

ADMINISTRATION MODE PANELS: A Card Sorting Study

Pascal Blöchliger, Carolyn O'Brien, Philipp Schaad

ETH Zurich

Abstract

The administration mode panels of VirtaMed AG's surgical simulators is meant to house all the settings for the simulator. However, the panels are disorganized and are unsatisfying to use by both experts and novices. This study uses card-sorting in order to find categories that would work for novices and for experts. Novices who have never seen the system and experts who have used this system for longer periods both categorized 30 cards from the panels in an open card-sorting exercise. The experts also weighted the importance of the cards. A structure of 5 categories is proposed for implementation in future software by VirtaMed AG based upon the results of these card-sorting tasks.

Keywords: human-computer interfaces; card sorting; administration mode panels

ADMINISTRATION MODE PANELS: A Card Sorting Study

This study reviews an existing administration mode panel (AMP) in a surgical simulator created by VirtaMed AG and provides suggestions for restructuring the AMP according to results derived from a card sorting study. The AMP is a specific user account in the simulator that is meant to troubleshoot and control settings. When logging into the account, the user of the system is presented with settings covering a broad range of topics, as seen in Figures 1-9. The authors selected the AMP for evaluation, due to its perceived “clutter” on the panels. The authors focused on the settings, users, and the advanced tabs. The course and history tabs have a very specific function relating to setup of individual training courses and are considered beyond the scope of this study. The settings tab originally covers many varying topics and is the longest of the tabs. The user tab contains some user settings. The advanced tab includes some identification and troubleshooting sections that are not included in the settings tab. The tabs currently would not be considered effective nor efficient by the users. Users of the system are both complete novices and experts with years of experience with the systems. The categories for the AMP should ideally be usable and accessible to both kinds of users.

While there are many potential methods to recategorize the settings tabs into new tabs, the method of card sorting was used. Card sorting has existed in various forms since the 1800s. Card sorting has been gaining prominence as a form of digital or human-computer interface categorization since the 1980s and 1990s (Hudson, 2012; Nielsen & Sano, 1995; Tullis, 1985). Tullis used card sorting in the early 1980s to design a user interface menu structure, creating a precedent for the task of the authors of this paper (Tullis, 1985).

Card sorting is the grouping of similar things in new or pre-defined categories. This sorting can be physical cards or virtual cards. The card sorting can define what things are called (terminology), what relationships they have (proximity, similarity), and what

categories they fall under (Hudson, 2012). Card sorting can be considered open, closed, or hybrid. Open card sorting allows the sorters to create their own categories; closed uses pre-defined categories; hybrid is some form of combination of the two (Hudson, 2012).

Card sorting also has the advantage that, if online card sorting is used, subjects can be at remote locations and do not need direct proctoring from the card sorting organizers. The setup is consistent for all subjects, and the online tools can often support rudimentary analysis and aid in data collection.

This study was motivated by the perception that the AMP is cluttered. So that the authors could evaluate quickly what the subjects subjectively perceived of the AMP, the authors used SUS. The SUS, or System Usability Scale, was developed as “[a] quick and dirty usability scale” (Brooke, 1996). Since usability is not an absolute measurement, the SUS uses relative measurements across many areas of interfaces. The survey evaluates the general quality of the interface to be “appropriate to a purpose” (Brooke, 1996). The SUS removes the difficult to define and always variable specifications, such as the precise tasks, the intended users, and all forms of the environment and the organization from the analysis of the interface. Instead, the focus is on the effectiveness, the efficiency, and the satisfaction of the users (Brooke, 1996). The ratings that are created vary greatly, but the mean and standard deviation from a SUS can be used to compare the interface to the SUS of other interfaces. In the last decades, large amount of SUS’s have been performed, allowing the authors to relatively compare the SUS with other interfaces forms, and allow for a subjectively evaluated interface to receive a “grade” for its usability (Bangor, Kortum, & Miller, 2009).

Method

Participants

Because the AMP aims to be easy to navigate by both novice users and experts, the study participants have been chosen accordingly. The authors recruited a participant group of

seven expert users with varying amount of experience with the system (the AMP), and nine novice users that have never seen the AMP before. All of them were presented with the exact same card sorting experiment, including an identical user-details questionnaire at the beginning and a System Usability Scale (SUS) questionnaire at the end.

All participants were required to have access to a PC and had to have a moderate level of English.

The seven expert users between the ages of 25 and 54 were selected internally at VirtaMed AG, where they have been working with the simulator and the AMP for anywhere from less than one year all the way up to three years and more. The spread in how often they use the VirtaMed surgical simulators ranged from daily use to using the simulator less than once a month. All expert participants are employees at VirtaMed AG, and therefore have a degree from a college and/or university. None of them has received medical education. The improvement of VirtaMed AG's product served as a motivation for their participation, in addition to a small compensation in the form of sweet treats.

The nine novice users consist of the authors' friends and family members. They were offered no compensation for their participation. Their age ranges from 18 to 54 with an almost 50/50 gender split. As per selection criteria, none of them have ever seen or used a VirtaMed surgical simulator nor the AMP. The novice participants have a varying educational background, ranging from apprenticeship over High-School/Gymnasium and Fachhochschule/Vocation School all the way to being postgraduates. Two of them have received medical education.

Materials

To conduct the entire study, from pre-sorting questionnaire to actual card sorting and finally to SUS questionnaire, an online tool called OptimalWorkshop was used (OptimalWorkshop, 2017). The tool allows for the creation of card-sorting studies with up to

30 individual, completely customizable cards, using either open, closed, or hybrid sorting. The cards can contain images and hover tips, when the subject places their mouse over certain cards to receive additional information. The tool also allows for the addition of pre- and post-questionnaires. Those questionnaires can take multiple different forms, e.g., containing multiple-choice questions, open questions, or Likert-scale items. This flexibility allowed the authors to implement different pre- and post-questionnaires.

OptimalWorkshop was also chosen due to its ability to send a link to the study that can easily be sent to any participant, allowing them to complete the study in their own time and leisure. This online tool also allowed subjects from around the world to participate in the study. This flexibility may increase the likelihood that possible participants would want to take part in the study by removing several blockers to their participation.

