Designing Smart Campus Landscapes: Methods for holistic campus development

A Paper presented at CIB 2019 - World Building Congress 2019 “Building Smart Cities”
June 17th-21st, 2019, Hong Kong

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Abstract

Purpose Global trends are pointing towards a strong pressure to re-think higher education and their campus landscapes as part of urban development. Developing university campuses is needed to meet demands of digitalization, active learning, internationalization and increasing competition in higher education. Campus development should also take into account the evolutionary constraints in human experience, a perspective that is added in the framework in this paper. This study is part of a nation-wide 3-year DigiCampus project where digital learning environments and analytics and learning platforms are piloted to improve learning outcomes and well-being. During the project, a physical learning hub network is created for 24/7 studies and collaboration between universities and domains.

Design/Methodology/Approach The approach applies and discusses qualitative and mixed methods in studying user experience and usability of campus learning landscapes and digital affordances in achieving expressed goals. The participants of the study are academic staff, facilities management, and students of two faculties at a research-intensive university. The methods discussed include developing an instrument and a survey regarding space attributes and usability, and a participatory service design process for co-design and support for high performance of users in the campus facilities. These will be combined with longitudinal user experience data in the spaces, and eye tracking pre- and post-retrofitting of the test bed.

Findings Comparing user experiences in different layouts of learning landscapes using different digital solutions for learning and collaboration indicates that holistic approaches provide data for transdisciplinary co-creative development of learning landscapes. Taking all stakeholders into account enables turning needs into requirements and assessment knowledge in agile learning spaces where also learning analytics supports learning.

Practical implications The outcome is a needs-into-requirements process and assessment methodology for developing usable and smart campus landscapes. The tool can be used by transdisciplinary teams including FM, maintenance and educational leadership.

Originality The study describes a holistic integration of transdisciplinary assessment in campus landscape design. It sheds light on gaps often found in retrofitting processes.

Keywords: higher education, campus development, learning landscape, digitalization, co-design

1. Introduction

Higher education campuses comprise extensive built environment with various facilities and services that work as pioneers for innovation in terms of learning platforms (physical and digital) and sustainable development (economic, ecological and social). Global trends are pointing towards a strong pressure to re-think higher education and campus landscapes as part of urban development (Harrison & Hutton, 2014; Neary & Saunders, 2011; van Weenen, 2000). Developing university campuses is needed to meet demands of digitalization, active learning, internationalization and increasing competition in higher education.

A dimension in this research is relevance: campus development should also take into account the evolutionary constraints in human experience. For instance, office work, as it is seen at present and supposed to develop in the future, has been part of human society for such a short time that it would be unrealistic to claim people can change their behavioural patterns over extremely short periods of time – often a non-verbalised constraint in working and learning landscape retrofitting processes. (Skogland and Karsten Hansen 2017). The same goes for learning landscapes (Dugdale 2009). The key activity of higher education institutions is research-based teaching and quality learning (Knight and Trowler, 2000), and this should stay as the focus of all developments, from facilities management to educational leadership (see den Heijer 2011; Knight and Trowler, 2000; Sandström and Nevgi, 2017). This study is part of a nation-wide DigiCampus project where digital learning environments and analytics and learning platforms are piloted to improve learning outcomes and well-being. The project produces models for a physical learning hub network for 24/7 studies and collaboration between universities and domains on a national level. (The website of the project available from: https://info.digicampus.fi/?lang=en).

2. Campus development meeting the challenges of digital era

2.1 Developing university campuses – campus retrofitting (CARE)

The majority of university facilities were designed and built in times when digital solutions did either not exist or were rather limited. Today, a growing tendency on different campuses is to re-adjust existing spaces that no longer serve the purpose they used to serve. This process is termed campus retrofitting (CARE) (Nenonen et al., 2016). As a guiding principle in many retrofits, the solution should be agile and "future-ready". Future-readiness entails flexibility and a certain degree of edginess, which gives the users a sense of ownership and competence in adapting the environment according to their needs. Certain needs should be fulfilled for a campus landscape to be affording.

