next” again, they were now showed the instructions of the experiment. In these instructions, participants were told to group the cards that they felled belonged together into piles. Creating as much piles as they deemed necessary. After they had read through that, they were able to start with the card sorting on the next page. Participants were also able to go back to the instructions at any given time without losing their made progress by clicking on the “instructions” button. Then when a participant was finished sorting all the items into piles, they had to click on “next” one last time to go to the page that had the “submit all and finish” button. On this page participants were also able to leave a comment if they wanted to. Lastly, above the “submit” button a warning was stated,

making the participants aware that once submitted they were no longer able to change any of their given answers. After this, their participation was completed.

Data analysis

First, the questionnaire responses were analysed. This was enabled by implementing a pivot table in the excel file. The clear overview it created made it possible to identify which data needed to be taken out and which data belonged to each sample group. Therefore making it easy to create a clean file for each group for further analysis. Following, the demographics of both samples were easily deduced and the remaining data from the questionnaire was evaluated. Which entailed determining whether familiarity with the UT website was possibly be a factor that needed to be taken into account were a difference in mental models to be measured between the samples.

Moving on to the analysis of the card sorting data. The data was uploaded into SynCapsV3, the to-be-excluded data entries were taken out and the data was separated for each sample group. Allowing for an inspection of the descriptive statistics of both data sets. Then, in regard to establishing the mental models of the two sample groups. Previous research by Fincher and Tannenberg (2005) suggested that both traditional semantic methods as well as syntactic analyses would be suitable, but that it should be taken into consideration that a semantic method would be more time consuming the larger the sample size. Additionally, this paper highlighted the benefits of subjecting the data to cluster analysis by creating a similarity matrix (e.g., items x items matrix). On which Hudson (2013) adds that these analyses are not influenced by the names or spelling of the made groups. Furthermore, Fincher and Tannenberg (2005) propose producing a hierarchical tree diagram. Also called a dendrogram (Wood & Wood, 2008). Which shows how often cards were grouped together. To visualise the suggested similarity matrix, Kunert (2022) contributed that the creation of heatmaps would be the most suitable procedure.

Resulting these arguments, a matrix analysis was executed for the two data sets, creating an items x items matrix and an items x groups matrix for each. As well as their according heatmaps. The darker shades on these heatmaps indicating the item clusters made by the participants. Which provided a good base to establish the mental models of the groups. Additionally, two hierarchical tree diagrams were constructed. The used program, SynCapsV3, determining the amount of groups within the dendrograms based on the average amount of groups made by all participants. On the diagrams the short branches indicated that items had a strongest connection. Meaning that they had been grouped together more frequently than the ones connected by the larger branches. Concludingly, a comparison was made between the outputs of the data from the current students and the data from the prospective students. This was done in order to conclude whether two different mental models were to be implemented in the before mentioned domain to ensure its usability by both sample groups.

Results

Questionnaire results

After establishing the demographics of the participants, as well as their minimal familiarity with card sorting, the remaining questionnaire data was analysed. This data concerned participant familiarity with the educational pages of the University of Twente website as it was hypothesised in the introduction that current students might have a different mental model than prospective students due to more experience with the website of the UT. Looking at the results (see Table 1), it seems that the majority of current students (79.54%) uses the website at least weekly, whereas the majority of prospective students (80.00%) uses it at most 3 times a year. Hinting a distinct difference worthy of further consideration in case a difference in mental models were to be established in the following section of this paper.

Table 1

The two sample groups concerning their familiarity with card sorting and university websites

Answer	Current students	Prospective students
How often do you use University websites		
Daily	17 (38.64%)	
Weekly	18 (40.90%)	
Monthly	5 (11.36%)	1 (20.00%)
Every 2-3 months	4 (9.09%)	
Less than 3 times a year		4 (80.00%)
Total	44	5

Descriptive statistics card sorting results

Looking at the participant statistics from the card sorting performed by the sample group of current students, it was noticed that respondents distributed the items among an average of 5 groups (Min. 2, Max. 9, *SD* = 1.6) and that their overall answers on average for 61% aligned with

those of the other participants (Min. 38%, Max. 70%, *SD* = 7%). Examining the participants statistics of the card sorting data from the second sample group, the prospective students, an average of 4 item categories was calculated (Min. 2, Max. 5, *SD* = 1.3). Furthermore, these participants aligned on average for 59% with their co-respondents (Min. 53%, Max. 62%, *SD* = 4%).

