Developing learning environments for engineering education: Elements of user experience and supporting spatial solutions

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Conference Key Areas: Engineering education research, inclusive design in engineering education, new learning concepts for engineering education

Keywords: Usability, user experience, learning environment, new ways of learning

INTRODUCTION

Understanding the viewpoint of the users of academic environments, referring to both students and staff, is essential especially now when the demands for new ways of learning change the user needs set for academic facilities [see e.g. 1-5]. The widely applied ISO 9241-11 standard defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use" [6]. A redefinition is suggested for this original definition by substituting the 'experience' with 'satisfaction' [7]. Therefore, user experience is considered to be one of the main concepts in the development of learning and working environments and their usability [8-9].

Hence, this study investigated the user experience of the learning environment in the context of academic engineering education with an aim to identify development possibilities. This aim was achieved by the following research questions: (1) what the elements of user experience are from the viewpoint of both students and staff that the

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Aalto University School of Electrical Engineering (Aalto ELEC) building should support and (2) why this experience is considered important and by which spatial solutions it can be supported.

The paper is divided into four chapters. After the introduction, the methodology is discussed. The results are presented after that. The final chapter consists of discussion about the results, limitations and implications for future research and practice.

1   METHODOLOGY

The data were collected from the students and employees of Aalto ELEC, which is located in a late 1960's building situated in the centre of the Otaniemi campus area (Espoo, Finland). The size of the building is 29040 m^2 (gross value). The main user groups are students, numbering approximately 3300 or so, and staff (including teachers, researchers and faculty staff), being approximately 700 in numbers. The building is in its original condition except from the recent renovation of a few classrooms and study facilities. The mixed methods approach was used as the research method in this investigation. The mixed methods approach is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" [10, p. 17]. The explanatory sequential design process of mixed method research was implemented in this study [11, p. 69]. The research process consisted of two phases, as seen in *Fig. 1.*
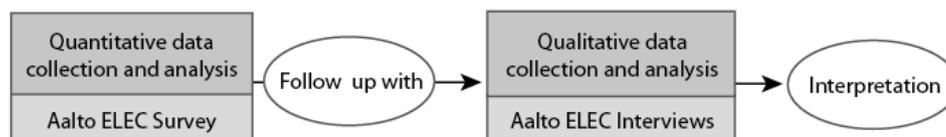

Fig. 1. The design of the research process [adapted from 11, p. 69].

The aim of the survey was to understand what the elements of user experience are that the Aalto ELEC building should support. The survey took place in October–November 2012. It included 8 background questions and 6 predicate questions addressing the needed user experience of the building. A six-dimensional model for capturing the intangible elements of user experience of places was applied as a framework for the predicate questions. The aim of this multi-disciplinary framework *(Table 1)* is to integrate different elements user experience of a place to one holistic model that consists of six dimensions, which are atmosphere, frequency, functionality, familiarity, narrative and importance. These dimension approach the user experience of a place from the viewpoint of sensory environment, use and sense of time, easiness of use as well as continuity and consistency of the story and brand of a place. Other point of views relate on how well the space supports its users performance or identity and values. The model is flexible and can therefore be applied in various user centred space development situations. [12] Thus, each predicate question included 6 claims that were based on the aforementioned framework, consisting of 36 claims altogether *(Appendix 1).* The respondents were asked to rate these claims on a 1 to 5 (very unimportant – very important) response scale from the viewpoint of the importance of the realization of the claim in the Aalto ELEC building.

Altogether 124 respondents participated in the survey, of which 89 were students and 35 staff members (including researchers, teachers and faculty staff). 49 of the students were either fifth (or higher) year or first year students. The rest, 46 students,

Table 1. The six-dimensional model for capturing user experience of places [12].

Dimension	Description
Atmosphere	Sensory environment and cognitive symbols
Frequency	Use of time, sense of time and rhythm
Functionality	Modifiability and support of activities and performance
Familiarity	Learnability and easiness of use
Narrative	Continuity and consistency of the story
Importance	Support of users' identity and values

ranged from second to fourth year students. 92 of the respondents were male and 32 were female. The majority of the respondents, namely 112, were Finnish. The remaining 13 of the respondents represented 10 different nationalities, such as Indian and Polish. Most of the student respondents (85) were 21 to 30 years old, and the age of the majority of the staff representatives varied from 21 years to 50 years. The educational background of the staff was mainly a licentiate/doctoral degree or a master's degree, whereas almost all of the students had either a matriculation examination or a Bachelor degree as their educational background.

