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The Complementary Roles of Intuition and Logic in Creative Design Ideation

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The interaction between intuitive (practice-based) and logical (theory-based) ways of thinking about creatively solving design problems is the focus of this project. Thirty-nine industrial design students were exposed to both intuitive and logical design approaches to resolving briefs during a 1-day workshop. The intuitive approach encouraged an open and informal take on idea development grounded in past-experience, whereas the logical approach emphasized structured and sequential problem analysis. In a within-subjects design, half the students adopted an intuitive approach in the morning and a logical one in the afternoon to solve design briefs, whereas the reverse applied to the other half. Students rated their experiences on five 7-point scales after 30 min into the session and on a different set of 10 scales at the end of the 2-hr session, and their design proposals were assessed by experts. Results showed that the intuitive approach energized participants and stimulated idea generation after 30 min, but teamwork was challenging. The logical approach lent confidence to the students and was easier to adopt, but only after applying an intuitive approach in the morning session. Students found it more challenging to complete their proposals after 120 min in the logical condition. Proposals by students in the intuitive condition comprised mostly images, while those created in the logical condition were highly verbal. Critical self-evaluation by students was reflected in higher ratings of proposals by the judges.

Keywords: intuition, logical reasoning, conceptual design, creativity, design education

Broadly speaking, the design process entails a series of actions that can be more or less structured depending on the complexity of the problem being addressed, the stakeholders involved, and the context in which it takes place (Cross, 2011; Roozenburg & Cross, 1991). This course of action might include different goals, phases, rules, methods, approaches, and strategies (Pahl et al., 2007). The processes underlying design activity, its principles and practices, have been studied extensively in design methodology (Andreasen, 2011; Birkhofer, 2011; Cross, 1984, 2006) and in the cognitive processes underlying design thinking (e.g., Cross, 2011; Hay et al., 2020; Lawson, 2006). Regardless of the approach being implemented in the practical world of design, the brief reigns supreme and a solution must be proposed that solves the problem in question.

Researchers have investigated many aspects of design activity (Cross et al., 1996) with a view to devising more encompassing and systematic methodologies (Birkhofer, 2011; Jones, 1992). Many structured design methodologies have been proposed (e.g., Pahl et al., 2007; Ulrich & Eppinger, 2016), often based on accounts of design activity. Approaches to the design process range from fast-paced and flexible ways (e.g., Scrum, see Schwaber, 1997; Kanban, see Anderson, 2010; and Sprint, Knapp et al., 2016), through to contemporary "philosophies" (e.g., agile, lean, and design thinking), to logically structured and systematic methodologies (e.g., VDI Guideline 2221, see Jänsch & Birkhofer, 2006), and product development process (see Ulrich & Eppinger, 2016).

Within the context of types of thinking in design, it is possible to see relations between intuitive unstructured and logical structured approaches as potentially complementary. For instance, in literature discussing different systems thinking skills, some authors talk about the difference between forest thinking—having a general picture of the system under consideration, versus tree-by-tree thinking—focusing on details and specific parts of a system (Richmond, 1993; Richmond & Peterson, 2001). In the creative thinking literature, for instance, Sternberg and Lubart (1991) describe their proposed investment theory of creativity as composed of six influential resources, one of them named thinking styles, which include the ability to think globally and locally. In design research, these types of thinking approaches are more commonly referred to as breadth-first versus depth-first solution development approaches (Ball & Ormerod, 1995; Ball et al., 2010). Some might argue that one should begin with a global perspective and get a feel for the overall forest terrain underlying a challenge, be it in design or pragmatic challenges from everyday life. Others might favor a local approach that focuses on details or nuances of a project that can be analyzed closely from the outset.

Badke-Schaub and Eris (2014) describe design intuition as holistic, fast, multisensorial, and experience-based and able to access unconscious processes, emotions, and creativity. Taura and Nagai (2017) describe out-of-the-box creativity that is related to intuition or gut feeling and holistic or unconscious thought. They contrast "experiential intuition" that enables instantaneous decision making based on past experience, with "associative intuition" that reflects a person's sensibility, and it is shaped by free association that leads to resonance. The flash of insight in experiential intuition is accompanied by eliminating

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fixation and the flash of insight in associative intuition is achieved when things are interconnected via sensibility (or resonance to sensibility). Dijksterhuis and Nordgren (2006) adopt a cognitive perspective, arguing that "unconscious thought" can resolve challenging problems through intuitive feeling that emerges from turning attention away from the problem at hand and letting things sort out in the shadows of the mind. Similarly, Smith and Blankenship (1991), in their experimental research on induced fixation and incubation, investigated how stepping away from the problem, and through "unconscious work," one might be able to solve previously failed attempts to address problems.

In contrast, a logical approach to design is more analytical and systematic and involves critical self-reflection. The differentiation between intuition and logic has, to a certain extent, been discussed in engineering design where researchers have differentiated between intuitive and logical idea generation methods (Shah et al., 2000). They claim that intuitive approaches trigger unconscious thought processes which may lead to original outcomes. Logical (or rational) methods, on the other hand, facilitate a thorough analysis of the problem, relying mostly on scientific and engineering principles for generating novel ideas (Shah et al., 2000, 2003). Some have explicitly advised against using an intuitive method and favored a logical approach. They argued that intuitive approaches might prompt designers to engage in arbitrary problem analysis (Alexander, 1964) and premature conclusions (Hubka, 1982). Conversely, systematic/logical methods are believed to support designers in methodically tackling the inherent complexities of any given design process. One of the repercussions of these standpoints is that the role of intuition has been largely disregarded in design methodology research, where the general bias favors well-grounded and logical modes of thinking.

There are different ways to frame the challenges that must be addressed in design pedagogy or with new practitioners joining an established company. Gero et al. (2013) contrast unstructured and structured techniques in their analysis of concept generation creativity that yield successful outcomes for undergraduate students in mechanical engineering. In essence, the contrast is between intuition and structure. Intuitive techniques, such as brainstorming, foster divergent thinking the goal of which is to generate as many solution proposals as possible. This would be accomplished by randomly exploring a very large solution space without a predetermined direction or judgment, and welcoming unusual ideas, while deferring till later the process of amalgamating and refining (Osborn, 1993).

Structured or logic-based concept generation creativity techniques, such as design by analogy, propose solutions based on principles or cataloged solutions from experience. They acknowledge, however, that the boundary between the unstructured and structured approaches is not clearly defined. A movement toward greater structure in design cognition involves "abstracting the core of a product's functionality, and then systematically structuring (shaping) a complex problem through its internal relationships" (p. 199) with a focus on opposing notions: decomposition and forced associations, followed by the emergence of potential solutions. Still more structured variations involve clearly defined and highly elaborated principles.

In their study, 75-min lectures were given on the different concept generation creativity techniques. The results of the study were analyzed in accordance with a function, behavior, and structure ontological view that transforms a set of requirements and functions into a set of design descriptions. For the purposes of building a bridge to our project, a contrast is drawn between earlier and later stages of the design process during which students elaborate and evaluate their design solutions. The researchers concluded that "the more structured a concept generation technique is, the more likely that designers applying this technique would spend more cognitive effort reasoning about the design problems rather than their solutions" (p. 210). A reason for this is that structured instruction requires "designers to engage in cognitive exercises pertaining to the requirement, function, and expected behavior of the design problem" (p. 210). The finding that more time was spent on problem analysis using structured logic is consistent with data reported by Chulvi et al. (2012). They further concluded that, "in the brainstorming condition, student designers tended to jump straight to activities related to solutions without fully scoping the design problem" (pp. 210–211).

The intuitive and logical modes of thinking in design are analogous to "bottom-up" and "top-down" processes, respectively, in the "dual-processing" model in psychology and economics (Evans & Stanovich, 2013a, 2013b; Kahneman, 2011; Stanovich & West, 2000). This bridge between design pedagogy and psychology must be tempered by the fact that, in both cases, practitioners and students are constrained by practical demands of the design brief. Dual-processing theory in psychology implies an interchange between spontaneous and deliberate thinking (Benedek & Jauk, 2018; Sowden et al., 2015) with a clear distinction between System 1 and System 2 types of thinking that readily applies to intuition and logic, respectively (see also Kahneman & Frederick, 2002; Stanovich, 1999).

According to Evans (2008), System 1 thinking is intuitive, holistic, perceptual, contextualized, pragmatic, experiential, implicit, associative, and reflexive, seemingly involving little effort. It is "unconscious, rapid, automatic, and high capacity" (Evans, 2008: p. 256) such that "only their final product is posted in consciousness" (Evans, 2003: p. 454). Real-world knowledge plays a central role in this model. System 2 thinking is logical, rational, analytic, reflective, controlled, explicit, rule-based, conscious, sequential, and involves high effort—"conscious, slow and deliberative" (Evans, 2008, p. 256). It fits well with a logical approach since it is predicated on "abstract reasoning and hypothetical thinking" (Evans, 2003, p. 454). System 2 "thinking is both volitional and responsive to verbal instructions" (Evans, 2003, p. 456), but requires high effort and, together with low processing capacity, limits a person's ability to attend to other input. Past beliefs or knowledge may come into conflict with an attempt to rationally analyze a design challenge.