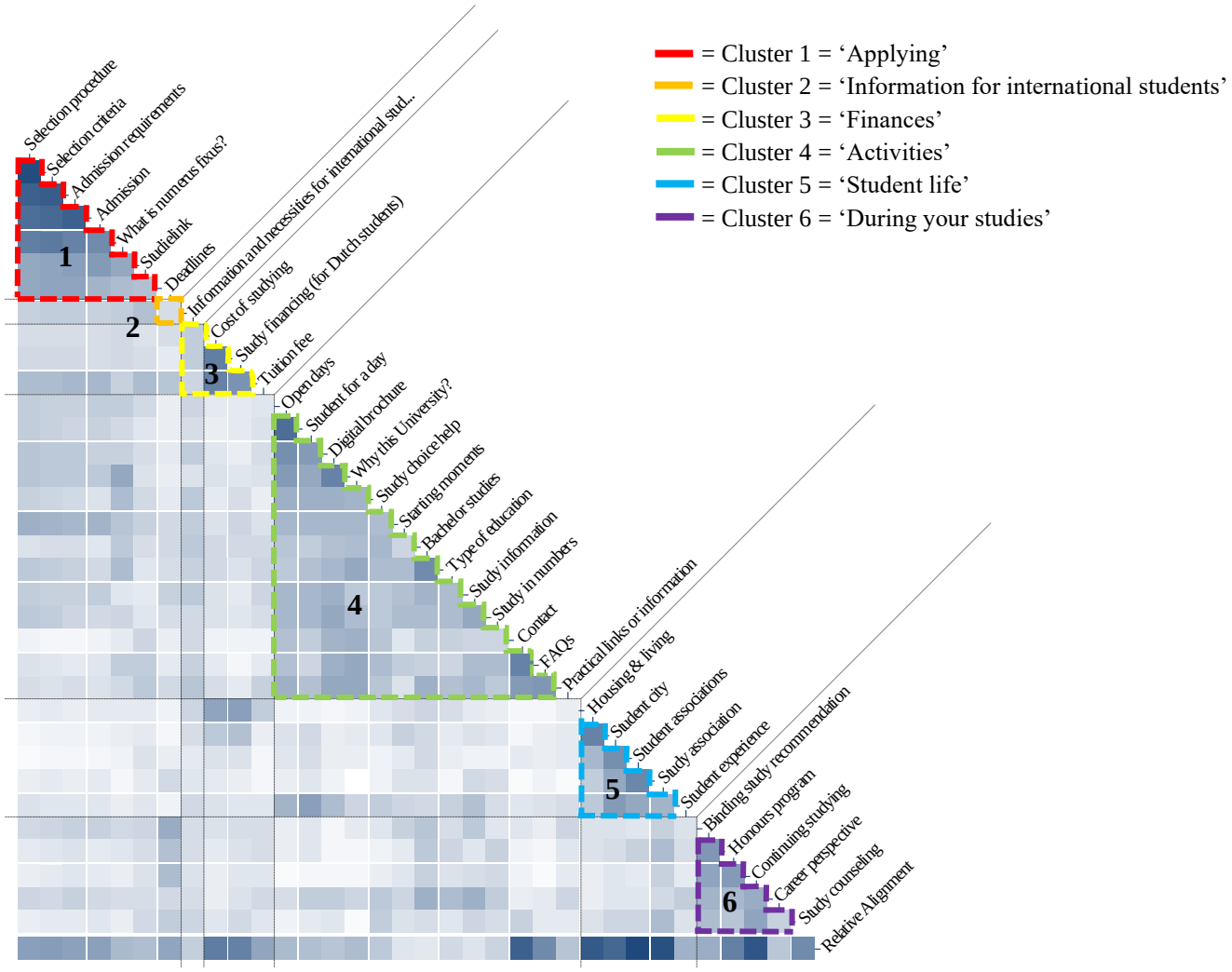
Card sorting results current students

Matrix analysis

To achieve the first objective of this paper, attaining the mental model of current students on how they navigate the defined domain, a heatmap for an items x items similarity matrix was created of the card sorting data of the sample group of 44 (see Figure 1). Overall, the figure shows a total of 6 clusters, indicated by the dotted lines between the items and the colours in the matrix. These clusters represent the different categories in which the sample of current students separated the topics. However, looking more closely at the heatmap, there is not a clear distinction between the clusters of topics. The shades that represent similarity are not that much darker within the groups than outside the groups. Meaning that the majority of participants that organised the items the same way was not that large. This is also confirmed by the items x items matrix data. Besides some peaks of similarity between the items ‘selection procedure’, ‘selection criteria’, ‘admission requirements’ and ‘admission’, the other items had an average similarity of 50%. An evaluation of the dendrogram (see Figure 2) also establishes that the proximity, i.e. similarity, between items is not that high. There is a lack of short branches and a majority of taller ones, implying that the items are not particularly strongly connected to each other. Meaning participants would not group them together that frequently.

Figure 1

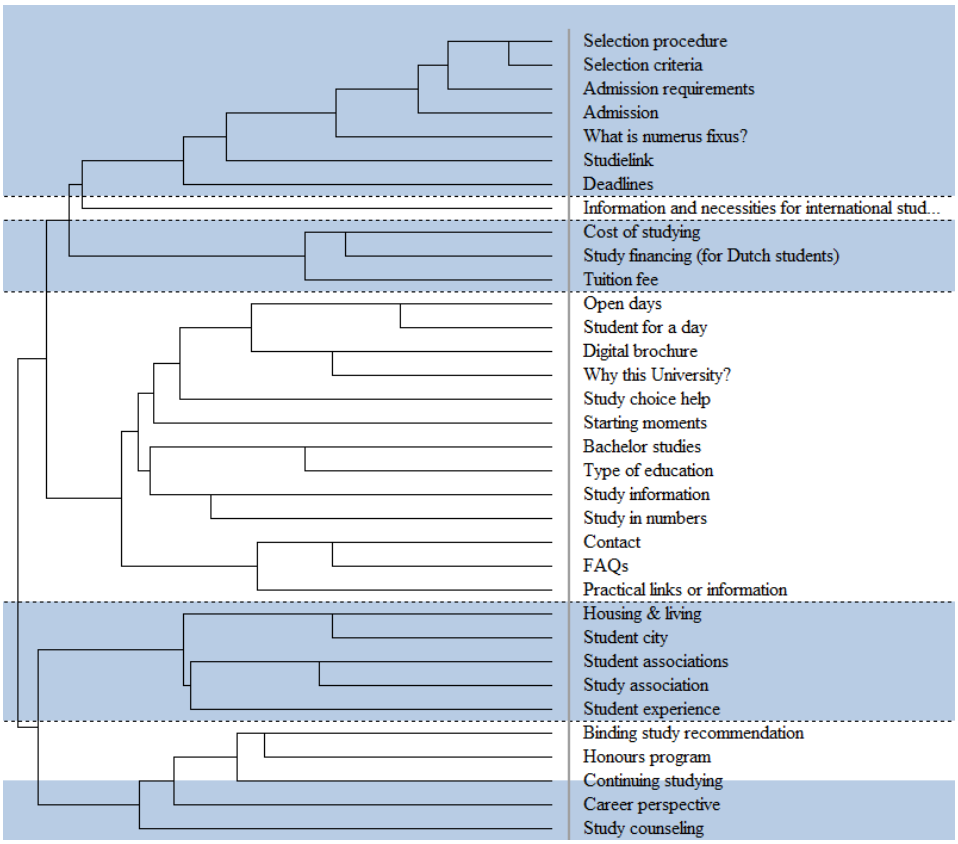
Heatmap representing the mental model of current students (N=44) with the clusters marked



Note. The broken lines indicate a total of 6 clusters. Each colour represents one cluster. The procedure of naming the clusters is explained further below.

Figure 2

Dendrogram representing the categorisation of the 34 items by the sample group of current students (N=44)



Note. The clusters are separated by the dotted lines, not the background colours.

Naming the clusters

Since an open card sorting procedure was deemed most suitable for the objective of this research, participants were given the instruction to provide their own labels for the piles they made. Resulting in the creation of 215 different labels. By extracting the labels there were just a number or a question mark and merging the labels that were only different in spelling or grammar, this number was reduced to 174. Labels that were merged were for example ‘general info’ and ‘General Information’, as well as ‘Information about study’ and ‘study related information’ with ‘Study

specific information' as the latter describes the same as the other 2. From these 174 labels, the items x groups matrix showed that the ones presented in Table 2 were used the most frequent by users for each cluster.

Table 2

Possible cluster labels determined by the % of participants using them

Cluster 1 (red)	Cluster 2 (orange)	Cluster 3 (yellow)	Cluster 4 (green)	Cluster 5 (blue)	Cluster 6 (purple)
• Applying • Admission • Application procedure • Studies • Requirements	• Beforehand • International students	• Finances • Costs	• For prospective students • Study specific information • General information • Practical information • About the UT • Choosing a study	• Student life • Living • Activities • Being a student at the UT • Associations	• Starting at the UT • Help • Starting at the UT • Information for current students • During your study

Note. Only the labels that were used by at least 5% of the participants were included in this table.