In a previous study, the most essential dimensions were identified based on user reports regarding campus usability and affordances (Sandström & Nevgi, 2019), especially in an activity-based setting (Figure 1). Based on the results, a well-functioning and usable campus learning landscape should enable activities on a trajectory from individual through co-quietness to shared and collaborative activities. Moving between these modalities should be easy and comfortable for users, and a sense of safety and belonging should be supported by the landscape, as well as connectivity and the ability to rely on the information network stability - a prerequisite for modern knowledge work (see also Castells 2004; Sandström et al. 2016). When enriched with technologies that support sharing, knowledge creation and learning - add well-being - a campus could be called smart.

The ability to create knowledge and work in a reliable campus environment is supported by a sense of

ownership in the spaces as well as a sense of competence (knowing what to do, how to work one's way from one space and situation to another). The ideal, holistic dimensions of what should be kept in mind when designing a usable and future-ready campus are presented in Figure 1. In addition, despite the fact that digitalization is pronounced as a current guiding principle for higher education, the importance of build environment cannot be said to have diminished; the case could be quite the contrary (Gros, 2016).

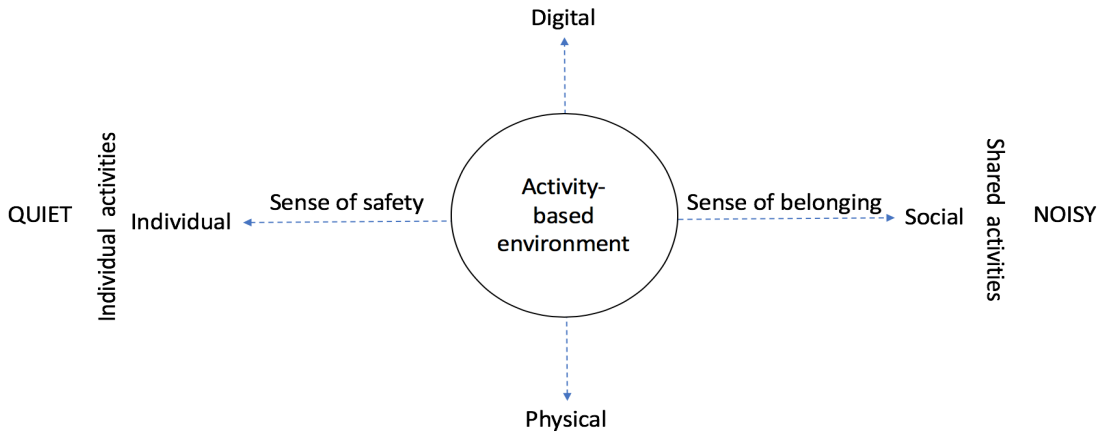

Figure 1. Dimensions of activity-based campus environment.

2.2 Evolutionary constraints of human experience - basic needs

> "*Homo Sapiens evolved around 400,000 years ago in natural environments, but people have only worked in offices for around 100 years.*"
> (Oseland, 2009, 250).

People have worked in modern type offices only for the past hundred years (Oseland 2009), Yet, as the nature of work (knowledge work from physical work with papers and books to work with digital technology and in paperless offices) has changed, the basic human needs for survival and safety, have not changed. Abraham Maslow has proposed the Hierarchy of Needs where five tiers of needs that should be fulfilled for people to reach their maximum potential (Maslow, 1943; Maslow 1970). The two lower order needs, Physiological and Safety, relate to the basic functions of physical environment such as providing food, shelter, security and comfort. The middle Social need relates to a sense of belonging and learning landscape should provide space for team work and social interaction, and jamming. The two higher order needs are Esteem and Self-actualization, and they are related to a feeling of becoming respected, of getting prestige, and of being able to have autonomy in working and studying (Maslow, 1943; Maslow 1970).

How are modern campuses meeting these needs? Do they provide spaces for social gathering, or spaces of privacy and safety? The existing spaces of campuses provide for students mainly corridors and lecture halls, libraries, and students' restaurants. The smartphones and digital technology have changed the actual need to come in person to campuses for lectures as the lectures are made available through video streaming, and online courses such as Massive Open Online Courses (MOOCs).