The use of the dual process theory as a lens to study design activity has recently been explored by a few researchers. For instance, Goldschmidt (2016) established links with the dual-processing theory in terms of shifts between divergent and convergent thinking. Cash and Maier (2021) studied the contrast between the use of gesture and sketching in design through this same dual-processing theory lens. Kannengiesser and Gero (2019), proposed a framework for applying Kahneman's model (Kahneman, 2011) to design based on the function–behavior–structure ontology (Gero, 1990; Gero & Kannengiesser, 2004, 2014). Kannengiesser and Gero (2019) applied the dual-system model to "thinking fast and slow" (Kahneman, 2011) in a design context from a cognitive science perspective. A System 1 intuitive approach is best applied "to uncertain or ambiguous situations" (p. 3) where fast design thinking is needed.

A downside of this application of fast thinking is that there may be a bias to selecting existing design solutions that have been coded in memory. Jumping to existing solutions may lead designers to design fixation—an inadvertent attachment to a set of ideas limiting the consideration of alternative concepts (Jansson & Smith, 1991). Kannengiesser and Gero (2019) describe brainstorming as an example of nonroutine designing in which System 1 plays a creative role. Accordingly, the problem statement is described at the outset and individual group members articulate their ideas and present them to the group without criticism or evaluation. The group then reflects on these ideas to extend or combine them. This approach is consistent with "experiential" and "associative" forms of intuition described by Taura and Nagai (2017) and Kahneman's (2011) account of System 1 as a source of more associative concepts than were demanded. The complementary role of System 2 in this context is to analyze and evaluate these ideas in a reflective manner. Following this line of reasoning, and particularly during design activity, these cognitive processes can be seen as shifts between divergent thinking and convergent thinking as discussed by Goldschmidt (2016).

Therefore, intuitive and logical approaches are not mutually exclusive, as designers might find themselves in circumstances where they have to shift between them. These two approaches can also be considered in accordance with Sternberg's (1997) distinction between "global" and "local" styles of thinking. While a global style explores abstract ideas, the local style is much more concrete. It has also been argued that a global approach, consistent with an intuitive strategy, precedes a local style that is appropriate for a logical design strategy.

This duality between "global" and "local" can be further interpreted from process-oriented approaches to the study of mental phenomena, more specifically that of microgenesis. Originating from the work of early experimental psychologists (J. W. Brown, 1977; Werner, 1956), microgenesis tells us that "any human activity such as perceiving, thinking, acting, and responding emotionally is an unfolding process in time consisting of qualitatively distinct stages" and alludes to the "phasic nature of cognition" (Bachmann, 2000, p. 23).

Werner and Kaplan (1963) described the earliest stage as being of "an affective-sensory-motor nature, representations which serve perhaps to establish global outlines of the experience" embodying "personal, idiomatic, and contextualized gestures or images" (p. 242). With time, there is a "differentiation and articulation of connotations...and a progressive channeling of meanings towards communually adequate verbal forms" (p. 242). This fits with the more general view that "mind unfolds from depth to surface, not from one representation to another" (A. Brown, 1988, p. 3) and "deep or developmentally early levels elaborate automatic functions, whereas 'higher' levels elaborate volitional performances" (A. Brown, 1988, p. 7). This implies a "whole-part transition," from "generalization to definiteness," in the face of "constraints" based on need or environmental demands (T. A. Brown, 2015, p. 27) as a movement from syncretic to heuristic thinking.

This can also be related to Campbell's (1960) "blind-variation-and-selective-retention model" which addressed inductive gains underlying trial-and-error problem solving that can be related to intuitive dynamics. Campbell stressed the need for a mechanism that introduces "blind variation." In relation to the term "blind," he refers to "systematic sweep scanning" that is recognized as useful for problem solving. This can be related to a sweeping exploration of relevant past experiences features of which might be relevant for solving the design brief. The speed and implicit nature of the process is what makes intuitive design thinking appear elusive. The "constructive episodic simulation hypothesis" of Schacter and Addis (2020) emphasizes the "important role of episodic memory … in generating simulations of imagined future events" (p. 112). Neuroimaging has underscored the importance of overlapping "patterns of activity associated with memory and simulation" (pp. 117–118). This kind of constructive activity is clearly relevant to accessing past experiences in solving design problems. In this case, the process is not "blind," and a directed parallel processing search can be fostered by an approach that favors accessing past relevant experience. The word "relevant" is important here because it refers to a lens that constrains the search to events that are directly related to outcomes specified in a brief.

It bears mentioning Polanyi's (1966) idea of "tacit knowing" whereby "we can know more than we can tell" (p. 4) and is the "outcome of an active shaping of experience performed in the pursuit of knowledge" (p. 6) so "We can, accordingly, interpret the role of tools…as further instances of the art of knowing" (p. 7). In the context of industrial design, we can address "the transformation of the tool or probe into a sentient extension of our body" (p. 16). For Polanyi, "to see a problem is to see something that is hidden" and "the experience of seeing a problem" relies on "prior tacit knowing" (p. 21). We can therefore build a bridge between "tacit knowing" and intuition based on prior relevant experiences brought to bear through a process of remote association. Accordingly, "all discovery is a remembering of past lives" (i.e., Plato aside, we refer to lived-experiences) so "that we can have a tacit foreknowledge of yet undiscovered things" (p. 23). Active engagement with colleagues in the search of solutions as part of a community of practice makes it possible for intuited tacit knowledge to become formalized and shared.

We frame the challenge of creating useful design solutions as a contrast between practice-based and academically founded research strategies always related to a formal brief. From an intuitive and practice-oriented perspective, a less structured, tacit, and spontaneous approach might be best suited for the early stages of creative design activity. This global approach draws upon episodic recollections of potentially relevant experiences and related exemplars. Academic researchers might perceive this intuitive approach as too diffuse and challenging for students. A logically structured approach might help students systematically deconstruct novel design challenges for which they have no past experiences. On the other hand, experienced designers often disregard systematic methodologies, perceiving them as entailing too much effort, being complex, abstract, or theoretical to implement in professional practice (Wallace, 2011).

Given that these approaches are potentially complementary and not mutually exclusive, one can inquire whether they should ideally be introduced to students in a particular order. The finding in visual experimental esthetics that global precedes local processing (Cupchik & Berlyne, 1979), and in cognitive theory that preattentive precedes focal attentive processing (Neisser, 1967), leads to the hypothesis that intuition is best practiced before logical creative design activity. Based on prior research in design creativity, the formal deconstruction technique entailed in logical design activity should also require more time compared with intuitive processing. The guiding hypothesis underlying this project is that an initial experience with global intuitive modes of design thinking will make it easier and more productive to then adopt a local logical approach. Conversely, adopting a local and logical approach to design thinking will inhibit or interfere with subsequent efforts to apply a global and intuitive approach.

Accordingly, this research is guided by the following questions:

1. How do intuitive and logical thinking modes influence early and later stages of creative design idea generation?
2. What is the impact of switching between intuitive and logical thinking modes across morning and afternoon sessions?
3. Does applying the logical approach to addressing a design brief require extensive processing that slows students down?
4. Is it more challenging for students to collaborate when applying the less structured intuition approach?

Method

To explore the potential relations between intuitive and logical approaches to design idea generation, we organized a 1-day workshop with graduate students in industrial design. We adopted an evidence-based approach to examining the impact of intuitive and logical design strategies on students' thinking processes while working in groups. Three perspectives were incorporated while developing this study. First, we considered the researchers/design educators' interest in comparing the effects of intuitive versus logical design approaches along with the impact of exposing students to such approaches in two counterbalanced orders, intuitive/logical, and logical/intuitive. Second, we considered the students' experiences of these approaches both early on, after 30 min, and at the end of a 2-hr design session. Third, we incorporated the viewpoints of judges (graduate students supervised by professionals) who assessed the student projects using six creativity dimensions chosen by the research team.

During typical design studio activities, students are often expected or requested to use particular methods while designing. However, they rarely engage in meaningful reflection about how a given method is perceived, interpreted used, and impacts their thinking. We aimed to encourage students to reflect more deeply about how methods influence their thinking and design actions. By "stepping away" from the typical design studio routine, and setting up a more experimental design context, we could collect data on the potential impact of thinking approaches during design idea generation. We had the following objectives in mind:

a. explicitly expose the students to two distinct modes of thinking (intuitive vs. logical),
b. set up the activity in a way we could collect data about their early and later perceived experiences along with project outcomes; and,
c. bring students together with researchers/educators in a panel discussion about their experiences at the end of the workshop.

