

Testing and evaluating sustainable design practices

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ABSTRACT: This paper presents an in-progress design research conducted by teachers and students of Chalmers University of Technology (Sweden) and the University of Houston (USA), in the form of a Habitation Laboratory (HabLab) (Nystrom, et al. 2000) design studio and in connection with a Sustainable Living Lab project.

The 'HSB Sustainable Living Lab', is a collaborative effort between the largest Swedish co-operative housing association, HSB, and Johanneberg Science Park, and will be built in 2014 as a student housing, located on Chalmers main campus¹. Its location offers a unique opportunity to merge research, education and outreach.

A 400 m² three-story building will accommodate 25-30 students and guest researchers. Student units are designed to be flexible and adaptable to possible layout adjustments and changes throughout a ten-year building permit timeframe. The structure will also include additional facilities such as an exhibition area, a common laundry room and various meeting zones.

The paper identifies and investigates experiments in sustainable design education through the use of a design studio as the first stage within the larger "Sustainable Living Lab" research and building environment project. The goal of the educational initiative is implementing practice and construction experience into the learning process by combining hands-on approaches with theoretical development in trans-disciplinary real-life contexts, where design serves as a link between practices and disciplines. This is argued to be essential in the shaping of future responsible architectural practices.

Possible applications of lessons learned for the design of future environments is a key inquiry. The project objectives are: developing participatory and user-centered design research methodologies and measures, as well as studying how sustainable innovations are applied and perceived in the living environments of everyday life.

KEYWORDS: Trans-disciplinary research, sustainability, design, practice

INTRODUCTION

This paper discusses approaches to test and evaluate responsible architectural and living practices related to a HabLab studio, with both educational and practical potential. The discussion is built upon examining an on-going study within an inter- and trans-disciplinary research development with the involvement of engineering, architectural and design researchers. The project is at its initial stage when potential structure, timeframe and level of multi-disciplinarity are still under investigation. Exploration of project potential at this early stage of the development is argued to be important to better define the project's goals and objectives, as well as the means of how they can be achieved.

The goal of the HabLab initiative is to explore new building and construction ideas and concepts, new materials implementation, design solutions testing, developing new technologies and adapting products and systems innovations to a local context culturally, economically and socially (Nystrom, et al. 2000). An educational aspect of the project, in the form of a design studio, is concentrated on developing and supporting sustainable living practices. An architectural input is focused on the definition of a sustainable living environment

and design practice, exploring students' interactions in the design process, construction and use of housing units while efficiently optimizing consumption of energy and other resources.

Important design considerations of the project include:

- Implementing research and empirical experience into design practice;
- Optimizing research, design and testing processes;
- Investigating industry needs and demands;
- Outlining possible project involvement benefits for investors, industry and academia.

Educational engagement of the project will include *Building Functions Analysis* studies in a full-scale laboratory in the form of on-campus student housing. The emphasis will be given to the role of designers and design education in facilitating academic methodologies, offering benefits of hands-on learning and real-time experimenting to students. The discussed research and educational approach mainly concerns full-scale research house studies (sustainable living environments) with an integrated instant design reviewing process. Uninterrupted feed-back by users is essential for optimizing design considerations and for advancing research in the test environment.

The paper also briefly discusses a critical interpretation of social, economic and environmental sustainability of contemporary design processes, moving towards a changing professional role and discourse within and between disciplines. It is recognized that the introduction of collaborative processes that promotes critical reflection is vital to applying sustainable practices to everyday life. There is however, a lack of effective communication between "users" (or clients) and "professionals" (Architects). Shaping those links by providing research in design and learning through building opportunities, along with creating new advanced outreach prospects for architects, are key steps towards new sustainable architectural practices. Applications analysis should be examined not only as final results but with an emphasis on human factors, systems and elements' relationships and inter-dependability in the context of the whole process. Based on the knowledge gained, a design and planning process is proposed to optimize sustainability approaches being put into practice.

1.0 CONCEPTS AND HYPOTHESES

Social, cultural, and even political aspects have to be addressed in the overall planning and throughout a design process. These present a high degree of design functionality, with a tendency to demand an adaptation from inhabitants to the technology. These aspects of human being correspond to multiple facets of sustainability and of course to sustainable design and planning in architectural practice. Sustainability as a definition was first mentioned in the very well-known Brundtland commission report in 1987:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains two key concepts:

- the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
 - the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.
- (Brundtland 1987)

The adoption of sustainable practices and strategies remains a main challenge, with slow structural changes in mainstream society, including the building industry, as well as several psychological barriers (Gifford 2011). Imposing a sustainably adapted environment on inhabitants without connecting it to their social and psychological background may create resistive behavioural patterns. People tend to refuse to accept new environmental conditions if they are not properly informed before those conditions are introduced to them and become part of their life (Steg, van den Berg and de Groot 2012).

