how designers think

ten ways of thinking in convergence for design education

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abstract

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Jan Siebers, Master of Education in Arts and Design, Piet Zwart Institute, Rotterdam University of Applied Sciences

How designers think, ten ways of thinking in convergence for design education

Convergence is the phase in the design process following divergence. Divergence, in the design context, mainly relates to idea generation and the broadening of possibilities. Convergence is needed to make choices and move towards the more specific.

Insight into convergence is lacking. This thesis aims to gain insight into the thought processes surrounding convergence to identify a stronger basis for design education. The main question of this research is therefore 'What is converging in design education?'

This research was carried out at the Amsterdam University of Applied Sciences, Faculty of Technology, in the Product Design study programme. The research methods were qualitative interviews with six design teachers with practical experience. Moreover, the study also gathered qualitative reflections on the preliminary results from those same teachers and from second- and fourth-year students.

The most important part of the thesis is the analysis of the interview and reflection data. This discussion is, when possible, further substantiated with literature studies related to ten ways of thinking, these are modes of thinking that are active during convergence: newness, criteria, divergence, selecting, iteration, reasoning, analysis, intuition, inspiration, and theories.

The literature study showed that few methods and models support convergence. Bias and subjectivity can easily influence the convergence process. Because criteria for innovations are not fully established and cannot be complete, using these criteria is difficult. Intuition is one means of thinking that leads

to convergence. Reasoning is the most crucial skill a designer needs to effectively converge. Although reasoning relies heavily on inferences and is not as powerful as it may seem, it allows designers to communicate about choices, to integrate personal considerations, and to account for intuition rationally. In the education context, the ways of thinking offer insight into the complexity of convergence, related pitfalls, and guidelines.

Follow-up research should take place at several design institutes and outside the domain of industrial design. Another recommendation is to translate these findings into design education. Converting these insights for education may further improve design education and perhaps reduce the number of breakdowns in students' design processes.

keywords:
design,
convergent thinking,
divergent thinking,
reasoning,
intuition,
inspiration,
design education.

What we see of things is things.

Why would we see one thing as being another?

Why is it that seeing and hearing would deceive us

If seeing and hearing are seeing and hearing?

The main thing is knowing how to see,

To know how to see without thinking,

To know how to see when you see,

And not think when you see

Or see when you think.

fragment of
'The keeper of herds'
of Alberto Cairo,
a heteronym of
Fernando Pessoa
translated by
Richard Zenith 1996

for Adelheid

Lidewij

and Bodiel

table of content

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The design challenge students and the students minoring in design intelligence reflected on the first findings halfway through the process. Their perspective was especially valuable in this phase.

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preface

As a lecturer in the 'Product Design' course at the Amsterdam University of Applied Sciences with 20 years of experience in design education, I have noticed an aspect of the design profession of which I have little conscious understanding and control: converging, or selecting from a multitude of ideas and possibilities to create a new focus.

In my practice as a designer, I have no problems with this. I manage successfully by using my experience and intuition to focus on a new concept. In education, however, I have experienced this lack of knowledge and understanding as a loss. Students have insufficient design experience, and their intuition in the design field is not yet developed. I want to explain to students how to best utilise the convergence phase and understand what is happening in their minds as they seek to identify a new focus. With my design teacher colleagues, I regularly discuss developments in the profession and how we teach our students, but I have not received satisfactory answers when I have asked how my colleagues handle students in the convergence phase. There seems to be no overall vision for this phase. Moreover, designers' statements regarding what they do when converging do not lead to a clear picture.

Designers first create multiple ideas (so-called 'diverging') and ultimately know how to achieve results, and the same is true of students. Hence, we all manage to converge without being particularly aware of what we are doing. I believe that as designers, we are unconsciously competent in this regard.

I have nothing against an unconscious ability in itself. However I suspect, that if we are consciously competent – knowing what we do and how we do it – we will be more insightful. If we know what we are doing when we are converging or helping students in the convergence process, we can more clearly see when the process is not going well. We will be able to develop better support, which will ultimately result in improved education. That is why I have researched converging in the design process, examining how designers think.

Jan Siebers

studied product design at ArtEZ University of the Arts, Arnhem. He graduated cum laude with 'The product as an ornament'. His work was exhibited through Europe, and his work is collected by various museums, including Boijmans van Beuningen, Art Museum The Hague, and the Netherlands cultural heritage agency. He published in 1992 the book 'The power of objects'. Jan was a lecturer at the University of Arts Utrecht (1990-1999). From 2009-2017 he was Head of Product Design at the Amsterdam University of Applied Sciences. Currently, he is developing the Design Intelligence programme for the Amsterdam University of Applied Sciences.
He graduated with this paper at the Piet Zwart Institute, University of Arts Rotterdam, Master Education in Arts and Design.

research methods and objectives /introduction

‘Curiosity is the engine of achievement’

Idea generation (divergent thinking) is used in most professions today; many workplaces regularly hold brainstorming sessions. Brainstorming is an umbrella concept incorporating a multitude of methods and techniques used to discover new ideas.

The work of the design professional also consists of generating new ideas, forms, possibilities, and insights – in other words, divergent thinking. It is generally understood that the need for newness is the reason for a divergent process. What is original, new, and innovative is highly regarded in design and design education.

What is the step after diverging? Various methodologies refer to a so-called divergence and convergence process. ‘Divergence’ means broadening the scope and idea generation, while ‘convergence’ consists of making choices and regaining focus.

The process of diverging has been well described by many, and various methods support the process. Most methods for diverging can be traced to Edward de Bono’s lateral thinking. Another critical method is to interrogate the problem by searching for the question behind the question.

A wealth of methods address divergence, while only a limited number of methods and insights consider convergence. Why is there such limited literature about converging? Why have we paid a great deal of attention to diverging without unravelling the logical next step? Do we, as professionals, lack knowledge of converging, or has existing knowledge been insufficiently disclosed? How are we able to transfer this skill to students? What are designers doing in this area? How do designers think? This research concerns what designers and design educators

Ken Robinson

[Ken Robinson inspires me as an education-designer. He is an advocate for allowing creativity and stimulating curiosity in education. He is opposed to standardization in education. Education should not be a factory.]

(Dorst, 2017)

PhD. Kees Dorst

educated at Industrial Design, TU Delft, Philosophy in Rotterdam. Professor at University of Technology Sydney. He studies how designers work and think. Works for the United Nations Development Program. His research is related to system thinking.

(Bono, 2016)

Dr. Edward de Bono

psychologist, doctor and management author. Studied at the University of Oxford. Worked for the universities of Oxford, Cambridge, London and Harvard. De Bono invented the term ‘lateral thinking’ and the concept of the ‘six thinking hats’.

do in the convergence phase. To answer the above questions, I searched for relevant information in the literature and interviewed design teachers. Then, design students and the interviewees reflected on the preliminary findings. The advantage of education is that it is an environment of knowledge transfer; both teachers and students proved rewarding sources in my search for the essence of converging. An inventory of factors occurring in the convergence process is the result.

These factors are modes of thinking that are active during convergence and concern issues such as intuition and its role, how to deal with criteria, when argumentation is valid, and what clear reasoning looks like. Elements such as uncertainty, ambition, and laziness, however, also play a role in the process of converging.

For each determining factor, interview statements were compared with the literature. In this way, each focus area led to new insights and determining factors related to converging. These determining factors, ways of thinking, provide insight into the thought process supporting reasoning and help to clarify this complicated process.

This research resulted in an overview of ways of thinking that play a role in the mental process of the designer in the convergence phase. These factors have no sequence or hierarchy and are almost always present to a greater or lesser extent, whether desired or not. The type of project and the nature of the designer influence these factors.

A model integrates these ways of thinking with the aim of offering designers deeper insight into the convergence process and design teachers a better understanding of design students' thinking and decision-making processes. This knowledge will help design teachers to assist students in their design process. The ways of thinking of the model will also directly help design students handle dilemmas and understand common struggles during the convergence phase of the design process.

research methods and objectives /problem statement

To a large extent, design education consists of training that simulates what professional designers do. However, design educators lack insight into what designers do when the design process is in a convergent phase. Since we are not sure what designers do in the convergence phase, we do not know how to teach students to understand convergence so that they can act more consciously during this stage of the design process.

Of course, designers generally learn to converge over time; they deliver many concrete products daily. Students know at the end of their studies how they can achieve results and therefore appear able to converge. This research also shows that teachers use strategies to teach students how to converge. However, they do not do so in a particularly conscious or structured way, and there is no common framework or strategy that teachers use. Their method has all of the characteristics of an unknowingly competent didactic approach: It works, but we do not know precisely how designers think.

The main question of this research is therefore the following:

What is ‘converging’ in design education?

This research is an inventory of phenomena that occur during the convergence process, including the operations and activities that take place. What do teachers do, and what do students do? How are these phenomena related?

research methods and objectives /the design professional context

For many, the concept of design is about beautiful, modern, and new objects, which is, to a certain extent, not unjustified. The key word is 'new'. If something is novel, then it will be experienced as contemporary or modern. For designers, the desire to create something original is an important driver.

Designers do not design something that already exists; they do not copy. In the course of the design profession's existence, the concepts of renewal and innovation have become increasingly central. To design is to create relevance. In the design field, the word 'new' also refers to originality; meaningfulness; added value, whether or not in an economic sense; and surprise. Designing is, therefore, an activity aimed at discovering something that was not there before.

(Dorst, 2017)

This newness and innovation have become increasingly central as the design profession has developed in the last 50 years. Today, a designer is expected to be innovative. As this is a quality in such high demand, this thesis pays particular attention to the concept of newness. By having a clear picture of the scope of the concept of newness, we can also understand more clearly what is needed to achieve that aim.

(Boden, 2003)

OBE, ScD, FBA. Margaret Ann Boden, *research Professor of Cognitive Science, University of Sussex. Her work embraces the fields of artificial intelligence, psychology, philosophy, and cognitive and computer science.*

Creativity is a skill or trait that a person uses to develop something new. In the context of this research, creativity is perhaps a somewhat broad concept. After all, creativity is also a trait designers share with musicians, artists, theatrical producers, architects, researchers, and others, and the concept of creativity is often deemed vague and difficult to grasp. Many view it as being highly personal. In the context of this research, a clear understanding of creativity is not needed. Within the creative spectrum, there is, in any case, the skill of generating ideas and configuring them. These two phenomena, also referred to as 'diverging' and 'converging', are interdependent and are the most crucial tools for creating something new.

Many methodologies cover idea generation (divergence). Most of these practices – whether 'thinking out of the box', brainstorming, pressure cooker sessions, the scrum model, or agile

(Boeijen, 2013)

MSc. Annemiek van Boeijen *researcher at Industrial Design Engineering at the Delft University of Technology. Research focuses on the role of culture in design processes.*

thinking – can be traced back to de Bono's work on lateral thinking and how to stimulate it. All of these methods share a focus on the generation of ideas and, to some extent, arriving at a selection of the generated ideas. Selecting entails choosing the best idea.

(Bono, 1992, 2016)

In addition to de Bono's lateral thinking, there is the abductive design method of Kees Dorst. The most important element of that approach is the re-framing of the principles 'What + How> Outcome'.

(Dorst, 2015)
see also thinking /divergence.

A designer can incorporate the interests of the stakeholders of a project into the result. A designer can visualise, is familiar with materials and production techniques, and manages to keep track of costs and ensure that the intended market is in focus. The field of design features a multitude of methods to put such interests and principles on the table. These methods can be a useful tool for developing a specific focal point. The 'customer journey', for example, ensures that the customer is involved in all facets of use. Alternatively, trend analysis is a tool for understanding current developments with an essential influence on the design process. Circular design provides insights aimed at fitting every aspect of the design within the circular economy. In essence, all of these methodologies help to retrieve relevant information and specify starting points. They provide the limitations and inspiration for the entire project. Within many of these methods, not only generating ideas, but also configuring or fusing ideas are important skills.

After all these inventory activities – designers call that the defining of principles and wishes – the designed must engage in the art of weighing and prioritising their relevance. This is a process of convergent thinking – configuring ideas and challenging principles. People often have an overly simplistic perception of the process, assuming that one should just choose the best idea. If there is a best idea, however, there must be criteria. Questions remain as to where these criteria come from and how applicable they are. Different ideas are also difficult to weigh. Idea A might meet one criterion but not another. The

reverse may be the case for idea B. How should one choose the best idea? Furthermore, if an idea appears straightforward to handle, how can the designer resist the temptation to choose the easy way? How should opinions about, for example, sustainability or child labour best be incorporated into the idea selection process? Thus, simply choosing the best idea is not so simple. It can be a quite conflicted process, especially if the project is large; with a large team of specialists, consistency must be achieved.

This paper demonstrates that convergence is not an isolated activity. Rather, ideation is stimulated and new ideas are developed in the convergence phase itself.
This characteristic has advantages and disadvantages. The risk of ever-broadening options can arise, and the designer might lose a high-level perspective. Alternatively, as Ed van Hinte, noted in a conversation with me, 'If someone is unable to converge, he keeps on diverging. There will never be a result.'

MSc. Ed van Hinte.
Studied Design Engineering at the Delft University of Technology. Lecturer at TU Delft, Rietveld Academy Amsterdam, designer, author, journalist. In 1995 he co-founded 'Eternally Yours', a foundation that focused on extending the life of products.

research methods and objectives /the design educational context

As the design professional context illustrates, designing is a sophisticated and creative profession. This research was carried out at the Amsterdam University of Applied Sciences' Faculty of Technology as part of the Product Design programme. Students prepare for this with design education. With theoretical courses and practice-oriented assignments, students learn the process step by step. Via practical assignments, and project education in particular, instructors teach as many aspects related to the professional context as possible. The Product Design programme uses a mixed structure with the ultimate goal of students working in professional practice as junior designers.