OptimalWorkshop includes several data-representation visualizations when evaluating the outcome of a card-sorting study. Resulting categories can be easily visualized, and cards that often get sorted together get nicely displayed in a similarity matrix. Additionally, the raw data can be exported, allowing for further analysis and calculations to be performed on the resulting data.

Procedure

Links were sent to the volunteer participants via e-mail and instant messaging systems. Participants clicked on the provided link and were sent to the OptimalWorkshop page appropriate to their status as novice or expert.

Participants were first asked to complete a basic questionnaire regarding demographics. Those questions include age, gender, education and experience with the system in question. The questions were all multiple-choice. No identifying information, such as name or address was recorded. OptimalWorkshop did automatically store the country that the subject was logging in from.

After that, participants were asked to sort the given 30 cards into categories they thought the most appropriate. They were told that there is no right or wrong way to sort the cards, and that they should use their own intuition, independent of their understanding of what the cards are supposed to represent. Here, the participants were given no limitations. Open card-sorting was used, allowing the participants to have full freedom in creating any number and kinds of categories they wanted. This sorting was selected, so as not to artificially constrain the subjects with what may be undesirable or confusing categories, such as the categories in the current AMP.

After completing the card-sorting, participants were then brought to an SUS questionnaire page. The goal of this part of the study was to determine overall happiness with the current state of the administration panel. This questionnaire was mostly directed at the expert users, that already were familiar with the system. The questionnaire was, however, also presented to the novices for completeness and to gauge what they thought the system was like, based on what they could gather from the cards they had to sort. The novices were told that they could skip questions if they did not understand them.

Experts were sent to a final card sorting page, where they were presented with the same 30 cards from the previous sorting task. Using a closed-sorting technique, the subjects were presented with a 5-point Likert scale, ranging from very unimportant to very important. The subjects then assigned each of the cards to category that they felt was appropriate. There was no pre- or post-questionnaire for this section of the study.

After completing the tasks, the subjects where thanked and the surveys were completed.

Results

Demographics

The participants were located in 4 countries: Switzerland (12), Belgium (1), Germany (1), and United States (2). 6 participants identify as female, 10 identify as male. Age ranges were 4 participants between 18 and 24, 9 participants between 25 and 34, and 3 participants between 45 and 54. Highest completed education had 3 who completed High-School/Gymnasium, 1 who completed Fachhochschule/Vocation School, 1 who completed Apprenticeship, 4 who completed University/College, and 7 who completed Post-graduate studies. 2 participants have received additional medical education.

7 subjects have previously used the simulator. Of those seven, all of them have used the AMP. 4 subjects had experience administering the simulator system. 4 subjects had more than 1 year of experience working with the simulator. One of these subjects had more than 3 years of experienced working with the simulator. 4 subjects use the simulator once a week. 1 uses it daily, 1 uses it once a month. All others use it less than once a month or did not answer.

Subject Groups

Experts: Card Sorting.

All users that participated finished the sorting and the surveys without aborting mid process. The average time of the open card-sorting was 6.98 minutes with an interquartile range of 5.68. The lowest and highest observed times were 5.62 minutes and 23.98 minutes, respectively. In total, 43 unique categories were reported, of which two had the same name and cards in it, one pair called "Tools" the other called "Bones". 33 Categories are distinct if the title is not considered. One category has between 1 and 13 cards with an average of 4.88 cards per category. The Expert users sorted the 30 cards into 6 groups on average.

The similarity matrix (Figure 10) shows a percentage value of two cards sharing the same category over all the expert sorting. The matrix is organized so that clusters are placed near each other for increased visualization clarity. This clustering was performed by OptimalWorkshop. The dendrogram (Figure 11) provides another visualization of the data, where the cards are clustered into similar categories across the user group.

One comment was given by a participant: the anatomical models and tool calibration should be in the same tab, but either be extendable or have sub tabs for easier navigation and access.

Novices: Card Sorting.

All users that participated finished the sorting and the surveys without aborting mid process, with an average time of 7.39 minutes and interquartile range of 5.07. The lowest and high observed times were 4.85 minutes and 14.62 minutes, respectively. In total, 50 categories were reported. One of the categories has the same name and cards in it: Tools. 33 Categories are distinct if the title is no considered. One category has between 1 and 13 cards with an average of 5.4 cards per category. 7 categories are similar up to the title to one from the experts. The Novice users sorted the 30 cards into 6 groups on average.

The similarity matrix (Figure 12) and dendrogram (Figure 13) were created by OptimalWorkshop. The clusters in the similarity matrix were also created by the tool.

No comments were recorded by the novice users.

Importance Study.

The importance evaluation is shown in Figure 14. The sorting for importance shows that 10% of the items are very important. 53.3% are somewhat important and the remaining 37.6% are either very unimportant, somewhat important, or not unimportant/important, depending on the participant. The importance evaluation shows that most items are somewhat important to the expert users.

SUS Survey.

The SUS survey was presented after the open card-sorting task. The mean of the SUS amongst all participants was 51.25 with a standard deviation of 14.97. The SUS mean for the novices was 47.78 with a standard deviation of 14.33. The experts had an SUS mean of 55.71 with a standard deviation of 15.66. Using the Welch's Two Sample T-Test, we cannot reject the hypothesis that the two populations are significantly different, because the p-value is 0.31 (significance $p < 0.05$).

Blocking on the demographic data previously presented, according to age, gender, education, previous experience with the AMP, admin experience with the system, and medical background, no statistically significant ($p < 0.05$) groups were found when performing a factorial ANOVA. Figure 15 shows the variance of the groups along the mean for the SUS of all the participants. This image was created using R's plot.design.

Discussion**Card Sorting**

The card sorting for the experts, following the dendrogram and the similarity matrix, can be categorized into either 5 or 6 categories.

5 categories

- Logging options
- Scene configuration
- Calibration
- Localization
- User Administration

6 categories

- Logging options
- Scene configuration

- Anatomical model
- Tool calibration
- Localizations
- User Administration

The differences between the two categorizations is the only between Calibration and Anatomical model and Tool Calibration. As noted from the one user comment, the anatomical models and tool calibration could be in the same tab, with expandable tabs or subsections for clarity. If this simplification and possible implementation is taken into account, the 5 categories proposed represent the categories of all the expert users.

