# Usability of an Open Space Class Location and Schedule Application

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***Abstract*—Students are surrounded by technology, it helps them with their school tasks and their orientation. The trend of software systems is in creating natural user interfaces, that would be convenient to users that use them. We created an open laboratory at our department to analyze such interfaces. We created an application for this laboratory: Schedule, in which we display the information of class locations and lectures that are taking place. In this article we describe the methods we used to evaluate this application and try to present the results in a form that would be applicable to future applications used in the space of our open laboratory.**

## I. Introduction

Computer systems are used by students on many occasions, ranging from submitting assignments, browsing study materials and communicating with lecturers and classmates. This was noticed by Wang [1], especially as smart-phones are being commonly used by students and researchers. The common goal of designing such systems nowadays is to create them as a natural user interface [2]. Designing natural user interfaces [3] is a complicated process, as it is difficult to differentiate between what is natural for the users and what encumbers them.

As we want to create space in which it would be possible to motivate students to learn, we focus on the natural user interfaces as forced teaching has negative effects on students motivation [4]. Through creating a platform in which students would get unforced access to information we want to indicate thirst for knowledge in students similarly to the work of Rotgans & Schmidt [5].

For such spaces it is important to observe the emotions of the users. There are multiple approaches that are being used nowadays for this field of the study. Examples of that could be recognizing emotion through voice recognition [6], face recognition with creating 3D model of human head [7] or through heat maps.

To research natural user interfaces together with students behavior we created an open laboratory on the hallway of our department. This laboratory is accessible by students and researcher all the time and students go through it when they go to attend lectures and exercises. Because of this it is possible to show different applications [8], informations and videos to students. This makes the laboratory a suitable space for long term experiments that include larger audiences [9]. We named this laboratory *OpenLab*.

### A. About OpenLab

Main reason why the OpenLab was created is as a space in which researchers can develop and evaluate natural user interfaces. Also it is meant to be used for researching internet of things [10]. Secondary goal of the OpenLab is to use it as a tool to better motivate the students, so that they would work on assignments more responsibly. This is intended through showing student assignments directly in the OpenLab. Following examples by Ciampa [11] and Buckley & Doyle [12], we want to create competition between to students to motivate them to create the best application and therefore to increase their growth. Third goal of the OpenLab is to move students from crowded hallways next to the rooms and place them in the open space of the central hallway.

Basic structure of the OpenLab consists of two main types of devices. To the first category fall the devices designed for collecting data. At the time of writing this article the sensors used in the OpenLab are:

- 17 HD cameras
- 6 multifunction sensors
- 2 microphones

The cameras are, aside from ensuring security of the OpenLab space, used to identify how many people are moving through the OpenLab. It is intended to use them in the future for better adjustment of the interface to different users, as face recognition could be used to accurately identify people moving through the OpenLab. Another use of the cameras could consist of identifying what actions or gestures are the people performing and use them for human-computer interaction. 6 sensors used in OpenLab measure the temperature, volume, humidity, lightness and pressure in the space. 2 microphones are used to capture spoken words which could be at later date used for example to control the OpenLab. We plan to further extend the OpenLab with additional sensors [13] that would allow us to collect even more data in much higher quality.

There are also 8 loudspeakers inbuilt in the OpenLab that are used to play music. They can be also be used to play synthesized speech [14] that could improve the use of different applications and also create natural human-computer

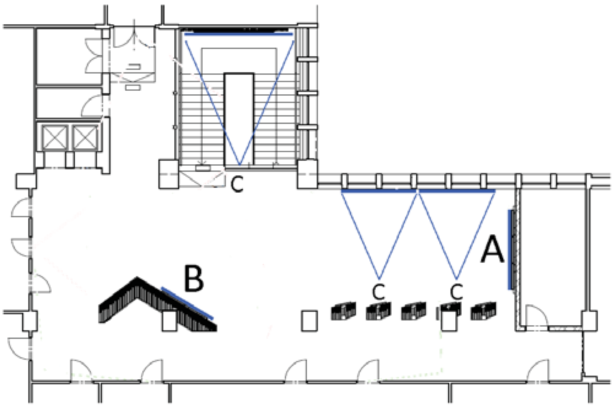


Fig. 1. OpenLab display spaces

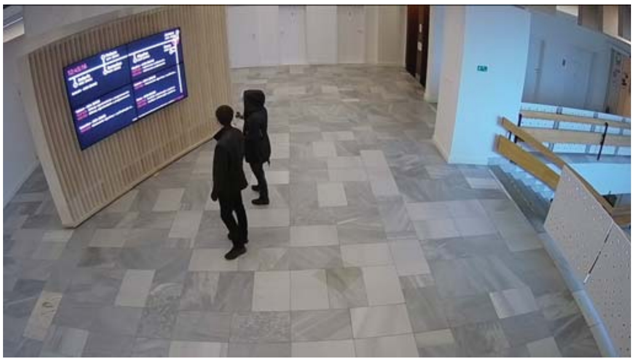

Fig. 2. The main hall with 4K display showing the target application.

interaction by enabling speech conversation between human users and the system.

