Paper 75. The Potential Role of Design in a Sustainable Engineering Profile

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Abstract

Sustainability is still a relatively new term in everyday public discourses, yet broad consensus is emerging that issues of sustainability should take a central part in future development strategies. Some of the professions most seriously effected by the complexities and challenges of sustainable development are the engineering professions. As a consequence many institutions are now engaged in rethinking the professional engineers' role and contribution in contemporary society and concretize the implications that such a change will hold for engineering educations.

Design, on the other hand, is an old concept, but its use has always been fluent and changing. Today it is no longer solely a matter of formalist aesthetics employing materials and tangible form for iconic recognition. The design field is rather shifting towards a reflective, creative practice working across disciplines and professions, and the objects of design are shifting towards systems, services, and experiences rather than material products.

Illustrated by two concrete engineering programs I will argue that a reflected design practice makes it possible to deal with open, complex challenges, and that it enables a more contextually situated approach to problem solving across professions. In other words, how a reflected design practice makes it possible to deal with issues of sustainability.

1 Introduction

Historically, technology (here understood broadly as both artifacts, processes, visions and knowledge) has become a growing part of our culture and in many respects integrated in our visions of dealing with the future problems our societies are facing. Therefore engineers, as the makers of technology, have also been seen as society's problem solvers through many years (Downey 2005). Engineering educators have correspondingly been determined to prepare the coming engineers for analyzing and solving such future problems.

Since the 80ies environmental issues have been widely accepted by scientists, politicians and the broader public as integral parts of most of the contemporary challenges that our societies are facing. Efforts to simply reduce negative impacts through end-of-pipe approaches are no longer enough; instead industry, state, and research should work together to *prevent* environmental problems. This eventually resulted in the adaption of the sustainability concept, which broadened the scope even further to include not only concerns for the environment but also societal needs and ideas of allocation (Boyle 2004, Ashford 2004). Technology has played a dual role throughout this development – both as problem (polluter) and solution (preventer).

A natural consequence has been the integration of environmental concerns in new technology development. But engineers (along with many other professions) are still struggling to meet the political ambitions for a *sustainable* development. The typical engineering translations into

measuring equipment, tables, and physical technologies seem to fall short as a more broadly defined conception of sustainability is starting to gain foothold. Sustainability raises a new set of dimensions related to a far more complex and interlinked level than the individual specifications of a technology. This underlines that engineers do not singlehandedly *define* technology and its use, though they do have great influence on it. From a social constructivist perspective technology is instead constructed through the input, application, experience etc. of many different actors, bringing 'life' to the technology at hand, not only in its design and production, but also use and disposal (Jørgensen & Yoshinaka 2009).

There have been many discussions of the relevance, role, and inclusion of sustainability in engineering curriculum (see e.g. Mulder *et al.* 2012, Mulder 2006, Ashford 2004, Boyle 2004). There is a general agreement on the complexities involved in sustainable engineering and of the need for a more systemic approach. However, how engineering education may tackle this challenge of bringing students such new, widely unfamiliar, dimensions in an already crowded curriculum remains largely unanswered.

In this paper I will explore how 'design' may be used as a way to deal with those complex challenges. First, the introduction briefly pins down the main challenges linked to the two central concepts of sustainability and design around which this paper revolves. In section 2 I present two concrete examples of new engineering programs using these conceptions of sustainability and design. The paper then ends with a reflection on how new sustainable profiles in engineering could benefit from the integration of elements of design, setting the foundation for a new generation of engineers able to collaborate actively and creatively with other professions in the pursue of sustainable development.

1.1 The Sustainability Challenge

Ever since the so-called Brundtland Report (World Commission on Environment and Development 1987) promoted the concept of sustainability in 1987, it has been an ongoing struggle for scientists and politicians alike to pin down the concept and come to a common (global) agreement. At the same time, though, it has been suggested that the power of the concept does not reside within such a shared understanding, but rather across the *discursive field* surrounding it (Becker *et al.* 1999).

The environmental concept was defined within the natural sciences and based on quantifiable measures and calculations, and engineers have been working with the environment for many years with relative success, e.g. handling issues of waste and energy consumption. But with the introduction of the sustainability concept it has become increasingly evident that we are now moving in the junction *between* both natural sciences and social sciences (Becker *et al.* 1999).

