# DESIGN QUESTIONS FOR LIFE: CONNECTING ENGINEERING DESIGN, APPRECIATIVE INQUIRY, AND OTHER QUESTION-BASED MODELS

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## Abstract

The "Design for Life" philosophy is an invitation to create new products,services, processes, and experiences that enhance human life. Research further suggests that a good life is qualitatively different than simply not having a bad life, and implies that the inquiry process during design is important.
However, current engineering design approaches are not particularly clear as to which specific design questions should be used in the design process, and even less as to the role various design questions might play. Some of the current approaches even seem to use questions that inhibit Design for Life due to their strong emphasis on only solving deficiencies.
This paper aims to highlight the unexplored potential of a more deliberate choice of design questions in the engineering design process. By mapping out four question-based design models and analyzing their differences in relation to the traditional engineering design process, an overview of design question types and their various sequences is produced. The analysis further highlights practical implications and potential gains when it comes to choosing design questions more deliberately in the engineering design process.

**Keywords**: Design theory, Design management, Human behaviour in design, Appreciative Inquiry, Question Theory

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# 1 INTRODUCTION

Design for Life is an invitation to create new systems, products, services, processes, experiences and transformations that enhance human life. Whether it is for a more contented life, a healthy life or a sustainable life, Design for Life is about contributing to, and expanding the possibilities for a good, and even flourishing, life. Research in psychology (Seligman, 2012) suggests that a good life requires qualitatively different elements than the absence of a bad life, just as the research of Kano et al. (1984, 1996) suggests that "attractive quality elements", which contribute to satisfied feelings, are qualitatively different than "must-be quality elements" that reduce dissatisfaction. Thus a process focused on Design for Life should include the inquiry into, and creation of, good life enablers and attractive quality elements, and not simply solve what is negative. In other words, the design questions used when designing for life need to reflect and inquire about "problems" related to both negative and positive gaps, as formulated by Basadur et al. (1994).

However, the current engineering design approaches are not particularly clear on which questions should be used in the design process, and even less so the role different questions can play, implicitly or explicitly. Although the need for further research in this area has been argued historically, by e.g. Eris (2003), the topic appears to remain as one understudied. This is somewhat surprising given that design and new product development can be understood as a process of knowledge management or learning (as elaborated by e.g. Carlile (2002) and Goffin and Koners (2011). A process strongly driven by curiosity, a sense of wonder, and a continuous ability to question and challenge the existing status quo, which ultimately gives rise to the generation of new relevant knowledge in areas such as customer needs, perceived benefits of competing products, and alternative design solutions. Consequently, the questioning and the specific questions asked during the design process are likely to be critical for successful engineering design. It could be the challenging question looping in the mind of the individual designer which gives guidance to a specific new solution; it could be the explicit curious question asked directly to a customer in search for critical insights; or the "calling question", which attracts resources and stakeholders to realize the specific solution´s intention and potential. Sticking to this "learning metaphor" of engineering design, it is reasonable to assume that the questions asked during the design process will strongly determine what comes out of this process, similar to how, for instance, the formulation of the research question has proven to be absolutely crucial in the process of research as argued by e.g. Alvesson and Sandberg (2011). The questions asked during design processes have for example, a definite role as a driver of the overall design process, and in providing a lens or focus for adequate learning and ideation to take place. Recent thinkers such as Berger (2014) also suggest that as expertise is now losing its "shelf life", as a consequence of massive information volumes becoming easy accessible to everyone by super-search-engines, the value of framing questions and perceptive questioning is rising, and will continue to rise in the future. Consequently, bringing the currently implicit construction and choice of design questions for engineering design more explicitly into the spotlight is of great importance.

In doing so, this paper explores what roles various design questions actually can play in the engineering design process. By mapping out four explicitly question-based design models and analyzing their differences in relation to the traditional engineering design process, an overview of design question types and their various sequences is produced. The analysis further highlights practical implications when it comes to choosing design questions that enable a Design for Life, but also for increased innovation and increased workforce engagement as well as for clarifying the direction when going into and during the design process.