However, students still need to socialize and meet other students, and to gather together. In creating and developing campus environment, the campuses should be changed to meet both the needs of safety and belonging, and the needs for self-actualization and developing both academically and as a person.

2.3 FM, educational leadership and sustainability in campus development

Researchers have focused on the need for institutional transformation that universities must undergo to change their campuses to become sustainable. The transformation towards sustainable campus must be reflected and revealed in all areas of universities' everyday life: in research and in teaching and in collaboration with society (Calder and Clugston 2003). However, sustainability in higher education has only recently become part of universities' strategies, as previously it has mainly been based on separate project-based operation initiatives. Systematic linking of research and teaching with FM remains scarce (Beringer and Adomßent 2008). Furthermore, there is a strong need to link educational leadership with FM for successful institutional transformation towards sustainable university (see Sandström and Nevgi 2017), as the successful transformation requires also fundamental changes in the paradigms and assumptions concerning what universities are based on - not only a surface change of the structures and management of university as an organization (Pittman 2004; Van Weenen 2000).

Sustainability in universities has been mainly approached from the economic and environmental perspective, and interest in social sustainability is often overlooked (Arroyo 2017). Social sustainability means the capability of a community of developing structures and services that support both current and future generations in maintaining a functional and healthy community. It can also refer to the creation of spaces and places that promote well-being and democracy, and that allow for citizen engagement (see e.g. Barron & Gauntlett, 2002, Chiu, 2003). Higher education institutions are inherently contexts for pioneering work and learning, which are also components in promoting social sustainability.

Universities as organizations are complex systems characterized by having several stakeholder groups. The most common organizational structure of the universities is the division into staff and faculty, yielding to separate functions and responsibilities. Faculty's responsibilities focus mainly on duties in teaching and in research, and in outreaching society and participating in public life. Academic leaders are also responsible for the university's financial resources. The main task of the administration is to serve faculty and students, and to see that the operative tasks are functioning well, to prepare budgets, to organize facilities for teaching and learning. The organizational division means, however, that FM is mainly responsible of the physical and digital environment of the campuses, and academics are responsible of education and developing teaching and learning in the university. To manage future-ready campus development, educational leadership is needed (Nevgi & Korhonen, 2016).

2.4 Approaches in holistic campus development

One of the guiding principles in campus retrofitting process presented in this paper is stakeholder engagement in the form of participation and co-design (Eriksson et al., 2014). Some of the dimensions as to the approaches are presented in Table 1 (page 5).

Table 1: Comparing approaches in campus development

Approach	*Strengths*	*Challenges*
Co-design	*Comprehensive stakeholder engagement*	*Time constraints*
Service design	*Professionally facilitated process and data collection*	*Generalisability* *Time constraints* *Often seen as an extra cost*
Instrument development for measuring space attributes and usability	*Subjective, contextual user assessment of their learning landscape*	*Self-report*
Eye tracking	*Data on focus of visual attention*	*Finding out which factors have which impact and how they can be adjusted to support learning*
Longitudinal data sampling	*Combinations of physical measurable attributes (temperature, CO2 etc.) and evolving user experiences*	*Expenditure* *Alignment of measurements with retrofitting process (management)*

3. The study

3.1 The context of the study

The context of the study is one Finnish university that aims to decrease the number of buildings in order to respond to the economical challenges of reduced resources. At the same time, the aim is to change and develop the remaining buildings and physical resources to meet the challenges of digitalisation and new active teaching and learning methods. To succeed to meet the challenges, the university supports the approaches of participatory design where members of FM, members of IT staff and two researchers form a basic team with support of a service designer and an indoor architect.

In order to study how teachers and students experience their campus learning landscapes and use digital affordances in the learning environments, both qualitative and mixed methods were applied in the study. The methods were developed on two different campuses, representing two different domains: Humanities and Science. The methods will also in the future include physical and technical measurements combined with longitudinal user experience data in the spaces. Eye tracking pre- and post retrofitting of the test bed (one classroom that is being retrofitted) will be performed on one of the campuses.