The Aalto ELEC survey was followed by Aalto ELEC interviews, with an aim to understand why the elements of user experience reported as a result of the survey study were considered important and by which spatial solutions they can be supported. 15 of the survey participants took part in approximately 30 minutes long recorded and focused (or semi-structured) interview. The focused interview is a qualitative research method. It consists of a sequence of themes and questions that are covered during the interview while retaining openness to changes in the sequence and form of the questions. This enables following up on the answers given and the stories told by the interviewees. [13, p. 124]. The interviews took place in February–March 2013. The interview guide consisted of 8 background information questions, followed with 6 themes that were received as a result of the Aalto ELEC survey and which were based on the highest rated user experience claims of each predicated question group (Fig. 2). During the interviews, each theme was discussed from the viewpoint of what the importance of the element of experience is and by which spatial solutions it can be supported.

The interviewees were 8 students and 7 staff representatives including both researcher and teachers. The majority of the students were taking their first or second study year and the rest were further along in their studies. Four of the interviewees were women and the rest were men. All except three of the interviewees were Finnish. The age of the student interviewees varied mainly from 21 to 30 years, and the age of the staff varied from 31 to 50 years. The educational background of the staff was quite evenly divided, being a master's degree or a licentiate/doctoral degree. Most of the students had either a bachelor degree or a matriculation examination as their educational background.

In the analysis of the interview data, content analysis, which is a partially quantitative method that typically results in a numerical description of the features of a given text [14], was used to identify the reasons why the elements of the user experience were considered important. Thematic analysis, which pays greater attention to the

qualitative aspects of the data [14], was used to describe and analyse the supporting spatial solutions. Qualitative data analysis software was used as part of the analysis process.

2   RESULTS

2.1 Elements of user experience that the Aalto ELEC building should support

The elements of user experience that the Aalto ELEC building should support from the viewpoint of its users can be seen in *Fig. 2*, which shows the mean values of the highest rated user experience claims of the Aalto ELEC survey. All claims with their mean value responses can be seen in *Appendix 1*. The top rated claims were related to familiarity (4.67) and functionality (4.65), indicating that the spaces of the Aalto ELEC building should be easy to use and enable getting one's work done. The next most important claims were related to importance (4.23) and frequency (4.22), pointing out that the building should allow its users to be themselves when using it and also to make it possible to spend there a long or a short time, depending on individual needs. The fifth rated claim was related to atmosphere (4.03), showing that the visual appearance of the building is especially important to the users when compared to other sense stimulations. The final claim was related to narrative (3.83), indicating that the users of the Aalto ELEC building consider it important to see what work is done there.

Fig. 2. Elements of user experience that the Aalto ELEC building should support.

2.2 Importance of the user experience and supporting spatial solutions

The interviews resulted in a diversity of suggestions relating to the reasons why the elements of user experience reported as a result of the survey research were considered important and what spatial solutions would support them. The most common suggestions are discussed next.

Easy to find and modify

Over half of the interviewees considered that the spaces should be user-friendly, referring to a broad term that includes concepts such as self-explanatory and easiness to find, access, or starting usage. One student described a user-friendly space as "a space that is easy to access and adopt by anybody". Easy usage was seen to reduce users' stress and save their time and energy. As a student claimed, the spaces should be "easy to find, access and book beforehand if needed with the necessary information relating to what you can and are allowed to do there". Therefore, as a solution, the building should include a consistent instruction system with signposts and other guidance. Spaces should include all necessary tools and equipment and they should be easy to use for different purposes. According to a staff member, "the classroom should be designed so that I can modify the layout with the students in three minutes to be suitable for the teaching purpose I currently need". Moreover, classrooms should have technology that can be seamlessly put to use. As an example, one staff member described a scenario where "I know where to put my

laptop and how to start using the projector or how to get the sounds on, or where the chalks are or the sponge". The classrooms should also contain easily movable furniture and enough space on the walls for more than one video projector screen,

whiteboards and bulletin boards. Relating to the workstations of the staff, they should be made easily accessible for other staff members when unoccupied by the regular user.