Consequently, this paper highlights the belief that a better, more explicit use of design questions is potentially a hidden key for successful engineering design. More specifically, the utilization and construction of design questions inspired by positive deviance research, such as that related to Appreciative Inquiry and positive organizational scholarship, is a potential key for successfully accomplishing a Design for Life.

# 2 APPROACHING THE DESIGN QUESTIONS

Engineering design literature and models are not very explicit about the actual design questions used in the process. Instead, the existing process models of engineering design appear to focus on prescribing the "stages" or main activities of the design process, typically four to eight, with names such as "Strategic Planning", "Ideation" or "Concept Phase". For example, a large number of such

stages and main activity descriptions are seen in the overview of 23 process models of engineering design as summarized by Howard et al. (2008, p.163), where, for instance, the classical and frequently used model of Ulrich and Eppinger (1995, 2012) is included. That specific model can be used as an example of a typical product development or engineering design process model with its division into six phases as seen in Figure 1.

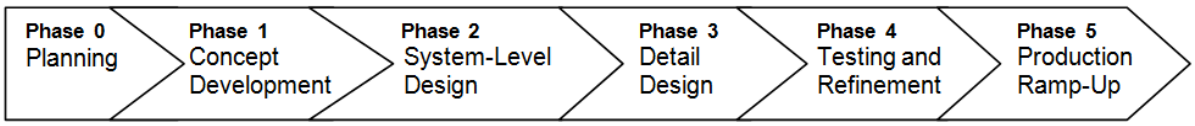


*Figure 1. Typical phases of the product development or engineering design process model (from: Ulrich and Eppinger, 2012).*

## 2.1 The Design Questions of Engineering Design

The focus in this paper is however not on the name of the phases, nor typical tasks, but rather the actual design questions that drive each of these phases. As the model does not explicitly provide them, the designers have to find and formulate these design questions by themselves. Such a search and formulation of the actual design questions of the process model of Ulrich and Eppinger (2012) would then result in individually decided questions. The resulting design questions would probably end up somewhat similar to the ones formulated in Table 1. As argued, it is hard to provide one answer here, as the model by its nature does not explicitly give any actual design questions. If these play such an important role, then this is an area of possible improvement.

*Table 1. A mapping out of possible design questions in the process model by Ulrich and Eppinger (2012).*

| **Phase of Engineering Design** According to Ulrich and Eppinger (2012) | **Core Design Questions Identified** Implicitly given by the phase model of Ulrich and Eppinger (2012) |
|---|---|
| Phase 0: Planning | WHAT are the target market, business goals, key assumptions and constraints for the product to be? (Mission Statement) |
| Phase 1: Concept Development | WHAT are the needs of the target market?<br>WHAT alternative product concepts can meet these needs?<br>WHICH of the product concepts should be selected for further development and testing? |
| Phase 2: System-Level Design | HOW should the product be designed on a system-level? (When it comes to product architecture, subsystems, components and a preliminary assembly/production process?) |
| Phase 3: Detail Design | HOW should the product and production process be designed in detail? (When it comes to product geometry, materials, cost and the assembly/production process?) |
| Phase 4: Testing and Refinement | HOW well does the product design actually satisfy key customer needs?<br>WHAT engineering changes are necessary to secure the performance, reliability and durability of the product design before launch?<br>WHAT refinements are necessary in the fabrication and assembly processes? |
| Phase 5: Production Ramp-Up | HOW should the intended production system, and workforce, be trimmed and trained to secure product launch? |

## 2.2 How "Design for Life" Calls for New Design Questions

The "Design for Life" invitation stresses the importance of taking a systemic approach to both the human being and the planet. Also, the invitation encourages enhanced designs that not only eliminate deficits but also create new possibilities. Seligman's (2012) research in the science of a good life shows how the removal of pathology only created a contented life, whereas the optimization of specific elements of a good life (i.e., positive emotions, engagement, relationships, meaning and purpose, and accomplishments) could create a flourishing environment for humans, that is, an opening up for new levels of life that goes beyond content.