For novice users, the results can be categorized into 6 groups, with two possible outliers.

- Version information
- Account options (equivalent to User Administration from Experts)
- Reporting and Logging
- Course administration
- Tool calibration (equivalent to Tool Calibration from Experts)
- Body Parts

The items that could be separated are Case Selection or Localization.

The novices unsurprisingly have a less cohesive view of AMP compared to the expert users. Lack of certainty on the purpose of some of the functions and difficulty discerning the nuances and differences between related cards could explain these variations in the categorizations. Detailed explanations or training would be needed for complete clarity. Training was not implemented in this study, since often the novice users of the surgical simulator do not receive training.

Since some amount of overlap and equivalency can be seen between the two groups of participants, one could theorize that if there is a categorization that would be acceptable for experts, that the same categorizations may also then be acceptable for the novice population. One caveat is that the vocabulary for categories would have to be intuitively obvious, or hover tips or similar exposition aids would be needed, if training is not a possibility.

Importance Evaluation

Importance evaluation was implemented for the expert users, in order to help aid in determining if all the cards needed implementation in the AMP at all. Since so few cards were deemed unimportant, the authors do not feel it is appropriate to currently remove any of the functions from the AMP at this time.

SUS Survey

The results of the SUS surveys in all the blocks previously mentioned firmly place the AMP in the regions of OK, with the standard deviations being around poor to barely under good. If these were letter grades, the SUS would place the AMP in the F realm, being very marginally acceptable. Figure 16 demonstrates the scale. This result validates the assumption that the AMP is not very usable, by both expert and novice users.

Recommendation for future work

The authors recommend that the AMP is modified so that the 5 categories created by the expert users are used as the basis for restructuring the AMP panels. The expandable option, including compressing the calibration status of the tools and anatomies should also be implemented. Overall, redundancy and better clustering should be the goal.

The following structure is suggested to be implemented by this study:

- Logging options

View last log file

Export log file

Select reports directory

License keys

Version Information and updates

- Scene configuration

Case selection

Enable audio

Enable recording

Show score in feedback report

- Calibration

Check tool calibration

Fast Dome

Anatomy (expandable)

Acromion

Femur (Hip)

Humerus

Femur (Knee)

Pelvis

Tibia

Tools (expandable)

Guide Wire

Handle

Hook

Scope

Shaver

- Localization

Localization (Language)

TrakStar Power line frequency

- User Administration

Enable user passwords

Allow empty user passwords

Enable guest account

Enable self registration

Search User

Edit / Delete User

Ideally, once the AMP is modified, a new SUS with novice and expert users should be performed again, to verify that the AMP has been improved.

Acknowledgements

We would like to thank our friends, family, and co-workers who took their time to aid us in this project.

References

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Figures

ArthroS™ VIRTAMED

Administration mode | Logout

Settings | Courses | Users | History | Advanced

Set new administrator password


- ☒ Enable user passwords
- ☒ Allow empty passwords
- ☒ Enable guest account
- ☒ Enable self registration
- ☒ Enable audio
- ☒ Enable recording
- ☒ Customize selection of cases

☒ ArthroS FAST 

- ☒ FAST: Tool handling

☒ ArthroS Hip 

- ☒ Hip Arthroscopy: Basic Skills
- ☒ Hip Arthroscopy: Diagnostics
- ☒ Hip Arthroscopy: Therapeutic Cases

☒ ArthroS Knee 

- ☒ Knee Arthroscopy: Basic Skills
- ☒ Knee Arthroscopy: Diagnostics
- ☒ Knee Arthroscopy: Therapeutic Cases

☒ TherapeuticAdvanced 

- ☒ Knee Arthroscopy: Concepts of ACL reconstruction

☒ ArthroS Shoulder 

- ☒ Shoulder Arthroscopy: Basic Skills
- ☒ Shoulder Arthroscopy: Diagnostic Cases

Figure 1. This figure is the first section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

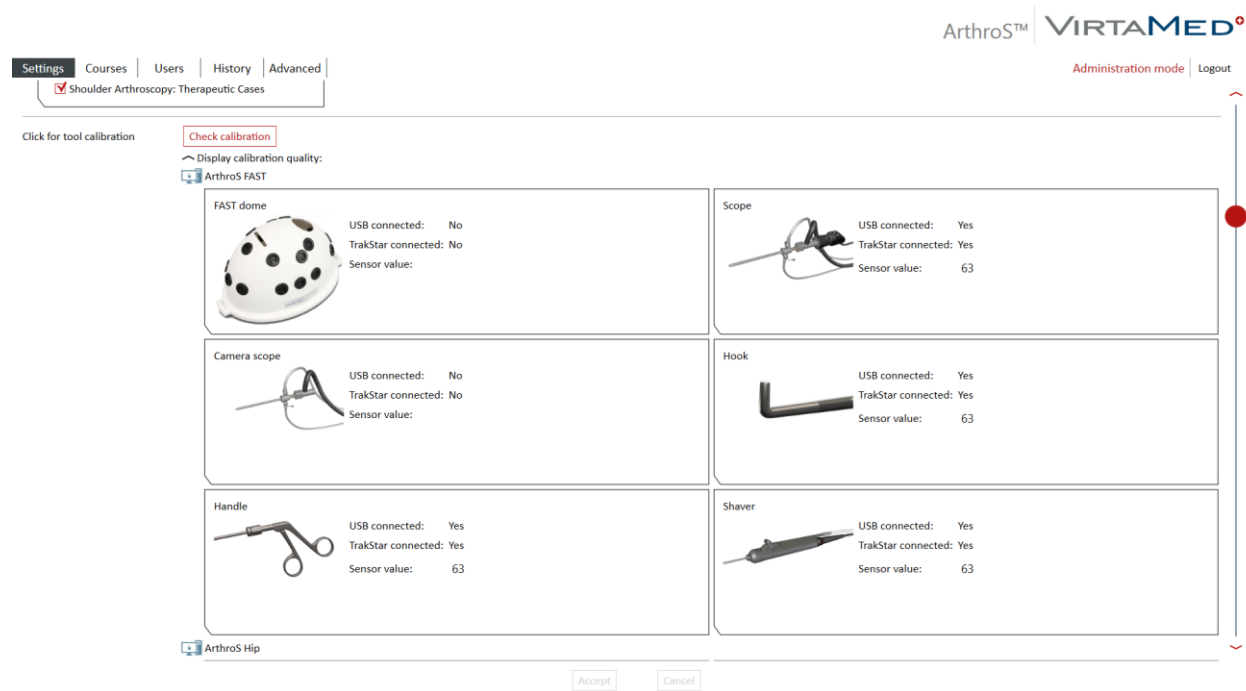


Figure 2. This figure is the second section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