To decide which labels would best represent the clusters within the mental model of the current students, the items x groups matrix was consulted once more. Looking at the average amount of times a label was used for a certain cluster (%), the matrix indicated that the label 'Applying' was used the most for the first (red) cluster (7.67%). For the second (orange) cluster it was the label 'Practical information' (7.00%). However, participants also used this label to name another cluster. Therefore this study created a new label 'Information for international students'

to represent the second cluster. This label was chosen based on its only item ‘Information and necessities for international students’. For the third (yellow) cluster, the most frequently used label was ‘Finances’ (14.00%). For the fourth (green) cluster, ‘Student live’ seemed to have been used the most (5.33%). However, this label was established to be more suitable for cluster five. For this cluster (blue) 20.40% of students used ‘Student life’. Therefore, the second most used label was chosen. Namely ‘Activities’ (5.00%). Lastly, ‘During your study’ was deemed the best fitting label for cluster six (purple) (5.50%).

Cluster analysis

Focusing on the clusters themselves, the following can be said about their size and average similarity; the first cluster consisted of 7 items and had an average similarity score of 62.23%, the second cluster consisted of only 1 item and had a similarity score of 25.00%, the third cluster had a total of 3 items with an average similarity score of 28.70%, the fourth one had 13 items and an average similarity of 26.71%, the fifth cluster consisted of 5 items and scored 16.45% similarity on average, and lastly the sixth marked cluster contained also 5 items but had an average similarity of 18.91%. Coming to the conclusion that although their sizes ranged from quite small to rather large. The second cluster (‘Information for international students’) having only 1 item and the fourth cluster (‘Activities’) having 13. Their similarity scores were rather low (all beneath 30%) and within close in range of each other (maximum difference of 12.25%). With the exception of the first cluster (‘Applying’). This also contributes to the earlier statement that there was not a vast majority within the sample of current students that organised the items in the same way. With regard to which items were assigned to which cluster, Table 3 provides a clear overview of their exact content.

Table 3

Summarised clusters of card sorting data from the current student sample group

Cluster 1 (Applying)	Cluster 2 (Information for internal students)	Cluster 3 (Finances)	Cluster 4 (Activities)	Cluster 5 (Student live)	Cluster 6 (During your studies)
• Selection procedure • Selection criteria • Admission requirements • Admission • What is numerus fixus? • Studielink • Deadlines	• Information and necessities for international students	• Cost of studying • Study financing (for Dutch students) • Tuition fee	• Open days • Student for a day • Digital brochure • Why this University? • Study choice help • Starting moments • Bachelor studies • Type of education • Study information • Study in numbers • Contact • FAQs • Practical links or information	• Housing & living • Student city • Student associations • Study association • Student experience	• Binding study recommendation • Honours program • Continuing studying • Career perspective • Study counselling

Explaining ambiguities

The heatmap of the data also showed some outliers on the outside of the discussed clusters. Indicated by their darker shade, they stood out amongst their surrounding items (see Figure 1). Suggesting that a substantial amount of participants had categorised these items together. Looking more closely at their similarity score, it was determined that all outliers had a proximity of 30% or more. Which is more than the average similarity score within the clusters. Therefore making it

interesting to investigate whether they should be included in the final mental models of the sample. The similarity scores also indicated that there were in fact 3 different groups of ambiguities (see Figure 3).

The first group of outliers discussed combines the items with a similarity score between 30% and 40%. The ambiguities include ‘tuition fee’, ‘digital brochure’, ‘why this university’, ‘study choice help’, ‘starting moments’, ‘type of education, ‘practical links’, ‘student city’, ‘student experience’, ‘binding study recommendation’, ‘honours program’, ‘continuing studying’, ‘career perspective’, and ‘study counselling’ in relation to ‘selection procedure’, selection criteria’, ‘admission requirements’, ‘admission’, ‘what is numerus fixus?’, ‘studielink’, ‘deadlines’, ‘information and necessities for international students’, ‘study financing’, ‘bachelor studies’, ‘study information’ and ‘study associations’. Although these items seem quite random, coming from all 6 clusters, it appears that these are also the generally discussed topics in a digital brochure that universities provides. Suggesting these are the most basic topics when it comes to a university.

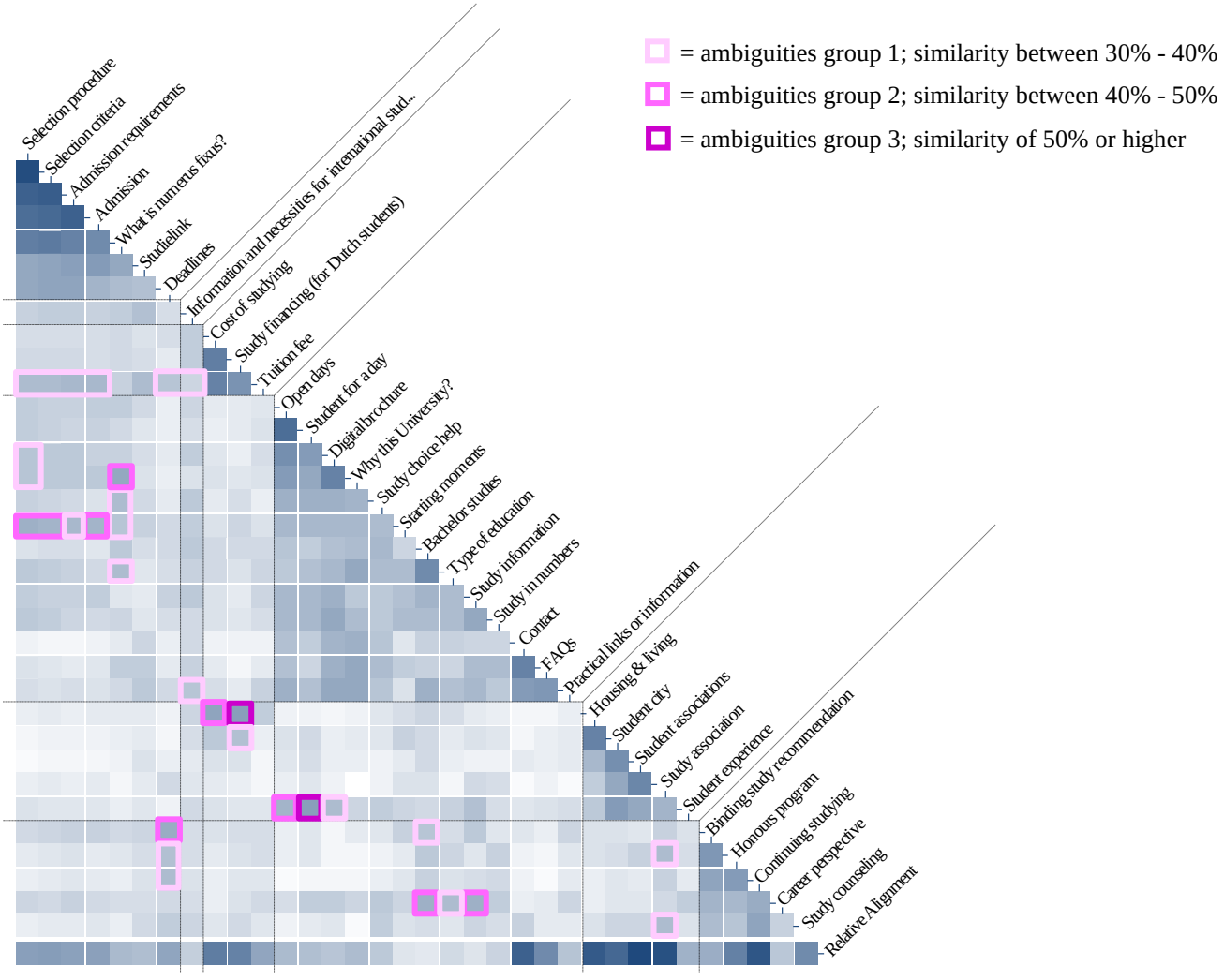
In the second group of ambiguities, with a 40%-50% similarity, the items ‘why this university’, ‘starting moments’, ‘housing and living’, ‘student experience’, ‘binding study recommendation’ and ‘career perspectives’ are combined with ‘selection procedure’, ‘selection criteria’, ‘admission’, ‘what is numerus fixus?’, ‘deadlines’, ‘costs of studying’, ‘open days’, ‘bachelor studies’ and ‘study information’. All off these items seem more relevant for prospective students than for current students. Which is not an overall topic of one of the clusters created by the sample of current students. Perhaps this could indicate another cluster.

