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Touch ground: Introducing design inquiry in higher education

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Abstract: In higher education, design thinking is often taught as a process. Yet design cognition resides in action and design practices. Dewey's pragmatism offers a solid epistemology for design thinking. This paper describes a design research whereby Dewey's inquiry served as the foundation for educating students. Three extensive educational case studies are presented whereby a design inquiry was introduced and became part of the curricula. It was found that students and coaches struggled with doubts experienced as a result of the co-evolution of problem and solution, means and ends. Four coping mechanisms were observed: (1) focus on problems, risking analysis paralysis; (2) focus on creative problem-solving, risking unsubstantiated design; (3) focus on means, risking fixation; and (4) focus on future ends, risking hanging on to a dream. By establishing a joint practice and a community of learners through show-and-share sessions, the students establish solid ground.

Keywords: design thinking, pragmatism, design education, epistemology, boundary objects

1. Introduction

Since it was popularized (Brown, 2008; Martin, 2009), design thinking has gained interest outside the world of design. We view design thinking as a human-centered, creative problem-solving approach that works by devising plans to turn an existing situation into a preferred one (Simon, 1996, 3rd ed.). It is taught at universities to future professionals who will work in communication, health care, tourism and so forth. Popular methods like the Double Diamond (Design Council, 2019) or the Stanford Design Model (Hasso Plattner Institute) present design thinking as a process that involves following several steps to solve a problem. This view on design thinking is criticized by Kimbell (2011), who describes how these methods separate thinking from doing and ignore the contribution of artifacts and tools.

Likewise, teaching design-as-a-process offers an impoverished version of design practice, whereby experimentation and reflecting on outcomes are central (Schön, 1983). In a university setting, it was observed that iterations were lacking (Liedtka & Barr, 2019) or that some studies "only rarely required students to engage in iterative prototyping" (Lake et al., 2021: p.349). Rylander (2021) contends that design-as-a-process loses sight of design's cultural and experiential qualities in a studio context.

Design is undertheorized from an epistemological point of view (Dixon 2019, 2020). Pragmatism offers a epistemological and ontological foundation for design thinking (Dalsgaard, 2014; Dixon, 2020) and a renaissance of Pragmatism in design sciences has been observed (Dalgaard, 2014; Dixon, 2019, 2020; Melles, 2009; Rylander et al., 2021; Steen, 2013; Stompff et al., 2021). Pragmatists view knowledge as an inextricable part of practice and activities: "knowing is literally something which we do" (Dewey 1916/2008, p.367). Using Dewey's lens, design thinking is no longer seen as a process, but as a practice in which thinking and making are inseparable.

Yet despite the interest in Pragmatism, it only rarely infuses design thinking educational programs. The research question we address is: how should we educate future professionals in design thinking, justifying design's experiential nature by incorporating a pragmatist approach? This paper describes a design research, lasting years, as part of which several educational programs were developed incorporating Dewey's epistemology.

2. Pragmatism and its relationship with design thinking

Of all Pragmatists, John Dewey is the one most often discussed in relation to design thinking (Dalsgaard, 2014; Dixon, 2019, 2020; Steen, 2013; Stompff et al., 2021), above all his inquiry (Dewey, 1938/1986). Dewey's inquiry has remarkable similarities with design research, a perspective authoritatively developed by Brian Dixon (2020).

For Dewey, knowledge cannot be separated from action. He overturns dualist worldviews that separate mind and matter; thinking and doing; and theory and practice, and puts *experience* front and center (Dixon, 2020; Lorino, 2018; Rylander et al., 2021; Talisse, 2002). As Biesta and Burbules highlighted (2003, pp.90-92): Dewey believed that knowledge should not be conceived as the correspondence between our "ideas of reality" and the "real world", but as relational: it concerns *knowing what to do in an ever-evolving situation in order to achieve certain ends*. We are actors, simultaneously undergoing a situation and acting upon it. Our acts constitute the situation on which we reflect and we establish meaningful relations between our acts and the evolving situation. Reflecting matures with experience, so in time we develop a wide range of possible ways to act upon a new situation, or conceive new ways. Dewey (1917/2008: p.137) considered intelligence our capability to "project new and more complex ends" and conduct informed experiments.

2.1 Inquiry

An inquiry starts with “doubt” (Peirce, 1878/2011: p.53) or an “indeterminate situation” (Dewey, 1938/1986: p.107) that occurs when the outcomes of our actions can no longer be predicted and ends once we know how to act to achieve our ends once again. The pattern of inquiry consists of several steps (ibid.: pp.109-122), including instituting the problem, reasoning and experimenting. This may be misinterpreted as *first* defining the problem, *then* reasoning and *subsequently* experimenting. However, Dewey pointed out that defining problems without reference to possible solutions is considered meaningless (ibid.: p.112).