On the Humanities campus, the informants were participants in an intensive participatory service design process led by a professional Service Designer and an Interior Architect who is also a sustainability and well-being expert. The process was designed as participatory workshops and individual interviews where the informants were presented with trigger materials such as colour schemes, pattern and layout schemes. Participants of the service design process were students ($n = 4$),

academics (n = 4), IT staff (n = 2) and FM (n = 2). For the eye-tracking pilot, second author was the teacher and 6 students took part. The two authors recorded and made notes of the workshops and interviews of the service design process, and wrote own reflections reflections regarding the change processes. The first author interviewed students in the eye-tracking pilot and the second author wrote her reflections concerning the use of eye-tracking tool in teaching immediately after the teaching session, and the first author also analysed the data.

The participants for the service design process were recruited using chain sampling (snowball) method (Patton, 1990). For eye tracking, the second author invited her students to participate in the pilot study. On the Science campus, students were recruited by a colleague who teaches on that campus and actively develops the learning environments. A total of 129 participants were involved in the study.

3.2 Case study

The case involved a traditional classroom space with a frontal teaching positioning. The eye-tracking investigation was applied in an experimental setting where one teacher participated giving a lecture that included activating teaching methods of group work and three students with eye-tracking glasses and three students without glasses. The students worked in pairs and were sitting in the front, in the middle and in the back row of the classroom. The classroom was organized as a traditional lecture hall with rows and for a teacher a desk with a computer in the front.

3.3 Development of an instrument for measuring space attributes and usability

On the first round, the instrument of 20 items with Likert -type scale (1 = not at all agree … 6 = fully agree) was developed to measure cognitive, emotional, physical and digital aspects of the learning landscape. The aim was to develop instrument to measure users' experiences of learning space. The instrument was tested with a small number of students (n = 11) and with one academic and one expert of acoustics, and based on the feedback, the items were revised.

On the second round, the instrument was further developed by modifying items based on the feedback from students at first round. The instrument of 20 items with Likert -type scale (1 = not at all agree --- 6 = fully agree) was used as a part of an electronic questionnaire in a survey to students at another campus of the target university, and 102 students responded in a survey. Exploratory factor analysis (Maximum Likelihood, Varimax rotation) was conducted to determine the factor structure of the instrument. The Kaiser-Meyer-Olkin measure (KMO = .772) verified the sampling adequacy for analysis and Bartlett's test of sphericity (χ^2 (171) = 696.895, p = .000) indicated that the correlation matrix is adequate for factor analysis. Kaiser's criterion of eigenvalues greater than 1 yielded four-factor solution as the best fit for the data accounting for 45.72 % of the variance. The internal consistency of the sum scales was examined by calculating Cronbach's alpha value: (1) Reliability of learning space (6 items, Cronbach's alpha = .80), (2) Support for concentration (5 items, Cronbach's alpha = .79), (3) Ergonomy (3 items, Cronbach's alpha = .72) , and (4) 2 Communal space (2 items, Cronbach's alpha = .68).

4. Findings

Comparing communities of users with their experiences in different layouts of learning landscapes, using different digital solutions for learning and collaboration, indicates that holistic approaches

provide data for transdisciplinary co-creative development of learning landscapes. Taking all stakeholders into account enables turning needs into requirements and assessment knowledge in agile learning spaces where also learning analytics supports learning. One of the dimensions in holistic campus development and retrofitting that this paper discusses as an additional part informing the change process is the inclusion of human basic needs (Maslow, 1970).

4.1 User experiences

Students' experiences of the classroom on the Humanities campus was examined by asking a small group of students ($N = 9$) to answer a questionnaire that included instrument of 20 items focusing on cognitive, emotional, physical and digital aspects of the learning landscape. Students participated in the course of teaching Finnish language, and as the participation in the lecture was voluntary, only 9 students out of the 44 students showed up in the classroom for the last lecture of the course. Students experienced that the space supported their learning. However, in open-ended answers they reported that the classroom was cold, the lighting was not good (made them feel tired after a while), and the furniture was not ergonomic. They reported the following:

Cognitive: Students reported that they could easily concentrate in the classroom both in their own learning (A1, $M = 4.9$) and to follow teaching (A12, $M = 4.6$). They could easily see the topics a teacher was presenting to them (A7, $M = 4.9$).
Emotional: Students do not experience the space as irritating (A10, $M = 1.7$) or they do not feel themselves restless (A5, M = 1.9). Most of them feel themselves being in peace and relaxed (A13, $M = 4.4$).
Physical: According to the students, the lighting of the space is good (A6, $M = 5.2$), and also the air is good (A9, $M = 4.4$). Students are also somewhat satisfied with the room temperature (A3, $M = 3.9$).
Digital: Students report that the use of digital solutions (A14, $M = 3.7$) and mobile technology (A8, M = 3.7) is satisfactory.