The team of lecturers of the Product Design programme is composed of designers with backgrounds ranging from technical universities to art academies. There is a healthy culture of participation and a healthy discourse. Everyone strives to be aware of current developments in the design profession, as well as design education. The team is curious and enjoys working with the most recent professional literature.

The design discipline itself is, like every profession, continually evolving. Society changes, new materials and techniques become available, marketing and target groups change, and so on. Design education moves with all of these changes so that the junior designer is in line with the profession. Over the years, the design process has become more theorised. More methods have allowed sub-processes of the profession to be performed differently or more effectively. In education, these theoretical frameworks are useful for didactics and offer insight. However, knowledge and insight regarding converging – configuring ideas and insights – are lacking. Professionals tend to lean on their experience in this context. Depending on the complexity of the challenge, they use weighted-criteria models; however, these are no more than supporting models for a process that is relatively complex and in which experience plays an important role. In education, where the aim is to help students with knowledge, insights, and skills, teachers tend to offer too little on this point. This research addresses the need for more insight into this phase of designing.

research methods and objectives /the research approach

The Product Design programme at the Amsterdam University of Applied Sciences was the primary field of research. Six senior teachers were interviewed about their perceptions of convergence's role within the design process and the way that design students learn to converge. The aim of the interviews was to identify decisive factors in the convergence process.

The empirical part of the research consisted of the interviews and a subsequent analysis of the findings. That process elucidated different ways of thinking that play a role in the process of converging.

Literature research was carried out on each way of thinking to test the results based on the interviews and reflections. All findings were related to convergence in an attempt to confirm the ways of thinking and their relevance. Wherever possible, didactic and pedagogical insights are linked.

The research had an inventory character and took an abductive approach in its analysis and conclusions. The identified ways of thinking were supported by the interviewees and the participating students. The results were tested against the existing literature. The outcome is a plausible explanation of the ways of thinking.

research methods and objectives /the conversations

The interviews were intensive but conversational in nature to allow for a less directed encounter where thoughts and reflections could unfold without time pressure and where all participants had time to think and to search for formulations that were as nuanced as possible. There was no time pressure precisely because knowledge about convergence is mostly tacit or unconscious. Hence, in this study, the term 'conversation' is usually used instead of 'interview'.

I interviewed six senior design teachers to gain insight into convergence in design education. I put forward as few terms as possible in the first half of the conversation. The central question was 'What is, or what determines, converging in the design process?' In the second half of the conversation, I mentioned more specific concepts and asked for the particular views of my conversation partner.

The conversations addressed three main perspectives:
How does convergence work for the professional designer?
What does a design teacher do, didactically speaking, to teach students the concept of convergence?
What are the pedagogical focal points?

Based on the analysis of the initial conversations, I selected key terms and developed a draft of all relevant issues mentioned. This draft was presented to the interviewees in a conversational setting, in pairs of two, and the discussions were recorded. The draft was also presented to a group of eight students from a design challenge programme and 30 students from the 'Essence of Design' minor. The students reflected on it in groups of four by writing their comments on a copy of the draft. Subsequently, all reflections were analysed and processed.

see 'defining the key terms'

The conversation partners were designers with various backgrounds and experience as teachers at the Universities of the Arts in Arnhem, Eindhoven, and Utrecht; the Universities of Applied Sciences in Rotterdam and The Hague; or the University of Technology Delft. All of these individuals also had

a teaching role in product design education at the Amsterdam University of Applied Sciences.
The conversation partners are also my colleagues and two student groups that I teach. Here is the list of the conversation partners in detail with their backgrounds.

Pauline Spaas

MEd. Pauline Spaas. Educated at the University of Applied Science, Amsterdam and The Hague (learning and innovation); teacher at the Amsterdam University of Applied Sciences (product design) and the University of the Arts Utrecht (innovative learning).

Ester Steenwinkel

BA. Ester Steenwinkel. Educated at ArtEZ University of the Arts Arnhem (product design); specialisation in product and architecture design; teacher at the Amsterdam University of Applied Sciences (product design) and former teacher at the University of Applied Science The Hague.

Jeroen van Vorsselen

MSc. Jeroen van Vorsselen. Educated at Delft University of Technology (industrial design engineering; product designer; teacher at Delft University of Applied Sciences and the Amsterdam University of Applied Sciences (product design).

Annelies de Leede

MEd. Annelies de Leede. Educated at Piet Zwart Institute, Rotterdam and ArtEZ University of the Arts Arnhem (product design); specialisation in product design; teacher at the Amsterdam University of Applied Sciences (product design) and former teacher at the Design Academy Eindhoven.

Maarten Meijer

MSc. Maarten Meijer. Educated at Delft University of Technology (industrial design engineering); product designer and product marketeer; design teacher at Delft University of Technology and the Amsterdam University of Applied Science (product design).

Seb Schneiders

MEd. Seb Schneiders. Educated at Piet Zwart Institute, Rotterdam and the National Art School Sydney, Australia; specialisation in art; teacher at Amsterdam University of Applied Sciences (product design).

Design challenge students

Eight students from a design challenge programme participated in the research. They were second-year students in an open innovation programme within the bachelor of engineering programme.

Design intelligence students

Thirty students minoring in design intelligence also participated in the research. Design intelligence is a fourth-year programme that focuses on creative thinking.

research methods and objectives /defining the key terms

The conversation partners seemed to have considerable difficulty in thinking about and – especially – describing convergence and related factors. It soon became apparent that there was little explicit knowledge or common jargon. Moreover, all of the conversation partners thought they knew what converging was, but none of them could concisely describe it or define it.

This resulted in long transcriptions that, following review and analysis, began to provide an image of converging, although one that was still not sharp and clear. The reason was that because the interviewees had to search for words to describe converging, they did not always use the same words. I hence clustered together phrases from the transcriptions based on an interpretation of their meanings. Eighteen key terms were thus defined. Some of these eighteen terms were combined after analysis. This resulted in 11 key terms with 11 clusters of excerpts from the interviews. To efficiently review and analyse them, I combined the texts where possible and shortened the excerpts to brief statements.

The interviewees then reflected on the draft text. Parallel to this, the group of 30 design intelligence students discussed the draft in a seminar in groups of four to five students and responded critically and constructively in writing. The eight students from the design challenge individually reflected in writing on the draft.
The result of all these conversations was a second draft. There, the concept of converging as a separate key term did not fit anymore because it was already fully described by the other key terms. In the end, ten determining factors, ways of thinking, were identified.

The concept of diverging emerged as an activity or mode of thinking that precedes converging. Without diverging, converging is out of the question. The set of conversations also illustrated interaction between divergence and convergence. most participants confirmed that iteration is an issue. The same was true for the interaction between divergence and convergence.

Thirty students minoring in design intelligence also participated in the research. Design intelligence is a fourth-year programme that focuses on creative thinking.

Eight students from a design challenge programme participated in the research. They were second-year students in an open innovation programme within the bachelor of engineering programme.

key terms:
diverging
iteration

In the design process, this interaction does not take only place two or three times, but recurrently in every phase, down to the smallest details.

theories

Striking in all conversations was the consensus that there are no significant theories about the concept of converging. References were made to existing theories and their limited influence.

reasoning
criteria
convergence

I found that reasoning is an essential skill for a designer, especially in the convergence process. Criteria were also frequently mentioned: Both their usefulness and ambiguity were cited. In all conversations, the various phenomena involved in convergence appeared to be very much intertwined or dependent on each other. Selecting and combining sometimes seem the same as convergence, but the later reflective conversations demonstrated that these activities are actually just one part of convergent thinking. For that reason, the two key terms 'converging' and 'selecting' were combined into one.

intuition
inspiration

For all conversation partners, intuition plays a strong role in the convergence process. On the one hand, it functions like a compass, but on the other hand, intuition is synonymous with bias. One might expect inspiration to be associated with divergence, but it was also mentioned as a means of converging. If ideas are inspiring, they are more likely to be useful.

analyse
new

Because ideas and possibilities are so amorphous, it is difficult to analyse them. Nevertheless, the conversation partners considered analysing an essential activity in order to achieve convergence. The concept of innovation or the new was not mentioned much during the conversations. It seemed to linger in the conversations as self-evident. During the reflection discussions, this was verified and confirmed as a fundamental principle in the design process.

research methods and objectives /theoretical reflection

Based on the analysis of the conversations, an image emerged of ways of thinking that arise during convergence in a design process. The coherent but complex image of converging is divided into factors that are easier to manage. This isolation not only makes descriptions easier to develop but also provides more tools from other domains and branches of the literature.

A significant amount of design literature exists, and there is an active shift towards more and more theorising within the design profession – a positive development. Most of the literature is about the development of methodologies to include specific topics within the design process. Examples include circular design, designing for interaction, and user-centred design. The literature also often focuses on larger, more complex problems that require design. Theorists have also written much about design thinking, although design thinking is just a fraction of how designers think.

Very little theory is directly related to the ten factors related to converging. Existing theories, however, are used to support the ten factors identified by this research.

Because only a few satisfactory starting points exist within the theoretical design literature, I searched for available literature in other science domains and found – for example, a useful taxonomy for the factor 'newness' in the artificial intelligence literature. The psychology literature provided insights into reasoning. Neuroscientists have learned much about how biases affect choice and intuition, and the behavioural sciences provided valuable insight into inspiration.

ten ways of thinking

Ten ways of thinking emerged from the research; these are modes of thinking that are active during convergence. They are based on the conversations in their entirety and the literature study, and they suggest insights and useful frameworks.

Together, they shed light on designers' process of converging. Other factors might influence the brain in the convergence phase of the design process; completeness is not possible. Moreover, the ways of thinking do not appear in sequential order, and the extent to which they occur is also not fixed. Rather, the outcome depends on the individual and the project at hand. There is also a high likelihood of several of these ways of thinking existing simultaneously. They cannot all be planned ahead. Sometimes they work as a mutual counterforce; sometimes, they are the key to an insight.
However, the most important goal for the design professional, as well as for teachers and design students, is to understand the ways of thinking of convergence.

educational insights

This research is grounded in an educational context, and didactic and pedagogical insights emerged from the conversations. These educational insights are not examined in a separate chapter, but thematically linked to the relevant ways of thinking. Moreover, this approach links each way of thinking to a direct practical application.

‘We cannot solve our problems with the same thinking we used when we created them’

Albert Einstein

[The first time I came across a definition of the concept of creativity was that of Albert Einstein. He is the creator of the ‘game of combinations’, as he called creativity, always gives room to experiment and where the chances to serendipity increases.]

What is new is what was not there in the past: That is how we deal with newness in daily life. However, there is a world of nuance in the concept of newness. Einstein defined the concept of newness as representing an unusual combination of existing things into something new and usable. While this seems like a conclusive definition, what can we do with it as designers? Should we blindly combine things and test them for usability? That would be impossible.

MSc. Maarten Meijer

educated at Delft University of Technology, Industrial Design Engineering. Product designer, product marketeer. Design Teacher at Delft University of Technology and Amsterdam University of Applied Science, Product Design.

Designing is creating something new. According to Maarten, ‘If there is no solution for a problem, then something new must be designed.’ A design challenge, however, does not necessarily have to be prompted by a problem. The challenge can also come from curiosity or irritation. However, if existing solutions or resources do not provide an answer, then the search for the new starts. This principle applies to products, services, and science. If knowledge is already available, then there is no need for research. If we lack knowledge, we need new knowledge.

A design process ultimately ends in convergent steps. Because a design process aims to arrive at something new, novelty is a determining factor in converging. In convergence, questions arise as to whether something is new enough and whether it should be more innovative, or even disruptive. Understanding the gradations of novelty and their impact is vital to making the right decisions.

One gradation of novelty, something new, can come from a variant. Margaret A. Boden, research professor of cognitive science at Sussex University, calls the variant: shifting the conceptual space. The concept remains the same, as do the function, role, and meaning. However, the concept of space is finite. Once

the function or meaning falls outside the original concept, we no longer speak of variation. The variant, shifting the concept, is the application of other existing insights. Alternatively, the result could have always been that way; the option may have been available but not yet implemented. We can speak of newness here. The association with something existing is evident, which is why we call it a variant.

Variation aimed at achieving newness is also possible in this context. In this case, it is not so much the product that is new, but the application. When a tall drinking glass is used as a vase, the product is not new, but the application is. We often see such shifts in the context with design hacking.

As soon as the variation space is no longer large enough to permit something satisfying and new, further research is needed. Boden then speaks of transforming the conceptual space. New connections with other domains, different insights, or novel techniques emerge. The entire system of related matters must adapt via a so-called 'disruptive change'. Here, too, the degree of innovation can vary. The degree of novelty is high.