The second category of devices used in OpenLab are devices used for displaying informations to the people who are present in the OpenLab space. Positions of the display spaces are shown on Fig. 1. These display spaces are:

- **A**: 9 Full HD displays placed next to each other forming a single 6K display
- **B**: 4 Full HD displays placed next to each other forming a single 4K display
- **C**: 3 HD projectors

As there are multiple display places in the OpenLab, we can track with the sensors on which displays are the students looking the most, ask people design related questions and much more. As the OpenLab is a space accessible to the public, even to people who are not from the university, like high school students, it could be beneficial for motivating people to learn informational sciences [15].

The initial testing that we conducted in this OpenLab after its launch is the user testing of understandability and usability of an open space application. Following sections will detail the applications in the OpenLav and about initial experiment in this environment.

## II. Applications in the OpenLab environment

OpenLab was opened at the end of September 2018, and because it is a unique laboratory it is still too software empty. Until today only a few applications have been created, primarily, to inform the students. These applications are displayed on a 4K screen (see Figure 2). One of the first applications was *Timetable* that depicts the current ongoing and planned labs in our department building. At the same time, the application shows a map of rooms on the floor where the particular labs are taught.

As the new academic year began and a large number of new students joined the university (approximately 450), most of them looks for rooms to be taught. At the same time, the numbering of the classrooms was changed in the whole building, which also changed the room numbering in the official student's timetables, so even the older students are disoriented. As added value, inspired by other universities, we named the rooms according to planets from well-known science fiction films. For these reasons, we would like to use the current situation when visitors of our university department could not rely on room numbering from previous years, so every visitor has approximately the same motivation to navigate by the chosen application. The created *Timetable* application should be used as an orientation helper.

## III. Research questions and methods

According to described resources in the lab and the situation listed in Section II we decided to test the understandability and usability of the chosen application *Timetable*. The application will be displayed on the 4K display (Figure 1, space B) during three days of testing, and we would like to observe users' comprehension in different views and forms. The application preview (2nd variant) can be shown in Figure 3.

### A. Research aims

As mentioned, we focus on 2 essential parts of information comprehension - understandability and usability. In comprehension of a presented content understanding and usability needs to be distinguished, as the user can understand the


Fig. 3. Preview of the tested application *Timetable*, variant 2.

content, but may not be able to really use it. The opposite is not the same, because using misunderstood information is impossible for a user.

Our focus in this paper is on random people passing through the main hall of our department building who have noticed the target application. The age of respondents is not important, but we expected test sample is approximately 100 respondents, most of them will probably be students. In this paper, we focus on the following research questions

- How does the color coherence of displayed elements affect comprehension?
- Does the color or semantics of the displayed elements affect the comprehension more?
- How does the color and semantics of the displayed information affect the speed of understanding?
- Does a respondent remember elements that are bigger and highlighted or there are more important information for him or her?

We will try to get answers to these questions by creating a questionnaire that will help us determine the correctness of the responses and the respondents speed to accomplish a task. The target app will be customized multiple times to determine which attributes are the most favor for comprehension, whether from the point of view of understandability or usability.

### B. Selected methods

We created a total of 4 variants of the application and we tried to identify the impact of changes on comprehension of same information. Specific variants of the application were created by changing the application colors or the method of representation of specific information. By changes we have attempted to influence elements on the screen that may affect the way of information comprehension. Changes were always made against app variant 1, which was initial. Changes and their intentions are described in the following sections:

*1) Variant 1: Initial design:* The first design is based on a black background combined with a magenta color. The general texts (names of courses, room names) and the map were shown in white, times were displayed in magenta color. There were 2 types of times on the screen:

- current time (left top, see Figure 3),
- teaching times of a particular course (other magenta times).