This finding corresponds with the research of Kano et al. (1984, 1996) who suggest that in a product the "attractive quality elements" which contribute to satisfied feelings, are qualitatively different than the "must-be quality elements" that reduce dissatisfaction. Similarly, Oliver (2010) remarks from a psychological point of view that "restoration" and "enhancement" are two special cases of reinforcement that both need to be taken into account when understanding and contributing to satisfaction, as seen in Figure 2. Imagine first the hedonic neutrality in the middle of the figure, that means a customer at rest, which implies a sort of contentment, a state of passive satisfaction in which all needs are met. On the agenda of Design for Life is then of course the issue of understanding and addressing "restoration" of life or the "deficit zone" below the horizontal line in Figure 2. That refers to the process of accurately understanding and addressing those deficits from neutrality, which when achieved, normally brings with it a feeling with relief for the customer. However, on the agenda of Design for Life must also be the understanding and addressing of "enhancement" of life which takes place above the horizontal line in Figure 2, in the "Surplus zone". Enhancement then refers to additions to the customer's state of contentment. Such a reinforcement provides, according to Oliver (2010) a different sort of satisfaction, for the consumer's life is enriched, not restored, and results in giving the customers feelings such as pleasure, joy, and perhaps even elation and delight.

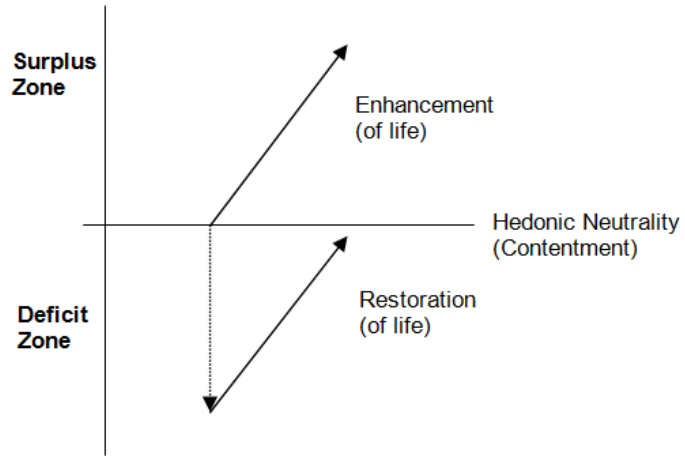


*Figure 2. An illustration of the two basic types of reinforcements needed to be understood and addressed when designing for life (modified from: Oliver, 2010, p.139).*

In sum, a design process focused on Design for Life must reasonably include an inquiry into both the "Deficit Zone" and the "Surplus Zone" of Figure 2. Only by such an inquiry may the process contribute to the creation of good life enablers, "enhancement" of life and "attractive quality elements", in addition to only solving or restoring what is negative, must-be, or deficits. Another way of putting it is that the design questions used when designing for life need reasonably to reflect and inquire into both negative and positive gaps, as formulated by Basadur et al. (1994). These arguments show how engineering design needs explicitly considered design questions in order to realize Design for Life, whether being design of complex systems for humans and the planet or being design of hedonic surplus.

## 2.3 A Closer Look at Question-based Design Models

In this section, four explicitly question-based design models are introduced as a source of inspiration for analyzing and discussing the possible role and use of design questions in engineering design. One of these, which was developed recently, is the design for the growth process model presented by

Liedka and Ogilvie (2011). In this model, the authors try to describe the essence of design thinking for managers who want to create innovative solutions, by the model illustrated in Figure 3. The model moves beyond activities and phases as it is question-based and organizes the entire design process into a framework of "what is? what if? what wows? and what works?".

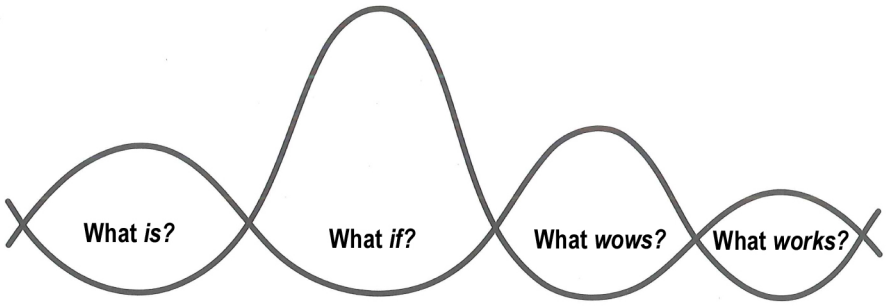


*Figure 3. The "design for growth" process model (from: Liedka and Ogilvie, 2014, p.13).*