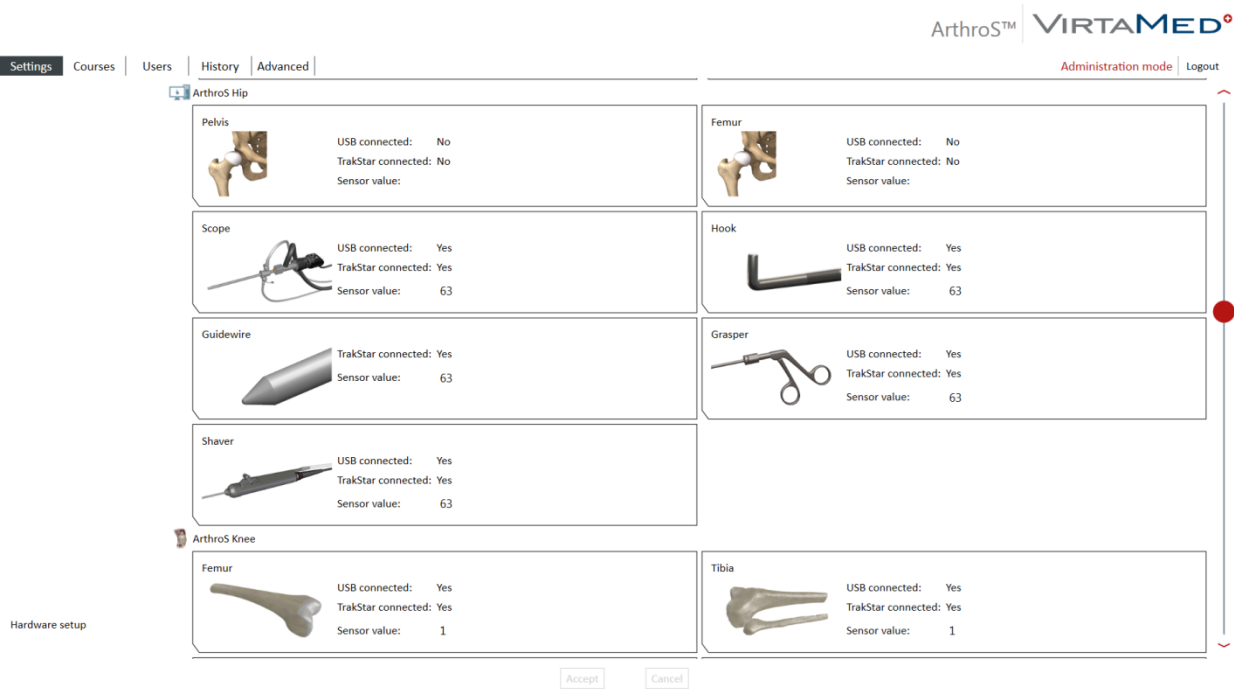


Figure 3. This figure is the third section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017)© VirtaMed AG

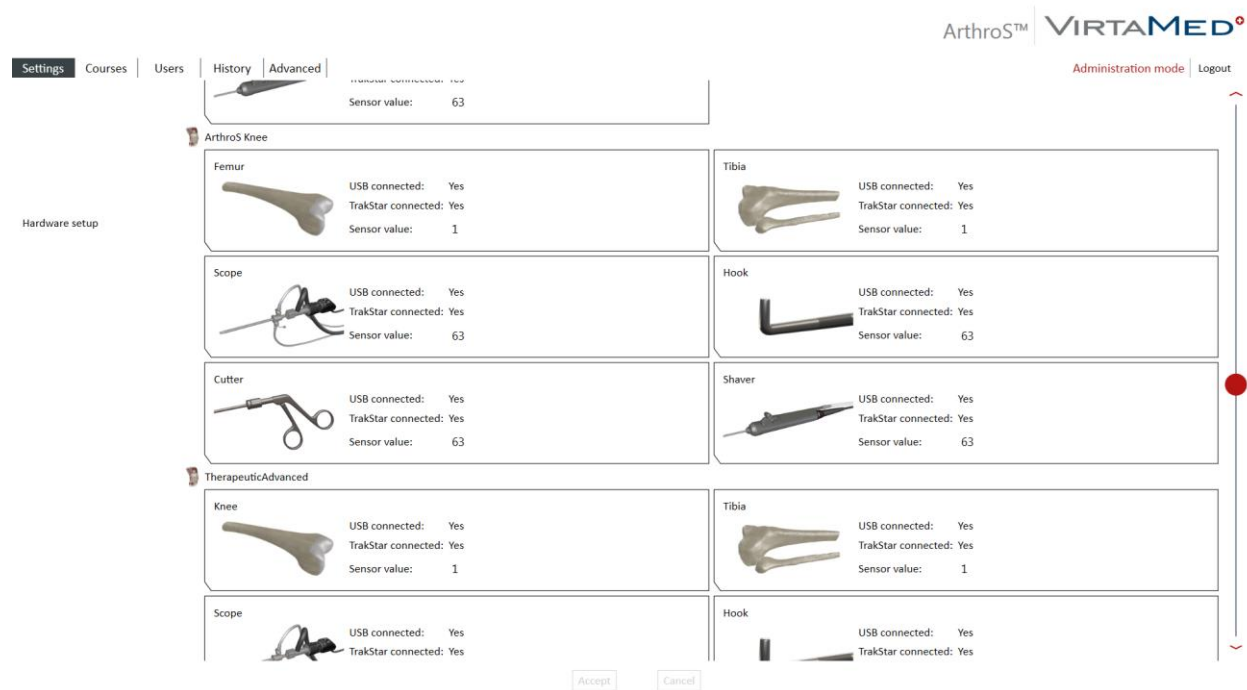












Figure 4. This figure is the fourth section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