Students' experiences of four different spaces (two classrooms, one auditorium, and a corridor furnished for independent and group work studies) was examined by a survey (N = 102) in the campus of sciences. Generally, students had experienced the learning spaces as well-functioning and reliable ($M = 4.6$; $SD = 0.81$), and that it was easy to concentrate in studies ($M = 4.4$, $SD = 0.93$). The responses regarding ergonomy ($M = 4.0$, $SD = 1.06$) revealed that students experienced the auditorium less ergonomic ($M = 3.8$; $SD = 1.18$). Students reported also that the auditorium less communal space ($M = 3.8$, $SD = 1.18$) than the classroom 1 ($M = 4.6$, $SD = 0.56$). However, there were no statistically significant differences between the three different learning spaces.

In the eye-tracking pilot, 1 teacher and 6 students participated in the traditional lecture setting with a peer-to-peer task. The eye-tracking method revealed that the teacher focused on her students, observing each student group intensively, however, the student groups in the front were observed by her more often that the student group in the back side of the classroom. She also focused more on the students with no eye-tracking glasses, as she later in her reflections reported that it was difficult to understand what the students with eye-tracking glasses were actually discussing and working on. She realized how important it was for her to have straight eye contact with the students. The students expressed their surprise about how little they made eye contact with their peers, and instead, they were totally engaged in the shared task and focused on the tasks and learning artifacts (paper and other affordances) in front of them. They reported that the teacher's movements close to them in the learning space made them feel relaxed, as she was available for them if they needed help in their task.

4.2 Participatory methods

Co-design processes
In academic facilities, it is essential that the spaces support learning in different forms (Matthews et al., 2011). Current pedagogical theories and educational discussions revolve around how social interaction, knowledge co-creation and sharing support learning (Greeno & Engeström, 2014; Scardamalia & Bereiter, 2014). In order to create sustainable university campuses that meet the challenges of new modes of teaching and learning using digital technology, the educational leadership and FM need to be combined, and these departments need to work as a team.

Co-design means including all embedded user groups working on campus, to reveal the needs and requirements that users really have and face. Regarding how users experience a space or a service, the involvement of users is essential from the analysis phase through synthesizing phases to decision making (Sleeswijk Visser et al., 2005). Co-creation and collective design can take formal (mediated by tools, facilitators etc.) or more informal ('on the job/duty') forms. In co-design, all users involved are regarded as experts. One way of sourcing for the best practices from users is using narrations of what the best situation, context of activities, professional performance etc. would look and feel like. We call this *high performance*.

High performance
In our process, the Interior Architect of the design team brought in the idea of studying what high performance in teaching would entail (see Grigoriou, 2019). This means listing the factors that should be fulfilled in order for a close-to-optimal pedagogical stance to form. Listing the optimal dimensions sheds light to how higher education faculty see their relation to the students and to the (domain-specific) requirements in a formal learning situation. This method was found useful as a pedagogical reflection tool also on the level of physical classroom design, and it will be used in the retrofitting process of the studied classroom.

4.3 Reliability of learning landscapes

Amounting to the reliability of the campus landscape, when the foundations are laid well and are stable, users can work on higher levels of cognitive processes, including learning. These foundations include inherently access to sufficient power sources and internet connectivity. Our interpretation in terms of electricity and connectivity is as follows: what people are talking about - and hoping for or needing - is *reliability* in the fulfillment of these needs. Reliability is not fulfilled if the primary digital age basic needs, electricity and connectivity, are not met or if there is a risk of not being able to perform the aimed tasks using technologies. In these cases, people actually lower their expectations and do not plan materials, practices or pedagogies that would depend on a well-functioning connectivity (Clark-Gordon et al., 2019; Ertmer et al., 2012). Connectivity has no bearing without sufficient power supply, and in such contexts, high-tech and high-end solutions and talks about digitalisation and its benefits will leave people with a lot to hope for. This is not only true on attitudinal level, but has a very tangible outcome: technological and digital affordances are left unused and resources will be lost.