Finally, the third group of ambiguities is rather small. It consists of the items with a similarity score higher than 50%. Meaning that these items have a higher similarity score than the average cluster. The items are ‘housing and living’ and ‘study financing’, and ‘student for a day’

and ‘student experience’. Both of these combinations seem logically connected or almost as synonyms for each other. Which could be the reason why these items were so often assigned to the same groups.

Figure 3

Heatmap representing the mental model of current students (N=44) with the ambiguities marked



Note. The three groups of ambiguities are marked.

Card sorting results prospective students

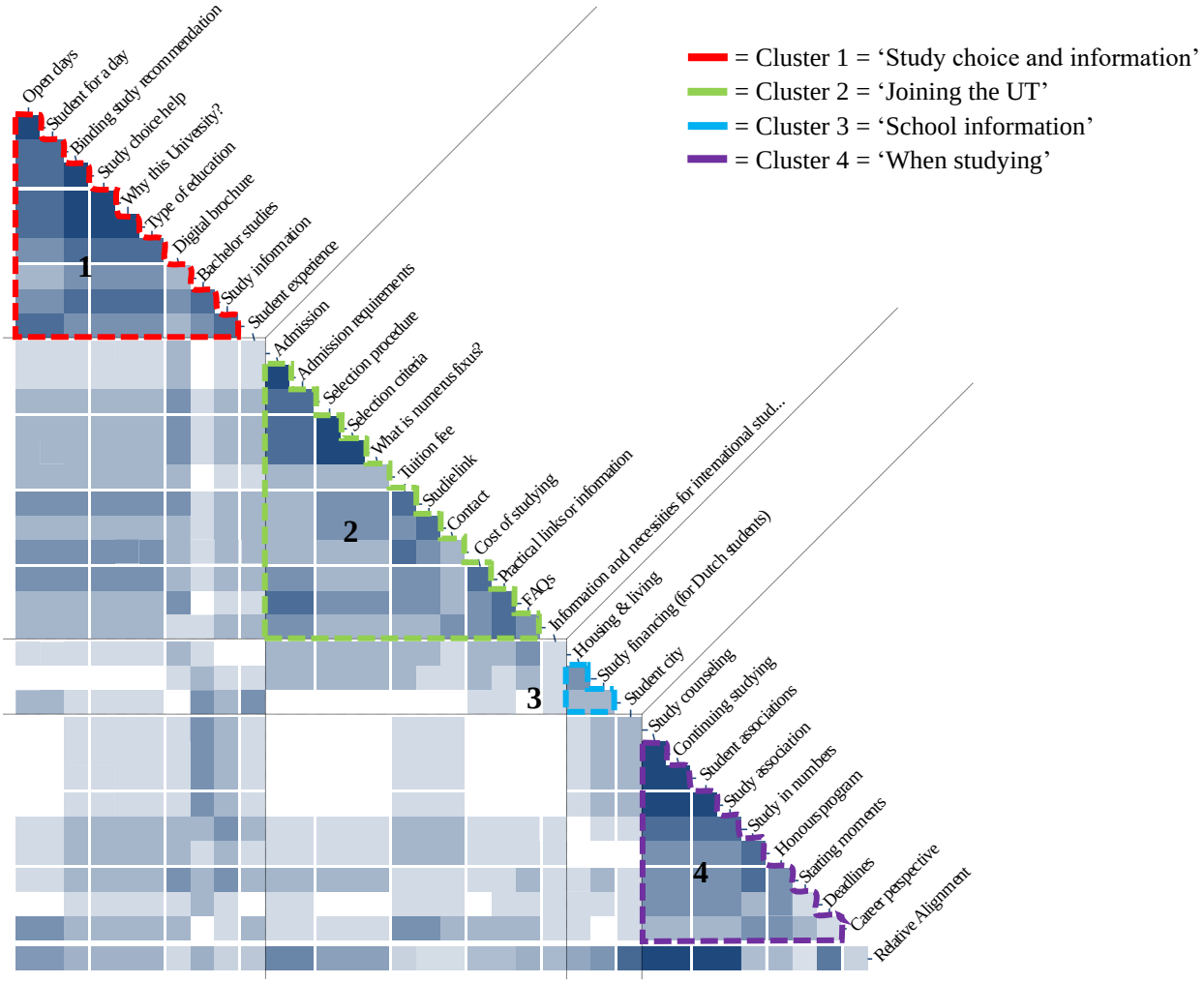
Matrix analysis

To accomplish the second objective of this paper, the same procedure as for the first sample group was executed for the card sorting data of the second sample group, the prospective students. First, a heatmap was created (see Figure 4). This figure shows a total of 4 clusters. Representing the groups into which the 5 pre-university students organised the 34 items, this heatmap shows some more distinct clusters. The shades within the groups are much darker than on the outside. Especially for cluster 1 (red). Implying that there was a large majority of participants within this sample that ordered the items into the same categories. Looking at the items x items matrix data, it also appears that there are some high similarity scores (max. 100%), as well as some very low similarity scores (0%). Contributing to the statement that most participants agreed a lot on their distribution of items. However, it was noticed that there was still an average similarity score of 50%. Suggesting that there also some strong similarity score outside the clusters. Upon further analysis of the heatmap, these outliers were identified. Therefore, a more in depth analysis of these ambiguities was included later on in the paper.

Evaluating the dendrogram (see Figure 5), more evidence that supports the previous determination that some items were grouped together quite frequently was made visible. The figure shows that some items have a high similarity to each other by connecting them with a short branch. Moreover, the dendrogram also shows that some items are not connected at all. Which complies with the low similarity scores in the items x items matrix.