ArthroS™ VIRTAMED®

Administration mode Logout

Settings Courses Users History Advanced

	TrakStar connected: Yes Sensor value: 63		TrakStar connected: Yes Sensor value: 63
Guidewire 	TrakStar connected: Yes Sensor value: 63	Grasper 	USB connected: Yes TrakStar connected: Yes Sensor value: 63
Shaver 	USB connected: Yes TrakStar connected: Yes Sensor value: 63		
ArthroS Shoulder			
Acromion 	USB connected: No TrakStar connected: No Sensor value:	Humerus 	USB connected: No TrakStar connected: No Sensor value: No data
Scope 	USB connected: Yes TrakStar connected: Yes Sensor value: 63	Hook 	USB connected: Yes TrakStar connected: Yes Sensor value: 63
Cutter 	USB connected: Yes TrakStar connected: Yes	Shaver 	USB connected: Yes TrakStar connected: Yes

Accept Cancel

Figure 5. This figure is the fifth section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

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Settings

Courses

Users

History

Advanced

Sensor value: 63

Sensor value: 63

Administration mode | Logout

Show scores in feedback report

All scoring

☐ Show the leaderboard

License key programming:

2-2603482

Copy to clipboard

Save to file

Product name	Status	Product code
ArthroFAST		
Simulator	✓	90000
Content	✓	90001
FAST: Tool handling	✓	90001
ArthroHip		
Simulator	✓	120000
Content	✓	120001
Hip Arthroscopy: Basic Skills	✓	120001
Hip Arthroscopy: Diagnostics	✓	120001
Hip Arthroscopy: Therapeutic Cases	✓	120001
ArthroKnee		
Simulator	✓	30000
Content	✓	30001
Knee Arthroscopy: Basic Skills	✓	30001
Knee Arthroscopy: Diagnostics	✓	30001
Knee Arthroscopy: Therapeutic Cases	✓	30001
Simulator	✓	30000
Content	✓	30051
Knee Arthroscopy: Concepts of ACL reconstruction	✓	30051

Accept

Cancel

Figure 6. This figure is the sixth section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

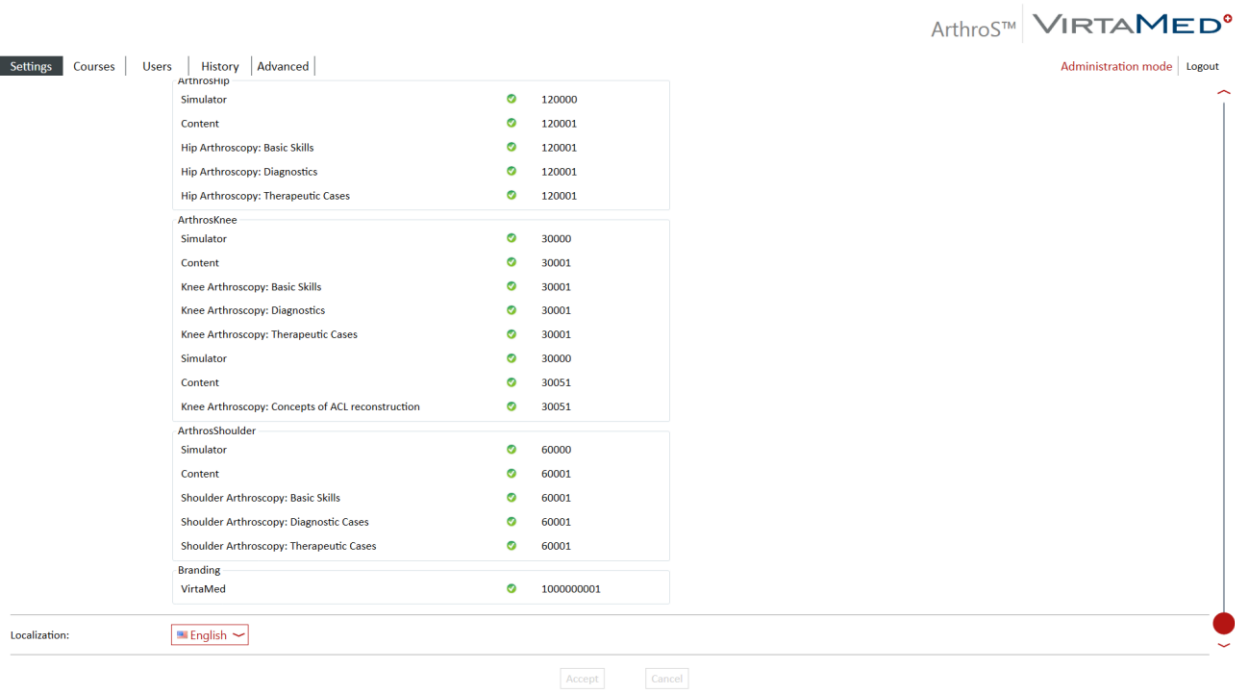


Figure 7. This figure is the seventh section of the Administration Mode Settings Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