(Boden, 2003, p.3-6, p)

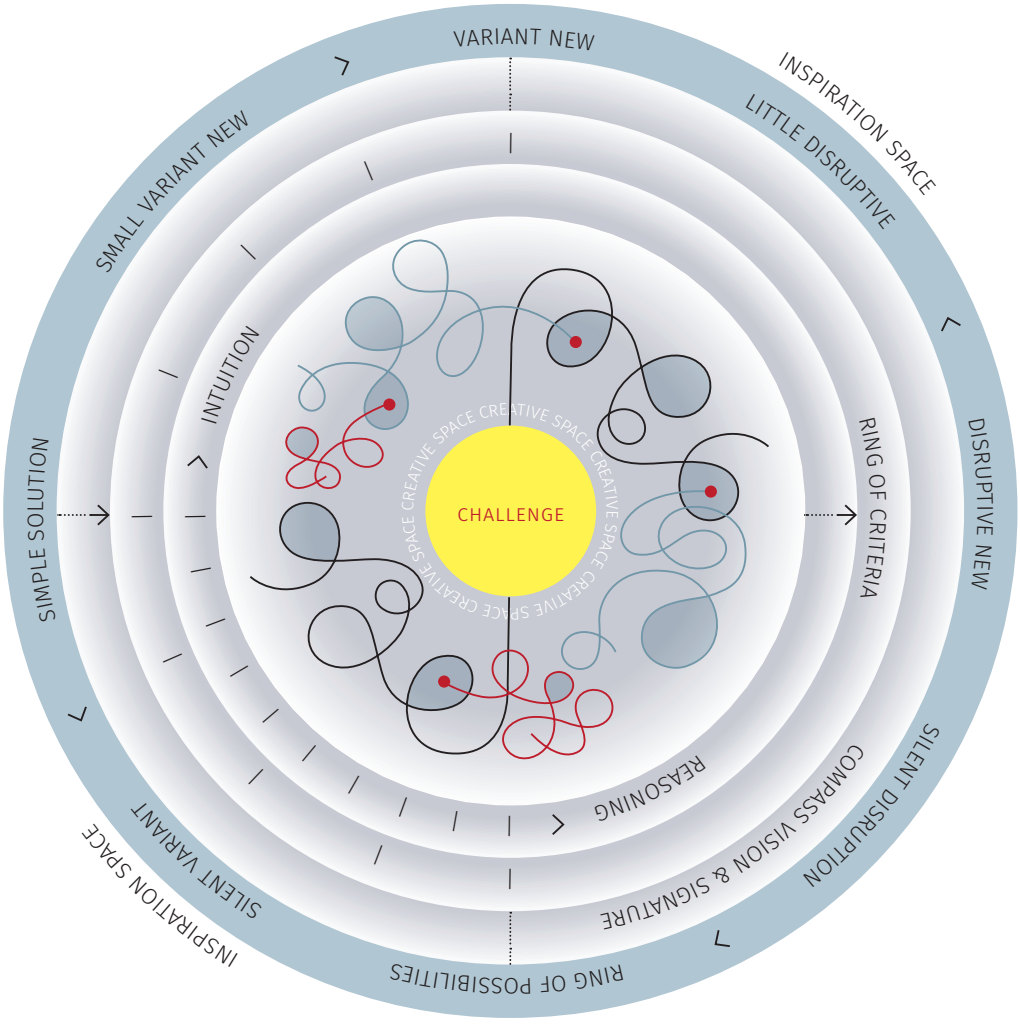
The silent renewal is as modest as it is ambitious. It is no different from the innovations described above. However, it takes place within a system. Silent renewal can be in the form of a variant, with the designer choosing a stronger material to reduce complaints. However, it can also be disruptive if the designer chooses a different production method which has a favourable effect on working conditions and the environment. A variant is easier to realise than a significant disruptive change. The disruptive change beckons every designer; there is nothing wrong with that ambition, but it is not likely that attempts in this direction will succeed regularly.

The degree of novelty can also depend on the extent of the variation or the stacking of variations. Very subtle alterations on multiple fronts are also possible and influence the degree of novelty.
The designer's own perception of novelty is important, or as

are perceptions within the environment. A designer may have designed something that he or she experiences as new. However, the concept might already exist elsewhere. Boden makes this difference clear through the concepts of psychological creativity and historical creativity, which she calls 'P-creativity' and 'H-creativity'. H-creativity means that something is new to the world, or 'H-new'. P-creativity results in something new for the designer, 'P-new'.

P-newness can easily lead to problems related to, for example, copyright law or patent law. It is crucial for the designer to conduct proper research into the existence of his or her concept. The designer may be disappointed to learn that his or her idea already exists. On the other hand, this can also be seen as a compliment: The idea is apparently so good that it has already found a market. Uninhibited designing, without fear of being just P-creative, is a condition for an effective design process. It can force breakthroughs in thought. Nevertheless, proper research regarding whether an innovation is H-new is needed to prevent the result from causing legal problems in the market.

(Boden, 2003, p.2-3)



taxonomy of newness

The ring of possibilities embraces the other rings and the process. Ambition level must be chosen in order to find direction: the higher the ambition, the more complex the process. Adjustment with vision and criteria is fundamental.

didactics
If innovation and newness are a part of the design profession, then it is important for students to understand what newness is. Seb indicated that clarification of the degree of novelty can be helpful. When is a concept direction not a renewal, but an existing solution? When is a variation small or large? When does a variation become disruptive newness? All gradation indications can help designers to understand the concept of newness and communicate about it.
For the new student, a variant can be a more accessible goal. Later, the gradation of novelty and, thus, the degree of difficulty can increase.

pedagogy
The degree of novelty is linked to the designer's ambition level and uncertainty, as Pauline indicated. As the level of novelty increases, so does the uncertainty. After all, much of what emerges as new solutions or combinations is unexplored territory. Whether a solution will work remains unknown. These uncertainties arise from the case itself, not from the student's uncertainty. That distinction can be confusing and deserves attention.

MEd. Seb Schneiders
educated at Piet Zwart Institute, Rotterdam and the National Art School Sydney, Australia; specialisation in art; teacher at Amsterdam University of Applied Sciences (product design).
(Biesta, 2014, p.92-95, p.106)
PhD. Gert Biesta
professor of Public Education at Maynooth University Ireland, Visiting Professor at NLA University College, Bergen & the University of Agder, Norway. NIVOZ Professorship for Education at the University of Humanistic Studies, the Netherlands. Educated at Leiden University.
MEd. Pauline Spaas.
Educated at the University of Applied Science, Amsterdam and The Hague (learning and innovation); teacher at the Amsterdam University of Applied Sciences (product design) and the University of the Arts Utrecht (innovative learning).

(Boden, 2003, p.2-3)

(Jolles, 2017, p.55-57, p.171-173)
PhD. Jelle Jolles
Educated neuro/biochemistry, neuropsychology, philosophy at Utrecht University. Professor Neuropsychology at VU University Amsterdam. Leader of the Brain & Learning Center Amsterdam.

Newness according to the perspective of the student may differ from historical newness. The student's perspective can be frank and therefore his achievement.
The historical perspective deserves attention – the investigation must be thorough – but the student's performance nevertheless deserves appreciation.

‘When our designs are succinct statements of purpose, easy to understand, use, maintain and repair, long-lasting, recyclable and benign to the environment, we inform’

Victor Papanek

[Already in the 1980s, I read Victor Papanek’s ‘Design for the real world’. He provided me with clear insights to be responsible and relevant as a designer. Now that the debate, about the role of the designer and his responsibilities, is fully there, the principles of Victor Papanek are more topical than ever.]

Without criteria, designing is highly difficult or even impossible. If there are no criteria, one cannot determine whether the result is suitable. Whether a design challenge comes from a client or the designer’s own initiative, criteria are always present, at least unconsciously.

Where in the process does the designer start to converge – to make choices? According to Ester, the designer’s own criteria are the starting point. A designer may have an ethical compass. If child labour is involved in the production, the designer will probably reject that method. If the assignment leads to a useless object in the eyes of the designer, he or she may struggle with that, while another designer may not care.

Additionally, every designer develops an idea of ‘good design’. Dieter Rams, a respected designer, developed 10 design principles based on minimalism and the idea that ‘form follows function’. His designs never contained decorations. Connected to this idea, Annelies stated that every designer develops his or her personal views on the profession. These views work as criteria in the convergence process and ensure that the designer supports the outcomes of convergence. In the development of a designer, the individual’s views on the profession and personal ethical compass both play a role. Together, they form a series of unwritten criteria. Such criteria are intrinsically present and often the reason that a client chooses a specific designer for a job.

BA. Ester Steenwinkel *educated at ArtEZ University of the Arts Arnhem (product design); specialisation in product and architecture design; teacher at the Amsterdam University of Applied Sciences (product design) and former teacher at the University of Applied Science The Hague.*

Dieter Rams, *educated at the Wiesbaden School of Art, graduated with honours. Famous for his ten principles for good design. Dieter Rams designed many memorable products for Braun.*

MEd. Annelies de Leede *educated at Piet Zwart Institute, Rotterdam and*

ArtEZ University of the Arts Arnhem (product design); specialisation in product design; teacher at the Amsterdam University of Applied Sciences (product design) and former teacher at the Design Academy Eindhoven.
(Dorst, 2015, p.9-13)

If there is a client, requirements are set in most cases and often expressed in a programme of needs and wants. However, it is impossible to record and measure all elements in advance – the more stakeholders, the more unwritten demands and wishes. Design is often an open process without clear criteria. Kees Dorst mentions this in his book Frame Innovation: 'open (no boundaries), complex (many elements and relationships), dynamic (change over time), and networked (across organisations)'. Establishing criteria in advance is at odds with the demands of innovation. If there are many criteria and these are described very precisely, room for renewal disappears. In other words, if something is new, how can one know what criteria it must meet?

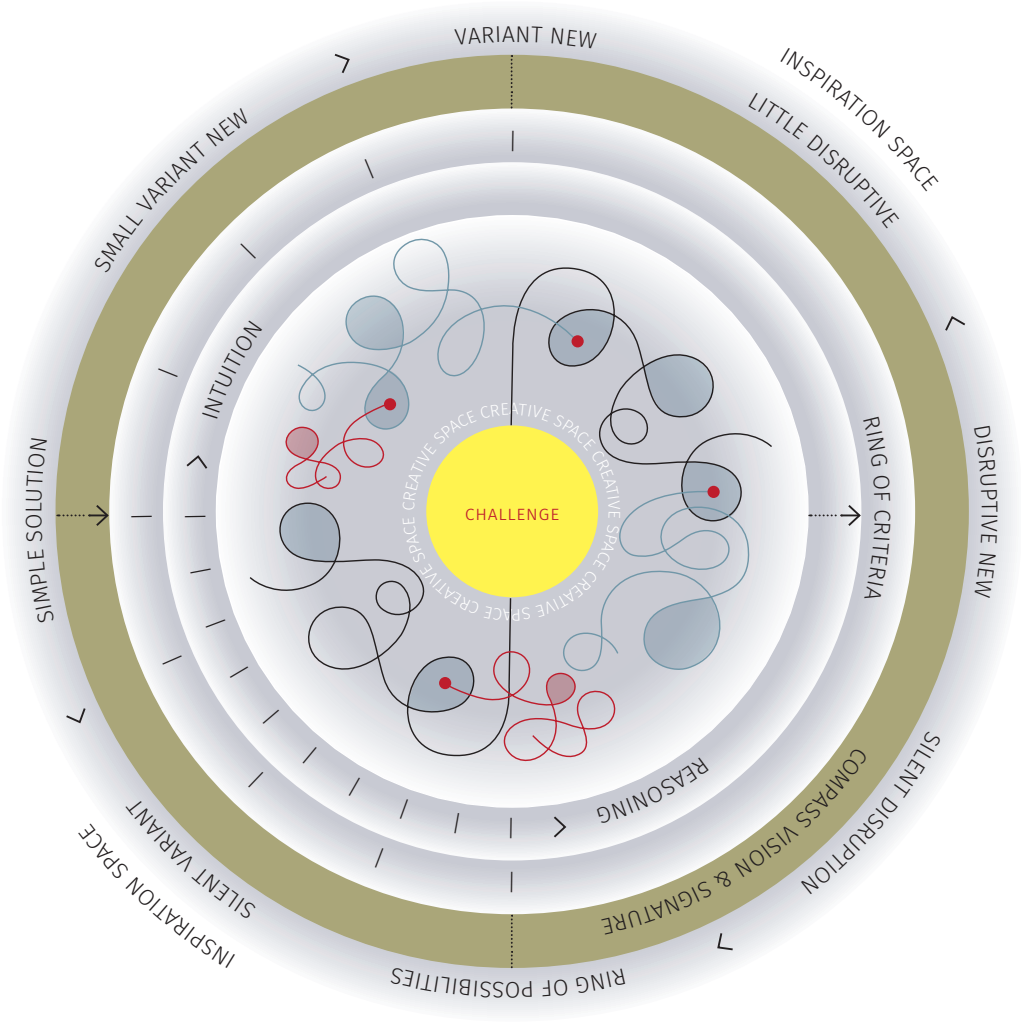
(Roozenburg, 1991, p.275-280)
MSc. Ir. Norbert Roozenburg *educated at Industrial Design at the Delft University of Technology. Lecturer at School of Art and Design, University of Seattle. Lecturer of design theory and methodology at TU Delft. His Co-author of the book 'Productontwerpen, structuur en methoden' is PhD. Johan Eekels.*

In their 1991 book Product Design Structure and Methods, Roozenburg and Eekels outline precisely how criteria should be described. The book is seen by many industrial designers as a crucial work. Being complete in a list of criteria is essential. However, because not every criterion is equally important, the authors provide an elaborate explanation of how to weigh different criteria. The method seems to result in completeness and precision. However, it ignores the impossibility of achieving completeness and does not address the role of bias in weighting various criteria. Additionally, it overlooks the possibility of criteria changing during the process.