Another recent contribution to explicitly question-based design process models is presented by Berger (2014). He puts forward a three-step design sequence of inquiry based on his studies of how the world's leading innovators, entrepreneurs, and creative thinkers ask questions, generate novel ideas, and solve problems. The sequence is seen in Figure 4 and the questioning follows a pattern of 1) Person encounters a situation that is less than ideal; asks why? 2) Person begins to come up with ideas for possible improvements/solutions - with such ideas usually surfacing in the form of What If possibilities. 3) Person takes one of those possibilities and tries to implement it or make it real; this mostly involves figuring out How.


*Figure 4. The Why/What if/How sequence of design (from: Berger, 2014, p.32).*

A third design process model that is explicitly question-based is the "four stage eight step process" of Basadur et al. (1994, 2000, 2011). This model puts a strong emphasis on developing the early phases of the innovation process and the matter of problem formulation by systematically asking "Why?", "What is Stopping…?", and "How might we…?" questions as seen in Figure 5.

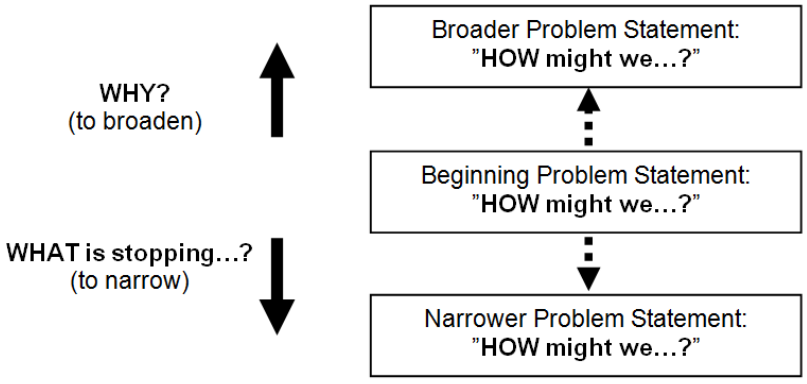


*Figure 5. The questions of Basadur placing problem statements (modified from: Basadur et al., 1994, p.635).*

Finally, Appreciative Inquiry (AI) is another question-based design approach that has been used for organizational development (Cooperrider and Srivastva, 1987; Bushe and Kassam, 2005; Cooperrider

and Whitney, 2001; 2005) as well as for a strength-based leadership perspective (Brun and Ejsing, 2012). The improvement approach that underpins AI is based on reframing negative problems into affirmative topics and thereby shifting focus from design questions such as "what to eliminate?" into "what should be created?". In this way, even before the actual design process has started, AI asks a design question of "what is it that we really want to achieve and that we could attract people to engage in? In doing so, the affirmative topic provides focus for all the design activities to follow. More specifically "four foundational AI questions" are used when approaching the selection of topic in the pre-design phase as presented by Cooperrider et al. (2008) and seen in Table 2.

*Table 2. The four foundational questions of AI used before the design process as presented by Cooperrider et al. (2008).*

| **Foundational Design Questions of AI**<br>(used before the actual design process for designing the affirmative topic) |
|---|
| WHAT would you describe as being a peak experience or high point in your organization? This would be a time when you were most alive and engaged. |
| Without being modest, WHAT is it that you most value about yourself, the nature of your work, and your organization? |
| WHAT are the core factors that give life to your organization without which the organization would cease to exist? |
| WHAT three wishes do you have to enhance the health and vitality of your organization? |

The next step in the AI design process is to create momentum from the best of what already is in place and gives life, and with these insights about core strengths move forward toward a positive guiding image of the future. This is done with the guidance of a question-based "4D-process" as seen in Figure 6. Appreciative Inquiry suggests a generative, dialogical and iterative experiential approach based on design and improvisation rather than the more well known diagnostic approaches relying on plans and formal decisions. More specifically, the question-based 4D design process model includes four questions normally asked in the order of "What gives life?", "What might be?", "How can it be?", and "What will be?", as seen in Figure 6.