Figure 4

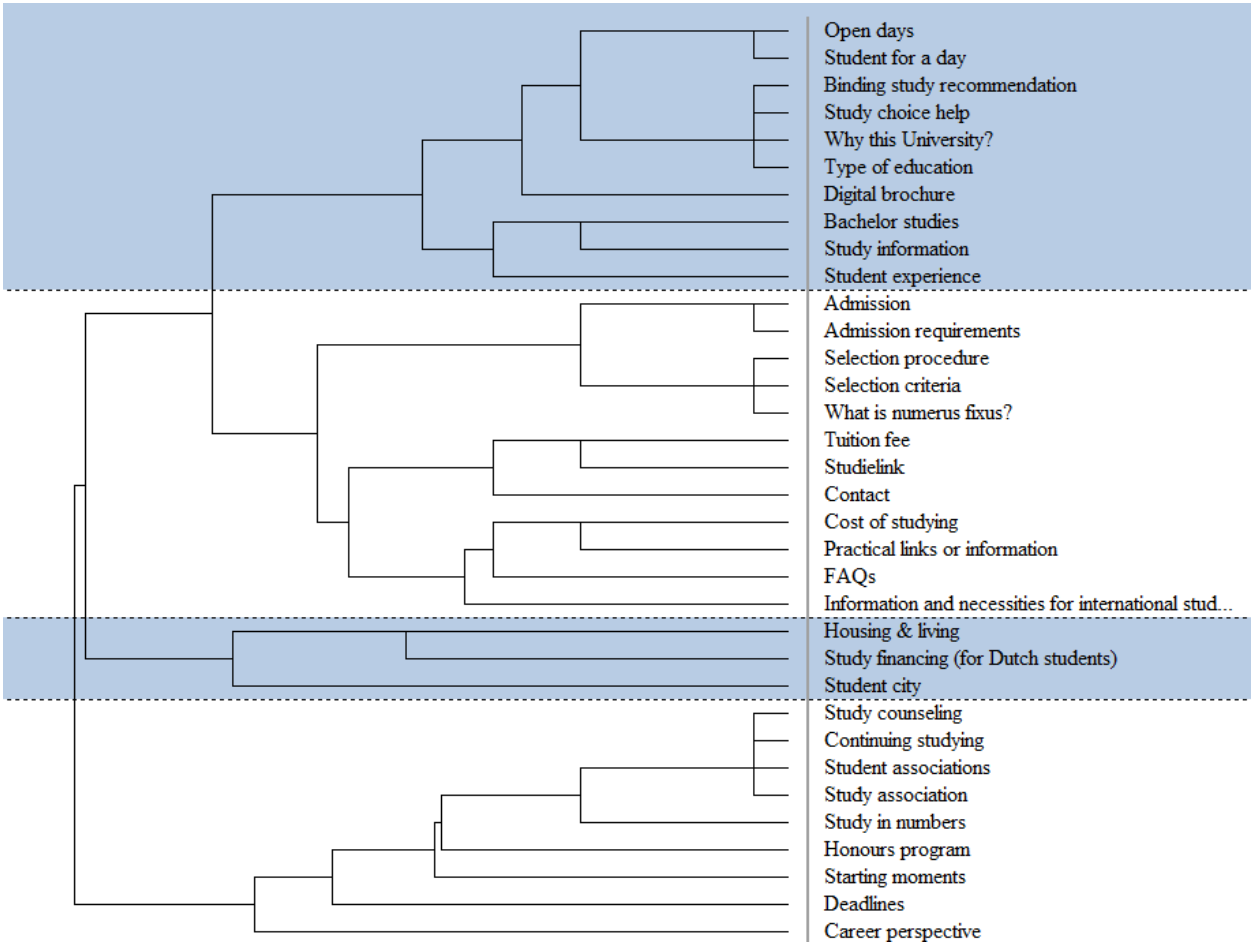
Heatmap representing the mental model of prospective students (N=5) with the clusters marked



Note. The broken lines indicate a total of 4 clusters. Each colour represents one cluster. The procedure of choosing the cluster names is explained further below.

Figure 5

Dendrogram representing the categorisation of the 34 items by the sample group of prospective students (N=5)



Note. SynCapsV3 determined 4 groups based on the average amount of groups made by the participants. These are shown by the dotted lines and the colours.

Naming the clusters

This sample group created a total of 17 labels. Of which 3 were removed due to the use of only a number, and two labels were merged. Namely ‘study choice and information’ and ‘studies and information’. The remaining 13 labels were distinctively different. Furthermore, the items x

groups matrix was analysed to provide an indication as to which label would be suitable for each cluster. Basing suitability on the percentages of students that used the labels in relation to each cluster. However, the matrix showed that, except one, all other 12 labels were used by exact 20% of the participants. Moreover, upon closer investigation it was determined that that label was in fact the merge of the above mentioned labels. Undoing the merging created a matrix with all labels being used by 20% of respondents. Therefore, this research decided to use a different approach to select the labels for the mental models of prospective students.

To be more specific, a comparison was made between the percentages of items within a cluster that were assigned to a group with a certain label. For example, the label ‘Orientation’ was used by 20% of participants to describe items within the red cluster, as well as by 20% of participants to describe the items in the green cluster. However, within the red cluster, 70% of the items were assigned to ‘Orientation’, whereas only 41.67% of the items from the green cluster were contributed to that label. Applying this method to the other labels and clusters, the percentages were calculated of items within a cluster that participants assigned to a group with a certain label within their card sorting. The results are shown in Table 4. To conclude which label suited which cluster the best, the label with the highest percentage in each of the clusters was chosen. For the first cluster (red), this was the label ‘Study choice and information’, the second cluster (green) was named ‘Joining the UT’, the third cluster (blue) ‘School information’, and lastly, the fourth (purple) ‘When studying’. As visible in Table 4, this last label was also used by the same amount of items as the label ‘Study choice and information’ within the purple cluster. However, that label was deemed more fit for the first (red) cluster.

Table 4

Possible cluster labels determined by the % of items within a cluster that were assigned to the label

Cluster 1 (red)	Cluster 2 (green)	Cluster 3 (blue)	Cluster 4 (purple)
• Study choice and information (100%) • Joining the UT (90%) • Orientation (70%) • Experience (30%) • The act of studying (30%) • School information (10%)	• Study choice and information (41.67%) • Joining the UT (100%) • Orientation (41.67%) • Limited entry (41.67%) • Other information (41.67%)	• Orientation (33.33%) • Experience (33.33%) • The act of studying (66.67%) • School information (100%) • Money (33.33%) • Living (66.67%)	• Study choice and information (88.89%) • Joining the UT (44.44%) • Orientation (11.11%) • Experience (11.11%) • The act of studying (66.67%) • School information (55.56%) • Other information (11.11%) • When studying (88.89%) • Extra credit (22.22%)

Note. Only the labels which were used by items within a cluster were included.