As stated earlier, designing without criteria is virtually impossible. It is essential to stress that criteria exist. Stakeholders should ideally put down all criteria in writing. Additionally, where possible, priorities should be stated, regardless of whether they are weighted with percentages. The most critical role of the criteria is not as a yardstick to test whether the result is satisfactory. As all conversation partners agreed, a set of criteria should enable agreements among stakeholders. The criteria should support discussions of options and ideas and should set the project direction. Discussions, reasoning, and argumentation are related to criteria. As Maarten mentioned, criteria that are not stated or made explicit can be forgotten. That also applies to the personal opinion of the designer. He or

she may be asked, precisely for his or her views or characteristic signature style. Writing down these thoughts can also help.

Criteria also arise from standards, safety, and legislation – the hard requirements. The design must comply with related criteria. It is useful to have a clear picture of these requirements in advance, but this is not always the case. In the design process, which leads to renewal, the concept may identify a new direction, which may require the aspects mentioned above to change as well. Here, too, not everything is strictly defined.



designers' compass

The vision and signature ring represents the compass of the designer. The designer aims to turn this compass in the process so that he can always support the result. The ring is in personal conflict if it does not match. It should be in the position of designer satisfaction.

ring of criteria

All stakeholders serve the criteria ring. Proper reasoning puts the ring in the right position or well-fit. This ring is always moving precisely because all stakeholders like to serve it. It is up to the designer to lead the conversation and to always diverge means and converge clearly in one direction.

didactics
For design students, understanding the role of criteria is essential. That criteria are not a yardstick in the first place; the criteria reflect the biases of not only the client and other stakeholders, but also the designer. Converging entails testing the criteria with argumentation and reasoning. Reasoning is an important skill to bring together design considerations and criteria. The adolescent also enjoys using his or her new thinking skills.

(Jolles, 2017, p.157-169)

The personal signature of the student takes shape in the overall picture of all the criteria. Ester noted that it is desirable for the student to get to know his or her vision and signature and to discuss these elements. Writing a personal vision or manifesto gives the student clarity regarding his or her personal 'criteria'.

pedagogy
It can be difficult for the student to have an continuous overview of all principles. The struggle to satisfy one criterion affects every other criterion. Relying on intuition and one's personal view can help the student in the study process. Seb reported that the student needs the confidence of his or her teachers for his or her vision to mature.

The fact that criteria are not fixed seemingly creates an opportunity, but can also be a trap. Some students struggle with the apparent vagueness of the shifting criteria and therefore find it difficult to arrive at conclusions.

Jelle Jolles, professor of neuropsychology at the VU University Amsterdam, has claimed that by early adolescent, individuals have developed their political preferences and ethical views. These views are not yet stable. Developing a personal belief regarding the design profession is helpful and is precisely what the jong student is doing. Such decisions are made in parallel with ethical development. The teacher can encourage the student in this regard, but the teacher's neutrality is

(Jolles, 2017)

‘You can’t use up creativity, the more you use, the more you have’

Maya Angelou

[Ethics is an essential foundation for the design profession. Ethics gives direction to the richness of ideas. For me, every designer should take Maya Angelou as an example. Equal rights, opportunities, and appreciation in every conceivable area for every individual.]

MSc. Jeroen van Vorsselen

educated at Delft University of Technology (industrial design engineering; product designer; teacher at Delft University of Applied Sciences and the Amsterdam University of Applied Sciences (product design)

Brainstorming symbolises what is called ‘divergence’ in this research, as do ‘out-of-the-box’ thinking, mind mapping, and word clouds. These are all methods to develop new ideas. Converging and diverging are almost always referred to together, with ‘diverging’ stands for broadening the number of possibilities and ‘converging’ for narrowing this range. In the context of this research, converging does not exist without diverging. Divergence provides the material enabling convergence. Jeroen clearly stated that diverging must cover the entire solution space.

If a problem or a need for change occurs, or if a solution is not readily available, then divergence is an almost self-evident activity. In our thinking, we explore whether there are existing possibilities and whether there are comparable situations that we can reflect on. If nothing is found, we generate new ideas, including possible and impossible solutions.

Before diverging, one must determine the reason. Is there a real problem that needs to be solved? Alternatively, is a change to a system desired? De Bono points to the concept as the focus here. He speaks about value concepts (‘Why does it have value?’), purpose concepts (‘Why do we do it?’), and descriptive concepts (‘What are the characteristic features of different things?’). You can see a bicycle as a means of transport, but also as a personal means of transport. You can see a bicycle as a human-powered vehicle or as a two-wheeled vehicle. With idea generation (divergence), the use of such different concept levels can be helpful.

(Bono, 2009, p.48-51)

Dorst describes framing and reframing. In that sense, framing is very similar to de Bono’s concepts thinking. Reframing is viewing the problem through a different frame and is a valuable tool to enable divergent thinking to achieve a broader result. With reframes, Dorst goes a step further with what he calls

'abductive design'. He does this through the equation 'what + how > outcome'. The 'what' is the product or service, for example, a lawnmower. The outcome is the result – in this example, the cut grass. The 'how' is the pattern – the method. In this example, the operation and use of the lawnmower are the 'how'. One can reframe all three elements of the equation – for example, the 'what' could be a cow. The outcome remains short grass. Or the 'how' could be a small robotic mower, which means that mowing no longer must be done by an individual and that the grass always will be short. However, one can also reframe the outcome. In this example, the cut grass could instead be short grass if one sowed a seed for grass that grows no longer than 4 cm.

(Dorst, 2015, p.44-50)

De Bono is the founder of lateral thinking. Since the 1970s, he has been developing theories and methods to support thinking resulting in new ideas and insights. Since then, many methods, such as creative thinking and creative techniques, have been developed. All these techniques essentially build on the lateral thinking of de Bono. In many such methods, the speed of the process is essential. The pressure cooker method is one of them. This is probably due to de Bono's idea that judgments should be postponed to prevent thinkers from stopping with the first or second idea. In many cases, these are the obvious solutions that do not lead to real innovation.
Rather, we should continue thinking at a rapid speed, distracting ourselves with the next thought instead of judging the current thought. However, introducing speed is simply one way to deal with such judgments. Moreover, while speed does lead to new perspectives, the quality is usually disappointing.
As Seb put it, ideas need time to grow.

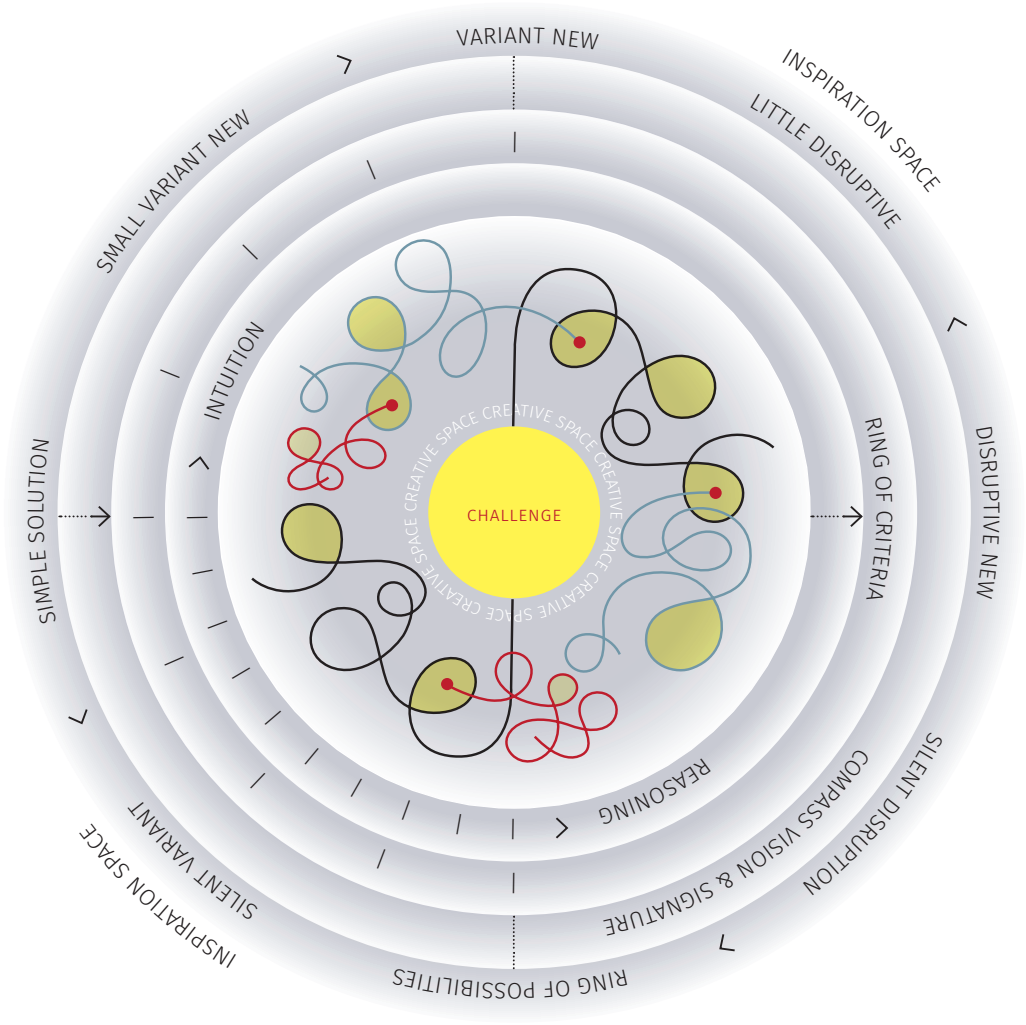
(Bono, 2016, p.95-99)

One of de Bono's methods for divergent thinking is what he calls 'the obstruction'. This means that an obvious method or solution is temporarily excluded. For example, imagine a man walking through a famous city and forbidding himself access to his favourite square. Using this approach, he is more likely to find new and exciting locations. Or, you can force innovation by banning existing drives (i.e., chain, V-belt and cardan

shaft) when designing a bicycle. The result may be pedals that directly drive a dynamo, which drives the electric motor in the wheel with a power wire. That solution probably would not have emerged without the barrier. *(Bono, 2009, p.170-195)*

A provocation is a variant of the obstruction: One temporarily assumes that something that seems absurd and impossible is just the starting point. De Bono uses a car with square wheels as an example. That thought experiment helped engineers to develop an intelligent suspension system that can predict large bumps in the road surface and immediately react to them more successfully. Provocation can also be a reversal, a distortion, an exaggeration, or wishful thinking. *(Bono, 2009, p.125-128)*

Associative thinking is also a common way of stimulating divergent thinking. Jeroen strongly advocates the conscious use of inspiration. Other domains can sometimes contain solution directions or analogies useful for the design task at hand. The barrier, the provocation, and the associative thinking of de Bono can also be used again after other frames are identified via Dorst's abductive design thinking.



the meandering ideas

The meandering lines represent the exploratory nature of diverging, the generation of ideas. Clusters of ideas appear so that areas within the creative space are defined: the coloured spaces.

didactics
Students must become acquainted with the breadth of ideation methods – not just brainstorming and variations thereof. Framing and reframing, along with questioning the question behind the question, are also good starting points for diverging.

Idea generation, in many methods, is supported by the speed of that process. However, speed does not always lead to the best result. Ideas need time to incubate. Especially for students, time to think is essential to make choices. *(Jolles, 2017, p.135-148)*

Maarten indicated that teachers should structure assignments so that partial aspects of the problem are gained. Every part of the problem requires diverging and converging. It is crucial for divergence to proceed in such a way that the ideas cover the entire design question. An analysis must reveal any possible gaps. According to Jeroen, convergence cannot take place before divergence has fully covered the problem.

pedagogy
According to Jeroen, divergence requires empathy from the designer or design student. If the result of divergence is poor, a lack of empathy regarding the case might be responsible. The student should thoroughly empathise with the problem definition.

Students often choose from their found ideas, that which they suspect their peers appreciate and focus on short-term results. For a student, a short-term result is more important than the final final result. *(Jolles, 2017, p.177-178)*

‘It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change’

Charles Darwin

[Designers are change agents. In Charles Darwin’s theory, I see a parallel with the design profession, always striving for better results. There is still a lot of work to do.]

This paper is about converging. Converging means shifting towards a point or focus. After the divergence phase, the intention is to focus on the multitude of ideas and possibilities. On that basis, choices – individual designs, combinations of designs, or conclusions – can be worked out further. Selecting is a necessity to achieve results. It goes hand in hand with testing against not only the criteria of stakeholders, but also one’s own ethical compass and signature. Our complex brain allows us to think intuitively and to reason.

There is also a form of divergence within selecting, without branching into part problems. Assigning value to an idea to determine if it can be developed further requires thinking in inferences. If something is selected, what are the consequences of continuation? A divergent process takes place spontaneously and more or less consciously. A divergent idea may be further considered to determine its consequences.

(Mercier, 2017, p.52-63)
see Thinking, reasoning
PhD. Hugo Mercier
educated Cognitive Sciences Psychology (Highest Honors), Institut Jean Nicod, Paris. Cognitive scientist at the French National Center for Scientific Research, Lyon. His Co-author of the book ‘The Enigma of Reason’ is PhD. Dan Sperber.