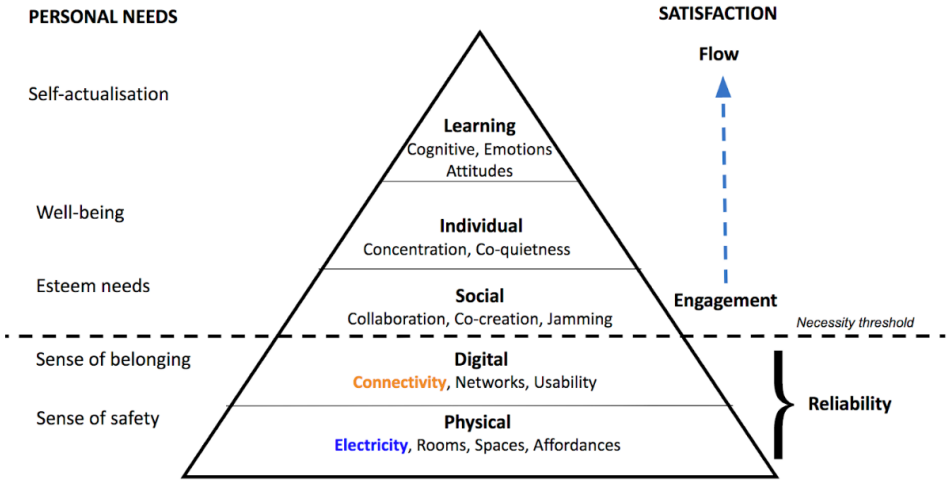

Figure 2. Digital basic needs in the hierarchy of human basic needs.

Needs-into-requirements
The fulfillment of human basic needs in usable campus landscapes was salient in many user interviews. An additional layer to the traditional basic needs hierarchy, presented in Figure 2, is that of power supply (electricity) and connectivity (Wi-Fi). Turning user needs into requirements – and including the needs to design briefing – requires a fresh perspective in terms of the design brief. The dimensions that basic-need hierarchies entail should be translated with a transdisciplinary design team that includes stakeholders from all the levels that have a user, supportive or managerial role in the designed facilities.

The physical (physiological) needs are comparable to electricity, and the digital include connectivity, i.e., Wi-Fi. Our study found that students want campus landscapes to provide them with seamless spaces for concentration and co-quietness (our term for studying together individually but feeling the moral stamina from peer students working on their own content in the same space) and collaboration and cooperation. The campus should support well-being by rich combinations of all kinds of spaces, and ideally, spaces that promote feelings of belonging and safety.

5 Conclusions:

layers of usability for smart campus learning landscapes

This paper looked at the layers of holistic campus development through the lens of user experience and methods that can be used to learn about and improve usability. Different priorities can be found when retrofitting is being planned and when it is being executed.

The students that participated in this study reported stable connectivity and sufficient power supply as key factors in campus attractiveness and thus, usability. It seems that connectivity and electricity supply form the backbone for the usability of modern campuses. In the digital age, the human basic needs, following the hierarchy proposed by Maslow (1970), have been amended by wireless connectivity (Wi-Fi). When this is studied more closely, the physical (physiological) foundation is something that precedes the wireless connectivity; the physical world must necessarily precede immaterial networks. To survive in the digital working and learning life, people need electricity and Wi-Fi, electricity being the foundation in the hierarchy of the digital age.

When the dimensions of activity-based campus environment (presented in Figure 1) are combined with Vischer's (2008) dimensions of functionally comfortable workplaces, the merging dimensions of campus learning landscapes as a three-dimensional picture start to take shape. The layering of these dimensions is shown in Figure 3 below.