I depart from the perspective that sustainability is a discursively constructed concept without any stable definition and interpretation. Instead I see it as a heterogeneous and contested set of perspectives that are continually defined and redefined through social, cultural, and political practices. A central implication of this perspective is that sustainability cannot be viewed as a finite goal or destination we can work towards as a global community. Like the pot of gold at the end of the rainbow, sustainability is more of a moving target never quite to be reached. Using a *navigational* metaphor thus captures the concept more comfortably: sustainability discourses help us steer in a sea of future challenges and navigate around the rocky patches of undesirable solutions. In this capacity, as a navigational device, the specific sustainability discourses are also locally defining the legitimacy of new socio-material arrangements, such as technological systems (Jørgensen 2013).

From this perspective it is no surprise that engineers have been struggling to deal with issues of sustainability. The traditional engineering approaches of setting up finite sets of goals or measures in order to develop tangible technologies to meet these goals are bound to fall short. Finite goals have no value when the desired destination is constantly changing – they will only result in redundant technological fixes without any significantly positive impact. As such, the

real challenge when incorporating sustainability in engineering, as I see it, is that it requires a fundamental break with traditional approaches and engineering thinking.

1.2 Introducing Design

The discursive field surrounding design also accommodates several understandings of what design is. Originally, design was strongly linked to the arts and craft tradition where aesthetics and essence on the one hand and craftsmanship and technique on the other were put front and center. In such an understanding design is primarily concerned with the aesthetics and shape of an object (as e.g. in fashion design). But as technology plays an increasingly central role in most design objects today, the design field has also shifted towards the field of engineering. In the engineering understanding, however, design is more concerned with the functionality of design objects (e.g. in mechanical design).

The discursive span can also be identified in the different representations of product development processes. In the more traditional part of the discursive field, design is perceived as something that has its own stage towards the end of the development process; it is where the product is styled and made attractive for potential buyers, while the functionality has been decided long before this by the engineer (e.g. Ulrich & Eppinger 1995). In the building sector it is interestingly the exact opposite – here the shape is given before the technically functional, however the engineering and design work is still viewed as two separate parts in the traditionally linear development process. Within engineering design, on the other hand, there is a tendency to view design as a process of problem solving, which spans most of the course of development – especially the early stages where creativity is attributed great importance (e.g. Cross 2000).

I take my point of departure in the part of the discursive field, which lies even further away from the artistic understanding. Here, design is to a greater extent seen as a way of thinking and engaging in the design process. Schön (1999) has called it the "reflective conversation with the design situation", which emphasizes the more interactive relationship between the designer, the design object, the design situation, and the other participants in that situation (clients, colleagues, users, computers, drawings etc.). Brown and Wyatt (2010) from the renowned design consultancy IDEO call it "design thinking", which they describe as a human centered approach that goes beyond conventional problem solving and products to new experiences with emotional as well as functional meaning. With this reflective design understanding it is openly recognized that design does not move along a linear line from analysis to synthesis or from problem to solution. Rather it moves back and forth between different domains as the design problem(s) and solution(s) are co-evolved and continuously up for revision (Downey 2005).

There is a strong social element in this way of thinking design, which is done more in collaboration than in unison (how the artist traditionally works). Bucciarelli (1994) has phrased it as "designing is a social process" to underline that the expert designer never works in complete isolation, but is rather navigating a social network of other actors. Taking this perspective also implies a shift from focusing on the final output of design (whether it be a tangible or intangible object) towards focusing on the *process* itself where life and meaning is co-constructed into the design even before it is finished. This also resonates well with the participatory design approaches, which allow non-professionals to take part in the design process as well.

The design perspective I suggest to integrate with sustainability is thus not the traditional artistic or engineering design approaches. It is rather to view design as a reflected social practice ideal for open, complex problems at the intersection with other professional fields. Integrating design of this character is no simple task but requires more fundamental changes in e.g. the construction of curriculum (Mulder *et al.* 2012). Due to limited space my reflections here will, however, be at a more general level and will not address the specific curricular implications.