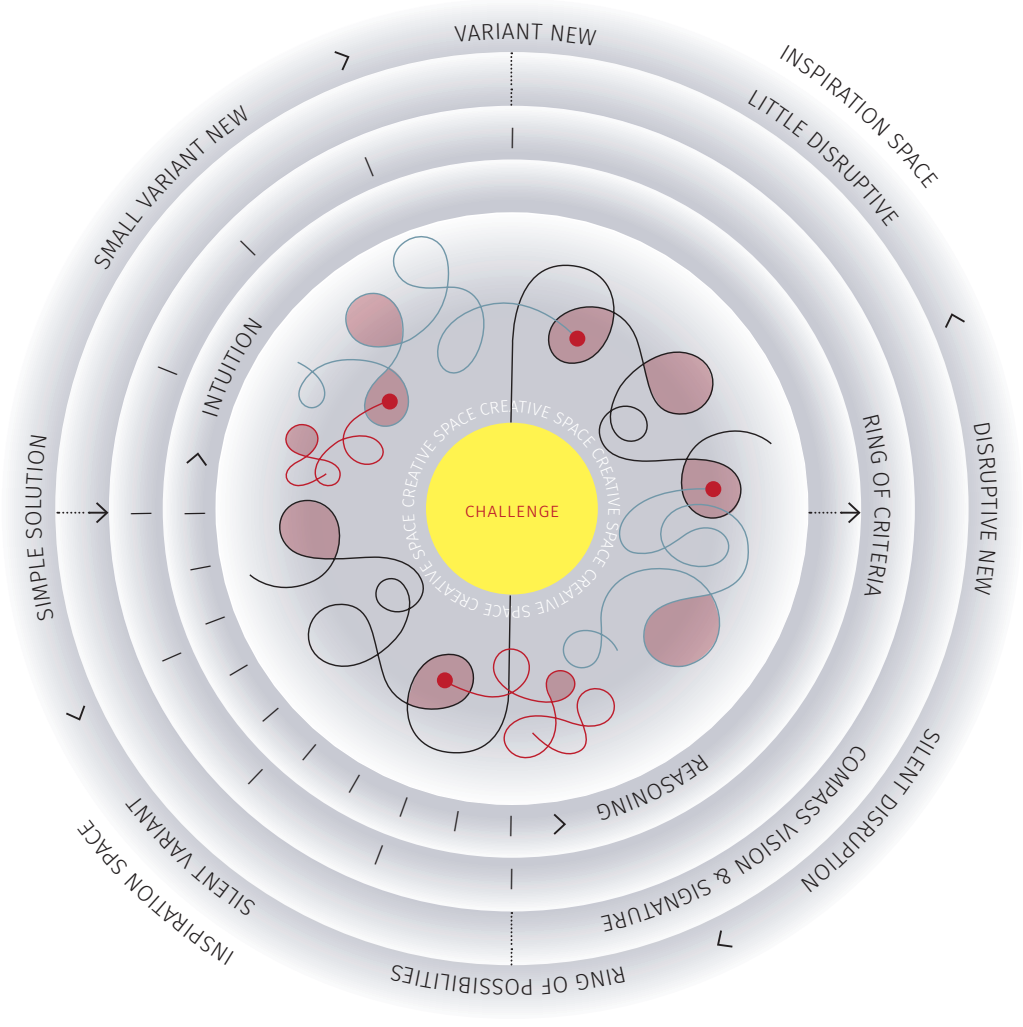
Selecting means attaining an overview of the possibilities and consequences, and overlaps or relationships with other ideas may be present. In many cases, selecting results in combinations. Ester and Annelies stated that for selecting ideas, designers may compare ideas to each other. Comparison helps to identify the best idea, although the designer must also show whether the criteria are satisfied.

Pauline stated that in her experience, students find it very difficult to make choices. Choosing one thing often means that something else is not chosen. Students find relinquishing other options to be difficult, in line with Jeroen’s statement

that 'It is an art not to choose things.' Students often experience what is chosen as a limitation. A new focus is emerging, but the designer must achieve the final result on that basis.

Seb compared selecting with the grammatical connections between ideas. Words are not the same, but the underlying grammar is. For example, ideas can differ from each other, but have a similar structure. Recognising that structure helps the designer to choose an idea. Annelies and Seb indicated that time can help one to overcome the struggle of selecting. Sometimes, ideas must sit for a while and mature; incubation time is needed to imagine the consequences. Selecting is then easier. Ester endorsed this notion but also claimed that time pressure can sometimes help force a decision when, for example, the iterative process has created a vicious circle.

The result of a convergence process is a new focus, selections, decisions, and combinations. The designer must analyse whether the problem or assignment is covered sufficiently. Sometimes, it can be helpful to keep options open – to work not towards a single point but towards a narrow range. One can diverge further from that single point or narrow range.



challenging the selection

The red dots represent the selection of ideas that will be further developed. Every dot is a new challenge.

didactics

Selecting – whether of individual designs, combinations of designs, or conclusions – deserves more attention in training. It is a challenging and complicated skill. Teachers encourage practising it frequently. A proper analysis of the potential ideas regarding the design criteria is desirable. However, the criteria are not as strict as they seem and are formed mainly by intuition and bias. *(Mercier, 2017, p.77-80)*

Reasoning, when undertaken together with colleagues and peers, helps the designer to evaluate the ideas against the criteria. In this way, a proper substantiation of the arguments for confident choices is possible. Annelies agrees fully with the insights of Donald Schon: The master's student setting in which coaching takes place and insights are transferred to the student while designing. *(Jolles, 2017, p.143-148)* *(Schön, 1987, p.76-93)*

PhD. Donald Schön

educated philosophy at Harvard University. professor at MIT Massachusetts Institute of Technology. Urban Studies and Education, a lifetime of interest in the subtle processes whereby technological and other change is absorbed (or not) by social systems.

Converging is also reducing uncertainties, according to Maarten. It means removing impossibilities. Alternatively, if it is unclear whether something is possible, one should investigate.

pedagogy

Considerable uncertainty can occur while selecting, according to Ester. Focusing mainly means making choices. As with all choices, stress can occur. Choosing one option means that another is not chosen. Students can experience that as a loss. According to Annelies, the idea which is chosen can be experienced as a problem because, in the end, that idea must work. Jolles indicated that for young adolescents, emotions can considerably obscure judgments. Expressing confidence in the student, and giving him or her time (e.g., 'Sleep on it overnight') can help. Students consider the opinions of their fellow students as very important. The structure of the social context is vital for young designers and can have a strong influence on choices. *(Jolles, 2017, p.142-147)* *(Jolles, 2017, p.183-188)*

According to Maarten, converging sometimes seems to produce the 'right' answer – an answer the teacher wants to hear. However, a teacher does not want an exact answer, but convincing reasoning and arguments that support a choice.

‘Designers often speak negatively about kitsch, because there is so much to see. However, seeing is simply the best thing there is’

Wilma Sommers

[During my studies and the first few years after that, I worked with Wilma Sommers in the ‘October group’ Wilma was the representation of a designer who saw ‘meaning’ in products as a fundamental value. In her view, the ornament earned first place.]

Iteration is the repetition of a process. All the conversations partners mentioned constant interaction between diverging and converging throughout the entire design process. The ultimate goal of an iterative process is for it to lead to convergence.

In much of the design literature, diverging and converging are represented as one-off processes or as procedures repeated two or three times. Sometimes, scholars indicate that the process is repeated iteratively. However, as explicitly indicated in the conversations, lengthy repetitions take place at all stages, from rough concept ideas to the smallest details.

(Oskam, 2017, p.214)

Iteration can also result in oscillation, a vicious circle, or chaos if convergence does not emerge or does not proceed effectively. According to Van Hinte, ‘If someone is unable to converge, he keeps on diverging.’ The result is an endless number of possibilities without focus.

If iterations continue to reflect the same thought pattern, no progress is made; there is a vicious circle. This can happen when convergence repeatedly fails. Forcing a breakthrough can be done by, for example, supplementing or redoing the previous step of diverging. Perhaps a new frame is needed to develop new ideas and possibilities. However, it may also be that the test against the criteria of the convergent result was affected by biases or unfounded judgements regarding quality. Perhaps there are unconscious criteria that the designer must

The students' reflections suggest that they see iteration as returning to earlier decisions and starting over. At times, the designer must move backwards in the process, but that is not the essence of iteration. Iteration is, as Ester said, 'getting further and further in steps'.

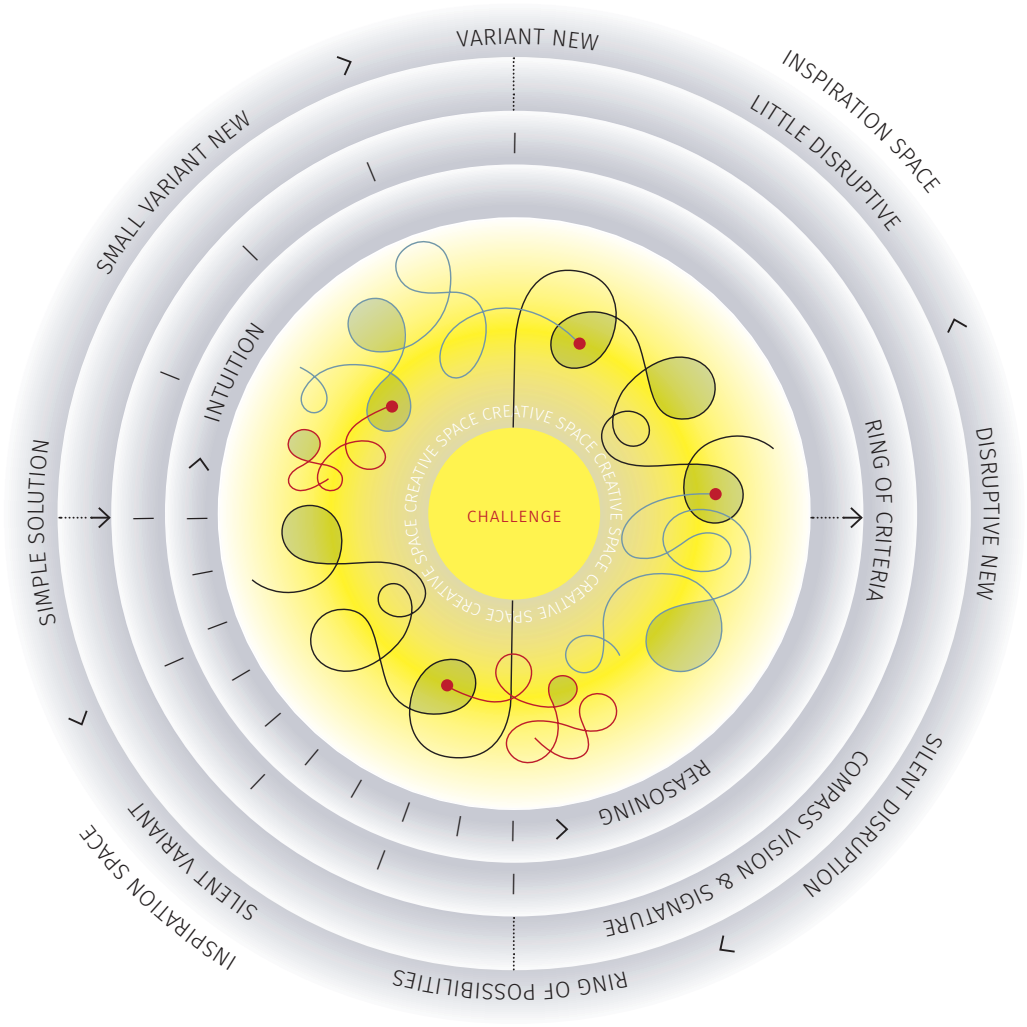
Divergence then continues to build on the previous convergence. In the first diverging steps, problem analysis is the starting point. Between steps, balance in divergence and convergence, is always achieved to a greater or lesser extent. Logical analyses evaluate the original principles – Both after diverging and after converging. Pauline warned against the inclusion of moderately satisfactory or unsatisfactory results. Because one continues to build on every step of convergence with divergence, moderately satisfactory results can become highly dissatisfactory and lead to stagnation in the process. Seb recommended involving others in the process to gather feedback, new insights, and useful arguments. Dialogue and reasoning with others can help a designer to achieve a breakthrough more easily.

Thus far, the process of iteration seems to be linear. Depending on the subject, this may or may not be true. However, an analysis of a convergent result raises questions, which can produce their own new iteration lines. A question can invite further divergence and then convergence. For example, a convergence phase may raise questions about ergonomics and materials. One can diverge and converge regarding each of these two questions. The ergonomics question might lead to a series of surface structures in favour of grip, the material question to a series of options that are not sensitive to perspiration. Convergence is again possible for both series, in turn influencing the production method. As a result, the production demand thought process will run parallel to the two previous questions.

Thus, iteration leads to an ever-branching process. Such side processes cannot be predicted at the outset. They occur in the process, often to test or substantiate earlier choices. Jeroen

indicated that the process of branching always occurs. There are sub-problems, sub-functions, and sub-solutions, and each requires a side process. Maarten emphasised that the process is not linear because of these in-between questions. According to Pauline, conducting interim testing and making models are ways to maintain an overview and manage the whole process. Overview by modelling and drawing is supported by both pieces of research of Annelies and Seb.