As the first texts with highest priority are shown room names, followed by a new room numbering, and the last an old room numbering (in brackets, see Figure 3). In this variant, however, teaching times are shown without a colon character and are only semantically coupled with the current time by magenta color. The aim is to find out if respondents understand semantics of numbers without a colon, based on color similarity.

*2) Variant 2: Impact of luminosity:* The application has been modified in order to change color spectrum of the displayed elements. We inverted the black background color to white (see Figure 3). The map and the texts are supposed to be black, but since the 4K display is composed of 4 separate Full HD displays, the map blended with the display frames. That is the reason why the black color was replaced with a gray one. The color semantic coupling between main time and non-colon time was retained in the view as in 1st variant. The magenta color looks softer and it is not glaring so much as on the black background. Thanks to that we can assume that users will look at other elements more. Also interesting is the impact of the whole application luminosity on the response time.

*3) Variant 3: Disturbance of semantics by color:* In this variant, we changed the design of the 1st application variant by using different color between the main time and the times expressing duration of the labs. The colon is still missing in these times and the color is same as for text (white). This way we would like to determine whether the time of understanding or searching for particular information will have significant differences compared to other application variants.

*4) Variant 4: Semantic rebuild:* At last the times returned to the magenta color and at the same time we added a colon between all times because it was a very frequent request from the respondents. We also changed the room names view as follows:

- New room numbers are displayed with the highest priority (biggest and bold font).
- Text names of rooms are listed as secondary.
- Old room names (known by older students) have been removed.

In this way, we try to get out users from their comfort zone of old-style room numbering and compare the speed of their comprehension after semantic changes. It will also be interesting to observe new students if such changes help them to understand the content displayed faster and more clearly.

## IV. Intents of the Questionnaire

Since we had multiple variants of the application we needed to choose the appropriate method for data acquisition. From out viewpoint the most accurate way to record people's opinions is a questionnaire. The respondents were random and did not have the motivation to fill in the questionnaire by themselves. Therefore we decided to record voice responses so the respondents spent a minimum time to answer and we have removed their possible disgust for filling out the questionnaire. At the same time, the questionnaire was in the form of an interview, so the respondents did not feel like a guinea-pig for a questionnaire. The added value of the interview recording is the ability to record the detailed duration of responses and analyze comprehension issues or overall respondent's attitude to the application in detail. If necessary, we can pair audio with camera recordings by a time stamp, so we can analyze the respondent's real behavior.

In order to be sure that respondents do not focus on the attributes we follow, such as speed and accuracy of the answers, we tried to put the questions in such a way that their focus was only to fulfill the given task. We stopped random respondents only if they passed through the hall and at least briefly expressed their interest in the application, e.g. they slowed down, looked at the screen, pointed at display, and etc. Questioner tried to be invisible for potential respondents to keep their interest unaffected. The respondent was asked for interview immediately after he stopped being interested in the target application.

### A. *Blocks of questions*

We have divided the questionnaire into three parts in order to analyze the way in which respondents think from different perspectives. These parts will be used to evaluate partial results and later we can also compare them against each other, for example, that the respondent has subconsciously used more one representation of information, but consciously prefers another. Since each block assumes a correct understanding of the previous one after completing questions from a block misunderstood application elements are explained. The parts of the questionnaire were as follows:

*1) Understanding the application as a whole:* The questions were focused on specific elements of the application and their correct explanation, respectively their purpose. For example, recognizing the goal of the app, the meaning of particular icons, texts meaning, recognizing the map, creating relationships based on color similarity, etc. During these questions we did not observe the speed of response, rather we were interested in the way of thinking and the ability to recognize the screen and its purpose. Similarly, we made topic changes in consecutive questions to ensure that respondents do not find the correct answers by connection of the previous ones (for example, we asked questions about the map, than something about texts and again about the map later).

*2) Request to complete a task:* This block was focused on the accuracy of the responses and the speed of comprehension of information from the screen. The comprehension time for us is the period from the end of a question until the start of the answer. The questions were formed like: *"In which room will you go to the course...?"* or *"When will be held the next lab of...?"*. Since the rooms were named by several names (new numbering, old numbering and text name of the room) we have observed what name the was used by respondent as first, or in what order if multiple. At the same time, we observed whether respondents who are accustomed to old numbering use new ones immediately. There were also several correct answers for one question in this block so we watched which part of the screen the respondent noticed as first and whether he noticed all the multiple correct answers.