The three major theories for enabling sustainable practices into the built environment are to be tested and evaluated throughout the execution of the project include:

- Improving design practices: experiencing all stages of designing, building and living would help future designers and architects to implement sustainable practices more successfully;
- Shaping sustainable lifestyles: the built environment may influence personal and group lifestyle towards sustainable living;
- Applying advanced technologies: application of advanced technologies into design solutions facilitates awareness of essential and unnecessary living demands and helps to shape sustainable strategies.

1.1. Improving design practices

There are two common values for architecture as a discipline: the use of the system of elements of the project, and design itself (Benjamin 2001). The first value implies a purpose of offering the user/client profits from the practical advantage and planned effect of the system. The second value is to deliver design with the deliberate effect and results that it provides the user/client with anticipated practical advantages. This may include: functionality of systems and interior arrangements, cost effectiveness and aesthetics. The final product – design of a home or other types of residential facilities cannot be considered as a successful experience unless the design also satisfies client's needs or expectations.

Architecture is interdisciplinary by its nature and the architects' main role is to make sure all elements of the project receive the appropriate amount of attention and apply that knowledge to the design. The architect can be considered as an "attending physician, who, though using the expertise of the physiologist, radiotherapist, or bacteriologist, is the only person who can actually undertake the treatment of a case" (Fathy 1986). This means that an architect should be able to summarize knowledge, experience, and expertise and apply it to the design process.

This participatory architectural and design process is to be implemented into the studio course, where students will experience all of its instances: as a client, an architect and a user (Fig. 1). A regular feedback during the design, build and living in the designed units is an important element of the process when students evaluate their decisions and see if those decisions offer benefits (or not) for their everyday life.

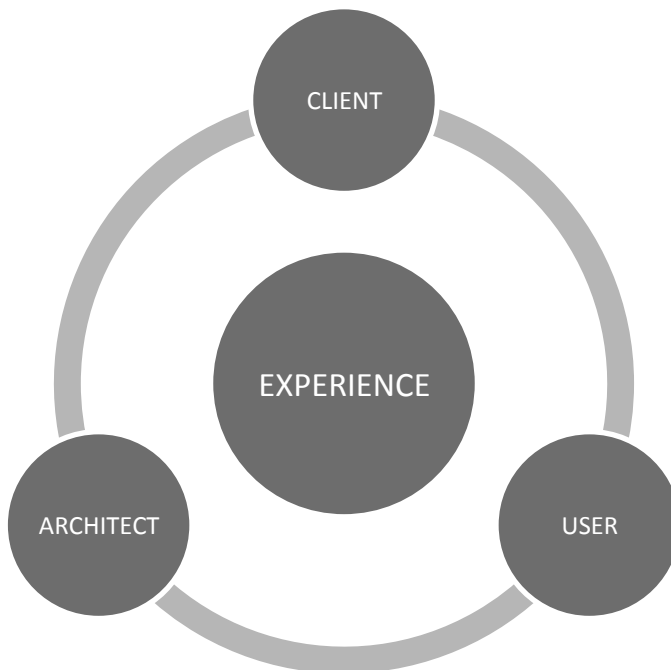


Figure 1: Collaborative efforts provide inclusive experience.

1.2. Shaping sustainable lifestyle

One of the major goals of connecting educational and built environments is to produce knowledge to advance and shape new sustainable lifestyles. Several strategies can be used in order to achieve that: information distribution, goal orienting, individual or group commitment obtaining, feedback on individual or group performance. But some psychological theories emphasize that informative techniques are not very effective if used alone (Staats, Wit and Midden 1996). Therefore a combination of strategies tend to be more effective in promoting sustainable behavior.

Discussions with students during preliminary workshop sessions that are described in this paper in the “Methods and approaches” section, confirmed that a “*combination of strategies*” theory exists, and revealed the importance of personal awareness of individual and group sustainable actions. Students also emphasized that proactive, and even demanding behavior, should play a positive role in pushing individuals to join a sustainable lifestyle that was promoted by their roommates.