(Leede, 2016)
(Schneiders, 2017)



recursive iteration, 'the Droste effect'

Meandering lines, coloured spaces and the dots:
Time after time, new areas of ideas – colour – emerge, always smaller. Sometimes there is a useful option – dot – within that to continue. New fields are developed from there. The processes repeat themselves endlessly. Nothing is fixed in advance.
Each designer will come to different results with the same principles.

didactics
As described, diverging and converging constantly alternate. It is advisable to take careful notes and to properly analyse each step. Iteration can be stimulated with a dialogue. Talking with one's colleagues about one's assignment and involving them in considerations helps a designer to switch gears carefully. The dialogue also helps in exploring the creative space and the solution space.

pedagogy
If convergence is not thorough enough, there is a risk of losing the overview. The student does not achieve a satisfactory result. The process can also be repeated several times with the same result – a vicious circle. Consultation with colleagues or teachers is then necessary to escape the vicious circle. Alternatively, the designer can examine the criteria from a different perspective or engage in reframing. Immediate steps that are too incremental can lead to a result that is not new. A conclusion is then drawn too quickly without exploring the breadth of possibilities.

‘You will only see it when you get it’

Johan Cruijf

[King of reasoning. Everything is logical or not logical. Johan Cruijf shows that reasoning always provides insight, an insight that others may or may not agree with.]

A designer must support the choices made in every form of collaboration. A personal preference without substantiation will rarely last. Substantiation must not only reflect a critical point of view but also – and above all – result in the designer communicating about the choices so his or her partners can understand what motivated a certain choice. Moreover, just as importantly, the designer’s colleagues then have a chance to disagree. It is, therefore, likely that for many designers, reasoning as an essential skill needed to both discuss the project with stakeholders and fully understand how all elements relate to the complex set of possibilities and decisions.

A designer strives for the best results in a design process and does everything possible to gather insights and knowledge, to optimally analyse and to apply. However, that does not mean that another equally effective designer will achieve the same result. Rather, all possibilities can be combined in many ways, producing multiple satisfactory results. At the same time, possibilities and insights cannot merely be calculated using a mathematical formula. Within a design process, work does not reflect an absolute truth, but leads to an outcome that is most satisfactory for the stakeholders.

Ideas, concepts, and possibilities are chosen or combined. How does a designer know if one composition is better than another? He or she determines this partly by testing the result against criteria. However, what is challenging is that criteria relate to an end result, and at the po int of consideration, an idea cannot always be tested against those criteria. For example, an idea may seem to work well in many respects. However, at an early stage, there is still no certainty about the technical operation or cost price. Because the number of options is enormous, a testable result is not possible. The designer must use his or her reasoning skills to determine whether this option can be successfull. Additionally, intuition plays a role.

PhD. Ozgur Eris
studied mechanical engineering design at Stanford University. Division Technology Integrator. Chief Scientist for Collaboration and Sr Principal Systems Engineer at MITRE

As a professor at Stanford University, Ozgur Eris has researched how designers engage in interactive conversations to make choices. He has found that in such a situation, designers ask each other diverging and converging questions. Divergent questions seek to arrive at possibilities from facts. Converging questions seek to arrive at facts from possibilities. Examples include 'Suppose this is true. What can be done?' (diverging) and 'If these are the options, what can we conclude from that?' Designers should always search for answers to those questions. Taken as a whole, this is a form of joint reasoning or, as Eris has called it, epistemological inquiry. All the questions and answers ultimately reflect plausible reasoning. Arguments are not present in advance but arise during the conversation.

(Eris, 2004, p.551-556)

Hugo Mercier and Dan Sperber have unravelled reasoning in their book The Enigma of Reason. An essential aspect, according to them, is the inference of possibilities and 'what if' thinking. In that context, a possibility is tested against its consequences. For example, one might think, 'There is no excellent film playing tonight, and the weather is bad; I might have walk back in the rain. On the other hand, there is this novel that Tomoko gave me, and that looks really good'. This type of reasoning helps us to make decisions, although in this example, there are several assumptions on which the decision is based. Whether the film is excellent remains to be seen, whether it rains on the way back is uncertain, and whether the book is good is just conjecture. The considerations are highly dependent on the person. In this example, the person may experiences a drop of rain as terrible, causing the inference to weigh heavily on him or her. He or she may like Tomoko a great deal and therefore be extra curious about the book. We compare possibilities based on inferences and tend to sum up such inferences.

(Mercier, 2017, p.52-67)

We come to conclusions via reasoning. If we want to convince others or to follow a certain line of thought, the quality of the conclusion matters. Is a conclusion credible? How well are the various conclusions aligned? Do they strengthen each other? Alternatively, are there conflicts? From everyone's experience, we create a narrative with which we try to turn the conclusion into a credible reality.

Mercier and Sperber make a distinction between retrospective reasoning and prospective reasoning. Retrospective reasoning is always after an event. A statement or justification can come out of such an event: 'It is wet outside because it rained', or 'I stayed at home because it rained.' Prospective reasoning is more important than retrospective reasoning for designers because designers create new things. That is why their conclusions are mostly speculative. We reason to develop arguments. In doing so, we use arguments based on retrospective reasoning. Where possible, we compare options with existing situations or experiences. Additionally, if the situation is new, we try to present it outside the context or to divide it into parts for which we have more retrospective arguments. *(Mercier, 2017, p.128-136)*

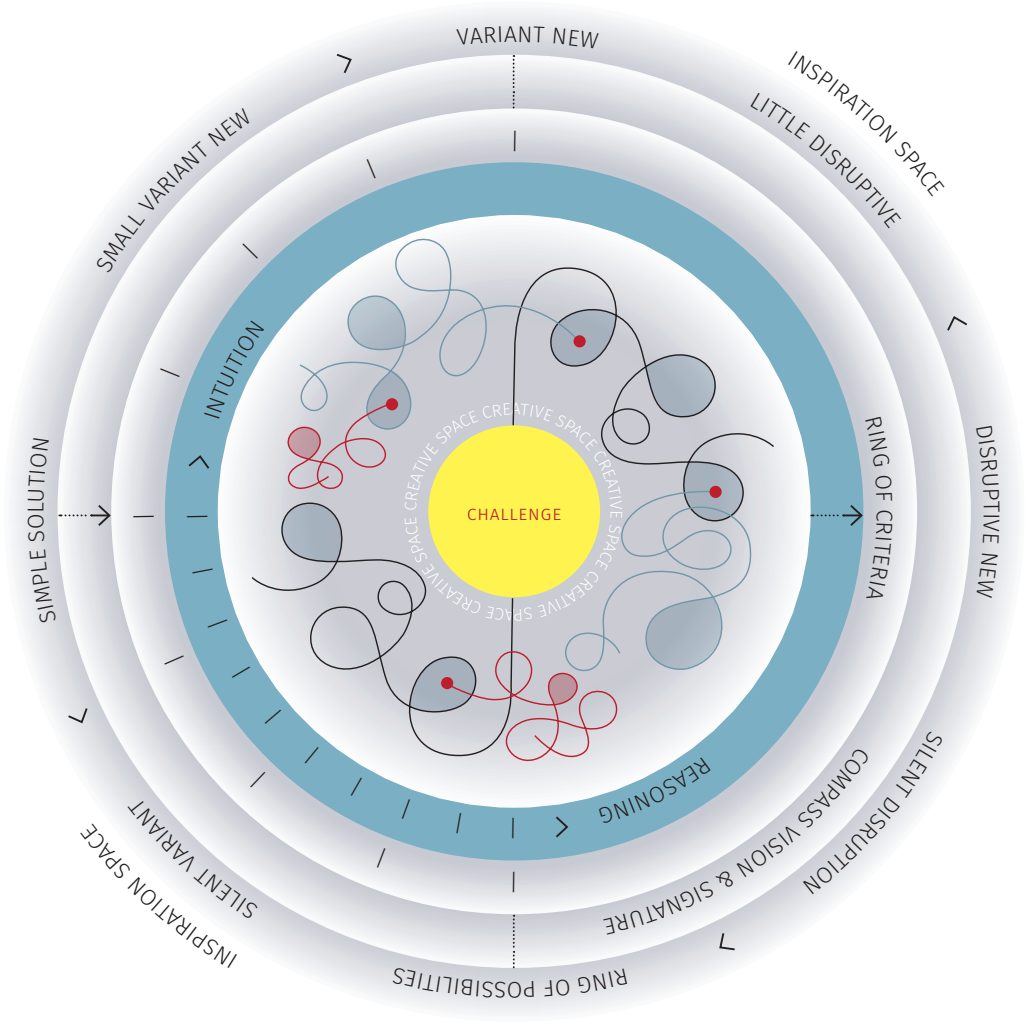
We usually place a situation out of the context by suggesting an exaggeration of the situation. Alternatively, we may isolate it from the context. Such a caricature distorts the facts, but can give us an idea of what would not have emerged without the exaggeration. Even without exaggeration, this argument may remain valid. As Maarten suggested, one can consciously omit one or more criteria so that the consequences become visible. The consequences can make arguments more recognisable.

Exploring possibilities, ideas, and concepts is fuelled by intuition. We try to reason based on intuition. According to Mercier and Sperber, we often do that through backwards inference: 'We infer what our reasons must have been from the conclusions we arrived at'. *(Mercier, 2017, p.148-153)*

Reasoning is also a form of ‘external thinking’ or imagining. The designer shares his or her considerations by writing them down or voicing them to others. Only if the designer takes this step, others can follow his or her thinking, to further support argumentation or to invalidate argumentation.

(Schneiders, 2017)
(Leede, 2016)

Similar to creating a drawing or a model In a sense, these are ways through which the designer’s thinking is expressed – drawing or modelling – and made accessible to others. Modelling or drawing is a way to share something that is still uncertain and lacking a foundation with others not only to find confirmation, but also to determine the quality and model in terms of advantages and disadvantages.



ring of reasoning and intuition

The reasoning is directly influenced by intuition. Here they both form one ring. The ring continually turns back and forth by reasoning. This ring provides insight for all other processes.

didactics

The reasoning within a design process is prospective; it is about something that does not exist yet. The considerations are, in a sense, speculative. We do not reason according to the generated ideas or possibilities, but we imagine the consequences via inferences. Didactically, that offers the possibility to provide students with 'what if' questions. Through practice, students can learn to conduct a conversation in which diverging and converging questions are central.

(Mercier, 2017, p.52-67)

As Maarten said, arguments can sometimes be found by exaggerating a point of departure or by excluding a frame. Sharper images then arise, making arguments more visible. After that, one can zoom out again and see if the argument remains valid. Annelies and Seb both claimed that creating and drawing models (i.e., external thinking) are methods to arrive at insights and arguments.

pedagogy

Reasoning is an extremely linguistic phenomenon and can be difficult for students who struggle with language. For such students, external thinking, such as drawing and making models, can be a tool for finding arguments. According to Pauline, many students find developing sound reasoning challenging.

(Jolles, 2017, p.159)

Intuition plays an important role, especially in reasoning. That can be confusing. What is valid, and what is not? Recognise that intuition plays an important role. Discuss the intuitively found arguments. The student benefits from multifunctional learning and thinking tools. Young designers are still discovering how they think and reason. Learning to think is therefore not only about thinking like a designer, but also about understanding thinking itself as an individual. In that way, a designer learns to choose an appropriate way of thinking. According to Jolles: 'The student enjoys thinking and reasoning, using his new thinking skills.' Take the student seriously as an equal discussion partner.

(Jolles, 2017, p.157-161)

‘Do we still know exactly which question we must answer? Or are we trying to find an answer to an easier question?’

Daniel Kahneman

[With reading Daniel Kahneman’s ‘Thinking fast and slow’, a whole new world opened up for me. Understanding how my inspiration influences my thinking and how my thinking affects my reasoning.]

Analysing within the convergence process takes place at two moments: after converging and after diverging. Before one can converge, everything that has been found from the divergence phase must be reviewed for completeness. Does the collection of new ideas cover the entire solution space? While analysing, no selection or judgement based on quality takes place; only completeness is considered. Jeroen suggested using a checklist. The designer should consider all known criteria and assess whether there is at least one idea covering them.

(Boeijen, 2013, p.135-151)

Analysis of interconnected decision areas is used by Roozenburg and Eekels. In essence, it entails mapping ideas and possibilities against the criteria for the result. The result map closely resembles a morphological map. The result is that the analysis becomes more effortless; it becomes easier to test whether the ideas jointly cover the entire solution space.

(Roozenburg, 1991, p.183-196)

For each idea, concept, or possibility, the meaning and scope are analysed. Which criteria does it meet? Are there similarities shared by different ideas? As the design challenge students noted, the analysis also raises new questions, which should lead to further information. Analysis is also critical to clarify what the inferences based on the new ideas already indicate and what is still uncertain and speculative. This gives the ideas more meaning. Annelies and Ester noted that the analysis is essential to find the question behind the question. It is, therefore, a question of re-analysing the original question even after the divergence phase and thereby sharpening the question again.

thinking /analysis

After converging, analysis again takes place to reassess the selected idea(s). The analysis should consider the original starting points. What new questions can or should be asked based on the selection? What new problems emerge? The analysis should take place without judgment and with the primary objective of determining certainties and uncertainties.

see also thinking /iteration

From thinking- iteration, we see that the interaction between diverging and converging is a frequently repeating process. Switching between them entails significant analysis. Reasoning can be a tool in this process. The identification of structured arguments and reasoning complement each other and contribute to the analysis, enabling choices.

didactics
The analysis is more manageable if an overview is made. For instance, matrix models can consider results in the context of principles, requirements, and wishes. Alternatively, an overview can be used to compare results with each other.

pedagogy
The different types of criteria, including personal criteria reflecting the views of the designer, are challenging to compare. This subjective process can be confusing. How do you decide if you must prioritise ergonomic factors over economic factors, for example? Students can struggle here or choose the most straightforward way.