Supports usage

All of the interviewees considered it essential that the space supports them to progress in their work. Half of them emphasised the importance of a distraction-free environment by excluding, for instance, factors such as coldness, noise, and people behind their backs or passing by. As a student pointed out, "if I need to read or do individual tasks, I need a quiet space where I can concentrate to get things done". However, another student pointed out that he needs distractions to be able to concentrate, as he stated, "if I do it [studying] by myself I need some stimulus on the background to be able to focus". The work of both students and staff consists of carrying out a series of different activities. Offering the users spaces that support these activities can assist the users in getting their work done. For instance, research related activities involve writing that requires concentration. Most of the staff members claimed that small office rooms shared by 2 to 10 people that are currently in use in the Aalto ELEC building would be more acceptable if there were separate places for having meetings or making phone calls. According to a researcher, "small meeting spaces are needed so that people wouldn't chat in the shared rooms, because when people start to chat, others are immediately interrupted". Another researcher stated that "having the feeling that somebody sneaks behind your back, that's the most disturbing thing to happen". At the moment, the staff members exclude the distractions of the surrounding environment by headphones and blocking visual contact. Relating to teaching, some of the staff members claimed that the lately renovated small group teaching facilities at the Aalto ELEC building are welcomed because they enable teaching that includes group working. These kinds of facilities are regarded as an essential part of today's teaching because, according to a staff member, "small group working and pair work are trends of today's education". Group work facilities can also be located in the corridors. As a student stated, "conversations are characteristic of collaborative work, so they can be done in the corridors". The essential thing, according to another student, is "to have enough space to study so that many student groups can fit in the same space".

Enables everyone's personal way of doing

It seems that, according to the data, the possibility for self-realization generates motivation among the space users. Self-realization means having a feeling that you can freely say your opinion about different matters and have an effect on what you do and how you do it. Therefore, the role of a space is to shape around the user, as a student claimed, "by supporting my personal way to learn". Offering for the users spaces the users are eager to use for studying and working can enhance self-realisation. For instance, relating to the surrounding areas of the Aalto ELEC building, elements of nature such as the presence of the seashore and parks were highly appreciated by both the staff and students. These places were commonly used for recovering, and some interviewees had also worked or studied in them. A student described this by saying "I think that it is truly amazing that there exists this kind of campus where you have nature … this was one of the biggest reasons why I applied here". Moreover, hanging around with other people is also relaxing, as one student

explained that "the space is not necessarily the main point but the fact that there are people – that's the reason why you go there." The Electrical Engineer Guild room located in the Aalto ELEC building was considered an important place by the students, as a student claimed that "nobody can focus on studying eight hours a day … it [the Guild room] is a good place to go and have a cup of coffee and move your thoughts elsewhere for a while". However, not every student uses the Guild room. For them, the lobby and the corridors are the places to be. The solution would be to create hang-around spaces to the lobby and to the corridors by sofas and amenities such as a coffee vending machine. As one student claimed, "I think that sofas really make you relax because you cannot sit on them otherwise but in relaxed manner". Another student mentioned the electronics workshop that is located in the Aalto ELEC building as an attractive possibility to actualize one's own ideas in practice. Relaxed settings are also needed in more formal classrooms. As a staff member claimed, "it creates an uneasy feeling when you have a space where you enter from a small passage and where everybody looks at you thinking, now she or he came … like from the door of the lecture hall when everybody else is already there". One student also stated that lifting a hand and saying something aloud in front of everybody else is more convenient in smaller classrooms than in bigger ones and continued that "for this reason, the calculation exercise class system functions well: there you get to a smaller group and you dare to make questions".

