

# 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 include in the curriculum , this was mainly related to general attitudes with focus on the environmental aspects and collaboration in the design process. Use of quantitative methods based on standards was in general absent. Implementation of sustainability in higher education, both in number of studies 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 [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 user 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 have a physical expression related to solve different uses need. Chooses made today will there have a long-term effect. This imply that engineering and product design includes wider perspectives, which includes more factors and wider assessments in design of a solution expressed as a product (which can be anything from a different type of material, to complex products consisting of multiple materials and other products). Sustainability is often coined as expressions of a holistic and long-term assessment criteria, or as good intentions [3]. This imply that learning sustainability should be 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. 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.

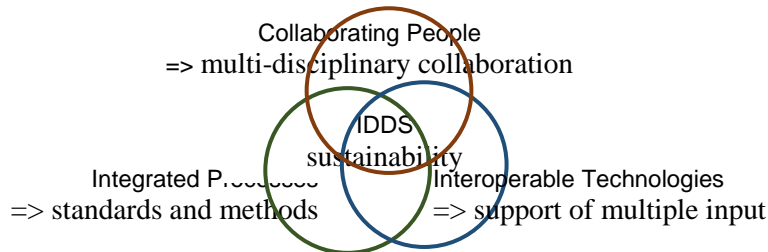


Figure 1. The three perspectives in IDDS [4] connected to sustainability

Assessment of Sustainability can be regarded as a type of integrated deliverable. The perspectives of IDDS can be embedded into sustainability in higher education in following ways in 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 are no joint definition of “Sustainability” [5], this do 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*... Search at International Organization for Standardization (ISO) resulted 48 standards [7] , while similar search at European Committee for Standardization (CEN) resulted in 43 standards[8]. National standards are resulted in international standards. A search at Standards Norway on “bærekraft” (sustainability) resulted in 20 standards [9], where 9 was NS-EN, NS ISO was 6, and NS-EN-ISO was 5. Of these 20 standards was none developed but standards Norway alone.

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 us of standards. This listing illustrate that there is enough numbers or standard to establish sustainability assessment based on professional method with defined input of facts and pre-defined criteria for processing and assessment.

## 3 RESULTS

This part start with a short to indicate that the industry have high focus on sustainability. The research part intend to illustrate that the product design community have a research within scientific.

### 3.1 Industry

The focus on sustainability is increasing and relatively high in the society, and products with negative sustainability impact is harder to sell. Torpp and Rød [1] express 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 – a business opportunity on the CEO’s agenda” [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 criteria list in both construction and refurbishing [11]. Sustainability is also a separate business domain in many consulting engineering companies, here illustrated by COWI, where sustainability is one of five business domains [12].

### 3.2 Research

There is many conferences and journals dedicated to sustainability. 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	Total
Sustainability	1	1	0	2	4	11
Sustainable	0	3	2	2	7	
Creativity	3	4	2	3	12	28
Creative	6	5	4	1	16	
Innovation	2	1	5	7	15	160
Innovative	1	0	0	1	1	

Sustainability within architecture have for a long time 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 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. The outcome resulted in 5 study programs total, all at master level and offered at the Norwegian University of Science and Technology.

- 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) has a 3-year Bachelor's Degree Program in Product Design. About the study: “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 obligatory part of curriculum do not include methods in sustainability. The four books in the supplementary part do focus on strategies for sustainable development, but 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]. In this respect can sustainability be regarded as a quality of the designed product.

NTNU has 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 6<sup>th</sup> 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 indicates 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 studies, 20 at bachelor and 7 at master level. Exploring curriculum did not identify sustainability as included. There were two study programs where profiled environmental aspects. The Master’s Degree Program, 5 years, at NTNU is 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]. However, one exception is the specialization Water and Environment focuses on environmental engineering issues, particularly related to the use of water resources and protection of these.

HiOA has both bachelor [22] and master [23] program within energy and environment engineering. As the program title indicates, environmental issues should be in focus. However, environment is related to indoor climate and air comfort. 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]. Students will acquire knowledge about energy optimal design of systems and combination of equipment as ventilation, shading and 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].

HiOA has also a 3-year bachelor program in building engineering. In the “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” [24]. Sustainability is likewise mechanical engineering perceived as an attitude related learning objective.

### *Architecture*

Studiebarometeret [14] identified 9 architectural studies 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 joint interpretation 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 connected to environmental factors, while societal and economic factors was under-focused. Criteria for choose 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 “klimagassregnskap.no” (Green House Gases (GHG) calculator or similar tools to measure impacts.

This study did no go into detail about how sustainability was in educated in practice. However, if sustainability is incorporated in a higher degree than this study indicate, this this teaching is 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 introduces as framework in figure 1. Figure 2 is a visualization of the general impression of the results. They indicate 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 technology and access to defined sources, preferably digital, for facts is essential for applying assessment of sustainability. Studies by Hjelseth [25] has identify lack of these factors as barriers for enabling practical implementation. This situation is also so gained by limited suitability for digital processing in the way standards and assessment methods are specified. This missing support contributes to make the assessment more demanding and time consuming, compared to digital support. This study has search for something that was not identified. This can imply that this study was not thorough enough, and more detailed search would identify that sustainability is included in the curriculum as a professional and documented assessment criteria of product quality. The findings and the conclusion from this study must therefore be regarded as indications, and not as significant facts.

## 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 like; 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 was profiled towards sustainability, had a 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 are 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 contribute to transform sustainability from feelings to facts.

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