‘Who often thinks long and abstractly, easily loses the ability to see’

Gerda Smets

[My first introduction to design theory comes from the book ‘form-theory’ by Gerda Smets. I learned a lot from it at the time, and it is still a good book.]

For many designers, intuition is a natural compass. However, there are also designers who distrust intuition. Research into the role of intuition in Robin Groeneveld’s design process shows that intuition is limited in design-related methods and techniques. Many designers apparently do not consciously involve intuition in their design process. Groeneveld’s 19 in-depth interviews with leading Dutch designers show that these designers do not actively or methodically use intuition, but they do allow it. The designers even report being unable to work without their intuition.

PhD. dr. Robin Groeneveld

educated at Industrial Design, TU Delft and psychology, University of Amsterdam

What is intuition exactly? Daniel Kahneman speaks about thinking fast and thinking slow. Thinking fast is the unconscious way of thinking; because of the speed, an opinion or preference arises very quickly – or, in any case, faster than a rational decision (thinking slow). As soon as intuition ‘advises’, we are inclined to follow it. Kahneman says that intuition suppresses doubt and even encourages us to believe false arguments to keep following it. If you think about buying something you want but do not need or cannot afford, fallacies supporting the purchase will quickly appear in mind. Sound reasoning is thus needed to understand the reliability of intuitive choices fully.

(Kahneman, 2016, p.88-93)

Daniel Kahneman

Nobel Prize winner in Economics PhD. Educated Psychology Hebrew University of Jerusalem. Professor at Princeton University and the Hebrew University of Jerusalem. His motivation is to integrate psychological insights into human judgment and decision making under uncertainty.

In her book *The Influential Mind*, Tali Sharot writes extensively about influencing behaviour through rewards. A seemingly good intuitive conclusion is experienced as a reward; it gives the feeling 'that the problem has been solved' and that the designer himself has done it – an ego caressing moment. Such a compliment encourages confidence in the intuitive choice. This does not mean that that trust is justified. Here, too, an ethical argument is needed to test the intuitive conclusion. All this does not mean that intuition is always incorrect. However, the quality of the intuitive decision is unknown at the moment it presents itself.

(Sharot, 2017, p.116-124)

PhD. Tali Sharot
educated at psychology and neuroscience New York University. Professor of cognitive neuroscience Experimental Psychology at University College London. Dr. Sharot is known for her research on the neural basis of emotion, decision making and optimism.

Every person has intuition, Ester claimed. It is a mechanism that we use in difficult or new situations where we must make choices and we have not yet identified an answer. Intuition also reflects our biases. It need not be addressed or activated, but is always present.
In both the conversations of this study and Groeneveld's 19 interviews about intuition, designers agreed that intuition is fuelled by experience. The more someone has seen, experienced, read, and heard, the more 'insight is stored' in intuition. That does not mean that intuition is only useful if a situation is the same as a previous one. Our brain is flexible enough to consider similar situations and recognise patterns. In a supermarket in another country we can easily recognise a pattern related to the supermarket at home. As a result, we know intuitively where we can find the cheese. Alternatively, a design assignment to design colourful garden tools will be intuitively supported by a previous assignment to design a town hall interior using many colours.

(Kahneman, 2016, p.97-101)
(Groeneveld, 2006, p.317-320)

Intuition relies on experience to identify a suitable 'solution' from the past. That may be useful in the kitchen. However, if a designer asks for something new, it is not useful if intuition always pushes the same result. According to Kahneman, intuition and laziness go hand in hand. The designer must make greater use of his or her creative capacity to develop something new.

(Kahneman, 2016, p.47-54)

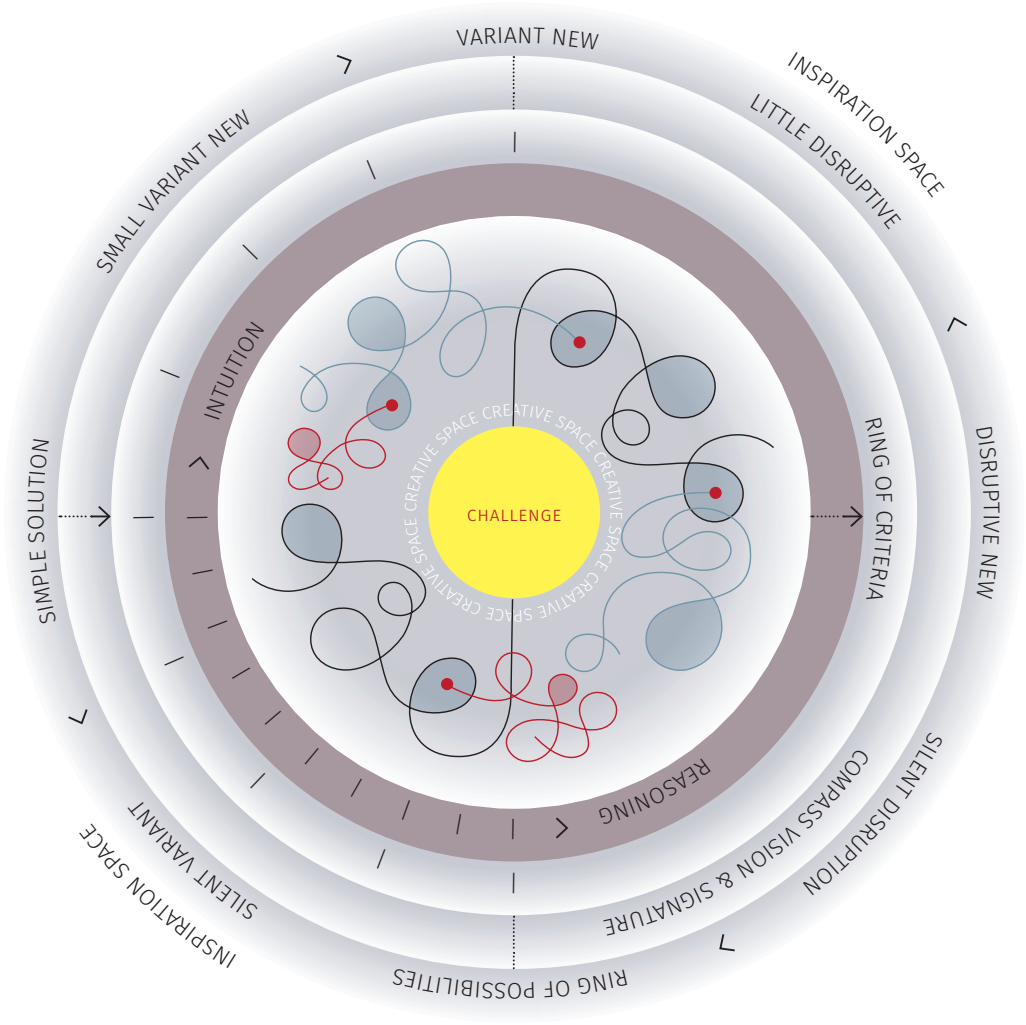
Because intuition is nourished by experience, commonalities, patterns, and repeat actions strengthen intuition. The views of the designer on form, use of colour, and decoration influence intuition as well. This principle also applies to social and political views. As a result, intuition helps the designer to make decisions consistent with his or her own views. The signature of the designer becomes firmer as preferences are applied.

According to Jeroen, when a problem or design assignment becomes complex and logical reasoning stagnates, intuition can help our thinking. Intuition paves the way to solution directions or new insights. Even if one does not know whether it is reliable, intuition indicates a direction. At this point, it is crucial to understand what has been found and to find reasoning. That reasoning may be incorrect, but provides insights that may support a new direction.

Reasoning often entails arguing intuitively chosen conclusions through backwards inference. From prospective reasoning, we proceed to retrospective reasoning, backwards reasoning to justify a choice or conclusion. We will understand the intuitive choice better.

see also thinking /reasoning

(Mercier, 2017, p.148-158)



ring of reasoning and intuition

Intuition is directly influenced by reasoning. Here they form one ring. Intuition is always pulling the ring, consciously and unconsciously. The reasoning is influenced by it, sometimes in a positive sense, sometimes in a negative way.

didactics
The concept of intuition is not formally present in methods. We know from the above discussion that intuition cannot be excluded and has a strong influence on all processes. It is important to recognise intuition and, where possible, to discuss it at every stage and to integrate it into design methods. If an intuitively chosen idea is not backed with arguments, it might be lost.

pedagogy
Intuition is unavoidable and is vital for many. Hence, a student can always easily rely on his or her intuition. However, intuitive choices almost always must find support among stakeholders and must be substantiated with arguments; the reasoning must remain intact.

As Pauline pointed out, wishful thinking and personal preferences are sometimes difficult for students to relinquish. 'Kill your darlings' needs help from teachers or fellow students. According to Jeroen, reliance on intuition is not always best. Intuition is a 'lazy' form of thinking and certainly not always the best counsellor.

‘The people who are crazy enough to think they can change the world, are the ones who do’

Rob Siltanen

[Rob Siltanen wrote the text below for Apple. I see it apart from the brand, as an ode to everyone who dares to think differently. ‘Here’s to the crazy ones. The misfits. The rebels. The troublemakers. The round pegs in the square holes. The ones who see things differently. They’re not fond of rules. And they have no respect for the status quo. You can quote them, disagree with them, glorify or vilify them. About the only thing you can’t do is ignore them. Because they change things. They push the human race forward. And while some may see them as the crazy ones, we see genius. Because the people who are crazy enough to think they can change the world, are the ones who do.’]

(Kahneman, 2016, p.128-136)

Some mystery still surrounds inspiration, perhaps because it is often associated with religion or other spiritual matters. While these domains can undoubtedly inspire, the romantic view that inspiration is everywhere is correct. In every situation, a useful association can emerge from any object or image.

Inspiration can be consciously and purposefully activated. Kahneman mentions the mutual influence of data, even though they have nothing to do with references. For example, if you are told that the Euromast is 185 meters tall and you are asked how high the Eifel Tower is, your estimate will be in the direction of that number 185. However, if the same question is asked without reference to the Euromast, you will probably arrive at another estimate. Kahneman calls that a conscious reference. Let us say that instead of the Euromast, a new-born rhinoceros weighing 250 kg is mentioned. If you are then asked the Eiffel Tower question, your answer will be influenced by that reference and will be in the direction of 250 number.

This is how our thoughts are influenced by politics and marketing. Interestingly, you can also influence yourself through inspiration from other domains and through searching for analogies for a current design assignment. For example, Tata Steel had a logistical problem related to transporting its employees to ensure 24/7 labour. At the time, it used TPG Post as a reference (i.e., inspiration), carefully studying the organisation’s approach to collecting and delivering packages. The one situation was not the same as the other, but this approach helped Tata Steel to tackle the problem. Another example is a Rotterdam hospital that tackled its waiting lists by studying the logistical operations of Schiphol Airport.

As Kahneman points out, the influence is relatively easy to organise. It goes through fast thinking and intuition. A designer can make conscious and targeted use of it to aid divergence. However, the process can also be less focused. One can, as Annelies and Jeroen mentioned, attend fairs, visit museums, and browse magazines. These activities provide a multitude of incentives and associations and also is 'food' for intuition. Moreover, this food is in line with the reference influence, as outlined by Kahneman.

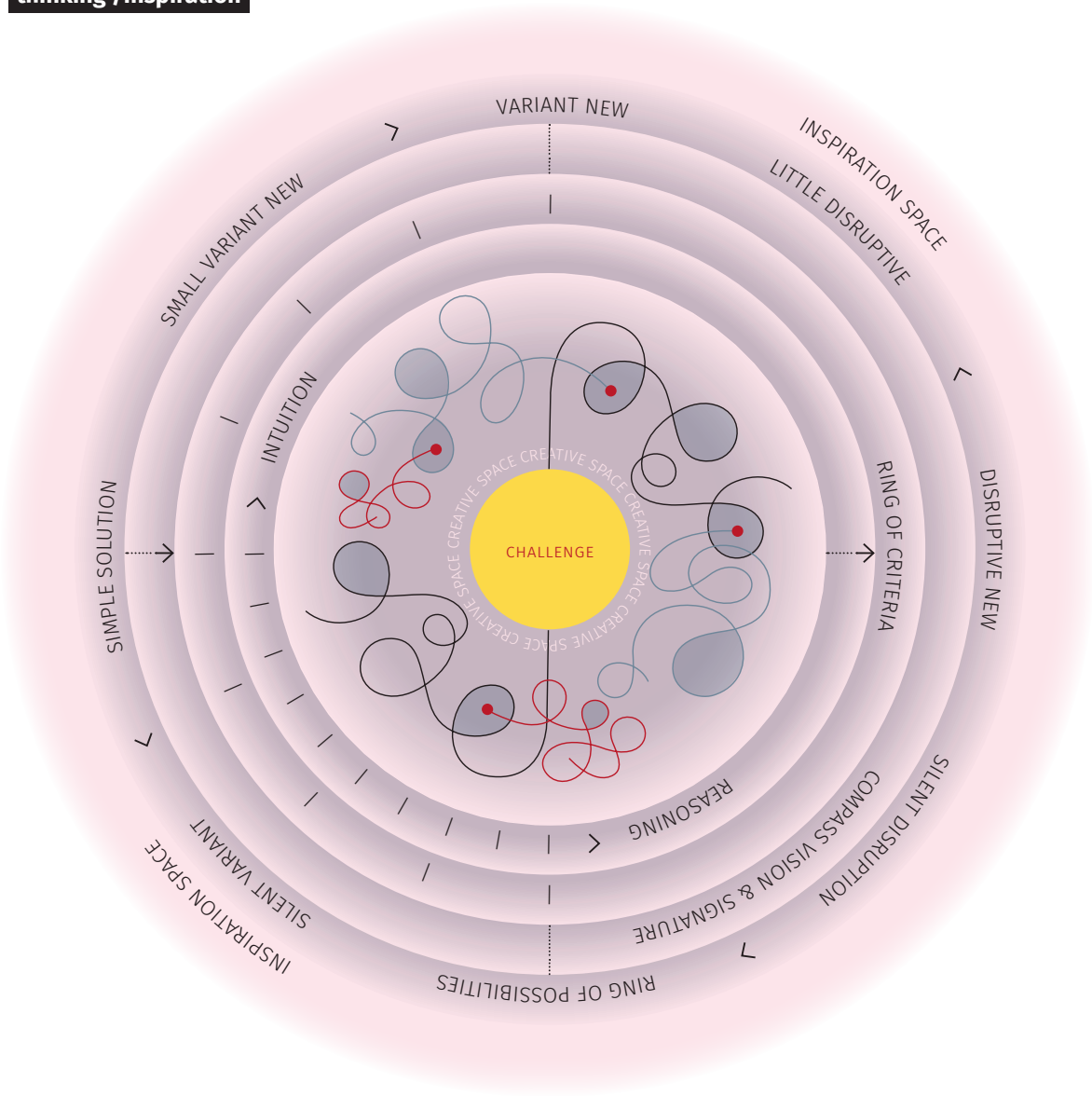
(Kahneman, 2016, p.134-136)

To make an association useful, one needs a strong imagination. One must be able to visualise the association. Drawing or making models can also help.