Cluster analysis

Focussing on the clusters themselves, the largest cluster (‘Joining the UT’) contained a total of 12 items with an average item similarity of 45.27%. Whereas the smallest cluster (‘School information’) contained only 3 items and had an average similarity of 24.06%. Establishing that these clusters ranged quite substantial in size (M = 8.5, SD = 3.9). Furthermore, the first cluster (‘Study choice and information’) was made up of 10 items and had the highest similarity score of 73.33%, and the fourth cluster (‘When studying’) consisted of 9 items with an average similarity of 27.66%. Coming to the conclusion that, even though the first one had a considerably high similarity

between items, the other clusters scored below average on similarity. The overall average between items being 50% similarity. This also contributes to the previous statement that, although there is a clear overlap in distributing the items among participants, there are also some considerable ambiguities to take into consideration when establishing the mental models of this sample. With regard to the average distribution of items, Table 5 shows the content of each of the established clusters.

Table 5

Summarised clusters of card sorting data from the prospective student sample group

Cluster 1 (Study choice and information)	Cluster 2 (Joining the UT)	Cluster 3 (School information)	Cluster 4 (When studying)
• Open days • Student for a day • Binding study recommendation • Study choice help • Why this University? • Type of education • Digital brochure • Bachelor studies • Study information • Student experience	• Admission • Admission requirements • Selection procedure • Selection criteria • What is numerus fixus? • Tuition fee • Studielink • Contact • Cost of studying • Practical links or information • FAQs • Information and necessities for international students	• Housing & living • Study financing (for Dutch students) • Student city	• Study counselling • Continuing studying • Student associations • Study association • Study in numbers • Honours program • Starting moments • Deadlines • Career perspective

Explaining ambiguities

As discussed in the matrix analysis section of these card sorting results, the items x items similarity matrix based on the prospective students sample group had both very high (100%) and very low (0%) similarity scores. Even though the average similarity score was 50%. Indicating that there are possible strong outliers outside the clusters. The heatmap (see Figure 4) confirms this. There are rather many darker shaded outliers outside the clusters. Taking a closer look at the proximity scores of these items, it appears that 27.35% of the items outside the clusters had a similarity score between 20% and 30%, as well as that 25.04% of the items had a proximity between 40% and 50%. Suggesting that more than half of the items outside the clusters had a similarity score between 20% and 50%. Contributing that 14.03% of the items did not have a similarity score at all. Meaning they were not categorized in the same group by any participant. It can be concluded that more research into the mental models of this sample group would be better suited than an investigation of the ambiguities.

Comparison of the two sample groups

Taking a closer look at both similarity matrixes, it appears that within this sample of current students, there were only 2 items that were not once assigned to the same category. Namely, ‘why this university’ and ‘study associations’. Whereas within the sample of prospective students, 33 of the items were never matched with at least one of the total 34 items.

Taking a more general look, it appears that the mental models of the two sample groups substantially differ (see Table 6 and Table 7). Firstly, there is an inconsistency in the amount of clusters that were generated. Current students created a total of 6 groups, whereas prospective students created only 4. Secondly, the content of the groups are not alike. Next to the amount of items within a cluster, the combination of items is also different. Table 6 shows the amount of

items within the groups made by current students ranging from 1 to 13, and Table 7 shows that prospective students made groups with an item total ranging from 3 to 12.

Table 6

The mental models of current students about organising educational topics on university websites

Applying	Information for international students	Finances	Activities	Student live	During your studies
• Selection procedure • Selection criteria • Admission requirements • Admission • What is numerus fixus? • Studielink • Deadlines	• Information and necessities for international students	• Cost of studying • Study financing (for Dutch students) • Tuition fee	• Open days • Student for a day • Digital brochure • Why this University? • Study choice help • Starting moments • Bachelor studies • Type of education • Study information • Study in numbers • Contact • FAQs • Practical links or information	• Housing & living • Student city • Student associations • Study association • Student experience	• Binding study recommendation • Honours program • Continuing studying • Career perspective • Study counselling

Table 7

The mental models of current students about organising educational topics on university websites

Study choice and information	Joining the UT	School information	When studying
• Open days • Student for a day • Binding study recommendation • Study choice help • Why this University? • Type of education • Digital brochure • Bachelor studies • Study information • Student experience	• Admission • Admission requirements • Selection procedure • Selection criteria • What is numerus fixus? • Tuition fee • Studielink • Contact • Cost of studying • Practical links or information • FAQs • Information and necessities for international students	• Housing & living • Study financing (for Dutch students) • Student city	• Study counselling • Continuing studying • Student associations • Study association • Study in numbers • Honours program • Starting moments • Deadlines • Career perspective

Discussion

This study aimed to determine whether university websites would need to be based on multiple mental models to improve intuitive searching and usability, as these websites have multiple user groups and poor usability can lead to serious consequences. To do this, two main user groups of university websites were identified, and their mental models were obtained and compared for similarities and differences. More precisely, this research used card sorting and similarity analyses to investigate the mental models of current and prospective students concerning their navigation of the educational related pages of university websites.

Looking at the results, the two obtained mental models showed a distinctively different pattern of grouping the items. There was not only a difference in the amount of groups made, the number of items within one group and the combination of items varied as well. Demonstrating that two user groups can have very different mental models regarding the same webpages. Which implies that, to guarantee intuitive searching and good usability of those pages, universities must combine two different mental models into their information architecture. Consequently implying that the developers of university websites must understand the mental models of all user groups to ensure the usability of the website as a whole. Furthermore, it is important to mention that in the experiment, participants were asked to indicate their familiarity with university websites. The objective being to uncover whether the mental models of current students might have changed as a result of getting to know the website. Meaning that users might have learned to overcome poor usability, which is not the goal of intuitive searching. And based on the results, students already attending the university were measured to have a distinctively higher frequency of using university websites than prospective students. Therefore, future research may want to investigate this possible influence of learning instead of intuitive searching in more depth.

Comparing to previous research, the results of this paper align with a study by Zhang (2008). Their research confirmed that it is possible to have multiple mental models in regard to the same topic among participants. Moreover, the paper also found a difference in navigation behaviours as a result. However, according to their calculations, these differences were insignificant. Looking for more literature to explain these results, it can be concluded that there has not yet been much further investigation into the implementation of multiple mental models into one website. There was one paper by Knapp (2006) that was looking into the consequences of implementing mental models that do not correspond with those of the test subject, and they determined that the perceived attractiveness (a.i. usability) of a website was negatively affected by the incongruence of mental model. Meaning that universities cannot just choose one mental model to base their website on and leave out the mental models of all other users, as it will harm the usability for the other groups.

The primary limitation of this study was the small sample group representing prospective students. After cleaning up the data, only 5 participants remained. Which may have been too small to make a proper estimation of their mental model and could have led to less reliable results in comparison to the other sample group. This limitation also became apparent in the analysis of the labels. The items x groups matrix contained not enough participant data to predict which labels would be the most suitable for the clusters. Moreover, as stated in the analysis of ambiguities for the second sample group, not enough data was gathered to provide a clear overview of outliers. To many items had a substantially high similarity score at the moment, due to the fact that only 3 participants needed to group the items similarly to create a majority. Resulting in a high proximity.

