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25 YEARS OF SHAPING FUTURE ARCHITECTS AND ARCHITECTURE- THE EVOLUTION OF A SUSTAINABLE BUILDING CURRICULUM

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Fig 1: Students on the Masters level design and construct an apartment for students for the international student competition "Solar Decathlon 2013", held in Datong China, 3rd place. www.halosweden.com

WHICH ARE YOUR ARCHITECTURAL (R)SOLUTIONS TO THE SOCIAL, ENVIRONMENTAL AND ECONOMIC CHALLENGES OF TODAY?

Research summary

In order to approach an architecture beyond green, the architect's role and knowledge base has been challenged during the last decades. How far have we come with the education of future generations of architects? The aim is to discuss the shifting paradigm for architectural education towards an integration of sustainability aspects. By looking back 25 years, we examine the development of the sustainable building curriculum at the Department of Architecture, Chalmers, Sweden. The story is told by staff, i.e. teachers and researchers involved to a varying degree in the development of the curriculum. Document studies and information searches has been carried out together with a focus group meeting. Based on four courses the discussion revolves around the extent of the curriculum, learning progressions, and collaboration with other disciplines and outside academia. The sustainable curriculum on the Masters' level is highly attractive for international students. Participation in the international student competition Solar Decathlon shaped a new generation of attractive architects. In order to keep up with knowledge development, integration of different disciplines and stakeholder groups from the construction sector is necessary as well as further education of the teachers. Improved cooperation with other universities, nationally and internationally, could support a better integration of the sustainability curriculum. Finally, evolution is a long-term process, it takes time to shape architects and our future built environment in a sustainable way. Important factors for success are integration, collaboration, continuity, progression, and enthusiasm!

Keywords: architectural education, sustainable curriculum, longitudinal study

1. Introduction

In order to approach an architecture beyond green, the architect's role and knowledge base has been challenged during the last decades. On the one hand a successful change of architectural practices and paradigms is a necessity for architects to claim a prominent role in development of more sustainable built environments without being out-ruled by engineers with expertise in energy and environmental aspects. On the other hand it can be argued that an architectural and holistic view based on system perspectives are necessary to promote resilient built environments in harmony with the ecosystems. Environmental work is becoming institutionalized as a strategic part in the building sectors' companies business (Gluch et al., 2013), and sustainability is becoming mainstream concern in design thinking and practice (Khan et al., 2013). However, research has pointed at a need for a shifting paradigm (du Plessis, 2011) and further exploration of the active role of educational institutions (Gluch et al., 2013). How far have we come within the field of architectural education?

In 2006-2009, at the Swedish Chalmers University of Technology (Chalmers), a reform project called education for sustainable development (ESD) was pursued. One task was to integrate ESD into all educational programmes, i.e. engineering and architecture (Svanström et al., 2012). Important conclusions were that embedding of ESD relies on the persons and the structures that exist more permanently in the organization. Efforts should also be directed towards starting learning processes and building competences affecting as many people in the educational organization as possible, in as many groups and at as many levels as possible. Furthermore, quality

improvement structures relating to e.g. course evaluation, programme development and competence building, should be improved in order to safeguard ESD in the best possible way (Svanström et al., 2012). The question is now, where are we today? What are the success factor and the barriers over time?

2. Research objectives and scope

The aim of the paper is to discuss the shifting paradigm for architectural education towards an integration of sustainability aspects. By looking back over a 25 years period, we examine the development of the sustainable building curriculum at the Department of Architecture, Chalmers. The University, situated in the city of Gothenburg, is the second largest and one of five institutions that educates architects in Sweden (~ 250 students on bachelor level and ~230 on master level).

3. Method

Based on a timeline, the development of the sustainable building curriculum is investigated on both the Bachelor's and Masters' level, in relation to research activities at the Department of Architecture, at the University as a whole, and regarding important local and global events affecting the sustainability agenda. The story is told by staff, i.e. teachers and researchers responsible and involved to a varying degree in the development of the curriculum. We have carried out document studies (course PMs, assignments, presentation material), information searches in the student portal, and a focus group meeting (3 hours) with involved teachers. The study focuses on courses held for more than 10 years.

