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DISCURSIVE CONSTRUCTIONS OF DESIGN AND IMPLICATIONS FOR ENGINEERING EDUCATION

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ABSTRACT
Recognition of design discourses at play in professional practice is key when discussing ways to reintroduce designerly ways in engineering education.
This paper outlines three design discourses discussed in literature and mirroring contemporary design practice: Viewing 'design as art' upholds traditional ties to the arts and craft tradition, where individual designers work with tangible form and aesthetics. Perceiving 'design as problem solving' focuses on the process viewed as a collective search for solutions. In 'design as dialogue' this is extended to a reflective practice where the designer is co-developing problem and solution.
From these discourses we learn that different professions practice and interpret design differently. No one discourse can capture all perspectives of the heterogeneous design notion, but instead highlight diverse qualities of good design practice.
Based on the discourses discussed, three key elements of design are highlighted: the materiality, the social, and the reflective sides of designing. All of these elements are represented in the issues of communication, which can be a central focus area when taking a designerly turn in engineering practice.

Keywords: design discourse, design education, design engineering, communication

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1 INTRODUCTION

'Design' is a foreign word in most languages and finds new interpretations in its many applications. But when discussing 'design' people (scholars and layman alike) tend to do so from a very situated point of view, most often without recognizing that their own perception of design may not correspond equally well with that of others. However, fact remains that as large and heterogeneous as the design community is, there is a similar abundance of design discourses at work across it.

1.1 A Linguistic Definition

The originally English word 'design' builds on the Latin word *designare*, meaning to designate or mark out/plan (Oxford Dictionaries, 2010). This English word has now spread to just about every other language in the aftermath of the industrial revolution.

One of the special capacities about the word 'design' is that it denotes both a process (as a verb, *to* design) and the result of that process (as a noun, *a* design). But beyond that, meanings are plentiful as to what that process might entail and what sorts of outcomes can be termed designs. The linguistic definition holds that *to* design is to "decide upon the look and functioning of (a building, garment, or other object), by making a detailed drawing of it" and *a* design is "a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made" (Oxford Dictionaries, 2010). This definition is quite symptomatic for the general discourse on design found in the public domain, but it also quickly leads to a rather one-dimensional understanding of design as nothing more than a "cosmetic layer" (Den Store Danske (2009), translated from Danish).

1.2 Design Professions

The professions utilizing design in their work practice, on the other hand, span widely. People with design titles can come from as diverse careers as fashion design, industrial design, architecture, systems design or engineering. But even though all these professionals may use design to describe their work, the way they practice this work shows significant differences (though it is often the similarities that are highlighted). It may even come to considerable controversies and disagreements when they meet in a design project.

To try to create consensus on one common understanding and practice of design across all design professions seems a meaningless and unproductive endeavor. Design is not owned by any one profession or one domain - it is shared by many and works under different conditions in different contexts. For something in such a state of heterogeneity and flux it seems more fruitful to acknowledge the breadth and actively learn from the experiences and developments happening in other parts of the design professions. My aim here is therefore not to introduce a new definition of design or generalize but rather to introduce an understanding of design ranging across and in interplay with different discursive constructions.

1.3 Preparing Future Designers

A discourse is not necessarily linked to a specific profession, but it is often institutionally bound, which is why certain discourses tend to dominate within certain fields. As such, the educational institutions are also primary agents in promoting and fostering certain discursive understandings in their students.

Most of the students applying for an engineering education do not see themselves as future designers but rather as technical problem-solvers. Educational planners considering introducing elements of design in engineering programs should therefore consider how such elements are communicated and perceived. This is no simple task, but the discourse perspective presented here can be of use and help bring words and light to some of the differences in perception a designer might come across.

In an attempt to rethink what some would call the *designerly* (Archer, 1979; Cross, 1982; Cross, 2006) dimensions in Danish engineering education, this paper thus looks at three such design discourses dominating in, around, and at the boarder of the engineering design practices: *design as art*, *design as problem solving*, and *design as dialogue*.

2 DISCURSIVE CONSTRUCTIONS

In reality, what the encyclopedias tell us about the meaning of the written word is one thing, but how a notion such as design is actually practiced and inscribed in various objects can go so much further. Using a discourse analysis can help bring this variety into light.