*3) Opinions and suggestions:* The last type of the questions was focused on general suggestions for the application, the parts that the user did not understand and the parts which confused the respondent. The questions were in form: *"What do you prefer...?"* or *"Which representation is easier for you?"*. On the basis of this block we can compare a subconscious choice towards a conscious choice of answers, e.g. whether user prefer text or numeric room names.

### B. *Questioner influence*

Interviews with the respondents were conducted by 3 questioners, which we can characterize as follows, according to the way of conducting the interview:

1) Quick and relaxed interview.
2) Medium-fast and official interview.
3) Slow and relaxed interview.

Based on the way questioner asked questions we will look at the fact whether the speed or interview lightness affects the speed of comprehension or it's correctness. Further, we will be able to suggest appropriate ways that could indirectly improve the comprehension of new information in courses.

## V. Questionare evaluation

To make a notion about users of application and also about respondents in our survey we introduce general information about them. 85 volunteers took a part in survey. We tried 4 variants of timetable application. Numbers of participants for every variant are shown in table I. 13 women and 72 men participated in our experiment. Number of respondents falling to grades are shown in table II, where not a student means departmental worker who has finished studding and is a lecturer now. The age of the respondents varied between 17 and 41 years.

### A. *Application understanding*

If application design is to be effective, the user of application has to get to understand its meaning in the shortest time possible. Understandability of the application was one of the first measured attribute. Task of tested subjects was to explain application purpose by their words. Consequently respondents answers ware evaluated. We have classified answers as true if the answers themselves covered at least a piece of application functionality, but if the description provided by the participant was completely different form the real application state, we classified the answer as false. From the 85 respondents,

TABLE I
Number of participants for application versions.

| Application version | Number of participants |
|---|---|
| version 1 | 20 |
| version 2 | 22 |
| version 3 | 22 |
| version 4 | 21 |

TABLE II
Number of participants for study year.

| Application version | Number of participants |
|---|---|
| 1. grade | 23 |
| 2. grade | 2 |
| 3. grade | 24 |
| 4. grade | 11 |
| 5. grade | 23 |
| not a student | 2 [a] |

[a] Employee of department who is also lecturer.

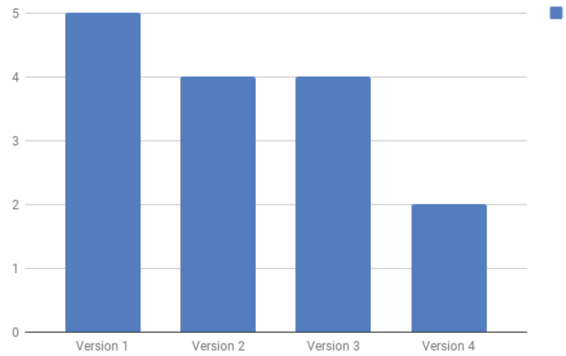


Fig. 4. Number of wrongly identified bold lines for application variants.

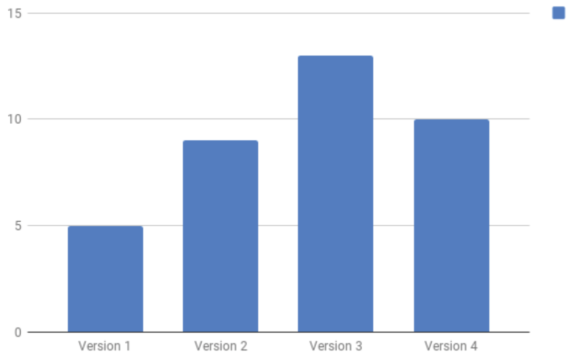


Fig. 5. Number of wrongly identified "you are here" mark.

75 estimated application meaning correctly at least by one functionality of the application. The remaining 10 respondents had theirs estimates completely wrong. As we looked at this numbers along with tested variant of the application, we noticed that the false answers are evenly spreed between all variants.

But this was the understanding of the whole application. We asked questions to ensure understanding of individual parts of the application. The first question of this type was the meaning of bold lines which we can see on figure 3. These lines represent map of floor or corridors. We noticed that many participants had problems with this question and they had given us incorrect answers 4. We have significantly changed the appearance of these lines only in the 2nd variant, where the color was changed to gray as the background was white. The color of these lines was white for all of the other variants. As we can see on the figure, there is not a significant difference in numbers of wrong answers in-between the variants.

In the right upper part of the floor plan on figure 3, there is a "You are here" mark shown as magenta circles. We asked the participants about their understanding of this mark. The results are shown on figure 5, as numbers of wrong answers for each variant of the application. Mark itself nor its place was changed during testing, although a significant difference between variant one and three appears without apparent reason.