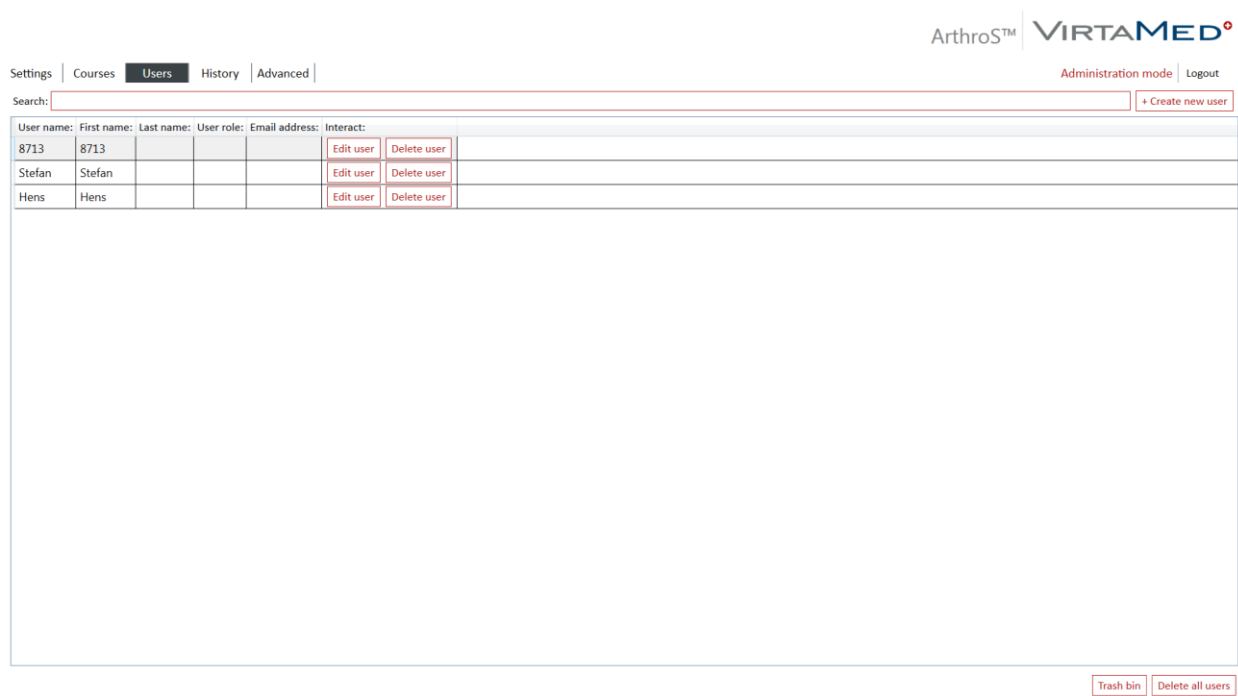


Figure 8. This figure is the Administration Mode Users Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

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Administration mode | Logout

Settings

Courses

Users

History

Advanced

Reports directory: D:\Simulator\Reports\ArthroS

Select driveReset

Version information:

ArthroS User interface

VirtaMed 1.3.8.0

ArthroS FAST

VirtaMed 1.4.0.44170

ArthroS Hip

VirtaMed 1.0.0.42454

ArthroS Knee

VirtaMed 1.4.2.44790

TherapeuticAdvanced

VirtaMed 1.4.2.44807

ArthroS Shoulder

VirtaMed 1.4.2.44791

Update simulator

Browse for update

Power line frequency

TrakStar settings:

50 Herz

Restart TrakStar

Log files:

Export log

View last logfile

ApplyCancel

Figure 9. This figure is the Administration Mode Advanced Tab as it is originally in the simulator. (VirtaMed, 2017) © VirtaMed AG

Similarity Matrix

```

Export log files
100 View last log file
57 57 Version Information and Update
57 57 100 License keys
28 28 57 57 Localization (Language)
14 14 42 42 42 TrakStar Power line frequency
14 14 28 28 14 42 Check tool calibration
0 0 0 0 0 14 71 Guide Wire
0 0 0 0 0 14 71 100 Handle
0 0 0 0 0 14 71 100 100 Hook
0 0 0 0 0 14 71 100 100 100 Scope
0 0 0 0 0 14 71 100 100 100 100 Shaver
0 0 0 0 0 14 57 57 57 57 57 57 FAST Dome
0 0 0 0 0 0 42 42 42 42 42 42 71 Acromion
0 0 0 0 0 0 42 42 42 42 42 42 71 100 Femur (Hip)
0 0 0 0 0 0 42 42 42 42 42 42 71 100 100 Humerus
0 0 0 0 0 0 42 42 42 42 42 42 71 100 100 100 Femur (Knee)
0 0 0 0 0 0 42 42 42 42 42 42 71 100 100 100 100 Pelvis
0 0 0 0 0 0 42 42 42 42 42 42 71 100 100 100 100 100 Tibia
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 Enable user passwords
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 100 Allow empty user passwords
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 100 100 Enable guest account
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 85 85 Search User
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 85 85 100 Edit / Delete User
14 14 28 28 28 14 14 0 0 0 0 0 0 0 0 0 0 0 0 0 71 71 71 57 57 Enable self registration
0 0 0 0 14 14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 28 28 28 14 14 28 Enable audio
0 0 0 0 14 14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 28 28 28 14 14 28 100 Enable recording
14 14 0 0 14 14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 28 28 28 14 14 28 85 85 Show scores in feedback report
0 0 0 0 14 14 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 42 42 42 Case selection
57 57 28 28 28 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 14 14 14 14 14 0 14 14 28 14 Select / Reset reports directory

```

Figure 10. Similarity Matrix from the expert users, with the cards along the diagonal.