An Important part in the process of shaping a sustainable lifestyle is creating a collaborative strategy towards optimized resources utilization. Implementing advanced technology in design affords a means for informing and coordinating residents’ responsible efforts, helping people to make conservative choices to become a part of their everyday routine (Fig. 2). Figure 2 depicts the basic level of essential relationships between an individual and a group, some of them may be present periodically while others belong to common attributes of human behavior.

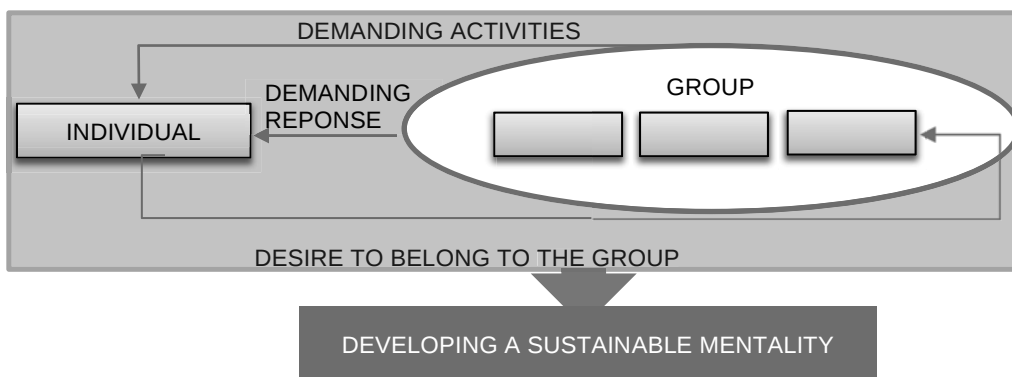


Figure 2: Individual and group relationships shaping sustainable behaviour.

It is important to consider a possible influence of human error or undesirable behavior, therefore relaying information about successful sustainable practices back to residents is also fundamental.

1.3. Applying advanced technologies

The idea of the Living Lab research project is to create an adaptable design of student housing units for testing new science and technology. The structure has to be flexible and intelligent enough to be able to accommodate various technological innovations in the building envelope and engineering systems and to implement sustainable principles into the project. An important part of the project process is analyzing and revising design solutions throughout the testing and building stages. Students’ involvement will include input on their everyday activities and usage of available spaces and resources; and testing living qualities of facilities after they are built. This approach presents hands-on learning opportunity for students and teachers, encouraging them to work together as a team to achieve the most optimized design and technological solutions.

The transdisciplinary nature of the project affords productive cooperation and almost instant application and testing of new materials, techniques and technologies both from industries and in cooperation with research teams within Chalmers University. The design will incorporate adjustability and will also provide opportunities for testing of experimental structural elements and technological innovations. A combination of these measures aims to provide a versatile platform for hands-on research and real-time applications of sustainable practices and technologies as well as evaluation of their performance throughout the lifespan of the structure (Fig.3).

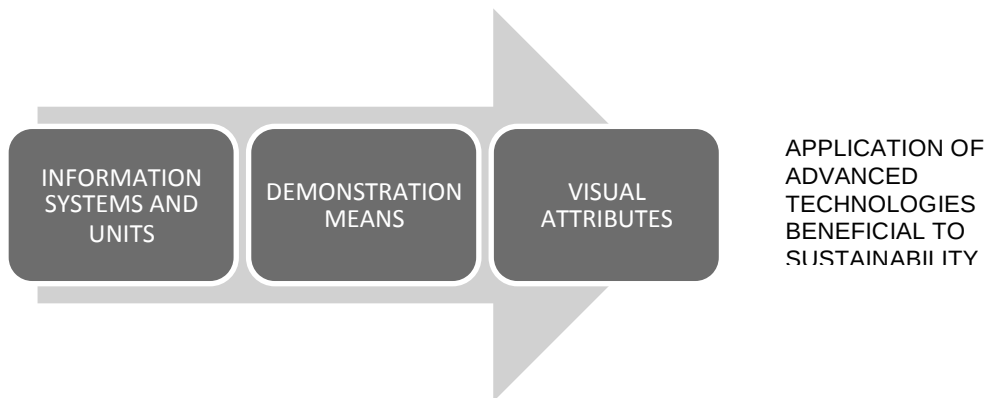


Figure 3: Application of advanced technologies that are beneficial to sustainable development.