2 Two New Initiatives

As laid out in the introduction, dealing with sustainability is not new to engineering education. What may be recognized, though, is that there are multiple ways of translating this into the individual programs. In many programs you can e.g. find a specific course dealing with sustainable elements, which is intended to provide candidates with a new perspective they can add to their classical competences (Mulder *et al.* 2012). Other programs are dedicated to specific technologies viewed as more sustainable, such as programs in sustainable energy technologies. In my view, these approaches to sustainability are insufficient when it comes to enabling engineers to work with sustainability at the more complex societal and systemic level. The challenge calls for a more fundamentally rethinking of the educations offered than adding a new course to a program or label to certain technologies.

In the following, two takes on engineering programs are introduced that have taken on this rethinking of the engineer's professional role as a response to the sustainability challenges. Both programs are aiming to use design actively in the creation of more sustainable engineering profiles. Each in their own way they show how a designerly framework can be used to tackle issues of socio-material dynamics, complexity, and interdisciplinary communication.

Both cases are from a multi-sited study looking at the junction between engineering and design in education as well as practice in the Danish context, which is conducted in connection with a larger research project on the opportunities and challenges facing engineering education in Denmark. The research is based on the basic assumption that doing engineering is a socially constructed practice produced and re-produced through both education and professional work. The two cases outlined below draw on qualitative, semi-structured interviews with central educators and planners as well as official descriptions, study plans etc.

2.1 Case 1 : Building Design

Civil engineering and architecture have lived side by side as professions for decades, mutually defining their respective roles through numerous building projects. But the professional distinction is also clearly embedded in the institutions of education and their approaches to the respective disciplines. As the political discourse on sustainability has gained influence and new strict building codes have been introduced it has, however, become increasingly apparent that the traditional division of labor between these two professions does not facilitate the type of holistic design solutions now called for. The international building sector is instead starting to demand new types of collaboration, which has resulted in several new programs in architectural engineering in Denmark. The case used here is a bachelor (from 2011) and master (from 2007) program called Building Design, which is offered at the Technical University of Denmark.

The building design program is deliberately defined in this junction between the established architectural and civil engineering professions that are mainly in charge of managing the design and construction of buildings. Architects traditionally place themselves (and are placed by engineers) in charge of the first stages of the process where the design is conceived. Civil engineers (here taken under one cap) enter afterwards to validate, adjust, and document the design. This can seem a reasonable employment of the professions' respective competences, but what is becoming increasingly apparent is that neither profession takes full advantage of the other's knowledge domains. What typically happens is that the architect provides an aesthetic or symbolic translation of sustainability (e.g. with visual elements such as green roofs), while the engineer provides a technical translation (typically based on standard guidelines and technical norms). Those two interpretations rarely match up and as a result both architects and engineers are dissatisfied with the level of compromise needed to complete the building. Meanwhile, both professions seem to be excluding the social element of sustainability linked especially to the daily use of a building.

With the building design education the wish is to circumvent these problems by enabling building designers to take active part in the early, creative stages of the design process, working alongside the architects in a collaborative manner while leaving the validation part in the

competent hands of traditional civil engineers (Karlshøj 2012). During these early stages important decisions are being made about the overall shape, structure, and functionality of the building based on a limited information level but with far-reaching influence on the performance of the final design, not least regarding its sustainability.

According to the heads of the building design program, working in these early design stages requires that at least two new competences are cultivated: working with messy and fluent problems and collaborating with other professions. Instead of determining the exact dimensions of supporting beams, joints, and foundations the building designer is rather to design the structural concept from a more aesthetically and sustainably informed position. As a result they have shifted the traditional from heavy calculations towards *conceptualization* where a design approach plays a key part.

The program in building design can therefore be seen as one attempt at utilizing design when facing complex implications of the fast-growing sustainability agenda. The social sides of designing is translated into the collaboration between engineer and architect in the early design stages, but what is not so clearly pursued in this program are the social sides of sustainability linked to the acceptance and use of technological solutions. It would seem that the building design program's sustainability agenda could benefit from taking the extra step of ensuring not only the integration of aesthetic and technical concerns, but also the social.

