

CRITICAL REVIEW OF IMPLEMENTATION OF SUSTAINABILITY IN HIGHER EDUCATION

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ABSTRACT

Sustainability is a widely used term in titles and descriptions of courses in higher education within design and product development. There is a general agreement in the society about the importance of sustainability, and this priority should therefore be expected to be reflected in the curriculum. Based on literature review aim this study to give a critical review of implementation of sustainability in higher education. The theoretical framework for findings and analysis is based on the Integrated Design and Delivery Solution framework. When sustainability was included in the curriculum, this was mainly related to general attitudes with focus on the environmental aspects and collaboration in the design process. The results indicate that use quantitative methods based on standards was in general absent. Implementation of sustainability in higher education, both in number of courses, and in use of professional method is far behind the need in the industry and the society. A systematic of implementation can contribute to turn sustainability assessment from feelings to facts.

Keywords: Sustainability, curriculum, pedagogical framework, standards.

1 FOCUS ON SUSTAINABILITY IN SOCIETY, INDUSTRY AND EDUCATION

Sustainability is a widely used term in titles and descriptions of courses in higher education within engineering and product design. There is a general agreement about the importance of sustainability in the society [1]. This study aim to have a critical review on implementation of sustainability as learning objective in higher education in product design related study programs. Examples of these types of study programs are: product design, architecture, mechanical and building engineering. The research question is therefore formulated as: *What is the priority of sustainability in education sector compared to the interest in industry and society?*

There is a general impression that higher education shall contribute to solve the societies current and future needs [2]. These needs are multiple, often contra dictionary and complex. The response in higher education is to give the students' knowledge about what is relevant factors (input) methods (for processing input) in various situation (context dependency choose of factors and methods), skills to apply this knowledge in an efficient way (e.g. by use of technology or other tools), and attitude to give priority to the impact of their decisions (make professional assessments). The impact of solutions developed by product designers, architects and engineers are product and/or services intended to solve different users need. Chooses made today will therefore have a long-term impact. This implies that engineering and product design must include more factors and wider assessments in design through the life-cycle of the product of service. Sustainability is often coined as expressions of a holistic and long-term assessment criteria, or as good intentions [3]. This implies that one should expect to find sustainability included as an integrated and extensive element in the engineering and product design curricula in higher education.

2 METHODOLOGY AND FRAMEWORK

2.1 Methodology

This study is based on literature review of study programs within product design and related studies as; architecture, mechanical and building engineering in higher education in Norway. These findings

are compared with a selected number of reports addressing the general focus and priority of sustainability in industry and society. The Integrated Design and Delivery Solution (IDDS) is used as theoretical framework for findings and discussions. IDDS focus on the integration of collaboration between collaborating people, integrated processes and interoperable technology [4], as illustrated in figure 1.



Figure 1. The three perspectives in IDDS [4] connected to sustainability

Assessment of sustainability can be regarded as a type of integrated deliverable. The perspectives of IDDS can be embedded into higher education in following ways enabling sustainability assessment:

- Integrated Processes => use of standards and documented assessment methods for sustainability
- Collaborative People => multi-disciplinary collaboration that ensures validity of constraints
- Interoperable Technology => software supporting input from multiple sources and registries

2.2 What is sustainability and how can it be assessed?

Even if there is no joint definition of “Sustainability” [5], this does not imply that it is undefined, or that most definitions are very different. A search on the ISO Online Browsing Platform [6] give 21 different definitions related to sustainability. The three most used indicators are related to *economic, environmental, or social impacts*”. A search at International Organization for Standardization (ISO) resulted in 48 sustainability related standards [7], while similar search at European Committee for Standardization (CEN) resulted in 43 sustainability related standards [8]. National standards are resulted in internationals standards. A search at Standards Norway on “bærekraft” (sustainability) resulted in 20 standards [9], where 9 was NS-EN, 6 was NS ISO, and 5 was NS-EN-ISO standards. None of these 20 were developed by Standards Norway alone, all was international based.

At management level has “ISO/TC 207 - Environmental management” developed the ISO 14000 series of quality assurance standards (similar to the general ISO 9000 series). Sustainability is a quality of the product or service, which can be assessed by use of standards. This overview illustrate that there is developed enough standards to support implementation of sustainability assessment in higher education. Use of standards enable use of professional method with defined input of facts and pre-defined criteria for processing and assessment.

3 RESULTS

3.1 Industry

The demand of sustainable solutions is relatively high in the society. This is resulting in products with positive sustainability “image” and/or documentation is easier to sell. Torpp and Rød [1] express this priority in their report to the Confederation of Norwegian Enterprise (NHO) about Green leadership following quote: “Environmental sustainability is no longer about “doing good”...”Resource scarcity and technological development are making sustainability critical to competitiveness across industries” [1, p.2]. Many Norwegian finance companies have taken into account the fact that sustainable buildings contribute to increased profitability and greater competitiveness. Financial firms see that the owners of eco-building will achieve significant cost savings over the lifetime of the building. They will also win the battle for the best tenants. Sustainability is therefore high on the list of criteria in both construction and refurbishing [11]. Sustainability is also a separate business domain in many consulting engineering companies. This can be illustrated by organizational structure of the international consulting engineering company COWI, where sustainability is one of five business domains [12].