The notion of discourse is widely used, though without much agreement of what it is or how it should be analyzed. In the linguistic tradition, for example, a discourse analysis would include a minute exploration of relations between individual sentences and statements. The understanding utilized here, however, was primarily coined and implemented by Michel Foucault. This understanding has its epistemological roots in the social constructionist break with the idea of Truth (e.g. such as can be looked up in an encyclopedia) and in stead focuses on the historical, cultural and situated nature of both knowledge and social practice.

Discourses are then viewed as sets of culturally assembled representations of reality that are produced and reproduced in particular social practices. Such articulations have a strong meaning-making role influencing what is perceived as meaningful within a given community of practice. Applying a discourse perspective can thus help us better understand the variants and controversies linked to design as we find it in the real world.

The paper is based on a review of academic texts discussing aspects of design from different views. This review has been done in connection with a multi-sited ethnographic study of engineering practices that are incorporating design and related educational initiatives found in Denmark. The ethnographic study will not be the focus in this paper, but forms part of the original basis for selecting these three discourses for the present discussion. The review is focused on exemplifying and tracing the discourses, thus building a more comprehensive understanding of their individual lines of argument.

2.1 Design as Art

The roots of design go back to the arts and craft tradition where aesthetics and essence on the one hand and craftsmanship and technique on the other are put front and center. Even today these are some of the most recognized qualities attributed to design in the general public and the most widely recognized discourse is therefore also to see *design as art*. Perhaps this is especially true in regions with a strong design tradition, such as the one you find in Scandinavia. Ask any man or woman on the street to give an example of a design and they will most likely highlight one of the furniture classics such as the Swan chair by Arne Jacobsen, the PH-lamps by Poul Henningsen or some more contemporary examples from the same design tradition.

Within the fine arts there is a strong focus on subjective values expressed through aesthetic choices of materials, colors, and shapes and the receiver of these artful expressions are primarily perceived as a beholder more so than a user or even participant (though you may find art traditions aiming to include their audience to a greater extent). The same can be said for some areas of the design world.

2.1.1 Focus on Tangible Form

Focus within the design as art discourse is thus on tangible form that artistically integrates both aesthetics and function. Design schools consequently focus much of their training on the appreciation for material and space needed to accomplish this. It is hence the design object, or the resulting material artefact, which is highlighted as the uniquely designerly characteristic (Brix and de Gier, 2011).

This strong focus on form is also emphasized in the traditional Danish word 'formgivning' (translates roughly to form-giving) used to denote the design activity before the entry of a more English vocabulary, yet still used to define the meaning of 'design': to design is basically understood as giving form to something. The Danish professor Anders Brix from the Royal Academy of Fine Arts, Schools of Architecture, Design and Conservation, for instance suggests this definition: "Design is to synthesize complex prerequisites into artistic form" (p. 2, 2010). 'Artistic' here translates to "appropriate, novel and exciting" form (Brix, 2010), which are certainly labels you could put on any of the design classics mentioned above.

2.1.2 Individualistic Identity

The design as art discourse is especially rooted in what you might call the traditional design professions such as fashion design, industrial design, and architecture. Here is also where we find the design icons – those iconic design objects clearly recognized in silhouette or those great individual

designers (lately also duos) with a signature style known and loved by many. Such individualized style and brand value again draws strong links back to the artist in fine arts (Coyne and Snodgrass, 1991).
In an institutional context the design as art discourse tends to promote an individualistic, artistic recognition of the designer at many traditional design schools. Viewed critically, this only produces individual designers striving to be the new 'Starck', the new icon, which in many cases leads to a production of unemployed designers unable or unwilling to adapt to the dynamic needs of the industry. This individualistic identity does so far not succeed in informing designers on the range of contemporary issues playing a significant role in successful design, such as social, cultural, economic, psychological, and ecological issues (Nay, 2009).

2.1.3 An Amorphous Notion

One of the great challenges about understanding design as art is exactly how to separate the two. As Lawson points out: "The products of design are frequently seen by the public as artistic, even sometimes actually as 'works of art', and designers themselves are indeed also often artists" (p. 63, Lawson, 1983). He suggests the distinction that "Design is directed towards solving a real world problem while art is largely self-motivated and centers on the expression of inner thoughts" (p. 100, Lawson, 1983). A fine line between art and design is thus maneuvered when the functionality starts fading from the objects of design.
In Scandinavia the notion of design has long been understood as more or less synonymous with aesthetics and form as reflected in the notion of form-giving. But the broader meanings implied in the English word is starting to gain influence. However, many subscribers of the design as art discourse are worried about this so-called expanding notion of design. In their view the notion of design is now up for grabs by anybody, regardless of them practicing design in tangible form or as immaterial concepts (e.g. in service design or experience design), which does not abide to the aesthetic and form-giving principles of design as art (Brix, 2010).
Opponents of the discourse, on the other hand, claim that clinging to the art-link also preserves an element of mystery, a legitimization of the subjective, which makes it harder to evaluate the resulting designs and effectively removes design from the context of everyday life. The emerging traditions of participatory or co-design has been one type of response to deal with this gap between design and daily use.