Accessible at different times of the day

The building should support the everyday rhythm of students and staff. Therefore, the users should be able to access the building at different times of the day depending on their schedule, and stay a longer or a shorter time. As a staff member stated, "eight-to-four office hours are undoubtedly not a part of the academic world, so the building should be open at least from the morning to the evening". Moreover, the Aalto ELEC building has several external doors and internal doors because of its fishbone-like layout. Therefore, making the people move into and inside the building more fluently was considered important. The two main external doors on the opposite ends of the building are open on weekdays from eight at morning to eight at evening, but the rest of the external doors and some of the internal doors close quarter to four in the afternoon. According to the interviews, the people flow of the building can be enhanced by introducing to the users a clear policy as to when the doors close. The external doors and internal doors could be open a longer time or they could have ringing bells so that the students could get to the evening classes or to other meetings even later in the afternoon. The students should also be informed where they can find 24/7 accessible spaces in the campus for teamwork, private work and computer work purposes and how they can access them. The general comfortableness of the building also has an effect on how long the people will stay there. As an example of a place that makes people to stay is the Guildroom, where, according to a student, "there are other people to chat with". Spatial elements and services such as sofas and the possibility to get coffee and snacks would also support this activity.

Clean and neutral space with lots of natural light

According to the data, a visually pleasant environment keeps the users lively and gives them strength to focus on studying and working. The majority of the interviewees considered that the most pleasant spaces were clean, spacious, with plenty of natural light, and where light colours dominate. As a staff member stated, "[using] colours that tie your brains into a knot is not the right way to make a

comfortable space". Bright colours can be found in smaller details as in furniture. A suitable colour environment recommended by a student is "white walls with colourful chairs and sofas".

Introduces the context of use

Almost half of the interviewees, both students and staff, felt that the university environment should raise inspiration and interest towards study related activities. This can be done, for instance, by having information on show about the activities taking place in the building. Staff members reasoned this by saying that "if we want to awake the students' interest, we should introduce our research projects … we need good students", or "information on show … describes to the student the context where they are". Knowing the context is essential from the viewpoint of students, as a student stated, "this would help the new students to know what they prepare for". Another student claimed that the university spaces should visually communicate the closeness of working life by saying that "the spaces should look less like an elementary school and more like an office". Overall, the information on show was considered important by the students, as they stated, "I would like to be able to see that it really is the School of Electronical Engineering, or "I am really interested in everything that is done here". This information can relate to teaching (e.g. introduction of courses and departments), studying (e.g. prototypes made by

Table 2. Summary of results.

| | Data source | | |
| | Aalto ELEC survey | Aalto ELEC interviews | |
Dimension of user experience	*Element of user experience*	*Function of user experience*	*Supporting spatial solutions*
Familiarity	It is easy to use the space	• Reduce stress • Save time • Get the most out of the space	• Guidance and instructions • Flexible spaces that are easy to modify • Spaces including the necessary tools and equipment
Functionality	I get my work done	• Get work done	• 2-6 person meeting rooms located all over the building • Teamwork settings in corridors
Importance	I can be myself	• Motivation by self-realization	• Easy access to the surrounding natural elements • Utilizing the lobby and the corridors to create informal meeting places • Supporting Guild room or its alternatives • Offering workshop spaces for both students and staff • Introducing cosy classrooms
Frequency	I can spend a short or a long time	• Support the everyday rhythm of students and staff	• Extending the opening hours • Informing the students of the 24/7 open study places • Improving the general comfortableness • Offering spatial settings and services that make people to stay
Atmosphere	I pay attention to what I see	• Gives strength to focus on work	• Clean and fresh space with plenty of natural light • Light colours dominate and bright colours in details
Narrative	I see what work is done	• Raise inspiration and interest • Communicate the	• Information on show on corridors and lobbies relating to the activities taking place in the building

		objective of the university	• In formats such as posters, showcases, info screens and vehicles or prototypes

students) and research (e.g. latest research outcomes), and be in formats of posters, showcases, info screens, and physical vehicles or prototypes. Also pictures and video material should be used as a means of communication. Some of the interviewees mentioned that the environment should communicate the objectives of the university such as modern teaching, top research, and high technology. Most of the interviewees thought that the narrative of the Aalto ELEC building should be more visible. *Table 2* summarises the results of the Aalto ELEC survey and interviews.