Participants and Design

The workshop comprised 39 participants (19 males and 20 females). All students had previously worked on several design projects both individually as well as in group settings, often with three to five people per group. The students recruited for the experiment were second- and third-year undergraduate industrial design students as many men as women. Their age ranged from 19 to 22 years. The third-year students already had some experience in applying the vision in product (ViP) process within a design course at the end of the second year. In the groups, the second and third years were mixed so that the method that was briefly explained in each group could be applied based on some experience. This was very welcome because the time within which they had to come up with a design was limited. They were randomly assigned to one of 10 different working groups. Eight groups comprised two males and two females. The ninth group involved three females and one male, while the 10th group included two males and one female. The structure of the workshop is presented in Table 1. Participants were randomly assigned to one of two clusters for the morning session, the intuitive condition (Groups 1–5) and the logical condition (Groups 6–10), and switched during the afternoon session.

In the morning session, the intuitive and logical clusters were given a short orientation on how to approach their design brief, before working on it for 2 hr. In the afternoon session, the workshop conditions were reversed with participants exposed to the other design approach before working on a new design brief for 2 hr. The research strategy focused on capturing how students experienced the design process early on (30 min into activity) and at the end of the session (after 120 min). Thirty minutes into the session, students rated their experiences on a five-item questionnaire using 7-point Likert-type scales. At the end of the session, after 120 min, they rated their experiences on 10 new questions again using 7-point scale. The final output from each group, containing A3 sheets of paper with drawings and written notations, was evaluated by two graduate students and two practicing designers on six-ideation metrics using 7-point scales.

An Intuitive Design Approach

Participants in the intuitive condition did not explicitly receive instructions about how to approach the design exercise at hand. The students listened to a 10-min in-person presentation given by a practicing designer with 25 years of experience in the areas of product design, service design, digital design, and graphic design. The speaker used a slide presentation (video of lecture, with accompanying slides, is available on a dedicated website) predominantly populated with images of different design projects the company had been involved with (projects unrelated to the briefs used in the workshop). A couple of very short statements were also used throughout the presentation. For instance, the first slide stated go for intuition and the presentation ended with trust your intuition. The designer expressed how, in the company, they felt pressured to use all available knowledge, tools, methods, and processes. And yet, when presented with a client brief, they claimed knowing very early on what the solution would be like, allegedly without (consciously) going through any thought process. Whereas the presenter also acknowledged that the company would always eventually follow a design process, it was repeatedly emphasized that they would often converge to that initial idea, reportedly based on intuition, where relevant past experiences play an important role to frame the solution space and come up with ideas. The goal was to encourage students to engage in a fast-paced approach to idea generation that does not necessarily entail a conscious discussion or planning about how to approach the problem at hand. Accessing past informal experiences was considered valuable. The same slides were used in the morning and afternoon sessions, and the verbal narrative was also very similar on both occasions.

Table 1
Workshop Structure and Timeline

Morning		
9:45 am	Welcome/general intro by workshop organizers	
10:00 am	"Logical" approach short presentation	"Intuitive" approach short presentation
10:30 am	Design Brief 1 Groups 1, 2, 3, 4, and 5 (working at separate tables with four people each)	Design Brief 1 Groups 6, 7, 8, 9, and 10 (working at separate tables with four people each)
Afternoon		
13:30 pm	"Logical" method short presentation	"Intuitive" method short presentation
14:00 pm	Design Brief 2 Groups 6, 7, 8, 9, and 10 (working at separate tables with four people each)	Design Brief 2 Groups 1, 2, 3, 4, and 5 (working at separate tables with four people each)
16:00 pm	End of design work	
16:15 pm	Panel discussion (students and researchers/organizers)	
17:30 pm	End of workshop	

A Logical Design Approach

Participants in the logical condition were explicitly instructed to follow a particular design approach. ViP design (Hekkert & Van Dijk, 2016, see Figure 1) is an approach to problem framing and early idea generation that advocates a systematic attitude to "possible futures" involving interactions between people and products, given a context of need (video of lecture, with accompanying slides, is available). The main principle of ViP is that designers should first define and design the raison d'etre of their solution (i.e., the vision) before generating any ideas. Thus, the ViP process involves careful consideration of multiple aspects before devising any sketches or drawing solutions. The focus on problem framing ends up encouraging a delay in the abstract manipulation and exploration of ideas, suggesting an approach that is favored over drawing, which might lead to design fixation at the product level (Jansson & Smith, 1991). The goal of ViP is, therefore, to envisage a context through the collection of relevant factors and, ultimately, propose a vision statement. ViP's systematic deconstruction of products in interactive contexts aims to provide a framework within which to address a design.

The logical approach, illustrated through ViP, was presented to the participants by a theoretically based researcher with over 20 years of experience in design thinking and in the experiential impact of design. The slide presentation encouraged students to think about the purpose of what they might design, rather than how it will be materialized. It was also stressed that ViP is about probable futures, rather than solving present problems. The presentation ended with the statement saying that the aim was not to generate many ideas, but one great idea, and that students should distrust their intuition. This was part of a playful competition between approaches given that the presenters are close friends. For a video of the presentation, with accompanying slides, see the below URL.

Design Assignments

For a video of the intuition presentation, together with slides, see https://www.youtube.com/embed/f8T3RJV7Kos.

For a video of the logical presentation, together with slides, see https://www.youtube.com/embed/-7UDDOJqjiE.

The presentations were intended to be: (a) meaningful for the participants (i.e., most, if not all, participants had probably experienced the problem themselves); (b) tackled by the different groups with the background knowledge they possessed at the time of the workshop, without having to resort to external sources (e.g., internet); and, (c) realistically devised within the available timeframe (120 min), either by allowing participants to generate multiple ideas or by exploring fewer concepts in more detail.

The design brief presented in the morning was the following:

1. "Get up" (Design Brief 1, see Table 1):

People know they should exercise more but they're often reluctant to do so. Design a way to encourage people to leave their bed in the morning and exercise.

The design brief presented in the afternoon was the following:

2. "Watch out" (Design Brief 2, see Table 1):

People walk out into busy roads or zebra crossings without looking because they are texting, chatting on their mobiles. Design a way to encourage people to engage more with the world around them and not just those little screens that hypnotize them into submission.

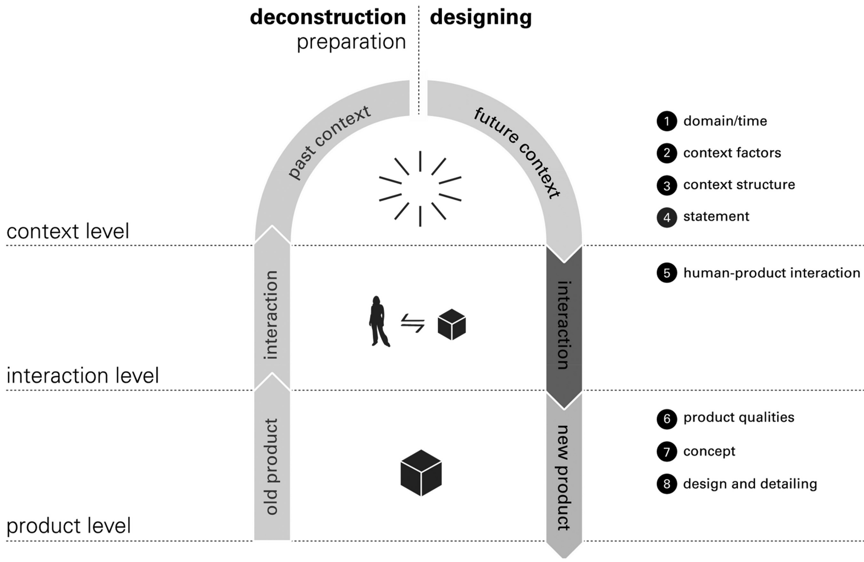
Along with each design brief, we asked participants to generate as many ideas/concepts as they wanted within 120 min, illustrate their solutions through sketches or words, and ensure that each idea was represented in a clear manner.

Experimental Design and Data Collection

The study was conducted in accordance with a 2 (approach: intuitive vs. logical) × 2 (order: intuitive first or logical first) mixed design. The approach variable was within-subjects thereby ensuring that each participant was exposed to both approaches. Accordingly, half the students were randomly assigned in the morning session to the intuitive cluster and half to the logical cluster. The clusters, and respective smaller groups of four, then switched in the afternoon so that all students had a chance to address design briefs from both perspectives. Order was a between-subjects variable enabling us to determine the effect of the morning session on the afternoon session for the two different approaches. Gender was a second between-subjects variable balanced as much as possible across working groups.