2.0. METHODS AND APPROACHES

In his "Designerly ways of knowing" Nigel Cross compares scientific, humanistic and designer problem solving approaches (Cross 1982). It can be helpful for identifying areas of cross-disciplinary between architecture, engineering, social and psychological studies. In discussion of Lawson's studies of design behavior Cross concludes that: "These experiments suggest that scientists problem-solve by analysis, whereas designers problem-solve by synthesis."

An ultimate goal of any design process depends on the successful definition of a design research problem, which always lays in finding a proper "translation from individual, organizational and social needs to physical artefacts" (Hillier and Leaman 1976). An applied testing and evaluating research approach is based on the collection of data from students' surveys, professionals' interviews, workshops and the construction and testing of design settings. The initial process is split into two stages: collecting data to make design assumptions; and testing and evaluating their implementation into design. Evolutionally, that will develop into proposing collective ways of implementing new design and living approaches into practice.

2.1. Data collection

In preparation for the studies, empirical data on students' daily living activities has been collected and analysed through a series of workshops and surveys in the form of activity diaries at the Architectural department of Chalmers University of Technology and the College of Architecture of the University of Houston (overall n=19). Preliminary data from student diaries at both universities were collected in December 2012 followed by workshops organized at Chalmers University in December 2012 and May 2013. Collected qualitative data on students' needs, activities and energy and resources requirements have been cross-analysed in regards to both current functional understanding and in a modified and/or extreme situation. A discussion of human factor conditions (physical, organizational or behavioural prerequisites) forms the starting point for student projects exploring alternative configurations for amelioration and optimization of living functions from a residential quality perspective as well as the radical reduction of energy- and resource consumption (Table 1). Table 1 represents classification of functions and activities based on personal preferences in sharing spaces and things while performing them. The particular inquiry of shared or private use is deemed relevant in the

context of energy and material resources, where a more sustainable living approach is to go towards smart collaborative uses of space and various home goods. It is recognized that personal perceptions related to this depends on geographical locations, cultural and religious beliefs, age and social status; and those conditions may alter the results.

The participating students demonstrated differential understanding and presumptions of collective and private values. For example, even though students belonged to the same age group and had relatively similar disciplinary background, their demand for privacy diverged, most likely based on cultural and social specifics and housing situation. This was further underpinned at two workshops held with respondents at Chalmers only.

Collected data are not quantitative but rather based on students’ qualitative impressions and recognition. It resulted in the functional breakdown of student housing according to: 1) Grouping of activities and human functions; 2) Levels of private or shared use of space and resources 3) Defined or perceived corresponding spatial, energy and resource requirements.

Table 1: Basic functions and activities related to acceptance of sharing.

Activity \ Sharing	Sleeping	Eating	Housekeeping/ cooking	Studying	Hygiene	Recreation
Collective (sharing activity and resources)	No	Yes	Yes	Yes	Not likely	Yes
Individual/ sharing resources	Maybe	Maybe	Maybe	Yes	Not likely	Maybe
Private/ not sharing at all	Yes	Not likely	Maybe	Not likely	Yes	Not likely

2.2. Design assumptions

Students’ surveys of daily activities and usage of spaces and places are used to make initial design assumptions that lead to developing a facility program. This stage also incorporates a participatory approach with inputs from clients, designers and future residents.

This stage of the project includes identification and classification of elements of the structure by their flexibility characteristics (if they can be replaced or modified with new features for testing alternative design solutions during the course of the project development) (Table 2):

- Elements of building envelope that are subject to modifications;
- Transformable elements of interior architecture;
- Upgradable equipment and engineering devices;
- Elements of building envelope that are stationery;
- Interior components that are fixed in place;
- Equipment and engineering elements that is not upgradable and cannot be replaced.

Table 2: Classification of building elements.

Elements \ Characteristics	Building Envelope	Interior Architecture	Equipment/ Engineering
Fixed	Foundation, roofing (support structure), insulation, external walls.	Some kitchen and bathroom utilities and fixtures, fire place, stairs	Plumbing, air ducts, mechanical equipment, power sources

<i>Adjustable/ Replaceable</i>	<i>Doors, windows, glazing</i>	<i>Internal walls, flooring & ceiling finishing, sound insulation, lighting</i>	<i>Electrical, lighting, communication & control systems</i>
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These assumptions lead to suggestive design where technological improvements may be tested and define up to what extend they can be implemented into living environments.