Secondly, some participants did not use names to label their created groups. Instead they used number. This has no effect on the similarity analysis of the data as discussed by Hudson

(2013). However it did make the mental models of those participants incomplete. The labels that they would have used, or would look for on a university website, could have attributed to the estimation of the most suitable labels representing the mental model of the sample.

Less prominent limitations of this research were the convenience sample and the specified mental models. All current students were recruited form the UT and all prospective students came from the area of Enschede. Which might cause all participants to have the same frame of reference concerning university websites. Possibly making the obtained mental models a little biased. This would have effect on the generalisability of this study; therefore it is advised for future research to recruit a more diver sample. Furthermore, due to resource limitations, the card sorting aimed to find the mental models about a specific part of university websites. Although the education related pages make up a large part of a university website, the results do not fully represent an entire university website. Meaning that the overall conclusion is still an estimation.

To conclude, this paper established that there are indeed multiple mental models to implement to allow for the corresponding users to experience usability. However, there is more and more research these days into the development of usable websites as the importance of user-oriented design becomes more relevant. Therefore more future research might provide more insight into possibility to incorporate multiple mental models into the same website without giving one mental model more precedence over the other.

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Appendix A

The landing page of the kardSort environment

This appendix displays the information that was presented on the first webpage of the digital environment that was created using the program kardSort.

Welcome to our study!

Please read this page carefully for if you choose to proceed, you declare to understand and consent to the described information.

You are being invited to participate in a research study titled "UNTANGLING THE MIND increasing website search efficiency through card sorting". This study is being done by Sander Overkamp, Linda Renes, and Laura Scharstuhl from the Faculty of Behavioural, Management, and Social Sciences at the University of Twente.

Goal of the study
The purpose of this research study is to attain the mental models of students regarding navigating university websites and will take you approximately 30 minutes to complete.

The experiment
You will participate in a study where we will gather information using a card-sorting experiment. More instructions on how the experiment works will follow on the next page.

Benefits and risks of participating
There are no physical, legal or economic risks associated with your participation in this study. This experiment has been reviewed and approved by the BMS Ethics Committee/domain Humanities & Social Sciences. However, as with any online-related activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential.

Voluntary participation and withdrawal
Participation in this study is completely voluntary. As a participant, you may stop your participation in the study at any time or refuse to allow your data to be used for the study, without giving any reasons. Stopping participation will not adversely affect you or any compensation already received.

If you decide to discontinue participation during the study, the data you have already provided will be used in the study until consent is withdrawn.

Do you want to stop the study, or do you have questions and/or complaints? Please contact one of the researchers:

- Sander Overkamp: s.overkamp@student.utwente.nl
- Linda Renes: l.e.m.renes@student.utwente.nl
- Laura Scharstuhl: l.w.scharstuhl@student.utwente.nl

Data Confidentiality
We make every effort to protect your privacy to the best of our ability. No confidential information or personal data from or about you will be disclosed in any way that will allow anyone to recognize you.

Before our research data is released to the public, your data will be anonymized as much as possible, unless you have given explicit permission in our consent form for your name to be mentioned, for example in a quote.

Anonymous data or pseudonyms will be used in any publication. Data that is collected will be stored at a secure location at the University of Twente and on the researchers' secure (encrypted) data carriers. Research data will be stored for a period of 10 years. At the latest after this period has expired, the data will be deleted or anonymized so that they can no longer be traced back to an individual. The research data will only be made available to persons outside the research group if necessary (e.g., for a check on scientific integrity) and only in an anonymous form.

You also have the right to make a request to the researchers to inspect, modify, delete or update your data.

Reimbursement
You will not receive compensation for participating in this study unless you participate in the study through SONA. In that case, you will receive SONA points for your participation.

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl.

By continuing you agree with the following statements:

- I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

- I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

- I understand that information I provide will be used for data analysis and research into the topic of mental models with regard to university websites.

- I understand that personal information collected about me that can identify me, such as my name or personal details, will not be shared beyond the study team.

- I give permission for the answers that I provide to be archived in anonymized transcripts so they can be used for future research and learning.

Appendix B

Questionnaire

This appendix shows the questionnaire that was on the second page of the kardSort environment. All of these questions were mandatory to answer to be able to proceed.

Q1. What is your age?

- Under 18
- 18-20
- 20-22
- 22-24
- 25+
- I don’t want to disclose

Q2. To which gender do you identify?

- Male
- Female
- Other
- I don’t want to disclose

Q3. What is your nationality?

- Dutch
- German
- Other
- I don’t want to disclose

Q4. What is your native language?

- Dutch
- German
- English
- Other
- I don’t want to disclose

Q5. What level of education are you currently following?

- VWO
- First year student
- Second year student
- Third year student or higher
- I don’t want to disclose

Q6. How often do you use University websites on average?

- Daily
- Weekly

- Monthly
- Every 2-3 months
- Less than 3 times a year
- I don’t want to disclose

Q7. How familiar are you with “Card Sorting”?

- I used it as a research method myself
- I never used it but know how it works
- I have only heard of it
- I don’t know it
- I don’t want to disclose

Appendix C

Instructions on the card sort experiment

This appendix shows the instructions on the card sort experiment that are provided on the third page in kardSort. Explaining to a participant how to execute the experiment that would present itself after clicking on next.

Instructions

Welcome again!

First of all, it is important to know that you can only participate in this study if you are 18 or older. If you are younger than 18 we want to thank you for your enthusiasm but sadly you cannot participate.

On the next page, you will find 34 cards on the left side of the screen. Each card contains an item that can be found on a university website. Your job is to make piles of cards that you feel belong together. In the end you should name these groups as categories. Keep in mind that there are no right or wrong answers, only your opinion!

The task works as following:

- To start you need to create a new category using the top right corner button. If you do not know the name of the category you can give it a random name like "1". You are unlimited in the amount of categories you want to create.
- To put words in the categories you simply drag them from the left section to the category you feel it belongs. You can also drag cards from one category to the other.
- If you feel that a certain card absolutely does not fit with any of the other cards, you can create a category for just that word.
- When you feel that a specific card belongs to more than one group, please choose the best of those possibilities.
- In the end you need to name the categories in a way that makes sense. You can change the name of the category by selecting the three vertical dots at the right upper corner of every category.
- If, in the end, you have an unused category, you can delete it by using the same three dots.
- You can always find these instructions by selecting "Instructions" in the top right corner.