Students individually rated their experiences on five 7-point scales after 30 min and 10 scales at the end of each ideation session. The questions were chosen after consultation among the four-person research team. The questions prompted students to reflect about three

Figure 1
Vision in Product Design Model (Hekkert & Van Dijk, 2016)



aspects of the session: (a) person—individual perceptions about their motivation and performance; (b) product—general perceptions on idea/concept progression, usefulness, and acceptability; as well as (c) process—perceptions on various aspects of using the two different approaches (see Table 2).

Judges' Ratings of the Design Concepts

The final design proposals, produced by each of the 10 groups (in the morning and the afternoon sessions), were assessed by two graduate design students under the supervision of two practicing designers. The graduate students, in the final year of the industrial design master program, had experience in research projects in international settings; one female specializing in design for interaction and the other, a male, in integrated product design. The two practicing designers included one female specializing in developing concepts and strategies and one male in user interfaces. The four judges chose the assessment scales. The final proposals for each group were rated by the graduate students in a randomized order and, thus, without knowledge as to which experimental condition they were examining.

The evaluations were conducted on six-ideation metrics; originality, practicality, elaboration, problem fit, elegance, and clarity, each presented as a 7-point scale (1 = *not original*, 4 = *somewhat*, 7 = *original, practical, and so forth*). These scales were chosen by four members of the research team. Agreement among the judges was statistically assessed.

The six-ideation metrics were defined as follows.

1. Originality (1 = *not original*, 4 = *somewhat*, 7 = *original*), or novelty, is interpreted as a measure of how unusual an idea is when compared to the other ideas generated, as well as to existing concepts or actual entities a judge might be aware of at the time of the analysis (Finke, 1996). Thus, this comparison is between the idea underlying the student proposal versus other ideas known to the judge (in the world, and not just in the pool of available ideas in the data set).

Table 2
Questions Used to Prompt Reflection About Person, Product, and Process

Amount of time after design activity	After 30 min	After 120 min
Person	How energized do you feel? How confident are you to come up with a good solution in two hours?	Overall, how valuable was your contribution to the design project? Did you at any point feel that you have run out of ideas?
Product	How many ideas do you have at the moment?	Is your idea closely related to the brief and to solving the problem? Is your idea good enough and worth investing in? Will society be happy? Have you ever done/designed anything similar to the task/problem presented in the design brief?
Process	How clear is the problem brief to you? How challenging is it to apply the method given?	How difficult was it for you to come up with a design solution? Did you have enough time? How difficult was it for you to work with others in your group? Looking back, how challenging was it to apply the approach you were assigned?

Note. Questions: 1 = *not at all*, 4 = *somewhat*, 7 = *extremely.*

2. Practicality (1 = *not practical*, 4 = *somewhat*, 7 = *practical*) is interpreted in terms of ease of application from a user's perspective (Finke, 1996). If a given idea was implemented, how demanding would the interaction with this entity be from cognitive (perception, intuitive use) and physical (motor skills) viewpoints?
3. Elaboration (1 = *not detail*, 4 = *somewhat*, 7 = *maximum detail*) is interpreted as the extent to which a given idea is (very) concrete or (very) abstract in terms of its function (how it works, what it is made of) and purpose (what is it for). Elaboration, as defined by Guilford (1950), is about the amount of detail, for example, "a doorstop," or more detailed "a door stop to prevent a door slamming shut in a strong wind."
4. Problem fit (1 = *no fit*, 4 = *somewhat*, 7 = *good fit*) is interpreted as how far a given idea answers the design briefs presented. Participants were assessed in terms of how far their proposals deviated from the brief as originally phrased.
5. Elegance (1 = *not elegant*, 4 = *somewhat*, 7 = *very elegant*) is assessed in terms of whether there is unity/coherence amidst the different aspects of any given concept on the page (i.e., elegance to the solution), which may be related to beauty and, therefore, to salience and marketability of the solution.
6. Clarity (1 = *not clear*, 4 = *somewhat*, 7 = *very clear*) is about how clearly the students communicated/represented (via the drawings and written notations in general) their ideas on paper. It involves an element of "coherence" of communication.

Results

The data analysis took into account (a) the researchers who were examining the impact of intuitive versus logical approaches to generating creative design ideas, (b) the experiences of students as the sessions unfolded, comparing early (after 30 min) and late (after 120 min) phases, as well as (c) assessments of the group projects by judges. The data analysis first looked at the effects of priming for intuitive or logical approaches during creative design idea generation using a within-subjects design. This made it possible to examine the effects of applying the two approaches in the morning and afternoon using counterbalanced sessions.

Analyses of variance were performed on the five self-rating scales introduced 30 min into the design activity, as well as the 10 self-rating scales completed by students after 120 min. The goal was to determine the effects of approach (intuitive vs. logical), and order (intuitive approach first and logical second, and vice versa), on how students felt about their proposals as the sessions unfolded. The statistical model comprised one within-subject variable, approach (intuitive vs. logical), since each student was exposed to both design strategies, and two between-subjects variables, order and gender.

Impact of the Intuitive and Logical Approaches After 30 Min

How did students assess their experience after 30 min on the five rating scales? In terms of main effects, while both approaches were seen as equally challenging across the morning and afternoon sessions, $F(1, 31) = 0.02$, ns, students generally felt more energized, $F(1, 31) = 5.93$, $p < .02$, and had many more ideas, $F(1, 31) = 48.22$, $p < .001$, in the intuitive compared with the logical condition after just 30 min (see Table 3). Female members of the teams were also more confident than were the males after 30 min, $F(1, 31) = 4.74$, $p < .04$. This implies that female students were more comfortable in group work settings than were the males.

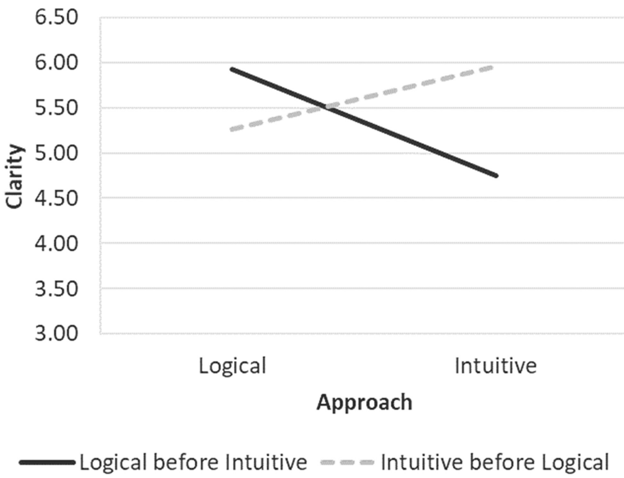
Interactions reveal how an effect is contingent upon or modified by the presence of another variable. A significant interaction between approach and order, $F(1, 31) = 13.51$, $p < .001$, shows how approach was influenced by the order in which it was introduced (first or second). Students were equally clear about the brief in the morning session for both kinds of approaches (see Figure 2). However, students were much less clear about the brief when applying the intuitive approach in the afternoon after having worked with the logical approach in the morning session. A similar but weaker interference effect was observed when the logical approach was applied in the

Table 3
Mean Self-Ratings for Approach, Gender, and Order After 30 and 120 min

Question				Significance
After 30 min	Approach			
	Logical	Intuitive		
Energized	4.45	4.99	5.93	.01
Ideas	2.29	4.36	48.22	.001
	Gender			
	Male	Female		
Confident	4.97	5.40	4.74	.04
After 120 min	Approach			
	Logical	Intuitive		
Enough time	4.45	6.65	41.31	.001
Difficult working with others	2.03	2.47	5.78	.02
Challenging to apply approach	4.08	2.87	14.67	.001
	Order			
	Logical first	Intuitive first		
Society happy	4.91	5.63	6.54	.02
Enough time	5.07	6.04	7.84	.01
Difficult working with others	1.88	2.62	4.89	.03
Experience with task/problem	3.61	2.70	7.03	.01

Figure 2

After 30 min, the Interaction of Approach and Order for How Clear Students Were About the Brief



afternoon after students had worked with the intuitive approach in the morning session. This shows that the two approaches are somewhat incompatible when it comes to framing a design problem, at least during the earliest stages of creative design.

