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## Nordic campus retrofitting concepts - Scalable practices

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### Abstract

Multidisciplinary collaboration and transformations in learning processes can be supported by activity-based campus retrofitting. The aim of this paper is to analyse the ongoing campus retrofitting processes at the three university campuses and to identify the elements of activity-based retrofitting. We answer the questions “What kind of examples of retrofitting are there at Nordic Campuses?” and “What kind of elements are typical for activity-based retrofitting concepts?” The 3-level framework of campus retrofitting processes was employed when conducting the three case studies. The cases were about the new ways of researching, collaborating and learning with the concepts of Living lab, Creative community for innovation and entrepreneurship and Network of learning hubs. The cases provided the first insights on retrofitting based on users’ changing needs and the requirements of more sustainable solutions at campuses. Notably, a technical and spatial solution covers only part of retrofitting processes. The activity-based retrofitting consists on multidisciplinary collaboration and learning processes where diverse users have diverse roles during retrofitting processes. A process and a product are equally important for a viable retrofitting concept.

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### 1. Introduction

The demand for multidisciplinary collaboration and transformations in learning processes is increasing. This can be supported by campus retrofitting concepts and processes. It requires widening the perspective of retrofitting

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process from building based retrofitting to activity based retrofitting. It means the identification of activities in an retrofitting process and assigns the processes of designing, realization and using the retrofitting concepts. This paper focuses on identifying campus retrofitting practices, where the activities and diverse users in diverse roles are in focus. Additionally retrofitting is approached from the perspective of sustainability. Alexander (2008) points out that environmental focus and socio-economic development as the key dimensions of sustainability are important as well as the importance of community engagement and empowerment as critical factors in achieving regeneration outcomes. In this paper, the emphasis is on economic, ecological and social sustainability.

The approach is based on the existing body of knowledge (e.g. Universitets- og bygningsstyrelsen, 2009; Melbourne City Council, 2013; Byggningsstyrelsen, 2013) in campus development, especially in retrofitting processes and Scandinavian tradition to involve users in the processes. The strategic perspective to campus retrofitting processes includes identifying the drivers of campus development. The retrofitting projects can be a mean to realize visions of campus. The tactical perspective focuses on retrofitting activities with emphasis on activities, which involve users e.g. in co-creation processes. Co-creation allows and encourages a more active involvement from the users, who can have diverse roles and diverse expertise.

Operational perspective emphasizes a need to retrofit, manage and share resources in university campuses internally and externally in connection with other stakeholders. There are various roles and key players involved in real estate and property management activities, like property owner, manager, user, hired workhands and authorities (Haugen, 2008) Retrofitting concepts need to be assisted by universities, campus management and service providers (Eriksson et al., 2014).

The aim of this paper is to analyse the ongoing campus retrofitting processes at three different university campuses and to identify the elements of activity-based retrofitting. The theoretical framework of the three levels of campus retrofitting was employed in the three case studies. We pose two research questions, i.e., “What kind of examples of retrofitting are there at Nordic campuses?” and “What kind of elements are typical for activity-based retrofitting concepts?”

In the paper, the definitions, buildings and people-based activities in retrofitting are discussed. The three case studies are presented and the results of the cross-case analysis are summarised. The results are followed by the conclusions and the proposals for further studies.

## **2. Perspectives of retrofitting**

### *2.1. Definition of retrofitting*

There are a variety of terms used in the building sector connected to retrofitting. Traditionally retrofitting is the process of modifying something after it has been manufactured. For buildings, this means making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation. Typically this is done with the expectation of improving amenities for the building’s occupants and/or improving the performance of the building (Melbourne City Council, 2013; Byggningsstyrelsen, 2013). According to International Facilities Management Association retrofit in building is to add new materials or equipment not provided at the time of original construction (Aalto University, 2012). In general terms, retrofit means to modernize or expand using modified parts or equipment. Retrofitting processes can include replacement or upgrade of the infrastructure systems such as site lighting, chilled water and steam supply; IT service; central plant development; site utilities such as power supply, storm water disposal, potable water feed; and signage and graphics (Sahni, 2010).

In relation to current buildings, retrofitting takes the form, for example, of changing windows from single- or double-glazing to triple glazing. Other examples would be such things as changing the lighting fittings or changing the heating system, or the heating system controls. During a refurbishment a building is improved above and beyond its initial condition. Refurbishments are often focused on aesthetics and tenant amenities, but they can also include upgrades to the building’s mechanical systems and can potentially have an effect on energy and water efficiency. Renovations are very similar to refurbishments and the terms are sometimes used interchangeably. The major

difference is the term renovation applies specifically to buildings, while refurbishment does not (Melbourne City Council, 2013; Byggningsstyrelsen, 2013).