(Schneiders, 2017)
(Leede, 2016)

Seb emphasised that re-drawing something helps one to observe it clearly. The more closely you look, the more you see. One can take inspiration from that – enrichment of one's knowledge and insight.

Maarten identified the risk of consciously seeking inspiration within the same domain in which one is working. There is a risk that one might unconsciously copy, which is something to be alert of. Ester put that risk into perspective by saying that there are always many other required steps and decisions. t



inspiration space

The inspiration lies within and outside the ring of possibilities. Everything is possible there. Everything can influence the challenge, inspire.

didactics
Inspiration can be consciously encouraged. Students can visit business fairs and stores or study magazines related to their case. References can be created consciously to stimulate thinking. Images, places, or concepts concerning the assignment or identified ideas can force them in one direction. As Annelies put it, 'The more inspiration, the better.' The more visual material collected, the better one can make associations and broaden the scope.

pedagogy
Inspiration and associations are highly personal. Two people can have completely different associations with chosen images or phenomena. Opinions or understandings of the source of inspiration itself can differ. What ultimately matters is what the student does with the inspiration: how he or she embeds it in the project and what arguments and reasoning he or she uses to support this move. If it is difficult for a student to continue the process, new inspiration can help.

In most cases, students are still adolescents. According to Jolles, there is a strong tendency to try new routes at that age. It is even painful at that age to not do so. In that sense, a teacher can easily provide inspiration, not mandatory. The teacher should avoid closed questions *(Jolles, 2017, p.60-61)*

‘Learn the rules like a pro, so you can break them like an artist’

Pablo Picasso
[I wish my signature, my actions, my thinking, were as natural and spontaneous as the way Picasso created.]

The literature study suggests that there are not many theories and methods that relate to converging. The conversations did not add much. Existing methods fall into three categories:
- **Methods that help with analysis before converging**
- **Methods for assigning value to found ideas**
- **Methods for achieving convergence through dialogue**

All conversation partners mentioned the morphological map. The most crucial function of this method is for mapping: creating an overview of everything that has been found concerning the starting points. Essentially, a morphological map is an analytical method used before actual convergence.

see also thinking /analysis

To achieve convergence, one can assign different values to the ideas found. The Harris profile was mentioned in all the conversations and the weighted criteria model by Jeroen and Maarten. The methods are both matrix models. In the Harris profile, the criteria all count equally. Roozenburg and Eekels have described the weighted criteria model in depth. They have provided resources to weigh the importance of the criteria. Ergonomic factors can be weighed against economic ones, for example. When using this sensible method, one must take into account that weights will differ per stakeholder. Additionally, despite detailed instructions, subjectivity is possible regarding many points. What is treacherous about the outcome is that it has the appearance of objectivity and accuracy. As long as that possibility is taken into account, this method can help designers to compare results and expand their reasoning.

(Roozenburg, 1991, p.287-301)

Other methods mentioned by Jeroen are the PMI method (‘plus, minus, interesting’). Alternatively, by assigning values with stickers. Less structured than the weighted criteria method. Additionally, here definitely influenced by bias and subjectivity. However, it can be a tool to achieve convergence. Here, too,

reasoning is essential to limit the influence of bias and subjectivity

Based on the students' reflections on methods, mentioned earlier in this study, they consider the methods to be relatively unimportant: 'You know without methods.' In a conversation about filling in a Harris profile, they also mentioned that there is much room for bias and subjectivity.

All conversation partners saw reasoning as an essential skill. Maarten mentioned a linguistic guide to support this process. Using 'I choose this because...' sentences helps the designer to identify the motivation for every choice. The opposite is possible as well: 'I did not choose this because...' sentences. This method intrinsically involves reasoning.

Maarten also mentioned roleplay as a method to support diverging through reasoning. Students or colleagues can play the roles of the various stakeholders. Assuming that the different roles represent the criteria, reasoning, argumentation, and discussion are used to achieve convergence and support. The thinking hats of de Bono are an additional method for establishing a good dialogue. The six thinking hats represent six mental focus areas: The white hat is about facts and figures; the red hat entails emotions and feelings; the black hat caution and care; the yellow hat positive speculative; and the green hat creative thinking. The blue hat represents control of thinking and is an umbrella hat to help achieve convergence. The six thinking hats can be represented by six students in a dialogue. Individual dialogues with specific participants are also possible. Variations regarding role distribution are conceivable. One can even play a different role by him- or herself every 10 minutes, using the different focus areas as a critical tool.

(Bono, 1992, p.16-24)

didactics
Didactically speaking, it is essential to state the scope of the methods. The result should be measurable and accurate, perhaps due to the structures used. It is essential to recognise that the outcomes are just tools to support choices with arguments.

The roleplay of stakeholders, as described by Maarten, or the thinking hats of de Bono are not about strictly measuring or weighing, but about identifying the arguments and reasoning motivating choices. They are methods that leave room for personal views and intuition and in which reasoning can produce a convincing argument. *(Bono, 1992)*

pedagogy
Executive functions help a student to develop and maintain an overview. Filtering, organising attention, impulse suppression, purposefulness, and planned action are some executive functions. Because of his or her age, a student does not entirely control these functions. The aim is not only ensuring planning and discipline, but also creating structure and organising involved elements. The teacher can provide coaching in this regard. The development of executive functions is not the same as the methods mentioned in this chapter. The executive functions and the methods can support each other. *(Jolles, 2017, p.143-149)*

Regarding many points, there appears to be considerable consensus among the discussion partners. For additional insight and further evidence, the literature from the domains of design theory and other fields is relevant. Knowledge from other domains does not always fit into theories in a particular discipline if no specific study has been done. Relativisation of the knowledge is therefore appropriate. Nonetheless, the identified theories were discussed with the discussion partners during a moment of reflection, and at that moment, it seemed plausible to apply toward convergent thinking.

The ten ways of thinking each suggest many insights. In both design theory and education, insights should not be viewed as truths. It is better to interpret this study's insights as an inventory and, to the extent that they can be used in design practice or design education, as plausible guidelines for thinking.

Regarding the sample size, only a limited number of design teachers and students were involved. The qualitative research approach brings balance to the size. The influence of the broader field of work is partly reflected in the professional literature and its international character. It is partly because of this factor that there are more works in the reference list than in the direct citations. That is not to be cool, but to strengthen the conclusions and to enable statements such as that the professional literature pays little attention to the concept of converging.

My own biases as a researcher are also relevant. I have been working in the design profession for over 30 years and in design education for 25 years. My personal knowledge and insights manifested themselves in all aspects of the research. Of course, I have done everything possible to put aside my own biases for this research. The statements of the discussion partners directed this work. But in the analysis of those conversations and the literature, my experience – and hence, my biases – were present. At the same time, I believe that my professional and teaching experience is rich and coloured with thousands of conversations with colleagues over the years. Biased or not,

my findings are likely relevant. Alternatively, as Kahneman has put it, 'Let us remove the correlation between errors by gathering different opinions. We will receive more information from independent evaluations'.

(Kahneman, 2016, p.96)

results /conclusions

The question ‘What is convergence in design education?’ led to ten ways of thinking, directly related to convergence. Although the conversation partners lacked knowledge about the subject, due to their unconscious competence, they managed to share many relevant insights about every way of thinking. The most important conclusion is that there is indeed a great deal of knowledge and insight regarding convergence, even if that is not yet reflected in the professional literature. In the future I hope to integrate my findings into design education. Of course to do so, will require further studies on how to integrate a consciousness of these ten ways of thinking in the classroom curriculum.

Boden’s gradations of newness can indicate if something is new for the design profession and can be used to clarify ambition levels. For educators, her description is a new taxonomy of novelty. This taxonomy could also help to increase the difficulty of the design tasks during the course of study.

Criteria are often seen as hard requirements, but when something new is created, criteria are frameworks for reasoning. Criteria such as the professional views of the designer and his or her signature are often only present due to the stakeholders’ choice of the particular designer. The designer should write down these personal criteria so that they can contribute to the overall starting points.

Divergence, as described in this study, can be differentiated from the multitude of brainstorming methods. De Bono’s lateral thinking is relevant, no matter how old this theory is. Asking the question behind the question helps the designer to start with fundamental principles. Dorst’s reframing is a valuable addition. The most striking insight regarding divergence is that it also takes place in the convergence phase. When selecting, the designer examines the possibilities related to the choice. These are divergent considerations.

Pedagogically, selecting is a process of uncertainty, not only because the decision to choose something also immediately

entails the limitation of that choice, but also because it means that the other options are not chosen. Students experience that as a loss.

The conversations demonstrate that iteration in the design process is often different than what design textbooks suggest. Divergence and convergence are repeated numerous times – not just two or three times, but hundreds of times. High-level conceptual ideas and small details are examined. The course of the iteration process cannot be predicted; it is reflected in the process itself.

Reasoning is seen as a fundamental skill in the design profession. Reasoning follows inferences, which are in turn highly intuitive. Because reasoning is strongly influenced by intuition, the results thus obtained are not always as correct as they seem. The most crucial role of reasoning in the design process is aiding communication. The designer must communicate with his or her experiments about what is happening. Additionally, communication with colleagues and stakeholders is needed to make decisions.

For the design profession, it is essential to realise that intuition is there by definition. Even though some designers think they can switch it off, that is not possible. Moreover, intuition is not always the best counsellor. In many cases, intuition provides incorrect advice. Backwards reasoning regarding intuitively identified ideas seems to be the best way to determine whether an idea can be used.

Inspiration can be easily encouraged. Trade fairs, magazines, or books can offer new perspectives. Images, data, and insights can intentionally or unintentionally influence thinking.

The methods mentioned in the interviews are analytical. They help designers to gain insight and support conclusions. However, these conclusions should not be seen as definitive. In fact, all methods are primarily or only suitable for supporting reasoning and identifying arguments.

results /looking forward

Design is a relatively young field. Design theories have their foundations in the 1960s and are still developing. Such theories are shared worldwide and build on each other. Researchers should determine whether and how the findings from this thesis fit with existing and new theories.

Follow-up research should be conducted at several design institutes. It would be interesting to see how the insights from this paper align with the work of art design universities and technical design universities, preferably international ones.

Design is a broad field in which idea generation is important. Hence, there must always be some form of convergence. Researchers should examine how convergence works within fashion, graphic design, media design, and other fields and to what extent this paper's findings are generalisable to these fields.

The most important recommendation is to convert the insights of this thesis into education. The inventory nature of this thesis provides a foundation for developing modules via which both major and minor insights can be embedded in design education. Additionally, researchers must monitor whether embedding these insights in education leads to better student results. Will the work of the students benefit from this approach? Will students' study processes proceed more easily? Attention to this study's findings in design education could lead to improved student development.

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text: Jan Siebers
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Frans-Willem Korsten
graphic design: Anka Kresse
infographics concept:
Jan Siebers
infographics design:
Anka Kresse

Master Education in Arts and
Design, Piet Zwart Institute,
Rotterdam University of
Applied Sciences

How Designers Think
Ten Ways of Thinking in Convergence for Design Education.

Bias and subjectivity can easily influence the convergence process. Because criteria for innovations are not fully established and cannot be complete, using these criteria is difficult. Intuition is one means of thinking that leads to convergence. Reasoning is the most crucial skill a designer needs to effectively converge. Although reasoning relies heavily on inferences and is not as powerful as it may seem, it allows designers to communicate about choices, to integrate personal considerations, and to account for intuition rationally.
In the education context, the ways of thinking offer insight into the complexity of convergence, related pitfalls, and guidelines.