2.2 Case 2 : Sustainable Design

It is not only within the building sector that the need for new engineering profiles has arisen. New products must meet increasing demands while development times are continuously cut down to keep up with the rapid technological developments. As a result engineers must be ready to engage in new multidisciplinary collaborations and take on new roles when it comes to incorporating technologies into larger societal contexts.

As many companies in Denmark have started to use design both in product development but also on a strategic level, several new programs combining engineering and design (in different interpretations) have started up. The case used here is aimed to strengthen the interplay between technology, sustainability, innovation, and design. This Sustainable Design program will include both a bachelor and master starting up in the fall 2013 at Aalborg University (the description here is thus based on the planning of the program).

The sustainable design program gives equal focus to technological insight, socio-material analysis and design synthesis (Det Teknisk-Naturvidenskabelige Fakultet 2013) and opens up for a broader interpretation of sustainability in engineering than the primarily technical and even environmental. According to the planners of the program this calls for acknowledgement of the multiplicity intrinsically linked to issues of sustainability. More specifically, they want their coming candidates to recognize that there is no unequivocal way of dealing with sustainability; no technology can by default be viewed as sustainable in itself; no approach can guarantee a sustainable result. In fact, engineers cannot – contradictorily to more traditional beliefs – ultimately determine the properties of technologies on their own. Informed by the fields of science and technology studies (STS) the program instead wishes to inscribe the conception that such properties are collectively negotiated across a number of actors – a process that continues even after the technology has left the engineer's drawing board and is taken into use.

Translated into curriculum it is first and foremost an integrated and experimental approach that is to provide the candidates with these new sets of competences. The classical engineering disciplines are grouped in new, more application oriented, ways in the individual courses and then actively utilized through team-based project work focused on solving real-world problems in a design dialogue with users and other stakeholders. At the same time the objects of design are shifted from the traditional devices or technical objects towards the systemic perspectives with all the heterogeneous actors and complexity that this entails. Instead of designing e.g. efficient cars the sustainable design engineer should rather design the transport *system* and focus on the implications on a whole.

According to the educational planners, the sustainable design program should be seen as a response to the general institutional reluctance to fundamentally update engineering education to better match the challenges of both present and future. The program is based on a design approach, which in effect breaks with the more traditional approach to engineering education. Critics will question whether these candidates turn out to be engineers at all as the integration of courses and project work makes it harder to discern the classical disciplines. But the motive is exactly to rethink the role of engineers in sustainable development and create new change agents that can enter into a broad range of enterprises and collaborate with anthropologists, technicians, designers, and users alike.

3 Reflections – The Role of Design in Sustainability

The two cases represent different approaches towards the integration of design in engineering profiles with the aim of creating candidates that are able to tackle the increasing demands of sustainability. The building design program is an example of how design elements are added to a classical engineering profession (in this case the civil engineer) in order to engage in a multidisciplinary reality. With the sustainable design program, on the other hand, educators are trying more fundamentally to rethink the engineering profile and role in order to create a new, contemporary, creative engineer.

In the following I point to three dimensions where the translation of design into engineering can potentially hold an important role related to a sustainably guided transition.

3.1 Solving Fluid Problems

Using the heterogeneous concept of sustainability to navigate amongst solutions when working to solve a specific problem it should be clear that 'the problem' is not a stable object. Problems too are constructed across collectives of actors with conflicting values and views and are therefore fundamentally indeterminate and fluid (Mulder *et al.* 2012). In order to deal with such wicked problems you have to take your point of departure in the concrete and local situation. Consequently it is also about time the sustainable engineer moves away from the well-defined, closed problems and towards the active participation in problem framing and structuring (Downey 2005).

This implies participation in the early design phases where uncertainties are tremendous and decisions have far-reaching impact on the final solution. Using design makes it possible to develop an understanding of the problem at hand through the solutions developed. Or as Lawson puts it: "we should not expect a comprehensive and static formulation of design problems but rather they should be seen as in dynamic tension with design solutions" (p.86, Lawson 1983). By 'testing' early design ideas the design situation will 'talk back', as Schön would phrase it, and provide a new dimension of problem understanding. However, this approach requires that you work iteratively and are ready to go back and re-frame the problem repeatedly as it unfolds. The engineer is unaccustomed to such a co-construction of problem and solution whereas it comes as a matter of course to most designers.