Brand (1995) has beside others introduced the life-cycle perspective to the traditional view of buildings. He has further developed the basic structure of three categories: space plan, services and structure into a model with six main elements, the “six S’s” approach. These elements describe the building in context of its surroundings and with focus on internal details in six different scales, scaling from a large external to a small inside perspective: Site (geographical setting, urban location, legally defined lot), Structure (building), Skin (exterior surfaces), Services (Electric, HVAC, elevators etc.), Space plan (interior layout), and Stuff (furniture and user equipment). Referring to varying life-cycles of these six elements he creates the term “shearing layers of change” and concludes that: “Because of the different rates of change of its components, a building is always tearing itself apart.” (Brand, 1995, p.13)

Retrofitting is many times seen as a renovation project. A whole-building renovation can be distinguished from smaller-scale energy conservation and maintenance projects by a replacement of the building HVAC system. The renovation may also involve replacing electrical distribution, lighting, fire protection, plumbing, and security systems. A renovation also offers the opportunity to consider architectural alterations to better align a building with its current function. This is the right time to consider improvements to the envelope such as window replacements and exterior wall insulation. Renovations are costly and disruptive, but they are the best way to adapt an aging structure to better meet occupant needs and significantly reduce energy use. ‘Building tune-up’ is a generic term that may encompass maintenance on the building’s existing systems, or aspects of retrofitting and retro commissioning as defined above (Melbourne City Council, 2013; Byggningsstyrelsen, 2013).

Retrofitting is in general discussed from the technical project perspective. However the building based retrofitting can be understood also in the context of changes in the performance of user. Retrofitting processes are the additions of new technologies, functions and services to existing built environment systems. In university campuses this means the development of embedded learning environments, new space typologies and a variety of platforms (digital, physical and social) supporting collaboration both within the university and in connection with diverse stakeholders. Nevertheless retrofitting is also about service concepts and new ways to produce services (Eriksson et al. 2013). Widening the perspective from building based retrofitting to activity based retrofitting requires new and systematic approach.

## *2.2. Building and people based activities in retrofitting*

The sustainability driver of retrofitting is in large role in recent research. The development of new technologies mean that building retrofits can allow for significant reductions in energy and water usage (Hushim, 2011). Retrofitting the existing buildings that comply with green building requirement, improves the environmental attributes of the buildings. There is a study that explores the potential to retrofit existing campus buildings that response to sustainable green building standard. The results show that all the twenty eight identified green elements recorded average index of higher than 3.5 which means that there is significant needs to retrofit the existing buildings to green buildings. This study concludes that it is urgently need for the campus to response to green building requirements in order to achieve higher energy efficiency and this can be done through effective retrofitting of existing buildings (Zakaria et al., 2012).

All Nordic university property management organizations emphasize, that their operations need to be sustainable from economic, environmental and social perspective (Nielsen et al., 2012). The very low usage rate, combined with specialized facilities and often buildings with cultural value calls for usability increase through actions with manageable environmental impact as well as economical sustainability. Retrofit concepts for unused spaces are needed due to the fact that the university resources are not in full use. Reviews of space utilization across different countries in higher education real estate indicate that utilization rates of teaching spaces were often between 15% and 20% during core learning hours. The rate of use of campus facilities is often very low - this creates wide sustainability potential and need for innovations and development – in terms of retrofitting and sustainability it is an important opportunity. At the same time there might exist an expressed need for more space and new buildings (e.g.

Nielsen et al., 2012). The achievement of energy efficiency in existing buildings can only be realistically achieved by retrofitting and therefore retrofitting is generally seen as an untapped resource (Murray, 2011).

City of Melbourne completed a comprehensive survey for building owners The Melbourne Retrofit Survey 2013 in order to quantify retrofit activity in Melbourne. According to this Australian study the drivers for retrofitting processes are the following: replacing a broken asset as the most common reason to retrofit (39%) followed by minimizing energy consumption (31%) and attracting tenants (21%) (Melbourne City Council, 2013).