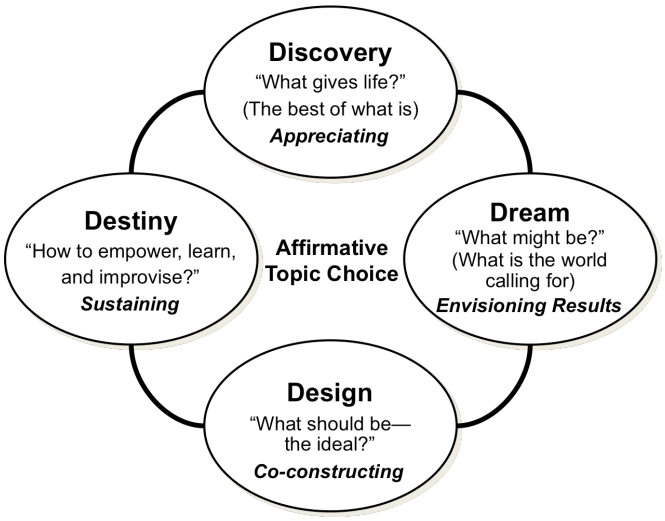


*Figure 6.The question-based 4D-process of the Appreciative Inquiry design model (from: Cooperrider et al., 2008, p.5).*

The practice of Appreciative Inquiry is further guided by a number of principles that Whitney and Trosten-Bloom (2010) describe stem from three streams of thought: social constructionism, image theory, and grounded research. The principles argue that human organizing and change is a socially

interactive process of discovering and crafting life-affirming, guiding images of the future. Social constructionism posits that "human communication is the central process that creates, maintains, and transforms realities". Image theory suggests that "the images we hold influence the decisions and actions we take in the present" and Grounded research is based on the belief that "participant observation is the best means of data gathering for those who wish to understand and describe living cultures". Avital et al. (2009) discuss how this lens can be used for design purposes for the management of information.

## 3 BRINGING THE "QUESTION PICTURE" TOGETHER

When approaching the various design questions it is instrumental to put them all together in relation to the typical phases of the engineering design process model as done in Table 3.

*Table 3. An overview of how the different question-based design models relate to the engineering design process and the nature of the questions asked in them.*

<table>
<tr><th>Design Model</th><th colspan="7">Phases and/or Design Questions Indicating the Design Process</th></tr>
<tr><td colspan="8">Typical Phases of Engineering Design and typical design questions<br>(for full questions see Table 1)</td></tr>
<tr><td>Ulrich and Eppinger (2012)</td><td></td><td>Phase 0<br>Strategic Planning<br>WHAT is?</td><td>Phase 1<br>Concept Development<br>WHAT are?<br>WHAT can?<br>WHICH should?</td><td>Phase 2<br>System-level design<br>HOW should?</td><td>Phase 3<br>Detail design<br>HOW should?</td><td>Phase 4<br>Testing and refinement<br>HOW do?<br>WHAT are?</td><td>Phase 5<br>Produc-tion ramp-up<br>HOW should?</td></tr>
<tr><td colspan="8">Mapping of Question-based Design Models<br>(in relation to the Phases of Ulrich and Eppinger, 2012)</td></tr>
<tr><td>(Liedka and Ogilvie, 2011)</td><td></td><td>WHAT is?</td><td colspan="2">WHAT if?</td><td>WHAT wows?</td><td colspan="2">WHAT works?</td></tr>
<tr><td>Berger (2014)</td><td></td><td>WHY?</td><td colspan="2">WHAT if?</td><td colspan="3">HOW?</td></tr>
<tr><td>Basadur et al. (1994)</td><td></td><td colspan="3">WHY? WHAT is stopping...?<br>HOW might we?</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Cooper-rider et al. (2008)<br><br>Cooper-rider and Srivastva (1987)</td><td>Affir-mative Topic<br><br>(see below)</td><td>WHAT gives life?<br><br>WHAT is/was the best?</td><td>WHAT might be?<br><br>WHAT are the ideals of what might be?</td><td colspan="2">HOW can it be?<br><br>WHAT is the content of what should be?</td><td colspan="2">WHAT will be?<br><br>WHAT is the experience of what can be?</td></tr>
<tr><td colspan="7">WHAT is it that we really want to achieve?<br>What could attract others to help to achieve that? (Affirmative Topic)</td></tr>
</table>