3 DISCUSSION

The study reported in this paper gave insights relating to how Aalto ELEC, a traditional academic engineering building from the 1960s, can be modified to better meet the expectations of its users from the viewpoint of carrying out today's academic activities.

Firstly, the Aalto ELEC building and its spaces should be easy to use and support the users to progress in their work. This can be done, for instance, by introducing a consistent guidance system throughout the building and campus and offering easily modifiable spaces with usage instructions and the necessary equipment. Moreover, the hallways and lobbies of the building should be harnessed to support informal learning by introducing group work settings and hanging out areas. From the viewpoint of the staff members, the current workstations located in the shared office rooms should be complemented with small meeting rooms that are designated for making phone calls and having meetings to offer the staff a distraction free work environment. Also the existing classrooms for small group teaching should be maintained and further developed.

The possibility to relax alone or with other people was considered to have a positive effect on the experience of being oneself. Nature is a place for relaxation, so therefore the access to and functionality of the surrounding natural elements of the Aalto ELEC building such as parks and the seashore should be improved. Moreover, offering attractive informal meeting areas for the users would support the possibility to relax with other people. These areas can also support the everyday rhythm of the users by offering a place to stay and work between lectures or other activities. Also extending the opening hours of the building and informing the students about study facilities on the campus that are open 24/7 would ease the day-to-day life of students.

The Aalto ELEC building should be thoroughly renovated to be visually pleasant, because clean, fresh and light-coloured spaces with plenty of natural light were considered to give the users strength to better focus on studying and working. What is more, at its best the academic environment can motivate and inspire its users. Therefore, the corridors and lobbies of the Aalto ELEC building could be used for informing the users about the activities that are taking place in the building.

The limitations of this research are related to the generalizability of the results. The sample size represented only a small amount of the total number of the users of the Aalto ELEC building. Therefore, the results cannot ne generalized but must be seen as directional. Future research could focus on investigating separately the experiences of students and staff members. To compare the results, the experience of users located in the other buildings in the campuses of Aalto University could be

studied. Also the view of the specific user groups such as exchange students and postdoctoral researchers or faculty staff members could be examined.

For practitioners in the field of higher education and in facility development in general, this research provides understanding of how to develop user experience based work and learning environments. According to the results, the recommendations to be considered are as follows. To begin with, flexible and easily accessible multi usage places should be offered that supports its users performance, and could be effortlessly transformed according to the different use situations. These places should enable its users personal way of doing, and when necessary, be accessible also outside the traditional office hours. The users appreciate clean and neutral places with lots of natural light. In addition, it should be considered to find ways to make the context of use visible in these places.

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Appendix 1. Predicate questions with the mean values of the responses of the Aalto ELEC survey.

Please evaluate the following statements. Keep focus on what you consider important, not how well the building supports the statements at the moment.

NARRATIVE

- The spaces and services of the place create a constant narrative
- I see who are working at the place
- I see what work is done at the place
- The vision of the place can be seen in the place
- The place has a distinct narrative
- The identity of the place is easy to recognize

FAMILIARITY

- The place is a safe place to work
- It feels like being at home at the place
- The place is a cosy place
- It is easy to use the spaces at the place
- The place welcomes me to work there
- The place is easy to enter

FREQUENCY

- The place has an informal atmosphere
- The place is open 24/7
- I can spend a short or a long time at the place
- There are different events at the place
- I come to the place to meet people that I do not know yet
- I come to the place to meet people I already know

ATMOSPHERE

- I pay attentio to the signs and symbols in the place
- I pay attention to the atmosphere of the place
- I can illustrate the place with a certain taste
- I pay attention to what I smell at the place
- I pay attention to what I see at the place
- I pay attention to what I hear at the place

IMPORTANCE

- I feel that I belong to the community and network of the place
- I am willing to work for the community of the place
- The place is in accordance of my values
- Being at the place is meaningful for me
- Being at the place supports my identity
- I can be myself at the place

FUNCTIONALITY

- I can get help when I face hands-on problems relating to the use of the place
- I can modify the place according to my needs
- Spaces of the place cen be used for many purposes
- I get my work done at the place
- I get benefical knowledge when being at the place
- I learn at the place