Retrofitting is a method of achieving energy efficiency for buildings for the future. The initial capital cost investment, the associated payback and the scale of the retrofit all need to be considered when undertaking a retrofit project (Murray, 2011). Analysis of the energy and CO<sub>2</sub> emission payback periods of external overhang shading in a university campus in Hong Kong shows that due to requirements of structural strength under typhoon situation, although introducing overhang shading system could reduce almost half of the cooling load in the related area, the energy and CO<sub>2</sub> emission payback periods of the project are still unrealistically long. This case study presents an example of multi-disciplinary approach being not only important to the energy-efficient retrofitting but also necessary for policy making in different climatic and geographic regions (Huang & Chung, 2012). The study of Pitz (1996) states that life cycle cost analysis comparing replacement of individual building heating and cooling systems to a central heating and cooling plant was performed using present worth techniques. A new central plant incorporating thermal (ice) storage, high delta T distribution and variable speed pumping proved to be the most cost effective approach. Qualitative benefits including improved system reliability, improved campus aesthetics, reduction of noise levels in academic and residential areas, reduction of air emissions and the elimination of buried fuel oil storage tanks were realized. In real estate and facilities management theory three main drivers or initial starting points for project development have been described: location, project idea, and capital. The existing location as main driver requires to develop the project idea and to raise capital. Is existing capital the main driver this requires to develop the project idea and search an appropriate location. An existing project idea or concrete user demand as main driver requires to raise capital and search an appropriate location (Diederichs, 2006).

Even the sustainability drivers are often considered as ecological or economical issue, the perspective of the user is also taken into account. Murray (2011) highlights that there is a great need for guidance in this area. This need can also be seen to stem from the requirement to allow people to make a judgment on their own individual case, as each project's retrofit potential is different. Retro-commissioning is performing the same process on a building that has been operational and occupied for a period of time to ensure it keeps meeting the design intent and needs of the occupants. Retro-commissioning or re-commissioning a building once every three to five years is recommended by some experts (Anon, 2013).

The campus building stock has limitations with regards to decrease of energy consumption and therefore there is also a call for an increase of user-efficiency in order to achieve an increase of energy-efficiency. The actors in the field of construction and real estate need new ways of working together in order to achieve success and overall sustainability. The use of retrofitted informal learning spaces and the implementation of space management systems as a method will highlight the true cost of academic space to the occupiers of the space. The effective facilities management techniques are an important management tool in the increasingly dynamic and diverse higher education environment. In addition there is a need for new services both to increase the user-efficiency and to manage the retrofitting processes. According to Junghans (2012), it is important to develop a common understanding and the respect of all participants in the building's lifecycle, such as building owners, architects, and facilities managers.

Gordon (2001) has described that the growing concern of educational institutions to integrate environmental education into the traditional school curriculum. The concern has led to the development of "sustainable" school campuses that model ecologically responsible modes of living and relating to the natural environment. The sustainable campus operates by relating to the whole student; incorporating values in to the curriculum and conveying a sense of environmental responsibility through the inclusion of experience based outdoor learning activities that are centered on the school campus.

According to Green Building Council's Center for Green Schools in USA (AACC SEED & GBC, 2014), community colleges redesign and retrofit campuses in greener ways. Many forward-thinking institutions are using these projects as hands-on learning opportunities for students. These so-called living laboratories merge academics

and campus facilities management to provide students with real-world skills and, for the institution, a path to meet its sustainability goals. It will require careful planning and collaboration - especially between facilities staff and faculty - for more colleges to develop these living laboratories in a way that maximizes all students' learning experiences and yields benefits for the college's bottom line.

An existing campus needing to respond to change in enrolment or modification of curriculum should undertake at least four tactical steps that would meet immediate needs and dovetail into the strategic campus plan. These tactical steps include pursuing green development, maintenance, in-place material testing and facility decommissioning (Sahni, 2010).

The existing research indicates that the activities of retrofitting have ecological, economical and also social activities. However the social sustainability and retrofitting has diverse aspects that could be clarified and structured in more comprehensive way in order to transfer the building based retrofitting to activity based retrofitting practice.