Third question via which we observed the understanding of application parts is "What you can see on the part of application where the text is present?". Only 3 asked participants could not answer the question. Rest of the participants identified the text at least partially. Excluding variant 4 there were the same problems with identifying time of lectures, as they missed the colon in their format.

### B. Orientation with application

As we mentioned earlier, our application should help student and teacher with orientation on the floor. We made series of question to prove or refute this fact.

First question was planed to show how accurately and fast can people in hallway find a room if we have a room label

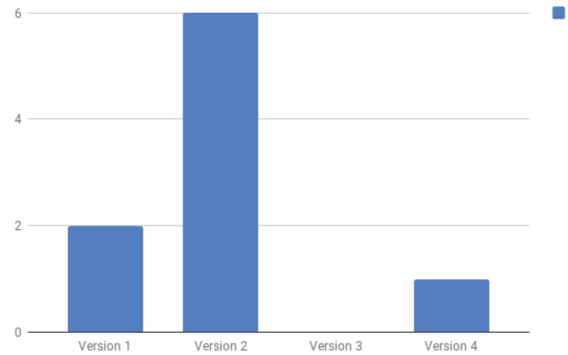


Fig. 6. Numbers of participants who have failed in navigation for application variants.

from school timetable. Many student had no problem with passing the navigation test. On the figure 6 there are numbers of participants who have failed in navigation via room numeric label for application variants. We expected that there could be some problems if finding answers to our questions during testing application variant 2, but not while asking this question. Variant 2 should be slightly less informative due to same color of lectures times and rest of text but this should have no effect while searching for room. This part of navigation should be done via plan part of timetable which is the same as in other variants. Our next assumption was that the problem with orientation would be especially noticeable on the first year students, because of fact that students from another year are already familiar the floor. This assumption was wrong, as only 2 out of 9 wrong answers were given by the first year students.

We also evaluated which type of labeling is less confusing, labeling by numbers or by names. Figure 7 shows numbers of participants who have failed in navigation by using room names for application variants. As we can seen the total number is lower than the total number of participants who failed by using numeric label.

Figure 8 shows numbers of participants who have failed in

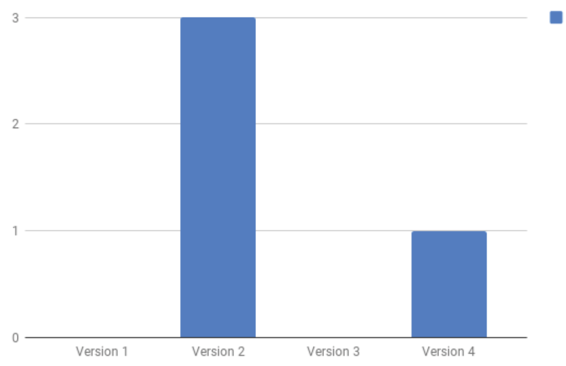


Fig. 7. Numbers of participants who have failed in navigation using room names for application variants.

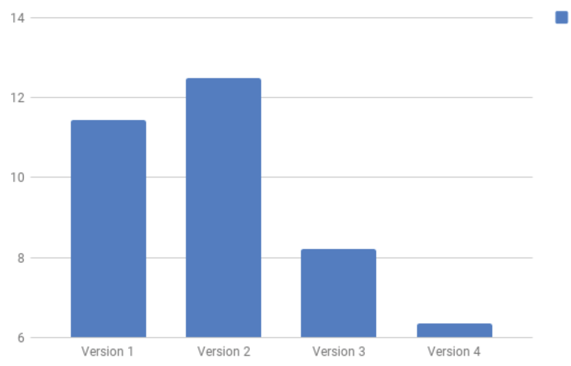


Fig. 9. Time to answer first question focused on the orientation for application variants.

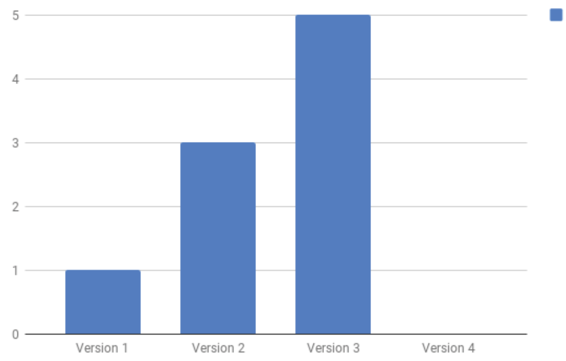


Fig. 8. Numbers of participants who have failed finding room via time for application variants.