Impact of the Intuitive and Logical Approaches After 120 min

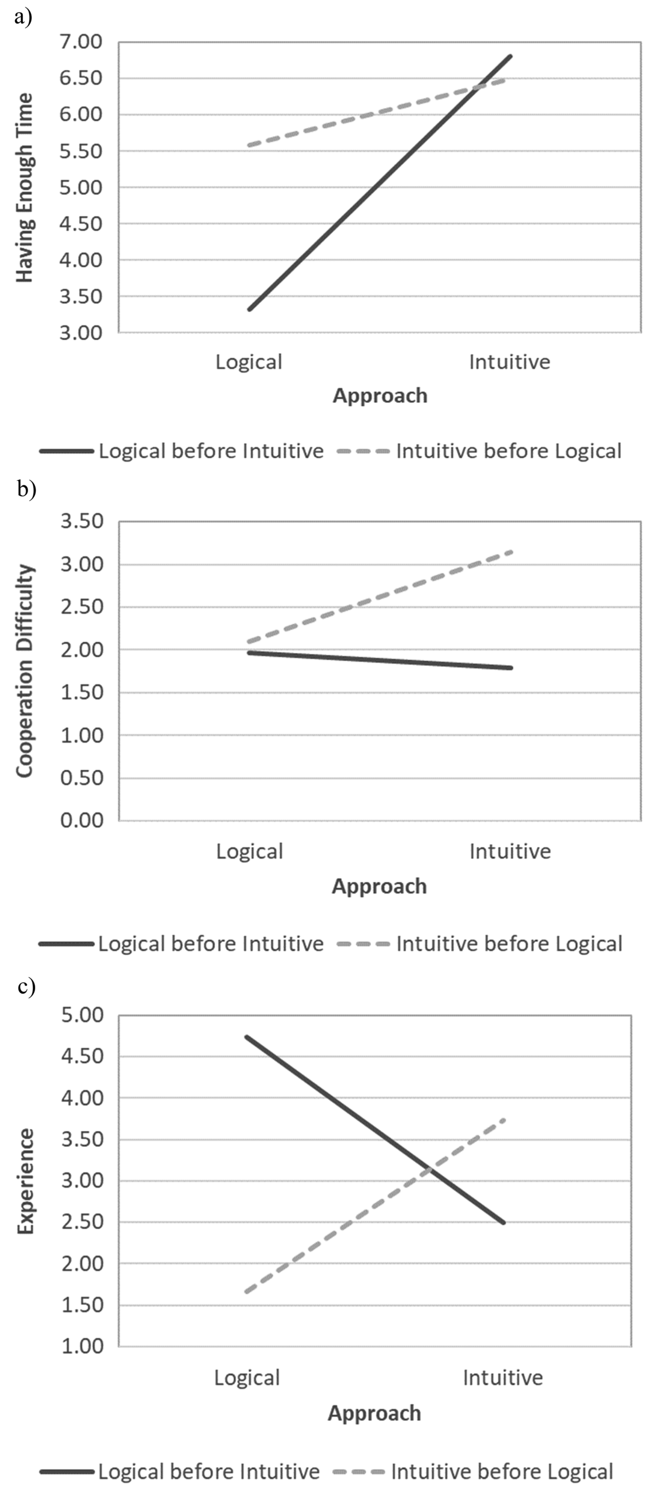
Students responded to 10 questions after the design session was completed which provided a sense for their overall experiences applying the two approaches (see Table 3). In terms of main effects, students generally felt they had enough time to complete their proposals, $F(1, 31) = 41.31$, $p < .001$, and it was less challenging, $F(1, 31) = 14.67$, $p < .001$, in the intuitive compared with the logical approach. This is consistent with idea that the logical approach matches System 2 thinking that is more deliberate and slows decision-making activity. The open-ended nature of intuitive cognition makes it easier to access potentially relevant ideas. On the other hand, it was somewhat more difficult to work with others in the intuitive condition where the approach is less structured, $F(31, 1) = 5.78$, $p < .02$. Diffusion of creative responsibility is particularly challenging when there is no clearcut method in the intuitive condition and team members negotiate the many ideas being proposed by group members.

Generally speaking, a significant main effect for order (see Table 3) showed that students felt they had enough time to apply the intuitive approach, $F(1, 31) = 14.67$, $p < .001$, and that society would be pleased with their design proposals when they applied the intuitive approach first, $F(1, 31) = 6.54$, $p < .02$. Clearly, starting a project with the more flexible and broader intuitive approach had a positive effect on how students felt about their project at the end of the 2-hr work session. There were no gender differences by the end of the design sessions.

There were also three significant interactions of approach and order after 120 min. According to the first interaction, $F(1, 31) = 14.20$, $p < .001$, students felt they did not have enough time, particularly when the logical approach was adopted first in the morning (see Figure 3a). However, they did have enough time if the logical approach was implemented in the afternoon once they had experience with the intuitive approach in the morning session. This finding suggests that, after beginning with the more flexible intuitive approach, it was easier to subsequently apply a structured logical one in the afternoon session.

Figure 3

After 120 min, the Interaction of Approach and Order for (a) Having Enough Time, (b) Finding It Difficult to Work With Others, and (c) Having Previously Designed Anything Similar



A second interaction, $F(1, 31) = 11.10$, $p < .002$, shows that students found it more difficult to work with others in the intuitive condition when it preceded the logical condition (see Figure 3b). Applying the open-ended intuitive approach, as a first step, poses difficulties because it is harder for students to adopt a unified strategy in the face of ambiguity and the diverse ideas of colleagues.

A highly significant interaction, $F(1, 31) = 48.22$, $p < .001$, was found when students were asked whether they had previously designed anything similar to the problems in the design brief. The design brief felt much more familiar when it was first approached from the logical perspective rather than the intuitive one (see Figure 3c). This may reflect the fact that applying a logical approach using ViP is part of standard training at their institution.

Factor Analysis: Examining Relations Among the Self-Rating Scales

Factor analysis provided a means for looking at relations among the five self-rating scales after 30 min and the 10 self-rating scales after 120 min. A factor analysis with Varimax rotation was done, collapsing across the intuitive and logical conditions, to determine groupings among the scales after 30 and 120 min. Factors that are derived from this process must have Eigenvalues >1.00 and individual scales that inform the factors must have loadings (in absolute values) >+.50 (indicating a positive relationship) or −.50 (indicating an inverse relationship).

After 30 Min

Two clusters of scales were derived with Eigenvalues >1.00 accounting for 58.11% of the variance (see Table 4). These factors are described below in accordance with the endpoints implied by the positive (+) or negative (−) factor loadings.

Factor 1 was labeled generating ideas (Eigenvalue = 1.79), comprising three scales with loadings of .50 (or −.50) or greater; generating *many ideas* (.75), *not challenging* (−.75), and *confident* (.69).

Factor 2, energized experience (Eigenvalue = 1.11), included two scales: *clear brief* (.79) and *feel energized* (.78).

Consistent with a two-factor model of emotion (see Cupchik, 2016), the ratings after 30 min reflect the impact of cognitive (Factor 1, ideas-based) and affective (Factor 2, energy-based) aspects of design imagination at the outset of a project. The first factor implies a central cognitive process related to generating ideas and the resulting sense of confidence, whereas the second factor is more affective and reflects the energy that drives a creative process, particularly when the design brief is clearly understood. Recall that scales representing these factors were central to the finding reported earlier to the effect that students had more ideas (cognitively-based) and felt more energized (affect-based) in the intuitive compared with the logical approach.

After 120 Min

A factor analysis with Varimax rotation found three factors which accounted for 55.37% of the variance (see Table 5). The factors reveal how individual students focused on the project outcome and sum up their experiences looking back at the unfolding process. These factors are described below in accordance with the endpoints implied by the positive (+) or negative (−) factor loadings:

Factor 1, successful project (Eigenvalue = 2.36) comprised four scales: *worth investing in* (.83), *solving the problem* (.69), *easy working with others* (−.67), and *my contribution was valuable* (.60).

Factor 2, *challenging project* (Eigenvalue = 1.74) included three scales: *challenging to apply the approach* (.80), *difficult to come up with a solution* (.68), and *needed more time* (−.62).

Factor 3, unsuccessful project (Eigenvalue = 1.43), involved three scales: *society won't be pleased* (−.68), *had too many ideas* (.68), and *previously designed something similar* (.57).

The first factor, successful project reflected the subjective experience, at an individual level, of successfully executing a design project. Note the complementary importance of personal satisfaction and ease of working with others that is tied to valuing the outcome, along with the belief that this idea will attract investors. The remaining two factors reflect concerns that students may have. Factor 2, challenging project, addresses problems faced when applying an approach and needing more time to accomplish the task. Factor 3, unsuccessful project, expresses a concern that the proposal would not be well received by potential consumers in part because there were too many ideas, implying that it was less coherent.

The Judges' Perspectives

The 10 groups taking part in this study developed 20 final design proposals (two per group) during the morning and afternoon sessions. It is evident that students in the intuitive condition favor images (see Figure 4) while those in the logical condition emphasize the use of words to convey their design ideas (see Figure 5).

These proposals were assessed by two graduate judges under the supervision of two professional designers. Pearson product–moment correlations were used to compare the judges' decisions on each of the six-ideation metrics across the 10 student groups. Agreement was significant for the clarity, $r = .71$, $p < .001$, elaboration, $r = .64$, $p < .001$, elegance, $r = .60$, $p < .01$, problem fit, $r = .58$, $p < .01$, and originality, $r = .63$, $p < .01$, metrics. However, the judges did not concur in their assessment of practicality, $r = .20$, ns, suggesting they had different views about the meaning of this term.