### **3. Cross case analysis method and sample**

The three case studies from the Nordic campuses were selected to the sample of this study. In order to understand the activity based retrofitting in different cases, cross-case analysis was selected to the research method. This research method can mobilize knowledge from individual case studies. The data of the case studies was based on public documentation of the cases in this phase of the study. The analysis was made in the first phase by using theoretical framework of three levels of campus retrofitting. The levels were strategic, tactical and operational retrofitting processes. The strategic level analysis included the identification of the main drivers in the cases. The tactical analysis included the identification of the key elements of the processes of the cases. The operational analysis included the identification of diverse users and stakeholders. The criteria of case selection were: they are on-going and actual retrofitting projects in the campus, they are based on common strategic visions, and they have diverse retrofitting processes. Case 1 was about new ways of researching. The case is a single-family house at NTNU Gløshaugen campus in Norway with a gross volume of approximately 500 m<sup>3</sup> and a heated floor area of approximately 100 m<sup>2</sup>. The house consists of traditional residential spaces such as living room, kitchen and two bedrooms and it is used as a living lab (Finocchiaro et al., 2014). Case 2 is about new ways of collaborating. The case is DTU Skylab, which is a creative community for innovation and entrepreneurship at DTU Lyngby Campus in Denmark. It consists of nearly 1600 m<sup>2</sup> of workshops, laboratories, office facilities as well as spaces for learning, prototyping and social activities. It is located to the retrofitted building at campus. There is also extensive equipment including for example 3D printers and scanners, laser cutters, CNC milling machines and a robotic arm. Third case is about new ways of learning (Anon. 2015). Case 3 is a network of learning hub facilities at Aalto University campus in Finland. The network consists off a growing number of different sized independent and experimental spaces for learning interaction and co-creation. The spaces form a network through joint drivers and a common co-creation process (Gryada, 2012; Aalto University, 2012).

### **4. Results**

Based on the used framework the results are presented organized according to three levels of campus retrofitting processes. The strategic processes of the cases are based on drivers, motives and values. Each case was based on new kind of core activities within university: new ways of researching, collaborating and learning. The ecological drivers for activities were low energy demand, passive and active use of natural resources and independency from the energy grid and lowering the environmental impact of the second home sector. There were various activities connected to social sustainability drivers. In case one they were creating a mountain cabin, which strengthens the feelings of distance from modern society and symbiosis with nature as well a increasing livability through high indoor comfort conditions (Finocchiaro et al., 2014). In Case 2, the emphasis was in supporting innovation and entrepreneurship by encouraging its users to think ambitiously, globally and fearlessly, by enabling interdisciplinary work and by enhancing cooperation between students, the business world and other external partners (DTU, 2015). In the third case the activities aimed to support innovation and co-creation by developing an ever evolving

educational interface between research, art and education as well as between researchers, students, companies, social influencers and the general public. Additionally offering facilities and expertise for professional education and lifelong learning is achievable (Gryada, 2012; Aalto University, 2012).

The identified processes in the tactical level had a character of testing and improvement – in more general terms learning from the use-experience both in design and use phase. Additionally the principles of co-creation were risen up in cases. In case one a twelvemonth integrated design process students and researchers conceived and developed a prototype of an energy positive house. The original concept has been since then developed, with the name of Living Lab, in cooperation with industrial partners inside the Research Centre on Zero Emission Buildings (ZEB). The design includes a wide range of components that can be adjusted according to users' needs and desires, functional program distribution and climatic context (envelope, furnishing, and technical system). Additionally users interact with buildings characterized by high indoor comfort conditions and low energy demand. The monitoring system of the use of the building has been designed in order to be flexible, expandable and easily reconfigurable. In addition sensors have been integrated in the building as it would be in a real house and chosen among those that can be installed in a real-world application - i.e. on-purpose-made sensors have been avoided as much as possible (Finocchiaroa et al., 2014).

In the second case a prototype has been developed continuously since 2012. The functions have been situated in different building on campus for periods of for example six months or a year. During the testing phase the DTU Skylab was evaluated by collecting tangible success stories where students progressed from idea to product and company, succeeded in attracting external funding, or generated results through working with existing enterprises. During its first year, DTU Skylab hosted around 50 open events on various aspects of innovation and entrepreneurship. In 2013, five out of ten registered start-ups from DTU had links to DTU Skylab. The DTU Skylab proved to promote innovation with a societal input and DTU has now invested DKK 25 million into creating a permanent home for the concept and reserved an annual materials budget amounts to DKK 300,000–500,000 (DTU, 2015).

The tactical level activities in the third case were collaborative involving different stakeholders. Stakeholders were encouraged to take care of and improve the space during the use. The development was made by continuous observing, learning and improving. The focus has been on rapid reaction to changing needs from different parts of the university organization, industry partners and professionals. The processes were case-specific, however following the created process concept including e.g. finding an underutilized existing space, recruiting a student team, involving local actors in planning, designing, communicating the process, involving local actors in constructing, celebrating the opening. Additionally the learning hub process aimed to take a systemic approach to grassroots activity connecting good initiatives with recourses to create tailor-made learning and working environments. The duration of the initial processes has varied from three to six months with budgets from 3.000 to 40.000 euros (Gryada, 2012; Aalto University, 2012).