# 4 PRACTICAL IMPLICATIONS OF DELIBERATELY CHOOSING DESIGN QUESTIONS

Based on the mapping presented in Table 3, six practical implications of more deliberately choosing design questions in the engineering design process are given below.

## 4.1 Choosing Design Questions that Enable "Design for Life"

The questions asked during the engineering design process determine the possible insights and thereby also the possible solutions, or the solution space of the design process. This is of special interest when approaching the challenge of designing for life and the two basically different zones in need of investigation, namely the "Deficit Zone" and the "Surplus Zone" as stated by Oliver (2010) and seen in Figure 2. The specific design questions mapped out in Table 3 show that, in relation to the "Surplus Zone," it might then be wise to complement the traditional design questions from engineering design during the "Detail Design" phase with the design questions "WHAT wows?" of Liedka and Ogilvie (2011) as well as the design questions used during the "Strategic Planning" phase with "WHAT gives life?" and "WHAT is the best?" from Cooperrider et al. (2008) and Cooperrider and Srivastva (1987).

## 4.2 Choosing Design Questions for Increased Innovation

Given the mapping in Table 3, it is also notable how the design questions of the engineering design process do not explicitly or actively ask for innovation. Instead of asking "WHAT might be?", "WHAT if?", or "HOW might we?," as is explicitly done in the other models, where they are actively fishing for the wild and visionary solutions of the future, the implicit design questions of the engineering design process rather ask for "WHAT alternative product concepts can meet the needs?". This might be due to the ideal of risk reduction that often is argued as critical in the product development process and rather suggests the selection of known, proven technologies from the shelf than the unknown innovative solutions of the future as argued by e.g. Ulrich and Eppinger (2012). Simply put, proven, robust technology can be integrated into products much more quickly and reliably. However, when using such questions, the engineering design process actually becomes more of an "assembly process" of combining existing technologies and solutions, than a truly innovative design process. Depending on the level of ambition, as to how innovative the design is to be, it might hence be instrumental to include some of the more actively innovation driving design questions into the engineering design process, like "HOW might we?" from Berger (2014).

## 4.3 Choosing Design Questions for Increased Thought-and-action-repertoire

When then taking a closer look at the design questions of Table 3, it is notable how the traditional engineering design process seems to keep a very objective relation to the design object and project. This is revealed in the design questioning used which is very much directed towards WHAT is "out there"? This is in sharp contrast with, for example, the AI process which very actively involves and engages the designer personally in the project and its vision, both during and even before the actual design as seen in Table 2. Without any doubt, a question like "WHAT three wishes do you have to enhance the health and vitality of your organization?" from Cooperrider et al. (2008), really does touch on more of the subjective ambitions and dreams. Thereby it is also likely to increase the personal engagement and energy during the design process. Furthermore, research by Fredricksson (1998) shows how the positive emotions created through dreams and engagement broaden out the human thought-and-action-repertoire and thereby enable more creative ideas and better connection to larger systems. The engineering design process might hence achieve greater workforce engagement and organizational capacity by including those types of questions explicitly in the design process.

## 4.4 Choosing Design Questions for Clarity of Direction Into the Design

Table 3 also shows that the engineering design process really does have a "fuzzy front end", also in comparison to some of the other question-based models. In particular, the models of Basadur et al. (1994) and Cooperrider et al. (2008) show a substantially more developed use of design questions in the early phases, but also even before the design process actually starts. By doing so, the direction into the actual design reasonably becomes clearer and the risk of "attacking the wrong problem or opportunity" decreases. This is one of the core arguments given for using the design questions

provided by Basadur et al. (1994). It might hence be wise to complement the design questions of the engineering design process in this direction in order to increase the clarity of direction into the design process.