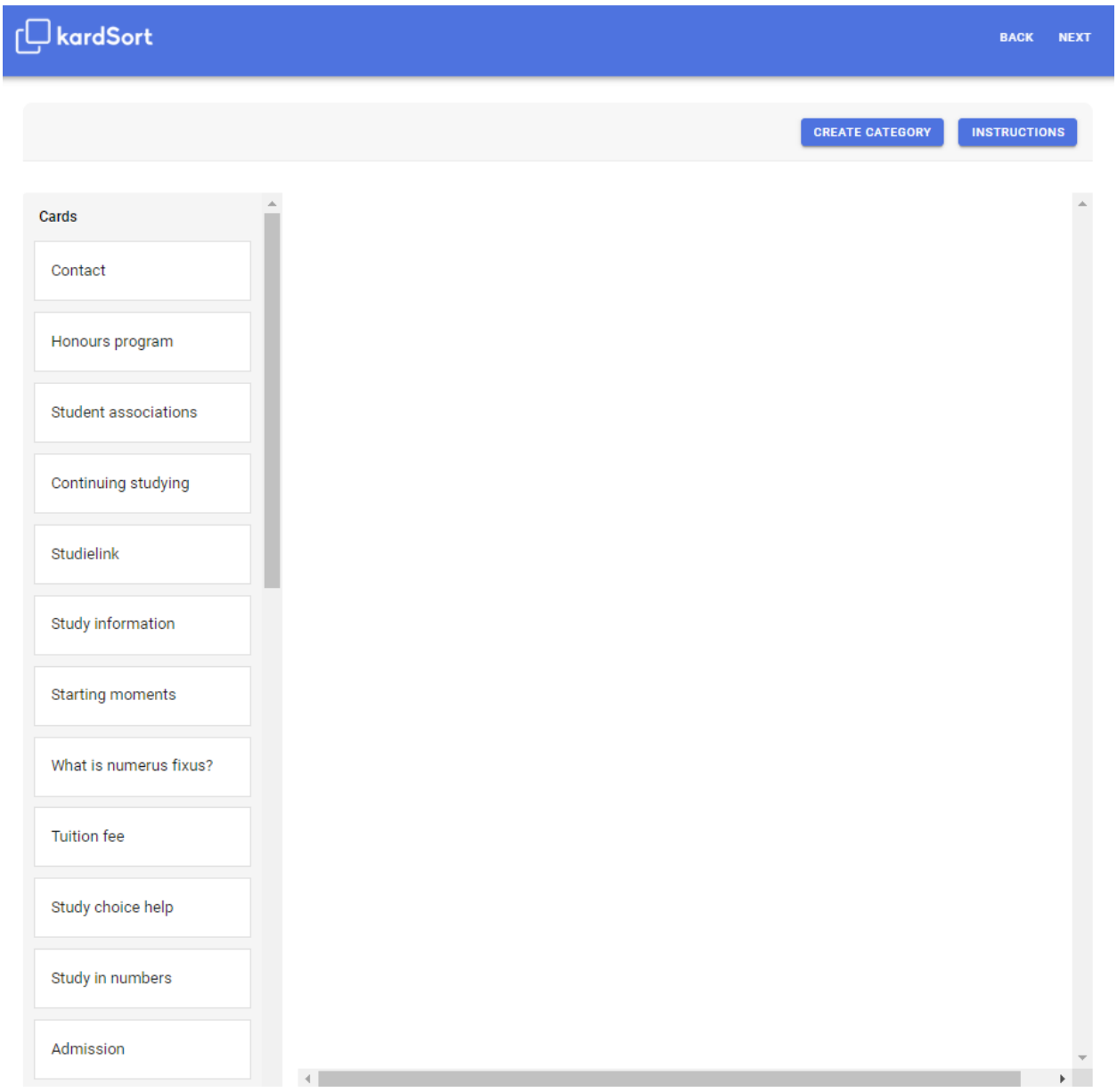
Once again, there are no right or wrong answers!

Enjoy the experience!

Appendix D

Preview of the page displaying the card sorting experiment

This appendix shows an example of what the card sorting tool and the cards with items looked like on the last web page of the digital kardSort environment.



Appendix E

Comparison of university websites

In order to establish which items were the most common with regard to the topic of education, the websites of 8 Dutch universities were compared. This table shows an X when a topic was addressed on a website.

Concepts	**University of Twente**	**University of Groningen**	**Radboud University**	**Eindhoven University of Technology**	**University of Amsterdam**	**Leiden University**	**Delft University of Technology**	**Maastricht University**
Open days	X	X	X	X	X	X	X	X
Bachelor studies	X	X	X	X	X	X	X	X
Student experiences	X		X	X	X	X	X	X
Digital brochure	X	X		X		X	X	X
Why this University?	X	X	X		X	X		X
Practical links / info	X				X		X	X
Starting moments	X	X	X		X	X	X	X
Modules and project-based education	X	X		X		X		X
Assessment and exams	X							
Study counselling	X	X	X	X	X	X	X	X
Elective space	X			X	X			
Study information	X		X	X	X	X	X	
Study in numbers	X		X	X			X	X
Study choice help	X	X	X		X	X	X	X
Tips and advise	X					X		X
Admission	X	X	X	X	X	X	X	X
Selection procedure	X	X	X	X	X	X	X	X
Selection criteria	X	X	X	X	X	X	X	X
Admission requirements	X	X	X	X	X	X	X	X
Binding study recommendation	X	X	X	X	X	X	X	X
Tuition fee	X	X	X	X	X	X	X	X
Deadlines	X	X	X	X	X	X	X	X
Continuing studying	X	X	X	X	X	X	X	X
Career perspectives	X	X	X		X	X	X	X
Student city	X	X			X	X	X	X
Student associations	X	X	X		X	X	X	
Contact	X	X	X	X	X	X	X	X

Honours program	X	X	X	X	X	X	X	X
Student for a day	X	X	X	X	X	X	X	X
Studielink	X	X	X	X	X	X	X	X
FAQ's	X	X		X	X	X		
Housing & living	X	X	X	X	X	X	X	X
Cost of studying	X		X	X	X		X	X
Information and necessities for international students	X	X		X			X	X
Study associations	X	X		X	X		X	X
Study financing (for Dutch students)	X		X		X		X	X
What is numerus fixus?	X	X	X		X	X	X	X
Scholarships					X		X	X
Topsport and studying					X		X	

Appendix F

Items used in the card sorting

Based on the comparison in Appendix A, this is the alphabetical list of the 34 most frequent items regarding education on university websites. And was ultimately used in the digital card sorting experiment.

- Admission
- Admission requirements
- Bachelor studies
- Binding study recommendation
- Career perspective
- Contact
- Continuing studying
- Cost of studying
- Deadlines
- Digital brochure
- FAQs
- Honours program
- Housing & living
- Information and necessities for international students
- Open days
- Practical links or information
- Selection criteria
- Selection procedure
- Starting moments
- Student associations
- Student city
- Student experience
- Student for a day
- Studielink
- Study association
- Study choice help
- Study counseling
- Study financing (for Dutch students
- Study in numbers
- Study information
- Tuition fee
- Type of education
- What is numerus fixus?
- Why this University?