The analysis of third level in retrofitting processes identified the variety of different users, who have been involved to the retrofitting activities. In the first case the multidisciplinary effort to develop the Living lab involved students, researchers and industry partners. The living lab concept is suitable for different user groups such as families with children, young couples, old couples and students (Finocchiaroa et al., 2014). The second case included openness both regarding use and users as well as on facilitation of the use. The facilities are divided in three categories with different opening hours, from regular office hours to actual 24/7. The facilities are open for relevant courses at DTU, for interdisciplinary partnerships with other universities and for projects open to everyone, as long as there is a DTU student on the team. In addition students have access to business coaching, technical spit-balling and assistance with developing their ideas in prototype workshops, with free materials and help from the workshop staff. In addition companies and other organizations are supported in making contact with students (DTU, 2015). The Learning hubs serve as meeting points, venues for varying events, working spaces and cozy living rooms where people from different backgrounds and varying disciplines come together to communicate, collaborate and discover. Interaction between strangers is encouraged (Gryada, 2012; Aalto University, 2012). The results are summarised to Table 1.



Based on findings one can claim that the activity based retrofitting is have the following characteristics. The driver is in new ways of doing core functions, in the case of campus new ways of researching, collaborating and learning. The sustainability is based on both the spatial solution and the process of realizing the concept. The importance of multidisciplinary, cross-organizational and learning processes is evident. This includes co-design, co-use and continuous testing and improvement. Thirdly the activity based retrofitting includes variety of user groups both in design and use phase. The users are from university but also from industry and they have different roles in designing, realizing and using the retrofitting concepts.

The analysis reveals remarkable similarities reflecting the key dimension of the cases however the dimensions might occur on different retrofitting levels. For example, collaboration between diverse disciplines occurs on all three retrofitting levels. This is a topic for future studies in order to identify the ways to scale the retrofitting practices.

Table 1. Cross-case analysis.

Campus retrofitting process level	Case analysis factors	Case 1	Case 2	Case 3
Strategic	Key drivers	Living lab for new ways of research Ecological values: Energy positive Close to nature Indoor comfort	Creative community for innovation and entrepreneurship – new ways of collaborating Interdisciplinary Cross-organizational	Network of learning hub facilities for interaction and new ways of learning.
Tactical	Characteristics of activities	Co-creation of living lab with multidisciplinary team: Academy, Industry and ZEB Centre	Developing prototypes, testing, measuring and establishing the concept	Co-creation process Bottom-up approach and case specific experimental space
Operational	Users	Different residents User-building interface providing possibilities for testing and measuring Evolving monitoring	Open to all users Facilitation and service provision for comfort use of space and efficient long opening hours	Ownership of empowered users of co-creation process. Ongoing improvement by follow up studies

## 5. Conclusion

The intention of this paper was to find out what kind of examples of retrofitting there are at Nordic campuses as well as what kind of elements are typical for activity-based retrofitting concepts. The analysed cases provided the first insights on retrofitting based on users' changing needs and the requirements of more sustainable solutions at campuses. The important issue is that retrofitting as technical and spatial solutions covers only part of the process. The activity-based retrofitting consists on multidisciplinary collaboration and learning processes where the diverse users have diverse roles during the retrofitting process. One can claim that a process and a product are equally important for a viable retrofitting concept. It is important to identify how to achieve functional and iterative retrofitting practices with defined activities.

The data used in this phase of the study is very general by its nature. This is the weakness of the research design. However it provides the first insight how to structure and understand the characteristics of activity based retrofitting. The operationalization of these characteristics as well as using both qualitative and quantitative methods to capture

empirical evidence for activity based retrofitting are important to investigate in the further studies. The cross case analysis provided potential results to be investigated in a more detailed way. This allows research to develop metrics for collecting evidence of value creation.

Additionally the scalable activity based retrofitting practices are not campus context dependent. It might be possible to apply the retrofitting practices in more typical urban development. However, one need to be careful in identification of user groups and their demands in urban context. It can be proposed that also this topic is a potential path for future research. Within the analysed case studies one can already get idea that the practices do not relate solely to the individual university's activities: the university opens up towards the surrounding world – also physically – and thus actively affects the area and the surroundings as well as the area and the surroundings affect the university. This brings the campus closer in characteristics to the general urban area. The drivers of change and retrofitting are partly equal, partly diverse. The activity based retrofitting concepts, as non-campus case studies would be valuable in the future.

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