### 4.5 Choosing Design Questions for Clarity of Direction During the Entire Design Process (A "Meta Question")

Another interesting inspiration from Table 3 is the unique use of the "Affirmative Topic" in the AI model by Cooperrider et al. (2008). What is unique about this approach is that it provides an attractive topic that serves as a provider of direction, inspiration, and engagement both within the team and for external stakeholders through the entire project. It is furthermore often formulated as a question and can hence be seen as "the" design question of the entire project. The engineering design process might hence achieve greater clarity of direction, internally and externally, by including that type of questions early, or even before, the actual design process.

### 4.6 Choosing Design Questions that Systematically Search into the Past, Present and Future

Some of the question-based approaches in Table 3 inquire not only into the present, but into "WHAT was?", "WHAT is?", and "WHAT might be?", e.g., the 4-D process of Cooperrider et al. (2008). The combination of systematically using insights from the past, the present, and the future has several implications: 1) Connecting to the past puts the present into a greater context or story, thus increases knowledge generation during the design process, 2) The process of connecting to the past together in a team, and in particular to success experiences, increases secure organizational attachment that in turn increases confidence and the ability to be ambitious and take chances during the design process (Neilsen, 2005), 3) Inquiring into the future allows for shifts in mental models and thereby creating broader solution fields to explore in the in the subsequent design process. When it comes to the engineering design process, it is much less explicit or clear whether or how the design questions systematically inquire into the past, present and the future, as illustrated in Figure 7.

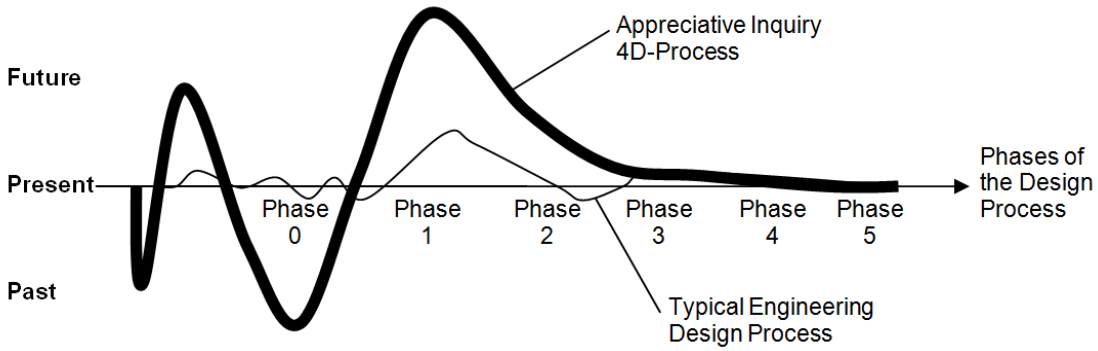


*Figure 7. Time Dimension in Focus of the Design Questions in Appreciative Inquiry by Cooperrider et al. (2008) versus the typical design questions of engineering design as described by Ulrich and Eppinger (2012).*

## 5 CONCLUSIONS

This paper highlights the unexplored potential of a more deliberate choice of design questions in the engineering design process. In the paper four question-based design models were mapped and analyzed for their differences and possible contributions to the traditional engineering design process. Further analysis of the design questions highlights six distinct aspects to consider for a more deliberate choice of design questions in the engineering design process:

- Choosing Design Questions that Enable "Design for Life"
- Choosing Design Questions for Increased Innovation
- Choosing Design Questions for Increased Thought-action-repertoire
- Choosing Design Questions for Clarity of Direction Into the Design
- Choosing Design Questions for Clarity of Direction During the Entire Design Process
- Choosing Design Questions that Systematically Search into the Past, Present and Future

These findings show how a deliberate choice of design questions can be seen as a prerequisite for enabling an engineering design processes to "design for life". We believe that this simple yet powerful insight along with the progress of theory and methods for engineering design will be keys for designing solutions to humanity's greatest challenges and for elevating human life from the "Deficit Zone" towards flourishing in the "Surplus Zone".

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