Factor Analyses for Judges' Ratings

Can the ideation metrics on which judges rated the students' proposals be grouped to reflect common underlying concerns?

Table 4
Factor Analysis of the Students' Self-Ratings After 30 min

Factor and eigenvalue	Loading	Item
1. Generating ideas	.75	How many ideas do you have at the moment?
1.79	−.75	How challenging is it to apply the method given?
	.69	How confident are you to come up with a good solution in 2 hr?
2. Energized experience	.79	How clear is the problem brief to you?
1.11	.78	How energized do you feel?

Table 5
Factor Analysis of the Students' Self-Ratings After 120 min

Factor and eigenvalue	Loading	Item
1. Successful project	.83	Is your idea good enough and worth investing in?
2.36	.69	Is your idea closely related to the brief and to solving the problem?
	−.67	How difficult was it for you to work with others in your group?
	.60	Overall, how valuable was your contribution to the design project?
2. Challenging project	.80	Looking back, how challenging was it to apply the approach you were assigned?
1.74	.68	How difficult was it for you to come up with a design solution?
	−.62	Did you have enough time?
3. Unsuccessful project	−.68	Will society be happy?
1.43	.68	Did you at any point feel that you have run out of ideas?
	.57	Have you ever done/designed anything similar to the task/problem presented in the design brief?

Practicality is excluded from these factors because of lack of agreement. A factor analysis, with Varimax rotation, was performed on the average concept ratings (collapsing across the intuitive and logical conditions) by the four judges on the six metrics and two factors were extracted with Eigenvalues >1.00, accounting for 72.5% of the variance (see Table 6).

Factor 1, global assessment (Eigenvalue = 3.16) had absolute loadings of .50 or greater on four scales: *elaboration* (.93), *elegance* (.84), *problem fit* (.83), and *originality* (.73). Practicality is not included because of a lack of statistical agreement on its application.

Factor 2, clarity of communication (Eigenvalue = 1.19) had a loading on only one scale, clarity (.95) with which students conveyed their ideas.

Regression Analysis: Predicting the Judges' Ratings Based on Student Self-Ratings

What relationship can be derived between how individual students rated their design experiences after 120 min and assessments of the group projects by the judges? It is important to note that each student

Figure 4
Examples of Ideas Generated by Groups in the Intuitive Condition (Design Brief 1: "Get Up")

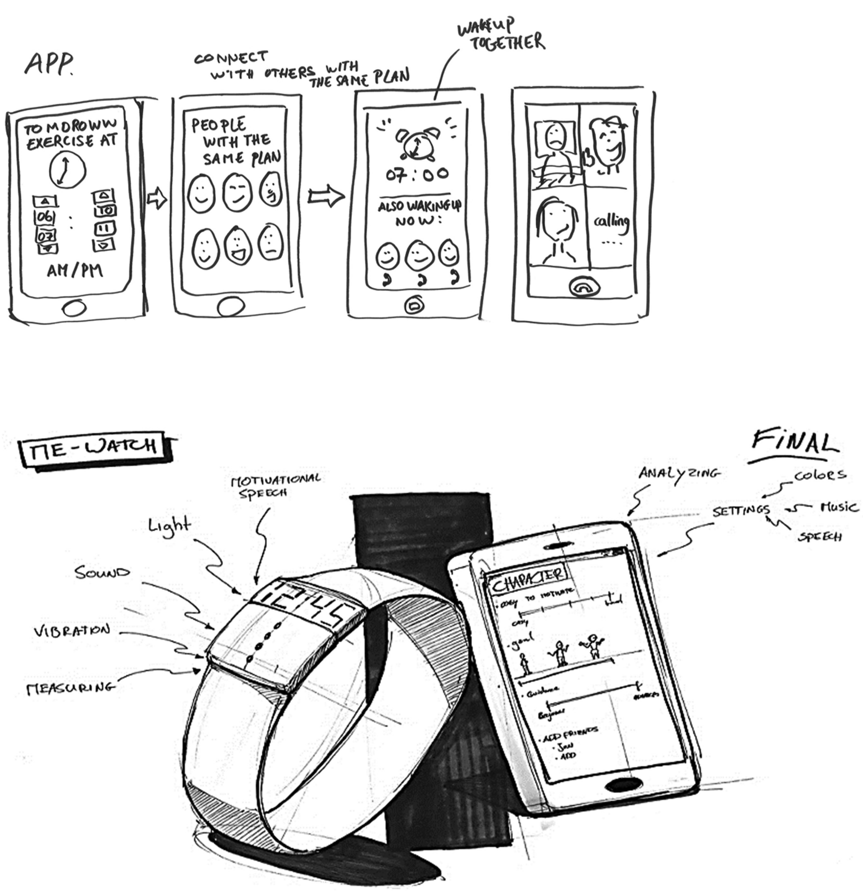
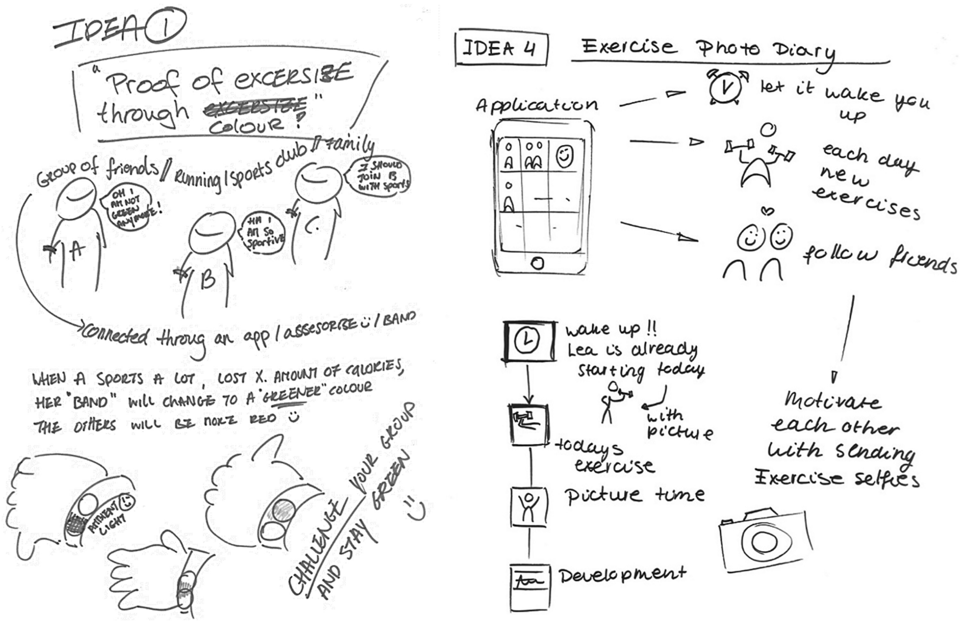


Figure 5

Examples of Ideas Generated by Groups in the Logical Condition (Design Brief 1: "Get Up")



in a group received the overall evaluation of the proposal they collectively developed. Stepwise linear regression was applied to determine whether factors derived from the student self-ratings after 120 min could predict evaluations of group work by the judges along two factors, global assessment and clarity of communication. The predictor variables included gender along with the three factors that were extracted after 120 min from student ratings of their design experience.

Predicting "Clarity of Communication" After 120 min. No significant model was derived, $F(4, 34) = 0.55$, ns).

Predicting "Global Assessment" After 120 min. A significant model (R-squared = .52) was obtained, $F(4, 34) = 8.13$, $p < .001$, showing an inverse relationship between judges' ratings and students' self-ratings on Factor 1, successful project, $B = -.58$, $t = -4.46$, and a positive relationship with Factor 3, unsuccessful project, $B = .40$, $t = 3.11$, $p < .004$ (see Table 7).

Recall that Factor 1 of the student self-ratings, successful project, comprised four scales: *worth investing in*, *solving the problem*, *easy working with others*, and *my contribution was valuable*. The global assessment was based on four scales including: whether the *solution fit the problem*, was *elaborated*, *elegant*, and *original*. The more self-critical students were about their projects, the higher the global ratings by judges. Here again we find the positive impact of critical self-reflection in the design process. This finding demonstrated that greater critical self-reflection by the students (e.g., regarding solving the problem, group work dynamics, personal contribution to the effort) was associated with more successful projects in the eyes of the judges.

Factor 3 in the student self-ratings, unsuccessful project, included *society won't be pleased*, *had too many ideas*, and *previously designed something similar*. This finding shows that, the more individual students were concerned that society would not be pleased or that they had too many ideas, the higher the judges' global evaluations. Together, these two effects show that critical self-reflection and having a sense for where one stands with the project appears to be a key to success at the end of this design exercise. Thus, critical self-awareness should be cultivated in design students as part of their training.