4. Architectural education and stakes

The architectural education, consisting of a 3 year bachelors' level and 2 years masters' level, has to manage many different interests, (Fig 2), where the implementation of a sustainability curriculum is one of them. On the master level, Architecture offers two programmes, one dedicated to sustainable

building and planning, the Master Programme Design for Sustainable Development (MPDSD), and one focusing on architecture, the Master programme for Architectural Design (MPARC). The number of enrolled students at MPDSD during the period 2007 to 2014 varies from 27 to 54. In this paper we focus on describing sustainability courses at the bachelors' level and the "building track" at MPDSD.

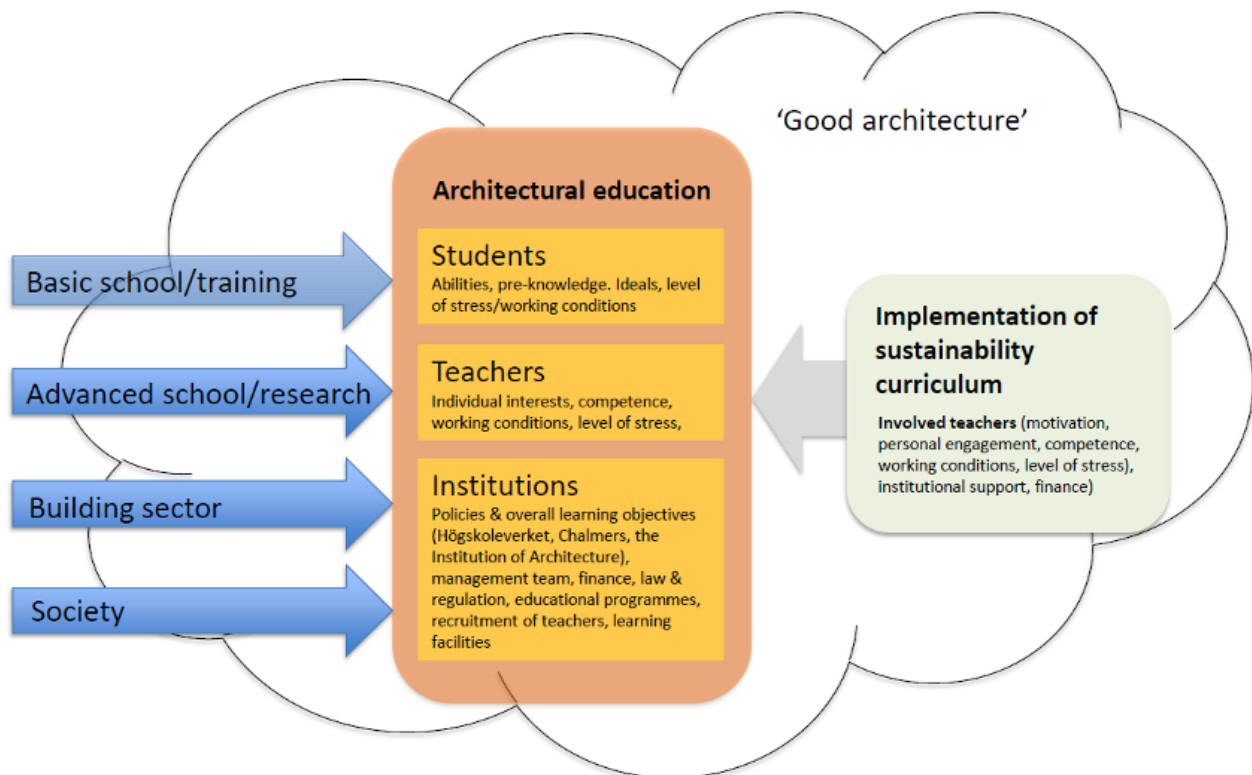


Fig 2: Architectural education, aiming to contribute to good architecture, has to manage different interests.