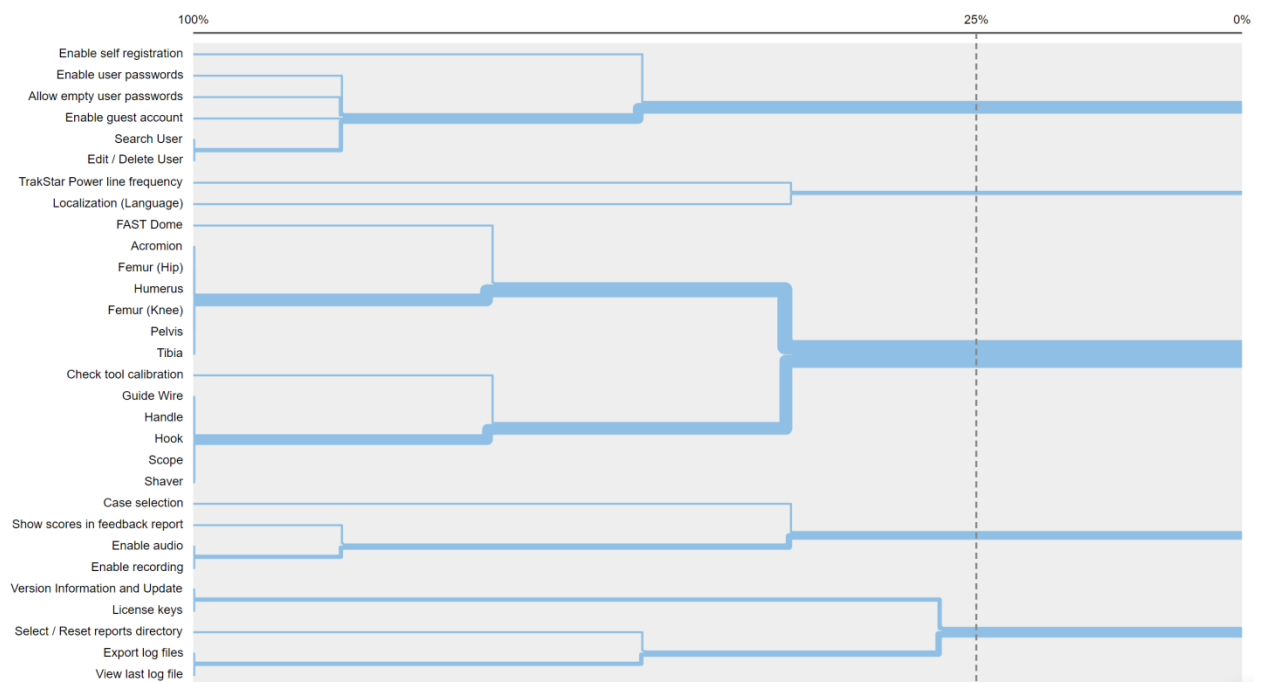


Figure 11. Dendrogram from the experts, with the cards along the left side

Similarity Matrix

```

Export log files
100 View last log file
77 77 Show scores in feedback report
77 77 77 Select / Reset reports directory
55 55 77 55 TrakStar Power line frequency
33 33 44 33 55 Enable recording
22 22 33 22 44 88 Enable audio
11 11 33 33 55 55 55 Check tool calibration
33 33 44 44 22 11 22 33 Localization (Language)
44 44 44 44 22 0 11 22 77 Version Information and Update
44 44 44 44 22 0 11 22 77 100 License keys
22 22 22 22 0 0 0 0 33 33 33 Allow empty user passwords
11 11 11 11 0 11 11 0 22 22 22 88 Enable user passwords
11 11 11 11 0 11 11 0 22 22 22 88 100 Enable guest account
22 22 22 22 11 0 0 0 33 33 33 77 77 77 Edit / Delete User
33 33 33 33 22 11 11 11 22 22 22 66 66 66 88 Search User
33 33 44 33 33 22 22 22 33 33 33 55 66 66 66 77 Enable self registration
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 FAST Dome
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 100 Guide Wire
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 100 100 Handle
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 100 100 100 Hook
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 100 100 100 100 Scope
0 0 0 0 11 0 0 22 0 0 0 0 0 0 0 0 0 100 100 100 100 100 Shaver
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 Femur (Hip)
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 100 Femur (Knee)
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 100 100 Pelvis
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 100 100 100 Tibia
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 88 88 88 88 Acromion
0 0 0 0 0 0 0 0 11 0 0 0 0 0 0 0 11 11 11 11 11 88 88 88 88 100 Humerus
0 0 0 11 0 33 33 33 22 11 11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 Case selection

```

Figure 12. Similarity Matrix from the novice users. The cards are along the diagonal.