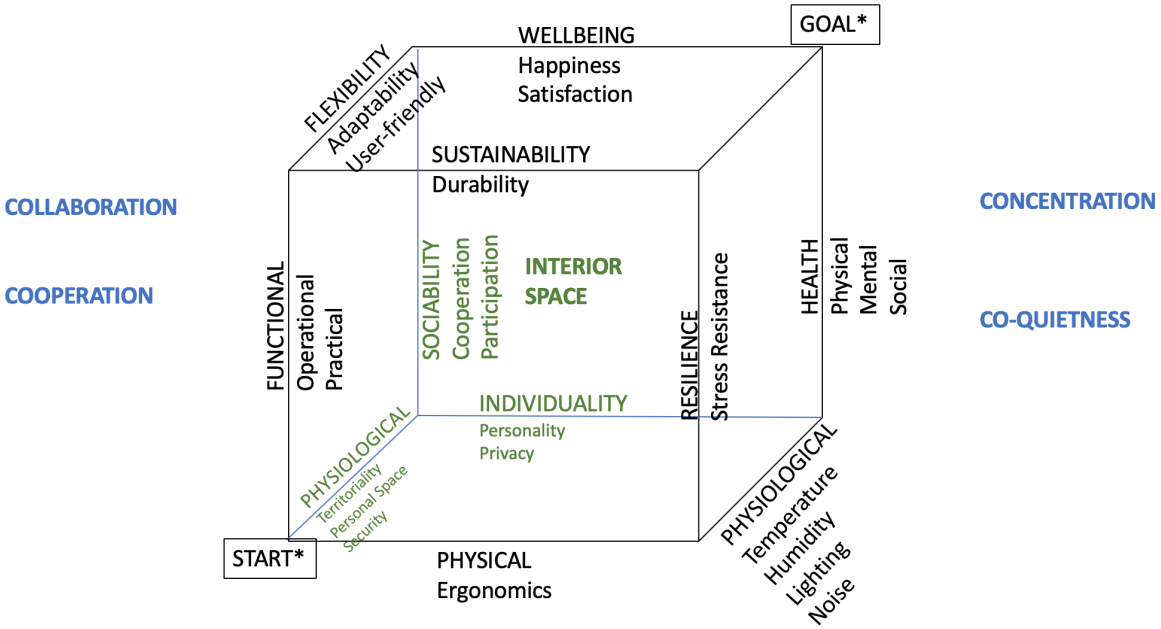

Figure 3. Merging the dimensions of campus learning landscapes (adapted from Vischer, 2008).

Some of the crystallised findings of this paper include the following themes that the authors are working on to be included in campus design briefs. The briefing should be performed applying e.g. use-walks with end users, highlighting aspects of the campus learning landscape that function well or that should be improved. The dimensions and tools (physical measurements, questionnaire and self-report data, interviews and observations, eye tracking, etc.) discussed in this paper provide possibilities for combining different kinds of data that can be used in smart campus development. These include the following:

- Spatial solutions on a campus should support and facilitate impromptu, unplanned social encounters between different stakeholder groups. Creating attractive, open and transparent spaces is a way of facilitating such encounters.

- Sense of privacy and sense of safety should be supported by visual cues, and there should be a continuum of different spatial solutions, intertwined in a seamless fashion.

- The digital basic needs (electricity and connectivity) should be secured and sufficient for the campus to be *reliable*.

Different methods bring different data to retrofitting processes. It remains the duty of management to make sure that the right information meets the right people involved in the process. The methods discussed in the present study merge physical, measurable attributes to user experiences, visual cues and eye tracking (focus of attention) and self-report. The dimensions, thus, are both visual-physical and mental. Co-design is a way to reach goals that satisfy different users and engages them in co-developing the facilities even in the future. Looking back at the DigiCampus project goals, when building a learning hub network, the foundations, for creative work and learning should be laid properly and stably. This can be achieved through the application and combination of various methods that merge physical measurements with user experiences, that all in turn inform facilities management and educational leadership.

Acknowledgements

This research was partly supported by the project DigiCampus, led by the University of Eastern Finland (subproject: Retrofitting Campus Learning Landscapes) funded by the Ministry of Education and Culture, and support was also received from the Faculty of Educational Sciences of the University of Helsinki, for the co-design participatory process.

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