Table 6

Factor Analyses of the Judges' Ratings of Students' Proposals

Factor and eigenvalue	Loading	Item
1. Global assessment	.93	Elaboration
3.16	.84	Elegance
	.83	Problem fit
	.73	Originality
2. Clarity of communication	.95	Clarity
1.19		

Table 7

Regression Analysis Predicting Judges' Ratings on Factor 1 (Global Assessment) Using Gender and Self-Rating Factors After 120 min

Variable	*B*	*SE B*	β	*p*
Gender	0.19	0.27	.09	.49
Self-ratings factors				
1. Successful project	−0.61	0.14	−.58	.001
2. Challenging project	0.07	0.15	.06	.65
3. Unsuccessful project	0.42	0.134	.41	.004

Note. B = unstandardized regression coefficients; β = standardized regression coefficients.

Discussion

This study was conducted in accordance with an evidence-based approach to the role of creativity in design education and was promoted to students as a "Workshop in Design Imagination." The project was characterized as a contrast between the roles of "intuition" and "logic" in creative design to graduate students who volunteered to participate. They were motivated to experience a contrast between the founder of a major design company and a senior professor in design education whose book on logical design strategies is foundational. This workshop could be organized because the speakers were close friends and colleagues who represented applied and academic communities and engaged in an ongoing dialogue about their respective approaches. Reflecting on the study, here is what the two "protagonists" have to say about their respective approaches.

Our "logical" design protagonist asks whether we have a contrast between "a methodological approach (ViP) vs. a non-methodological approach (i.e., intuitive, experience-based), or are we contrasting two methods, a top-down, vision-driven one vs. a bottom-up, iterative one?" As a bridge between the two participants who "Talk all the time," "Designing is both a creative and methodological process to generate ideas and realise them! I would argue, creativity is an essential part/process of each design activity." Accordingly,

> The intuitive approach … is not (necessarily) global, nor is the ViP approach focusing on details. Not at all! The logic of ViP is that we first ask designers to carefully build a holistic worldview *before* they come up with directions and solutions. This has very little to do with a "focus on details". It's more postponing judgment and questioning all your preconceptions.

Our "intuitive" design protagonist says the following about design practice in a business context.

> I/we almost always worked for a commissioner, a client …who pays us. The assignment is often framed in a very rational brief since he/she wants to be as certain as possible that the designer or design company delivers value for money which means that the design has match the intended effect—often a commercial one. The context is often complex and dynamic. Applying creativity … plays an important role in getting to the right solution.
>
> When a brief is communicated, it is impossible for me to stop thinking about solutions. They pop instantly in my head. … I'm able *to imagine* how the design is manifested and how it works. I often refer to *previous situations and experiences*, often from other domains. I recognize patterns or cues. Maybe it is my back pocket with a lot of experience, hidden memories but I can always support ideas with arguments.
>
> I can even recall the process of decision making in my head (*it cannot be like this because… and if we do it like this it will fail here*, and so on) while the idea was their instantly. Apparently, my brain follows a high-speed variations process to explore *the solution space* but I'm not aware of it. In this process variations are explored, categorized, and judged/assessed, maybe even iterative. But, given the complexity, some fact checking is needed. Knowledge and intuition cannot be separated; they are intertwined. The solutions often manifest themselves as concepts, as ideas, the initial formulation of a design solution with still possible variations in the execution. Intuitively generated solutions take in most cases a holistic stance, it is almost impossible to ignore this. One way or another, the process stops as a certain moment when the question "is it good enough?" is answered positively.
>
> Note: the profession of design is rapidly changing, from designing products, to product-service systems to designing for system changes. The latter asks for more in-depth knowledge and more research. The intuition about possible solutions grows during the process of diving into and embracing \the complexity.

Both protagonists see their approaches as having a "holistic" quality. From a psychological perspective, the logical and intuitive approaches map onto a distinction between serial and parallel processing, respectively. The logical approach follows a systematic method for deconstructing design challenges, whereas the intuitive approach follows multiple tracks reaching back and laterally to potentially relevant design exemplars from past experiences. Both share a constraint defined by the practical requirements of the brief in question. However, the intuitive approach more readily accesses episodically based past experiences that may contribute to solving a problem posed by the brief using complex analogies.

This study examined the impacts of "intuitive" and "logical" approaches on earlier and later stages of design creativity. A within-subjects design made it possible to examine order effects of practicing these approaches in morning and afternoon sessions. Accordingly, the researcher's interests were embedded in the design. The students' experiences during different stages of the design process were captured by the self-rating scales, and judges assessed group proposal outcomes both in terms of content and form.

The findings indicated that, early in the design process (after 30 min), students generally found that the intuitive approach was more energizing and stimulated more ideas, compared to the logical one. This fits with our intuitive protagonist's account of creative processing in an applied business context. This energy is also the type of behavior that would be expected from participants undertaking a brainstorming type of approach to design ideation to promote the fast generation of multiple possible solutions (T. Brown, 2008). This is consistent with Gero et al. (2013) account of an unstructured technique in concept generation creativity.

From a psychological perspective, this finding fits with a System 1 response to uncertainty (i.e., by devising ideas to solve the open-ended problem presented in the design briefs) that is both fast and effortless and typical of brainstorming for new ideas. The unconscious characteristic of System 1 processing (Evans, 2008) can also lead to potential cognitive biases, such as design fixation (Jansson & Smith, 1991), that might lead to poor decision making and missing out on unexplored avenues. These problems associated with System 1 processing are particularly salient for students who are early in their design careers.

The logical approach (facilitated via the ViP process), on the other hand, enhanced a sense of confidence (about coming up with a good solution) regardless of whether it took place before or after students were exposed to the intuitive one. This effect carried over to the afternoon session where students were less clear about implementing the intuitive approach after adopting a logical one in the morning. It was harder to switch over to an open-ended intuitive approach once students were first exposed to the structure of a logical one. In relation to psychological theory, the logical approach demands a higher level of cognitive effort to deconstruct the problem whereby one intentionally goes through a conscious, gradual, and methodic associated with System 2 in dual-processing theory (Wason & Evans, 1974). Following a clear sequence of phases, stages, and actions (i.e., a methodology) seems to bring confidence in situations of uncertainty. Consciously committing to a predefined design methodology (e.g., ViP) is in alignment with research stating that one's capacity to tolerate uncertainty, rather than intelligence, is a better predictor for performance during complex problem solving (Dörner, 1996; Dörner & Funke, 2017).

After 120 min, students adopting the intuitive approach generally felt they had enough time to complete the project and that society would be pleased with the results. In contrast, those who adopted a logical approach felt that they needed more time if they were first exposed to it during the morning session. However, they felt better able to complete the project during the afternoon session after first having adopted an intuitive approach in the morning. Students felt that the rigors of the logical approach were not easy to implement, suggesting the value of beginning with an open-ended intuitive technique before approaching the problem in an analytical way, favored by the logical approach. The logical ViP approach, though, follows a methodical sequence of phases that requires the thorough exploration of each one, and thus might require more time to reach an expected level of completeness. Students adopting an intuitive approach, where there are no clear plans about phases/stages/iterations, are more flexible and can end their process at any given point. The contrast in final products between a use of images in the intuition condition and words in the logical conditions raises very interesting issues regarding the kinds of mental processing favored by the two approaches to creative design ideation.

A different issue emerged regarding ease of collaborating with others. Students found it harder to work with others when first adopting the unstructured intuitive approach during the morning session. This issue disappeared in the afternoon, if they had practiced working in a structured logical manner in the morning. Clearly, there are trade-offs. An open-ended intuitive approach stimulates idea generation and a sense that the project can be managed, whereas a logical approach helps students learn to work together in a structured and collaborative manner. ViP seems to work here as a beneficial anchor point, because students are guided to follow an explicit process with a clear strategy and goals. In an intuitive setting, different mental models about how to proceed and what to aim for, might make it more challenging (or take longer) for individuals to come together as a team.

Research into theory of group dynamics (Tuckman, 1965) describes the development phases groups of individuals might go through when transitioning into a cohesive and high performing team. In the context of our study, it could be that those following the intuitive approach take longer in the forming, storming, and norming phases (Tuckman, 1965) before they reach better performance levels. The data suggest that it may be helpful for design students to begin a project in a way that encourages the discovering of many approaches to solving the brief with an appreciation of the challenges faced working collectively in a group with four colleagues. A structured approach, associated with ViP, might provide better direction for new practitioners when it comes to choosing among potential solutions.

The judges' assessments of the final proposals included a global qualitative judgment of different attributes encompassing; elaboration, elegance, problem fit, and originality, and a secondary evaluation related to the clarity with which students conveyed their ideas. The global evaluation shows a significant negative correlation between how students rated their own performance after 120 min and how judges perceived their produced outcome. The more highly students rated their projects as worth investing in and as having solved the problem, the lower the judge's evaluations. We can refer to this as an overconfidence bias on the students' side (i.e., subjective overestimation about one's own judgments and performance levels). In contrast, those students who were more self-critical about their work, were also those whose concepts received higher evaluations by the judges. Critical self-reflection appears to be important when it comes to having projects well received by judges. A little humility never hurts, for all of us!