2.2 Design as Problem Solving

In the engineering professions the design discourse springs from quite a different background than the artistic. The roots can here be found in the scientific, polytechnic tradition within the fields of construction and product development, which took off with the technology excitement after World War II. 'Design' as such was not part of the engineering vocabulary, but you can find a clear wish to develop a better understanding of technical constructions and their functioning and optimization through the application of mathematics and natural science (Heymann, 2009). In this realm of understanding design is typically seen as *problem solving*.
During the 60ies the design perspective starts emerging in the engineering curriculum as part of the construction subjects, most notably in the mechanical tradition. This also led to a more systematic description of the construction processes and phases. Several books of formal engineering design methodologies subsequently emerged in the 80ies (e.g. Hubka and Eder, 1982; Pugh, 1991; Cross, 2000). These prescriptive models are symptomatic of an instrumental understanding (also to be found within other professions) that any problem solving activity warrant a method – in fact inert qualities of design problems will warrant the use of specific methods to solve them. Design problems are thus juxtaposed with scientific problems and the methods are greatly inspired by the logic and objectivity of scientific methods.

2.2.1 A Search for Solutions

The problem solving discourse therefore links to the felt need within parts of the design community to develop a disciplinary science base for design, moving away from the mystery and developing "a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process" (p. 113, Simon, 1996) - or a *science of design*, as Simon advocates. Taking his offset in the realms of artificial intelligence, Simon coins the wide-ranging design paradigm of rational problem solving, suggesting that: "Everyone designs who devises courses of action aimed at changing

existing situations into preferred ones" (p. 111, Simon, 1996). This focus on 'courses of action' underlines that the problem solving discourse is not nearly as bounded by the material as the art discourse, but rather focus on a cognitive process (Visser, 2009). Focus is thus on the methodic process of design*ing* an output; a search process for solution(s) (Dorst and Dijkhuis, 1995). This process is typically seen as consisting of a series of activities and successive stages, giving it a linear structure with a start and a finish and outputs to be handed over to the next stage (an example can be found in Ulrich and Eppinger, 1995).
The understanding of the problem to be solved is in this process assumed to be relatively stable and to outline a solution space within which the designer should search for the right solution (Dorst and Dijkhuis, 1995). Emphasis is put on the design decisions that must be made throughout this search, often linked to lists of design criteria and constraints. In Simon's interpretation this is a rational, logic process, if a complex one at that, which is also reflected in many of the methods linked to this discourse, such as making morphological charts to examine different combinations of sub-solutions a technology be might be constructed from (Cross, 2000; Pahl and Beitz, 1984).

2.2.2 A Collective Effort

The design objects that engineers work with are typically very complex and incorporate knowledge from several professional domains. Perhaps therefore we find an acknowledgement in the engineering profession that the individual cannot handle the design process on his or her own. Even though individuals may be proclaimed as the inventors of a certain technology, there is a strong tendency to see the search for solutions more as a *collective* effort, differentiating the problem solving discourse even further from that of art. This effort can be organized within a team of professionals (who may or may not have explicit ties to the design profession). With the collective efforts also comes the possibility of distributing responsibilities and introduce the scientifically inspired concept of 'experts' or 'specialists' having particular knowledge within specific parts of the solution space.

2.2.3 Designers as Consultants

To this day design as problem solving is the discourse dominating the majority of engineering schools, whether the design aspect of engineering is openly prioritized or not. Any attempt at characterizing engineers will end up something along the lines of 'problem solvers', equipped with a toolbox of different methods to apply to different types of problems. But one of the challenges about seeing design as problem solving is the role attributed to the designer. Downey (2005) calls it a danger of becoming society's consultants: the (engineering) designer adopts a role of being "there to help but only when asked". Within this discourse the designer does not assume an active role in identifying what problems to throw their problem solving abilities at. Instead it subsumes that the designer is presented with well-formed problems to solve and not the messy, ill-structured and often poorly understood problems that designers will usually face.
In this light, one may start to question whether engineering education is succeeding in preparing their students to face the complex, intertwined, unstable, and ever conflicting reality awaiting them at the other end of their education.