3.2 Research

There is many conferences and journals dedicated to sustainability in general. To give an indication of priority of sustainability within product design has the annually International Conference on Engineering and Product Design Education has been chosen as indicator. Table 1. presents an overview in use of sustainability, creativity and innovation in titles of papers [13].

Table 1. Overview in use of sustainability, creativity and innovation in titles of papers

Term in title of paper	E&PDE 2013	E&PDE 2014	E&PDE 2015	E&PDE 2016	E&PDE all year	Total (S / C / I)	Total (S / C+I)
Sustainability	1	1	0	2	4	11	11
Sustainable	0	3	2	2	7		
Creativity	3	4	2	3	12	28	44
Creative	6	5	4	1	16		
Innovation	2	1	5	7	15	16	(80%)
Innovative	1	0	0	1	1		

Sustainability within architectural education have for a long time been had focus on sustainability. These professions are larger in numbers than product designers are, and by this have capacity to develop specialized communities. However, even if it is easier to identify, it can be expected that sustainability have a relative limited focus in education compared to the high volume/ focus of traditional design themes.

3.3 Education

Exploring “sustainability in higher education consist of two parts. The first one is a simple overview of study programs including sustainability in their title. The second part explore focus of sustainability in curriculum in selected studies within product design, architecture, mechanical and building engineering.

3.3.1 Study programs including sustainability in their title

A listing by the “Studiebarometeret 2016” [14] of the education group “Natural sciences, vocational and technical subjects” result in 441 study programs, 205 at bachelor level and 226 at master level. Visual art and crafts resulted in 43 study programs, all at master level. Search on study programs included variants of sustainability, as sustainable, resulted in 5 study programs total. All where at master level and offered at the Norwegian University of Science and Technology (NTNU).

- Innovative Sustainable Energy Engineering (Nordic Master's Program) 8 students
- Sustainable Urban Transitions (Nordic Master's Program) 2 students
- Master in Sustainable Manufacturing 21 students
- Sustainable Architecture 33 students
- Sustainable Energy 3 students

Total of 5 study programs with 67 students

This indicate that sustainability is offered mostly within architecture and manufacturing [14]. The total number of students are very limited compared to numbers of students in traditional study programs within product design, mechanical and construction engineering

3.3.2 Focus of sustainability in curriculum in selected studies

Based on the interests for sustainability in the industry and the society, it should be expected that it would be included in the curriculum in product design, architecture, mechanical and civil/building engineering study programs. Search in the “Studiebarometeret” [14] in the education group “Natural sciences, vocational and technical subjects” identified 33 study programs at nine universities/university colleges. This group include design related studies and following selected studies are presented:

Study programs within Product design

Oslo and Akershus University College of Applied Sciences (HiOA) offers a 3-year Bachelor's Degree Program in Product Design. This program is described as: “In product design program students learn to plan and implement a design process from idea to finished product. Important considerations are the relationship between the products form, function, application and material properties” [15]. There is no courses in the curriculum that includes sustainability. Their 5-year Master's Degree Program in Product Design: Materiality, Processes and the Future Environment has in the first semester a course

called: "MAPD4100 Sustainable Design Approaches". The two textbooks in the mandatory part of the curriculum do not include methods in sustainability. The four textbooks in the supplementary part do focus on strategies for sustainable development, not on quantitative methodology and standards [16]. The aims and contents of the master are: "The program focuses on empowering students by combining theoretical and practical knowledge. Through learning activities, students acquire skills to make the choices necessary for the creation of high-quality products" [17]. This perspective regard sustainability as a quality of the designed product, but with limited focus on calculated values.

NTNU offers a 5-year "Master's Degree Program in Industrial Design Engineering". The description of the study program states: "The course aims to develop students' knowledge and commitment towards sustainability in product design. The course includes theory and methods for sustainable design, environmental assessment of products and services, improvements of product and services, in addition to communication with, and involvement of actors [18]. However, there was only the "TPD4200 - Sustainable Design" course in the 6th semester that includes sustainability. The course content description says: "This course aims to develop the candidates' knowledge and personal engagement towards sustainability issues in product design. Topics include theory and methods of sustainable design, environmental assessment of products and services, product- and service improvement, communication with and involvement of stakeholders" [19].

Mechanical engineering

Mechanical engineering is designing and operating products for industrial use, and can in this perspective be regarded as a design study. Based on the volume of designed products, small improvements will have significant impacts. A search in "Studiebarometeret" [14] reported 14 study programs. However, sustainability was not detected as part of the curriculum in all programs. At the mechanical engineering program at HiOA is sustainability indirectly mentioned in at the study homepage: "An important goal of the program is to educate responsible and environmentally conscious engineers who can develop good products and technical solutions" [20]. This indicate that sustainability / environment is regarded as an attitude, not as a profession methods for quality assessment.