In order to engage in these early design stages the engineer must therefore be able to use his/her analytical skills for estimations and setting parameters, which the design team can then work from. The benefit is that such an early incorporation of technical aspects can help frame holistic solutions where sustainability is a fundamental guideline rather than a separate add-on thrown in at the end of the development process.

3.2 Engaging in Interdisciplinary Communication

The challenge of working with sustainability thus goes beyond merely thinking in solutions. When problems are constantly changing and being renegotiated in the specific design situations, then *communication* becomes a key competence. Engineers have in many respects been a relatively isolated profession with a reputation of being hard to communicate with for non-

engineers or scientists. Looking at engineering education at large it is also remarkably rare to find programs that attach any greater importance to issues of communication (exceptions are often found among the programs focusing on sustainability). Typically it is translated into students presenting or promoting their solutions at the end of a project. The communication I am talking about, however, starts long before any 'final' solution is ready. It is the day-to-day interaction inside and around a development team, which will more often than not span across and even outside professions to e.g. users when dealing with sustainable development. These collaborators may have different traditions of working, speaking, and attaching importance, which puts demands on engineers to both recognize the input of others as well as communicate their engineering knowledge to make it interesting as well as applicable for these collaborators.

Providing engineers with design competences are not about turning e.g. the civil engineer into an architect, but instead making them able to collaborate and communicate actively across their different disciplines. In the building design program it is thus attached with great importance that the candidates are forming an understanding of these other disciplines (primarily the architect's but also e.g. the contractor's), which their knowledge must engage with. Both programs furthermore incorporate a component of visual communication to aid the process.

3.3 Staging Sustainable Transitions

Increasing collaboration and communication across a sector such as the building sector is a good start, but it does not fully encompass the sustainability challenge as laid out in this paper. There is a need to think beyond technical solutions within the individual sectors and instead focus on a transition spanning *across* sectors. Issues of transport, for example, does not only involve the transport sector; it is not merely a question of making more efficient cars or better infrastructure. Instead, it also relates to how we live our lives, issues of mobility, congestion, health, time etc.

Staging transition processes at this scale is a new challenge for engineers and fundamentally changes the conditions for developing technological solutions. Physical products can no longer stand on their own but has to be seen in a systemic and dynamic perspective where surroundings and constellations are brought into the equation (Mulder *et al.* 2012). In the sustainable design program it is correspondingly acknowledged that what is seen as an acceptable solution is negotiated, not only across professions, but also across collectives of stakeholders, which effectively breaks with the existing structure of sectors. Therefore a fundamental participatory approach to design is included in the program, training students to engage with stakeholders at all levels and working with systems rather than products.

The reflected design practice could be part of a strategy to start preparing engineers for these types of complex challenges unfolding in unfamiliar territory for the engineering disciplines.

4 Conclusion

Engineering is a profession in constant progression and dependent on being at the forefront of development. At the same time it is gaining more and more recognition in the broader public that sustainability should be the overarching keyword for future development. In line with this, engineering programs working with the sustainability agenda in various ways have regularly seen the light of day over the past 20 years. In this paper I have discussed how such programs could be strengthened by the active incorporation of design.

With the two cases from the fields of civil and product engineering I have exemplified some of the advantages of linking design and sustainability. First of all, design thinking is a valid way of dealing with the tremendous complexity of sustainability issues in a productive manner. It can enable engineers to take part in not only problem solving but also in framing the problems. But engineering work is not done in isolation and a design approach can also help engineers become active collaborators alongside other professions and non-professions, even spanning across sectors. Being aware of the social dimensions of design work can make engineers stronger

communicators and better at understanding and incorporating new types of input in their work. Using a reflected design approach thus promises to strengthen the impact of engineering solutions. With a new eye for the socio-material dimensions of a solution in its context of use, for the cultural traditions and boundaries a solution must respect, and the larger socio-political systems in which a solution must enter into and function, engineers can facilitate their technical knowledge much more constructively. Together with many other professions engineers can thus help design the sustainable solutions of tomorrow.

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