2.3 Design as Dialogue

It is not only within the engineering community that design has been an 'object' of study. Informed by the social sciences several researchers have taken a different road to open up the black box of design. As one of the first, the organizational learning theorist Schön (1987; 1999) introduced the idea of design as a "reflective conversation with the design situation". His work has been very influential on forming this third discourse seeing design more as a way of thinking and engaging in the design process - seeing *design as dialogue*.
Schön's emphasis of the design situation brings another element into the understanding of design than the previous discourses – it is not a tangible object, not a process with a start and finish, but it is a *situation*, which is influenced by many elements (context, history, people, materials etc.). This suggests a more interactive relationship between the designer, the design object, the situation, and the other participants in that situation (be they clients, colleagues or e.g. users). 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.

2.3.1 Dynamic Design Problems

In the design as dialogue discourse it is openly recognized that design does not move along a linear line from analysis to synthesis or from problem to solution. The process of dialogue is a more diffuse process than that of the rational problem solving approach and moves back and forth between different domains as the design problem(s) and solution(s) are co-evolved and continuously up for revision (Dorst and Cross, 2001; Downey, 2005). This idea of exploring a problem through different solutions was first suggested by Marples: "The nature of the problem can only be found by examining it through proposed solutions" (p. 64, Marples, 1961).

The point is that a design problem is rarely completely stabile in its definition once the design process takes off. Or as Lawson (p. 86, 1983) 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". By 'testing' early design ideas the design situation will 'talk back', as Schön would phrase it, and provide a new dimension of problem understanding, which requires that you work iteratively and are ready to go back and re-frame the problem repeatedly as it unfolds.

The dichotomies implied in the problem solving discourse separating problem from solution, analysis from synthesis, are thus being challenged: "By engaging in design activity at the outset a designer can gain an understanding of what information is actually required and what the site or context is capable of sustaining" (p. 130, Coyne and Snodgrass, 1991). Synthesis and analysis starts to blend together, making both problem and solution clearer as the process goes on.

2.3.2 A Language of Design

The medium of dialogue in design is important to note here as well. Design as dialogue does not take place through rhetoric and words alone, but is more often than not accompanied or even conducted through a visual medium (Brown and Wyatt, 2010; Schön and Wiggins, 1992).

Sketching on a piece of paper (or e.g. using a computer assisted tool) is an activity of exploration of the design (problem and solution alike) and ideas evolve along with the lines on the paper. "As a designer draws, and sees what she has drawn, she makes discoveries" and develops "an understanding of the problem of the design situation" (p. 155, Schön and Wiggins, 1992). But the materiality of the paper also allows the capture of fleeting ideas to be returned to or shared with others (Ferguson, 1992). The same can be said about physical models, which even in quite simple forms can contribute a lot to a design dialogue.

Many have discussed why the visual medium holds such great importance in the design process (e.g. Ferguson, 1992; Henderson, 1999; Schön, 1999). Overall you may say that the visual language enables a different type of dialogue and exchange than the codified, verbal or written language. There are simply types of knowledge in the design process that cannot be communicated through words alone. As such we may appreciate visual representations as an important design language to be mastered by the designer, also linking back to the artistic roots of design.

2.3.3 Design Worlds

Notions such as 'object worlds' and 'design worlds' can help us understand the exchange that takes place between the individual and the design situation. The individual's understanding of the situation is developed in continuous dialogue and confrontation with that of others, but is constantly referred back to personal past experiences etc.

Bucciarelli uses object worlds to denote the engineer's realm of understanding regarding the object he or she is working with: "These frames are constructed on the job, within the firm, as well as in the schools" (p. 162, Bucciarelli, 1988). The object world is thus a personal, but not a purely subjective construction as it is both academically and vocationally grounded.

Schön has coined the similar notion of design worlds to denote the ontological worldview that a designer operates within: "designing is a communicative activity in which individuals are called upon to decipher one another's design worlds" (p. 4, Schön, 1992). Such worlds are constructed through the interaction with materials and prototypes in the design situation and can be shared by more than one designer.