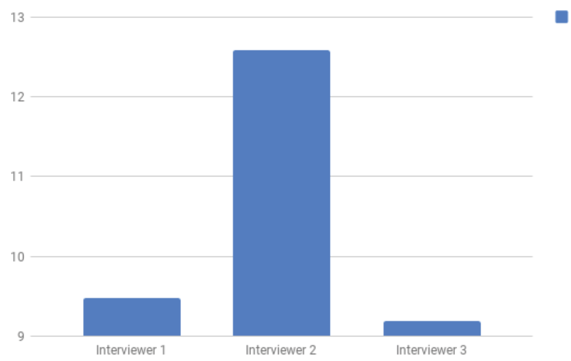


Fig. 10. Time to answer first question focused on the orientation for interviewers.

finding the room via time for application variants. From correct answers 27 contain two types of labeling, 21 of answers contains only name label and 28 choose only numeric label. From all numeric labels only two participants use old numeric labeling. This indicate that people got used to new form of labeling and also they prefer to use numeric labeling.

After this step we were testing ability of searching rooms via name of the lecture. Only one participant failed during this test. This mean that finding room label is an easy task if the users know the name of the lecture.

In this step we measured time it took the participant to answer to our questions (as described earlier). The time taken to answer the first question was the most interesting for us, as the participants were solving this task and they were also getting familiar with the application and the time needed for orientation in timetable is significantly shorter while looking at user interface. Based on this we measured times and calculated average time for every variant of the timetable. These times are shown on figure 9. We can see that changes made mostly in design part in variants 1 to 4 had not so important impact on the time needed to complete the task. In application variant 4 we changed not just colors but also the order of attributes and we excluded the part which we found considered by previous answers as unimportant (old class numbers). The changes made to the timetable made it more clear and we noticed shorter times needed by the participants to answer our questions.

As the questions were given by three researchers, we also wanted to measure the average times needed by the participants to answer questions based on what researcher interviewed them. Results are shown on figure 10. As we get to know, there is no direct relationship between speed of the interviewer giving questions and time needed to answer. But the longer time for interviewer 2 can be caused by interviewer official approach while another interviewers had more relaxed approach.

### C. *Participants opinions*

We not only deducted if the application is helpful for student but we ask them about it. Most of the questioned users thought that the timetable application helps them to find their class. Only 6 participants disagreed.

Every participant said that they liked the design of the application because of it simplicity. But most of the tested subjects which were evaluating variants of application different from the fourth variant wanted to have a colon between hours and minutes.

## VI. Future Work

OpenLab opens a lot of possibilities for applications, projects [16] and monitoring of user activities. It can be also used to display code examples [17] for the students to increase their code comprehension and perhaps even familiarize the students with correct coding standards. For our further research we want to focus on collection of the data for multiple applications that would be used by students, so we could improve the results that are achieved by our students. Electromagnetic fields can influence students [18], so from the longterm perspective of learning it will be possible to evaluate what fallout have the electronic devices on students.

Main problem with the experiment mentioned in this article is the method used for collecting subjective opinions of the respondents. Collecting data by creating voice recordings is time consuming for the researchers. The time needed to translate data from one recording into a format that can be easily manipulated by the researchers is at least as long as the time of the recording itself, as the researcher needs to listen to the entire recording. This time is even longer for parts of the recordings that are problematic for the researcher to transform.

That is why for our further research we want to diminish the need of researchers to be present in the OpenLab to execute experiments. For this we should be able to use voice recognition from the data collected by microphones that are present in the OpenLab and perhaps transforming them into form that is easily processed by a computer.

## VII. Conclusion

During the evaluation of usability of an open space class location and schedule application we have not found strong connection between the time needed to understand the application (and manage to use) and the changes we made in the visual site of program. We found that this time was lessened when we made changes in the major design like changing the size of the elements based on their importance and clearness of the application. We also found that the size of the elements is important to help people orientate in the space. For researching applications in the OpenLab we found out that users are willing to participate, although it is possible that this phenomena is caused by the appearance of something new. We found out that the questionnaires are a good way to evaluate interfaces in open spaces, although researchers which would want to conduct similar experiments in the OpenLab need to devote a lot of time for such experiments. Hopefully we will be able to use sensors embedded in the OpenLab space and conduct more experiments that would improve the eLearning on our university.

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