5. Mapping the curriculum

In the late 1980s, an immaterial school of Environmental Sciences was established by two universities in the city of Gothenburg. At the same time the Royal Swedish Academy of Engineering Sciences formulated a policy that all technical universities should integrate environmental issues in their education. As a quick response, the Department of architecture established two courses:

Architecture and environment and *Transport and Environment* for 4th year students (Edén, 2011). These courses were given between 1988 and 1997 as either compulsory or voluntary course. Two publications are indirect outcomes of these courses literature (Drakenberg et al., 1992, Ejvegård et al., 1991). Today, the examination regulations at Chalmers stipulate that a student must have passed at least 7.5 credits in Environment and Sustainable Development in order to receive a degree in

Architecture or Civil engineering (Edén, 2011). Thus, the Department of Architecture provides two compulsory courses addressing sustainable development of the built environment. One at the bachelors' and one on the masters' level.

5.1 Bachelors' level

The course *Architecture, environment and sustainable development*, has the longest tradition, i.e. held since 1997, about 18 years, for first year students (60-90 students). The course gives an introduction to the basic concepts and is intended to prepare for future design task in architectural education. The extent of the course has increased over time, from 3 to 7.5 ects (tab 1, fig 3-4), with three

different examiners. However, the two examiners that were responsible for the course after 2010, have been involved in the previous course as teachers. Up to 2010 the results of the course, a collection of reports, were compiled in binder (so-called "Environmental binder", and made available via the architectural library).

Sustainable building aspects are also integrated in the compulsory essay writing course "Theory and text" for third year students as one of the offered topics to write about (15 students). During the recent years we can see a growing interest by the students to reflect upon this topic.

Acad. year	Extent	Aim	Organization	Ex
<i>Architecture, environment and sustainable development (2011-2014, 4 years)</i>				
2014/2015 to 2012/2013	7.5 ects	<ul style="list-style-type: none"> To introduce sustainable building based on a holistic/lifecycle thinking taking into account social, economic and environmental aspects in relation to architects work and processes. To rise interests and provide basic knowledge of sustainable design and accessible tools for planning and design To be able to describe a buildings' environmental impact. To introduce an academic approach for knowledge production and gain basic knowledge about library resources 	Lectures, study visits of built examples and architect offices, interviews of architects, seminars, literature studies, design workshops, writing a group report (compilation of information and reflection), writing a personal sustainability programme to be used in coming studio work Introduction to library and information searches.	E3
2011/2012				E2
<i>Sustainability, building and planning (1997-2010, 14 years)</i>				
2010/2011 to 2000/ 2001	4.5 ects	<ul style="list-style-type: none"> - To prepare students to be able to integrate necessary aspect of sustainable development into coming projects and professional carrier. - To give an overview of the relationship between architecture and environmental effects in the context of basic concepts and policies regarding sustainable development. - To present the frontline of sustainable building and basic concepts of environmental science. - To train students to work independently and research oriented. 	Lectures, seminars, literature searches, writing a group report. Study visits (Eco-centrum, since 2002 built examples). Introduction to library and information searches.	E1
1999/2000 to 1997/1998	3 ects			E1

Tab 1: Mapping the sustainable building curriculum. 18 years teaching on the bachelors' level, year 1.

Mandatory course: Architecture, environment and sustainable development, 60-90 students. (Ex = examiner)



Fig 3: Group work in the course Architecture, environment and sustainable development.

5.2 Masters' level

All master students (MPARC and MPDSD) start with an introductory course called *Sustainable development and the design professions* (about 100-120 students). In the course different perspectives on sustainable development and the challenges involved are discussed and related to the profession. The course has been

WORKSHOP II PASSIVHUS

SOLAVSKÄRMNING

21 maj strålar solen in i 30 graders vinkel i väster och 30 grader i öster. Vi skulle få en 50% av solenergin från inslagning. Efterom vilket stöder i olika vinklar i de olika väderstrecken; behövs skärmarna vara olika stora. Fåna och med plus in tänka lösningen med skärmarna på de andra planerna valde vi att skärmarna vara olika höga av stor.



Fig 4: Results of a passive house workshop for first year students.

given since 2003, about 12 years (tab 2). When the international master programmes were introduced in 2007, it changed focus, from Nordic to international, and it was extended from 4.5 to 7.5 erts. The examiners have been the same over time. In the course, the students outline a personal strategy for their future architectural work.