Engineering of the built environment (construction)

Search in the "Studiebarometeret" [14] identified 27 study programs, 20 at bachelor and 7 at master level. Exploring curriculum did not identify sustainability as an included part. There was three study programs which profiled environmental aspects. NTNU offers a 5 year master's degree program called: "Civil and Environmental Engineering". This program is described as: "The work field is extensive, covering technology, economy, safety and environmental issues. The tasks include evaluation and choice of technical solutions, calculations and shaping, and building" [21]. Sustainability was not identified as a defined criteria, or domain of focus, in the curriculum.

HiOA offers both bachelor [22] and master [23] programs within energy and environment engineering. As the program title indicate, environmental should issues be in focus. However, environment is related to indoor climate and air comfort. Presentation of the bachelor program says that the students will acquire knowledge within energy optimal design of system that contribute to good indoor air quality in buildings, suchlike as ventilation, shading and heating and cooling systems [22].

In the "EMFE1200 / BYFE 1200 Introduction to Building Professions" course" is sustainability included as of the learnings objectives in general competency as "identify sustainable performance of their own profession, with emphasis on energy and environment" [22]. This course is also included in the 3-year bachelor program in building engineering. Sustainability is likewise mechanical engineering poisoned as an attitude related learning objective. Presentation of the master program says that the students will acquire knowledge about energy optimal designing of systems and combination of equipment as ventilation, shading, heating and cooling systems that contributes to good indoor air quality in buildings. The knowledge has to be adapted to recent regulations for buildings. Priority is also given to operation and maintenance of complex systems for managing energy and environmental technical installations [23].

Architecture

Studiebarometeret [14] identified 9 architectural study programs for buildings, and the one within interior studies. In architectural curriculum is environmental aspect mentioned. This situation looks to be likewise as for product design related study programs. Use of "hard" – quantitative assessment methods based on standards or detailed specified assessment methods was not identified.

4 DISCUSSION

Despite high interest for sustainability in general, it was hard to identify methodical actions for implementation of sustainability as quality criteria for assessment of design in courses presented to include sustainability in their title or course description. There was a general lack of multi-disciplinary approaches in the courses. Sustainability was related to environmental factors, while societal and economic factors were under-focused. Criteria for choice of designed solutions lack in general evidence and was often based on selecting materials in single products. This prescriptive can be related to lack of joint understanding and definition of sustainability [1, 3, 5, 6]. Use of standard as normative source [7, 8, 9, 10] is stated as a mandatory reference for assessment of sustainability of designed solutions. From an “engineers methodical mindset” this can be a good starting point. However, an easier way to introduce predefined calculation of sustainability impact can e.g. be use of net web based calculator for Green House Gases (GHG), like “klimagassregnskap.no” or similar digital tools to measure and document impacts in numerical values.

This study did not go into detail about how sustainability was in educational in practice. However, if sustainability is incorporated in a limited degree compared to the demand in industry and society [1, 5, 11]. Teaching is in limited degree not supported by textbooks or standards. Another aspect is that professional assessment of sustainability of designed solutions is demanding, and will often require multidisciplinary competence. IDDS was introduced as a framework in figure 1. Figure 2 is a visualization of the general impression of the results in this study. This indicates a lack of integrated perspectives in use of sustainability as a defined assessment criteria of designed solutions.



Figure 2. Lack of integrated perspectives in assessment of sustainability

Support of digital technology and access to defined sources, preferably digital, for facts is essential for applying assessment of sustainability. Studies by Hjelseth [24] has identified lack of these factors as barriers for enabling practical implementation. This situation is also so gained by limited support for digital processing in the way standards and assessment methods are specified. This missing support contributes to make the assessment to a demanding and time consuming manual process mostly used for documentation of final products, not for support during the design process.

5 CONCLUSIONS

The industry and the society has high focus on sustainability as quality criteria of products. It should therefore be expected that higher design education mirror this interest, or requirement, for sustainability in study programs within product design and development. However, this was not reflected, and sustainability appears to be a very limited part of curriculum in studies within product design, architecture, mechanical and construction engineering.

It was hard to identify a connection between sustainability in the general description for the studies – and adjacent professional methods in the curriculum. Study programs, which were profiled towards sustainability, were very general and strategic oriented, with limited focus on use of standards and documented methods for calculation of sustainability performance of designed products. Sustainability can therefore easily be regarded as a “buzzword”. This impression was amplified by the fact that there is no joint definition or understanding of the term sustainability.

In general is sustainability presented as an attitude of “good intentions”, but without references to processes, method, standards or valid and reliable methods for documentation and assessment. Higher education can by acting multidisciplinary and increase use of computable methods contribute to transform sustainability from feelings to facts.

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