2.3. Study design

A proposed design studio will be project-oriented and scheduled accordingly. The table 3 below summarizes some of the issues that have to be resolved before the semester starts, for example, a criteria for students selection process has to be established. It will be necessary though that a mixed group of students involved in design process will be residents of the unit. Students will have to conduct research of design solutions for sustainable housing, implement them in their studio project – a unit within the larger Living Lab– test them and propose and apply design adjustments during the course of living in the unit. It is suggested that each studio project will be a -semester-by-semester endeavour and each consecutive year a new group of students will evaluate previous design and repeat the process.

Expected learning outcome after completion of the studio would include:

- Knowledge gained
 - o understanding of essential human needs in context of enhancing sustainable practices
 - o better understanding of relationships between social, cultural, other personal background and physical environment.
 - o collecting knowledge about sustainable technological innovations and their integration into housing design.
 - o learning about technology transfer from non-housing related disciplines and how they can be implemented into design practices.
- Adopted skills
 - o ability to define potential problems of technological integration
 - o ability to explain their design solutions between disciplines and efficiently perform teamwork with them.
 - o be able to handle, classify and document large amounts of information
 - o demonstrate ability to transform information and data into knowledge
 - o work with the whole design process from problem definition, analysis and synthesis including design solution/proposals.
 - o be able to visualize and communicate ideas and solutions.
 - o understand systems analysis as a design tool.

CONCLUSION

Anticipated outcomes of the proposed research as part of the design studio and in connection with the Living Lab project are expected to be beneficial for students, researchers and industry. An emphasis is given to sustainable practices to stimulate responsible lifestyles among inhabitants and therefore shape future living environments. The radical reduction of residential energy and resource consumption may be achieved by a combination of strategies including relaying information to residents about the benefits of sustainable strategies and processes in context of spatial and material conditions. Cognitive and social strategies among residents as well as designers in creating or upholding sustainable living environments should be further explored. An iterative *Research By Design* and *Design With Users* processes can be developed and further studied by creation of a studio within the overall Living Lab housing structure where students are designers, builders, as well as residents.

Experiencing from the 'inside' and mapping such experiences based on spatial, social, economic and time requirements is essential for creating consistent sustainable practices (Yaneva 2011). A participatory design process can provide a foundation for responsible living and the recognition that sustainable practices are economic and environmental benefits.

The table below illustrates categorizing and summarizing the method applied to analyzing some of the issues that were discussed during students' workshops and that have to be included into the Living Lab project process. The method is based on a user-centred approach, mapping individual and joint activities and home functions (Table 3). Some of the issues will have to be addressed and solved before the programming stage of the project. For example, financial, legal and other official permissions and agreements should be obtained prior to students' signing-in process and before the beginning of the semester when this studio project will be conducted.

Table 3: Classification of design tasks.

Issues		Issues	
Student involvement	Who do we want to attract?	Structure/building	Envelop elements testing: what, how, when
	Only students or are friends also allowed?		Including spaces for lounging for the whole building
	Criteria for grouping people who will be living there		Measure impact changing envelope elements on heating/cooling
	Co-gender groups or mixed		How much change/not change in surroundings
	Mixed ages or different year students allowed?		What's changing with the environment? (e.g. Fire codes)
Organizational	Type of rental contract (timing, aligning with students' needs)	Layout	Living room wasted space? If the kitchen shared – is there need for a living room?
	Maintenance: who does what?		Kitchen is the "core" of home?
	Insurance		Neutral spaces are needed for meetings
	Rules and regulations		Multifunctional spaces: cooking/eating, library, something else?
	Security		Changeable interior walls and interior blocks
Social	Living with friends: groups up to 24 / strangers: no more than 4	Lifestyle	What to share and how?
	Accessible place to socialize		Recycling or sharing
	Creating positive and sustainable dominant living practices		Challenge laziness

Future development of the project proposes expansion of research in different contexts possibly outside of Sweden and involving faculty and students from the University of Houston (Houston, Texas) and Universities of Bondo and Maseno (Kenya) where next stages of project development may be performed and tested by local students. This international context would bring more levels of understanding of human behavior in relation to built environment and

involvement of international architectural students and researches would facilitate improvement of design practices. It will give students an opportunity to:

- Synthesize professional experience from different settings;
- Learn and integrate innovative solutions into diverse design projects;
- Test proposed sustainable design approaches in different cultural, social and climate conditions;
- Optimize sustainable design practices for better and faster applications in various environments.

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¹ <http://suslab.eu/partners/chalmers-th/hsb-living-lab/>