Extent	Aim	Organization
<i>Sustainable development and the design professions (2007-2014, 8 years)</i>		
7.5 erts	<ul style="list-style-type: none"> - To give the background to, and the content of, the political and global vision of sustainable development and challenges. - To present perspectives on what the sustainable development implies for planning, design and management of the built environment and for students future professional work. 	Lectures, film showings, study visits, literature studies, seminars in smaller groups, individual course assignment presented at the end of the course.
<i>Sustainable development in a Nordic perspective (2003-2006, 4 years)</i>		
4.5 erts	- See above	- See above

Tab 2: Course "Sustainable development and the design professions", 12 years teaching on the masters' level.

The "building track" consists of a series of studios dealing with solutions to minimize the environmental impact. Two studios, the Sustainable building and Sustainable building competition are presented here. In the *Sustainable building* studio, the concept of sustainable building is introduced, both as principles and as elements in design assignments (tab 4). The students are trained to carry map and analyse resources flows (fig 5), design for sustainable architecture, integrating environmental, functional, technical and aesthetical qualities.

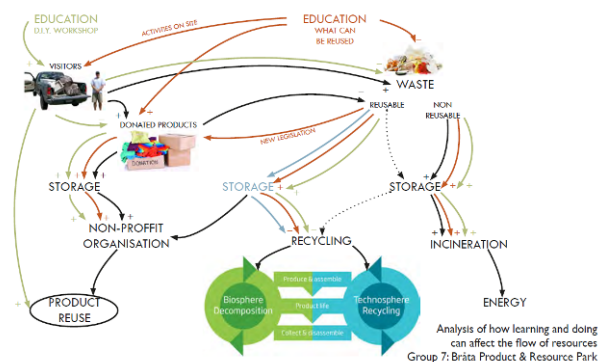


Fig 5: Mapping the impact of flows and learning cycles of a waste pavilion design. Students work, Sustainable building studio (Östlund et al., 2014).

Extent	Aim	Organization	Ex
<i>Sustainable Building (2008-2014, 7 years)</i>			
22.5 ects	<ul style="list-style-type: none"> -To develop knowledge, skills and tools to be able to design, plan and construct, evaluate and advise on the creation of low-carbon, sustainable buildings - To evaluate the environmental impacts of decisions. - To introduce the concept of sustainable building as principles and as elements in concrete design assignments. - To prepare for the Sustainable building competition studio. - To train the architect's ability to formulate proposals under limited time conditions. - To communicate the sustainable building between professional groups and to a larger public. 	Lectures, series of short design exercises around themes and basic systems (matter, energy, water). Design assignment. Involvement of real client. Group work. Outcome presented in report. Adaptation of sustainable building concepts to local climates and cultures including ecology.	E2 (2011 to 2014)
			E1 (2008 to 2010)
<i>Sustainability and architecture (2003-2007, 5 years)</i>			
3 x 7.5 ects	- See above	See above and elaboration of an environmental programme from a given functional programme.	E1

Tab 4: Course Sustainable building, 12 years on the masters' level. Up to 32 students. (Ex = examiner)

The course has had 2 examiners over time. The extent changed from 3 minor but interrelated studios á 7.5 ects to one studio with 22.5 ects.

The *Sustainable competition* studio consists of a competition in which architects and civil engineers cooperate in groups (up to 35 students, tab 5, fig 6). This course is synchronised with the study plan of the engineers which is quite a challenging as architects work

in full time studios and engineers in half time studios. The task is defined in a programme concerning a project on a specific place for a specific client. The competition programme contains specified environmental goals, in addition to the basic demands in any architectural project. The studio has its origin in a generous donation from a devoted architect, Hans Eek, who received the Gothenburg International Environmental Prize

Extent	Aim	Organization	Ex
<i>Sustainable building: Competition (2008-2014, 7 years)</i>			
15 ects	<ul style="list-style-type: none"> - To carry out design for sustainable building, integrating environmental, functional, technical and aesthetical qualities in a design concept. - To cooperate over professional boundaries in design processes. - To formulate and communicate main ideas and goals in an entry for an architectural competition. - To design sustainable architecture (since 2013 introduction to building certification BREEAM, LEED, Green Building, etc) - To visualize the performance concerning energy, environment and indoor climate in a building - To cooperate across disciplinary boundaries in design processes. 	Introductory lectures, seminars, and workshops. The final outcome are presented in a report. Architects and civil engineers cooperate in groups. Task defined in a competition programme with specified environmental goals for a project on a specific place for a specific client. External (international) jury.	T2/T6 (2 years)
			T2 (2 years)
			T1 (until 2010)
<i>Resource efficient building for the future (2003-2007, 5 years)</i>			
15 ects	- See above		