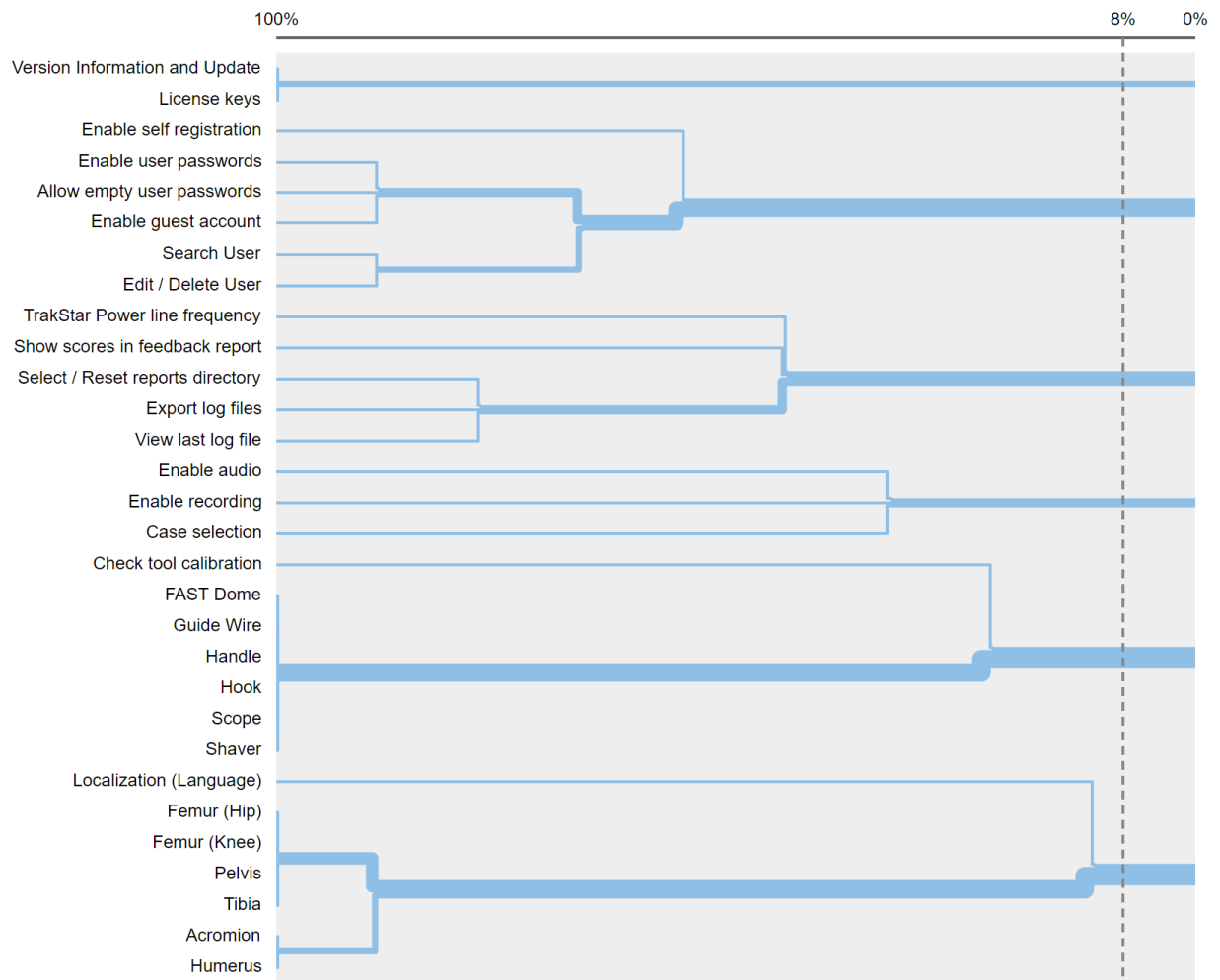


Figure 13. Dendrogram from the novice users. The cards are along the left.

	Very Unimportant	Somewhat Unimp..	Not Unimportant/...	Somewhat Import..	Very Important	unsorted
Enable self registration	43%		43%		14%	
Select / Reset reports directory	43%	14%	29%		14%	
TrakStar Power line frequency	43%		14%	14%	29%	
Allow empty user passwords	29%	29%	29%	14%		
Enable user passwords	29%	14%	29%	14%	14%	
Check tool calibration	14%	29%	14%	29%	14%	
Enable recording	14%	29%	14%	29%	14%	
Show scores in feedback report	14%	29%	14%	29%	14%	
Enable guest account	29%		43%	14%	14%	
Search User		14%	43%	14%	29%	
Export log files	14%		29%	29%	29%	
License keys	14%	14%	29%	29%	14%	
Acromion	14%	14%		57%	14%	
Enable audio		14%	14%	57%	14%	
FAST Dome	14%	14%		57%	14%	
Femur (Hip)	14%	14%		57%	14%	
Femur (Knee)	14%	14%		57%	14%	
Guide Wire	14%	14%		57%	14%	
Handle	14%	14%		57%	14%	
Hook	14%	14%		57%	14%	
Humerus	14%	14%		57%	14%	
Pelvis	14%	14%		57%	14%	
Scope	14%	14%		57%	14%	
Shaver	14%	14%		57%	14%	
Tibia	14%	14%		57%	14%	
Version Information and Update	29%		14%	43%	14%	
View last log file	14%	14%	14%	43%	14%	
Localization (Language)				14%	86%	
Edit / Delete User		14%		29%	57%	
Case selection	14%	14%	14%	14%	43%	

Figure 14. Importance weighting of the cards from the expert users. Cards are along the left.

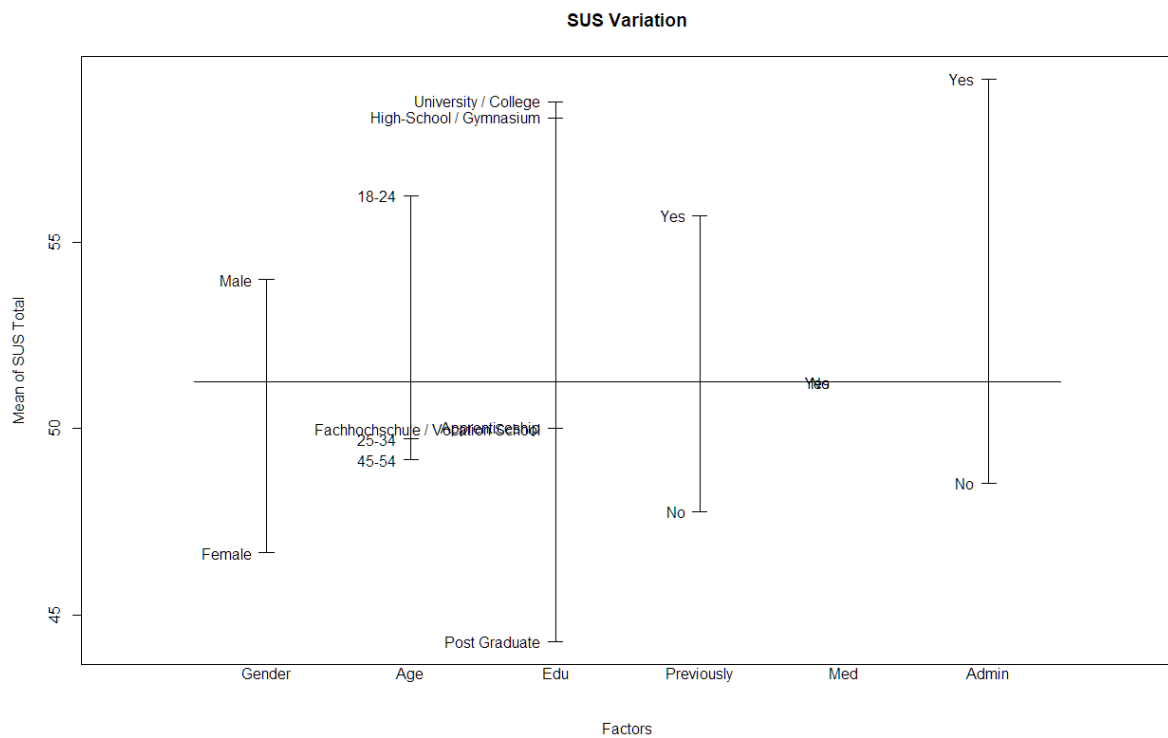


Figure 15. SUS Variance according to the blocks. Edu is education level. Previously is previous AMP experience. Med is medical education. Admin is administration experience on the simulator.

Adj.	Worst			Poor		OK			Good	Excellent	Best
Accept.	Not acceptable						Low Marg.	High Marg.	Acceptable		
Letter Grade	F							D	C	B	A
Grade	0	10	20	30	40	50	60	70	80	90	100

Figure 16. SUS table for grading scales. Adj. is adjective description. Accept. is acceptability grade. Marg. is marginal.