When practicing design as dialogue the individual design participants must interpret each other's design worlds and gradually create consensus around a common understanding. Lawson also recognizes this social dimension: "The relationship between client and designer itself actually constitutes part of the design problem. The way that designers perceive and understand problems is to

some extent a function of this social relationship" (p. 66, Lawson, 1983). He also points out that designers from different professions will often see different *types* of solutions to the same design problem. This comes as no surprise if we, like Bucciarelli, understand the designer's worldview as partly framed by both education and professional experience.
Educators could therefore benefit from thinking about the design worlds that their programs are shaping as well as those their students will have to engage with in the design dialogue with other professions. These worlds should be flexible enough adapt to each specific design situation with all the different materials, collaborators and views these contain and still tough enough to promote the engineering knowledge.

3 DISCUSSION

In this paper I have outlined three of the different design discourses circumscribing the design professions. The problem is not that such different discourses exist, but rather that their existence and implications are not openly recognized and articulated within and across design educations and consequently remain so across the professions. The different design professions have interests in and are trained for different types of design work, but through that work they will also meet each other, and with their colleagues they will meet these different design discourses over and over again in their professional lives.
The purpose of bringing such discourses to attention here is to actively reflect on what they each bring to light regarding the practice of design and how this might be made useful in an educational context.
I am not the first to highlight these aspects as particularly crucial for design. The now widely renowned INDEX: design award was founded in 2002 in Denmark to promote Danish design, but more importantly to break with the established tradition of "designing white tea cups and in stead focusing [designers'] creative skills on more pressing issues" and promote *design to improve life* (INDEX:, 2012). Three parameters are used to assess the designs' ability to do this: Form, Impact, and Context. With these three parameters we find indications of the three discursive constructions of design presented in this paper – an indication that they each have important dimensions to bring to contemporary design. The traditional design as art discourse is evident in the Form parameter, which is concerned with "color, material, aesthetics, surfaces [–] what you can touch and feel" (Hvid, 2012). The Impact parameter, on the other hand, leans on design as problem solving. Here the concern is how the design improves or addresses a challenge. The final parameter addresses Context, the fact that a design does not work in isolation in the real world, but has to function in a complex interplay of culture, geography, ethics, and society (Hvid, 2012). These are not easily dealt with or integrated in a design process, but requires the reflectivity Schön calls for and the dynamic, interactive approach outlined in the design as dialogue discourse.
Seen from an engineering education angle I will here focus on three recurring aspects that are important to sustain and develop when taking a designerly turn in engineering practice: the materiality, the social, and the reflective sides of designing.

3.1 The Materiality of Designing

These days the materiality of design is being challenged by the fact that our objects of design are shifting from physical artifacts to being just as much services, systems, and experiences. Looking across the discourses outlined here we also see different discursive constructions of the objects of design. In design as art the design object is typically the physical artefact (e.g. the exterior shape and material of a building), in design as problem solving the design object is instead articulated as a solution (e.g. the structural elements of a building), whereas in design as dialogue the design object is moving towards a social practice (e.g. the interaction in and around a building). At the same time the design process, like most other work process, is integrating more and more IT and web based tools. So it would seem the gab between our contemporary designers and the original craftsmen is widening even more. But why then is it important to maintain the material dimension?
Part of the answer to this question lies in the notion of *context* introduced above, but unlike INDEX: I would like to also highlight the context of the design process itself. In any design process there are important material elements acting in the design situation alongside the human actors and discourses.
Even though a design is focused on an immaterial service or experience, there will still be material objects involved in the design situation. Unlike spoken words or gestures then physical sketches created at a team meeting represent the reflective conversation that took place and can be carried to a

different setting or time to revive this dialogue again. Thus we may question what *types* of materializations are being produced in the design situation in order to make the design stabile, both in time and across the collective of actors taking part in the situation. But also how these materializations enter as communicative objects in the design process.
In education the materiality of designing should not be overlooked or diminished, not just because of the traditional ties to physical design artifacts, but because the material and visual domain provides different forms of representation and communication than the strictly codified, be it by words or numbers. Materials are able to seize conditions that cannot be worded or captured by the formal disciplines, but nevertheless hold a central part in designing (Ferguson, 1992; Henderson, 1999).