Tab 5: Course Sustainable building: Competition, 12 years on masters' level. Up to 35 students. (Ex = examiner)

for his work over decades to develop sustainable building (Edén, 2011). The course has been implemented since then, i.e. 12 years up to know. During 2005-2008, the sustainable building competition studio was carried out in cooperation with the Norwegian Department of Architecture in Trondheim. The studio was also host for Chalmers participation in the Solar Decathlon 2013. Team Sweden won the 3rd place (fig 1).



Fig 6: The sustainable building competition studio: Development of central urban site for mixed-use in Gothenburg, 2nd price entry year 2009.

6. Discussion

The implementation of the sustainable building curriculum at the Department of Architecture at Chalmers has been going on for more than two decades. We can see that during the last years, the pre-knowledge among students has raised along with their strong interest in and engagement for sustainability. At the bachelor's level the students' attitude towards sustainable building has changed from questioning why to deal with it into how to deal with it. This reflects a raise of the general understanding of sustainability in society, already taught in basic schools, but also a breakthrough for sustainability engagement in architectural practice reflected in new

constructions and mediated in architectural journals. Still, we perceive a conflict between the growing demand among students and what the Department can offer in terms of knowledge and education. Not all teachers have an interest and knowledge in the field. Those with a long experience struggle to re-develop teaching methods and up-date knowledge in a quickly developing field. Thus, a remaining challenge is to pass on the knowledge in the subsequent following studios. Efforts to overcome these barriers are the implementation of learning progressions through constructive alignment of courses. The 'environmental binder' from the first year course on the bachelors' level was an early attempt to built-up a knowledgebase for sustainable building. It was up to the students to apply this knowledge in the coming courses. The binder has been transformed into a personal 'declaration of intent' with an aspiration to be integrated in other studios. Education, research, and practice is tightly linked in the sustainable building curriculum and demands development and adaptability. Tutoring is carried out by doctoral students with frontline knowledge sustainable building and master thesis students. The successful participation in the international student competition Solar Decathlon is a result of this research-based and practice-implemented approach. All courses in the curriculum have a research-based approach and provide generic skills such as systematic information searches and report writing. Today the broad concept of sustainability is taught in terms of the more design-based philosophies such as regenerative design or cradle-to-cradle. Knowledge of concepts is important but not enough for making changes towards sustainable architecture. Theory must be applied in design assignments or studies of real built projects in order to provide the students with design skills.

7. Conclusions

The discussion revolves around the extent of the curriculum, the creation of learning progressions, the integration of and link to ongoing research, and the collaboration with other disciplines and outside academia, i.e. the local industry and public institutions. The sustainable curriculum on the Masters' level are highly attractive for international students, many of them even take their second master degree at Chalmers. Participation in the international student competition Solar Decathlon shaped a new generation of attractive architects partly creating their own market for work (founded own office). A challenge is to protect the architects' need to have a holistic view, which might lead to a loose of focus, and to leave over expertise to construction engineers, where there might be a risk that the architect loses (yet) more control over the design process. Architectural education should re-define the core of architectural knowledge in the context of a changing paradigm. In order to keep up with knowledge development, we believe in openness and integration of different disciplines, but also involvement of different stakeholder groups from the construction sector, especially through integration of their knowledge in architectural education. At the same time, the Department of Architecture should give attention to further education of the teachers so that future generations of architects are able to meet the needs of society. We also believe that improved cooperation with other universities offering architectural education, both in Sweden and internationally, could support the implementation and better integration of the

sustainability curriculum and lead to more viable discussion within the field. Finally, evolution is a long-term process and, in the same way, it takes time to shape architects and our future built environment in a sustainable way. Important factors for success are integration, collaboration, continuity, progression, and enthusiasm!

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