Conclusion

What are the implications of this study when it comes to using intuitive and logical approaches in creative design education? In reconciling the two approaches, one should be sensitive to their goals and assumptions. The immersive nature of an intuitive approach to creative design ideation assumes prior real-world knowledge related to the design brief. This was evident during the workshop session where the focus was on images of the space within which the solution was to be implemented. Quickly bringing to bear relevant knowledge regarding the purpose of the design setting makes it possible for students to rapidly construct multiple applications and variations on potential design solutions. We expect that design students (like those in this workshop) might often resort to readily available knowledge, which may range in different levels of relevance and appropriateness. Expert (more senior) designers ought to take advantage of their extensive accumulated experiences and thus rapidly retrieve and make use of relevant knowledge. They trust their inner compass in judging ideas (van Erp, 2020).

The methodical nature of the logical approach is more explicit and requires extensive working memory to engage in reasoning. Thus, there may be greater variation in the ability of students to follow System 2's logical activity. It is striking that such an account of challenges in syllogistic reasoning can be readily generalized to the design context. We can see how students faced with a novel challenge, and required to deconstruct it at many levels, may get bogged down in the process. System 2 requires not just a skill at abstract reasoning but also "the ability to comply with instructions" (Evans, 2003, p. 457). Those who are systematically disposed may have the patience to deconstruct the different elements that are fundamental to the ViP approach. On the other hand, we can conjecture that a design student with strong visualization skills may be less disposed to follow the kinds of analytical instructions involved in ViP. The sample products reveal that the intuition approach favored image development, whereas the ViP approach was more word-oriented.

Nevertheless, the logical ViP approach would appear to be well served when the challenge is novel and unfamiliar so that the design student must figure out different nuances underlying the problem. For instance, ViP promotes a logical and structured approach to design for a distant future, by encouraging designers to think in terms of four main dimensions: principles, trends, states, and developments. If one engages only in an intuitive thinking process when trying to tackle complex problems, it might simply be too much effort, from a cognitive viewpoint, to commit to memory all these and other relevant dimensions and possible interconnections. Therefore, to the extent that a student implements a more logical approach, there may be a feeling of confidence regarding how best to solve the problem.

For this research, we selected the ViP approach as a potential logical way to tackle idea generation. Yet further work ought to include other methods that are also aimed at bringing this type of mindset to the design process. Likewise, it would be equally important to investigate the impact of other methods that primarily trigger intuitive modes of thinking during the early phases of design. While we can describe a (design) method as a goal-oriented, explicit, and orderly procedure for doing design work, intuition is not the absence of a method. In fact, methods can activate unconscious thought processes with novel outcomes (Shah et al., 2000). For instance, brainstorming entails a simple (and yet goal-oriented, explicit) methodical approach that mostly encourages an intuitive thinking mode during idea generation (see Gero et al., 2013).

If we accept that intuitive and logical modes of thinking are not mutually exclusive in design, but that they ought to co-exist in a complementary fashion, it would be essential to reflect on how different (design) methods populating new or existing methodologies might support these two cognitive spaces. This requires that we look at methods, not only as means to facilitate designers' thinking process for achieving goals in an efficient and effective manner but also need to consider them from a designer-centered perspective. That is, we should investigate how far, for instance, these methods are devised to account aspects of the designers' cognition (e.g., divergent and convergent thinking modes), motivation (e.g., intrinsic, extrinsic, energy to develop ideas), and personality dimensions (e.g., tolerance of ambiguity, risk-taking). This is congruent with contemporary views on creative thinking that advocate for a focus on creative potential as a more holistic measure of performance, instead of the typical emphasis on output as a marker of creative achievement (Barbot et al., 2015; Runco, 2003).

The dual-processing theory (Kahneman, 2011; Stanovich & West, 2000) offers a useful lens to consider how method usage, and its methodological integration in the design process, might hinder or facilitate intuitive or logical thinking modes in designing. The challenge lies in deciding the ideal type of thinking mode, and respective activating method, at the right time in the design process. And probably more importantly, planning a diverse sequencing of methods to ensure that the (cognitive) switch between thinking modes is appropriate for the problem at hand and the person/team engaged in such process. Students need to learn which option is right for them in a context. Best to learn them both.

Looking back at what was accomplished in this study provides an occasion to look ahead at what might be done to explore the promise of logical and intuitive approaches. The design of the study teased apart the intuitive and logical approaches to contrast their effects in relief. We also examined order effects because students applied both approaches sequentially in a counterbalanced design; intuitive then logical or logical then intuitive. The researchers had a lot of experience in giving design workshops and knew that concrete results would emerge based on the briefing within this time 2-hr time slot. It would be interesting to investigate what the qualitative difference might be if we give the students more time. Which group would have an advantage?

An intuitive process is often followed by designers with experience in small manageable processes such as designing a book cover whose content and context are known or styling a new pair of jeans. It is interesting to investigate the effect of increasing the complexity of design assignments and the impact of intuitive design versus following a methodology.

This kind of simulation differs from what happens in real-life design situations where the brief orients a team toward a problem that needs solving. How a team arrives at the solution is not specified and this applies equally to experts/designers from the client side. Because of the 2-hr limitation, students did not have time to go through additional iterations, which is what would happen in a professional context. What if we repeat it with experienced designers who were instructed to approach the brief in either an intuitive, experience-based, or logical and formal approach? Would similar findings emerge showing that adopting an intuitive approach, where experience provides a context, made it easier to creatively work the problem from the outset?

This research was conducted with industrial design students who are quite rational. We have not been able to investigate whether the outcomes would be different within other design disciplines, for example with fashion or graphic designers. These are somewhat more autonomous designers, perhaps less formally trained in applying various methodologies.

What about the difference between an experimental situation, such as ours, and professional practice? Within the academic world of design, a lot is being developed and published about methodologies, models, and tools. These are generally developed from a one-sided perspective which can be used within closed assignments (the manifestation of the design is known, e.g., a car or a poster) and/or a controlled environment (a client with a clear goal in mind). They are also usually based on a strict vision of how to approach design challenges. For example, the ViP method is based on developing human–product interaction focused on a future context, and Scrum is a method in which digital applications are developed on an agile basis with the entire system at the table (designers, content creators, developers, user experience).

Another interesting variable for future research is the use of a different method. The ViP method is, in general, applied when a design is developed from a future perspective (the V is from vision). Furthermore, context and society-centeredness a very important aspects. In general, this method steers toward new and often radical solutions. It is a top-down approach. It is not suitable for incremental changes, for instance improving the performance of a product or a website. You could say that an intuitive process is a bottom-up approach. It is interesting to research the effect of different types of research, for instance, research through design such as the one developed by Stappers and Giaccardi (2017). Another interesting process is a more classic waterfall approach like the one from Roozenburg and Eekels (1995). In general, the nature of the context and the assignment define the preferred approach.

In design practice, none of the aforementioned methods prove to be the holy grail. The approach is usually tailored to the assignment, often mixing methods and models. Intuition within the process plays a major role because designers constantly assess whether they are still on track within the process. Most processes manage iterations, which does not alter the fact that the result of each iteration must be assessed. This is often done intuitively, followed by a check based on the briefing. Using a method and a process also has the advantage that the client has a handle to assess progress. In addition, using a proven process gives the client confidence, which is important to get the signature for an assignment.

One of the biggest differences between an academic setting and design practice is the dynamics between the design agency and the client. These are often companies or government institutions. Much depends on how experienced the client is. For both experienced and inexperienced clients, a common process provides guidance and can be deviated from in consultation, supported by good arguments—

and as indicated earlier, intuition when assessing iterations is of great value. When deviating from the beaten track, it is often the intuition of the designer (and sometimes of the client) that gives the signal that, if we continue to follow the process, we will not achieve the desired result. It is intuition that gives the signal, while the process indicators (progress reports, planning, etc.) do not ring any alarm bells. Within such a dynamic context, the interplay between intuition and logic is crucial to ultimately achieve a good result. Training both competences within design education is therefore recommended.

The complementary roles of intuition, association, and embodied organic experience versus logic, cerebral inference, and structured framing were explored in this project. Intuition can be tied to embodied cognition founded on affectively loaded and associated memories stimulated by a design brief. These implicit or tacit associations become helpful when the relevant link becomes explicitly articulated or formalized through conversations among team members. Logic is particularly appropriate when it comes to deconstructing and framing (Dorst, 2015) the implications of a problem within a structured framework of causal (if, then) statements. In essence, intuition offers a solution based on "insider" experience, whereas logic is helpful for designers working from the "outside" and in need of a background structure to approach the problem. In the end, a major value of this project is to stimulate a conversation regarding the complementary roles of intuition and logic in creative design.

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