3.2 The Social Sides of Designing

With the introduction of both the collective design effort and the design situation we are also made aware that designing is not something done in unison but is, as Bucciarelli (1994) calls it, "a social process". Educations therefore need to reflect this social side of designing in the programs and cultivate a dynamic practice amongst the future engineers.
Designers of today never work in complete isolation, but are rather navigating a network of other actors. Bucciarelli points out that during the design process the design therefore only exists in a collective sense – no one individual will be able to describe or define it all. Not even the formal drawings or diagrams can be taken for *the* design, but rather interim social agreements: "Artifacts are constituents of design, but like the dictates of a written constitution, they symbolize agreements, are capstones of social exchange and negotiation" (p. 168, Bucciarelli, 1988).
The typical response from engineering education is to introduce team-based work, which is intended to provide the students a sense of how it is to work in an engineering design team. The team, however, is but an organizational structure imposed in order to facilitate or tackle the delicate social interaction. This organization of teamwork builds on different traditions within different fields and therefore we will find quite different ways of working in teams among e.g. ethnologists and engineers respectively. As an organizational frame, teamwork alone is thus not enough to foster the social sides of designing. Instead, working towards an understanding of the material objects discussed above, the way they facilitate communication, and how they incorporate social elements may be key.
But the social sides do not only take place internally in a team – designers will also interact externally with stakeholders or other collaborators at different levels. The social sides thus involve creating or staging the space where designer and e.g. user can meet and engage in dialogue (see e.g. Clausen and Yoshinaka, 2007).

3.3 The Reflective Sides of Designing

We may all agree that a truly successful design process results in a design, which is subsequently used and incorporated in an everyday practice. Not a design collecting dust on a shelf or exhibited in a frame for its aesthetic qualities alone, but one that is used and successfully *domesticated* (Silverstone et al., 1992). How to accomplish this is what researchers in design fields have put much effort into uncovering.
When looking across the discourses presented here one thing that comes to light is the difference attributed to the person appropriating the design. In the art tradition this person is primarily seen as a *beholder* that is kept separately from the design. This person does not really exist until the design is finished and ready to be grabbed off the shelf. Within the problem solving discourse it becomes clearer that the person is a *user* looking for a certain function in the design. This need for a function is then what the engineer works to provide. Finally, in the dialogue-based discourse, this person can be seen as another *participant* in the design situation contributing to the dialogue, which might be accomplished through various participatory design approaches. The practice of use is thus not seen as a separate thing from the design object, but as co-constructed right along side it and through it (see e.g. Oudshoorn and Pinch, 2003).
Using a reflected design approach can in this way strengthen the impact of engineering solutions. With an 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. For educators this means that the scope of what constitutes engineering practice must be widened to include the reflectivity that will enable future engineers to better deal with the open, complex problems

at the intersection with other professions and non-professions (such as users) and translate all this into something designable.

4 CONCLUSION - DESIGNERLY IMPLICATIONS

A quick look on the curriculum, structure and visions guiding most engineering educations today will tell us that the designerly elements of materiality, sociality, and reflectivity are not a priority. At the same time industry is starting to look for candidates with other qualifications than the merely scientific. There is a need for candidates that are able to look beyond the 'standard solutions' of traditional engineering disciplines, candidates that understand how to interact in inter-disciplinary contexts, and candidates that can tackle the emerging social implications of new, complex technologies (Jørgensen et al., 2011).

Engineers have in many respects been a relatively isolated profession with a reputation for being hard to communicate with for non-engineers or scientists. However, if engineering designers are to be able to engage in design as a situation of dialogue then they must be able to understand, navigate, and translate what others in the design situation say and do. One consequent implication for the future of engineering education is therefore how the issues of *communication* will be treated. Looking at engineering education at large it is nevertheless remarkably rare to find programs that attach any greater importance to issues of communication. Typically it has been translated into students presenting or promoting their solutions at the end of a project. But the type of communication, which is important in the design situation, is rather 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. It is a way to merge design worlds, to bridge gaps in understandings, to negotiate the continued development of both problem and solution, and to plant the seeds of successful domestication – all of this from the very beginning (or perhaps even before) a development project starts up.

In engineering education it is fully recognized that students will not acquire their scientific understanding of the engineering disciplines from a single semester course. Instead mathematics and natural science can be found across the entire curriculum at all engineering schools.

If we want to start taking the *designerly ways of knowing* (Cross, 2006) seriously in engineering education, as something extending beyond scientific knowledge, then we must also accept that it cannot be accomplished through one or two add-on design courses. Rather, it requires an experience-based learning process dependent on repetition and continuous reflection across the curriculum, enabling students to communicate in a *reflective* design practice with and through both *social* and *material* elements alike. Enabling them to practice engineering in a contemporary world.

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