Whilst inquiring, problems become clear as ‘facts’ that constitute a situation, and solutions are suggested to us as ‘ideas’ marking *possibilities* to pursue (ibid.: p.113). These ideas “flash upon us” (ibid.: p.116) and are the base for hypotheses that are validated through experimentation, which offers new facts (ibid.: pp.112-114). Thus, “inquiry is progressive and cumulative” (ibid.: p.310) and researchers following a Deweyan inquiry have to *define* the problem *temporarily*, experiment with solutions, adapt the problem definition and so on, until an endpoint is reached whereby a plausible argument is developed (Dixon & French, 2020: p.19).

Dewey’s pattern of inquiry offers a robust logic for design and design thinking, combining research, experimentation and creativity, and we refer to design research based on his inquiry as d*esign inquiry,* whereby design methods and artifacts are a legitimate part of the research.

2.2 Co-evolution

In an inquiry, the problem cannot be defined unless a possible solution surfaces. We only know what the problem is when we know how to solve it: “Problem and solution stand out at the same time”(Dewey, 1933: p.201). This is similar to design practice: through crafting designs, ideas may arise that may redefine the original problem. As Dorst and Cross (2001) argued: problem space and solution space co-evolve. Besides, Dewey discussed the co-evolution of means and ends (1938/1986: p.490): “ends have to be evaluated on the basis of available means by which they can be attained”, just as means have to be evaluated in relation to ends they may effectuate. The implication is that, in an inquiry, there are no problem definitions, no premises, no first principles, no ‘absolute truisms’ that serve as a starting point for subsequent reasoning. Everything – problems, solutions, means, ends – is interdependent and all factors emerge together during the inquiry.

The emergence leads to a fairly messy process for outsiders, exemplified by means of the continuous adaptations of the problem definition or the ‘sudden’ breakthrough that seems to come out of nowhere, whereas it is in fact “prepared by a long and slow incubation”(Dewey, 1934/2005: p.277). The fortuitous nature of inquiry may strike us as odd, but as Lorino (2018: p.108) argued: “isolating and hypostatizing elements of an inquiry is one of the main mistakes of rationalist thinking. The inquiry may transform all of its components at any moment.”

2.3 Abduction

The doubtful situation requires abductive reason. This logic was first developed by Charles Peirce (1903/1998) and concerns inferring the best possible explanation for a doubtful situation. Abduction is a thoroughly creative process requiring an imaginative conceptual leap (Martela, 2015: p.548) in order to “put together what we had never before dreamed of putting together” (Peirce, 1903/1998: p.227). Dewey never used the term ‘abduction’, yet Dewey’s inquiry has remarkable similarities with Peirce’s abductive reasoning (Paavola, 2015).

In the context of design, abduction was developed by Roozenburg (1993) and Dorst (2011), as the logic needed to reason towards tentative solutions for problems when hardly anything is given and much is needed, requiring imagination.

3. A Deweyan stance on design thinking education

In an educational context, educators need to prepare students for the messy nature of design thinking, whereby problems and solutions, means and ends co-evolve and whereby a conceptual abductive leap is needed to fit emerging facts and ideas together into a plausible whole. We have developed four principles for design thinking education on the base of Dewey’s inquiry.

3.1 Learning by doing

Dewey had progressive ideas on education and is a well-known proponent of experiential education (Dewey, 1986). He put the quality of experience, such as the interaction between the learner and what is learned, at the heart of educational programs. This implies that students must interact with their environment in order to adapt and learn. Our interpretation is that for teaching design thinking, students need to work on lifelike/real-life challenges in a social context for a prolonged period.

3.2 Framing

Schön’s theories on reflection-in-action (1983) offer a pathway to teaching abductive reasoning (see 2.3) through the concept of framing. Framing is imposing a framework on a complex situation by naming ‘how the situation is seen’. Framing is at the heart of design reasoning (Dorst, 2011): due to the complexity and information overload, a designer cannot oversee everything and has to decide how to ‘frame’ the situation. Thus, the designer makes a conceptual leap by hypothesizing what may be an intelligent way to see the situation in order to explore it. Rather than trying to establish ‘what the problem is’, the challenging situation is framed using a specific lens. As an example: ‘housing shortages’ can be framed as ‘building more houses’ or as ‘novel ways of living together’. Each frame shapes what will be considered problematic, what kind of research is needed and what kind of ideas will arise. A frame sets the agenda for future activities, ensuring coherence in activities (Valkenburg & Dorst, 1998).

It is impossible to establish a priori which frame will be most effective. Several frames need to be developed and explored to compare their practical value (Dorst, 2011: p.120; Stompff, 2018: p.111). Consequently, we believe that students of design thinking have to name, explore and compare multiple frames: do they mitigate the problem? What are the expected and unexpected effects? Do they fit constraints?

3.3 Research for and through design

Dewey's inquiry (see 3.1) includes stages of temporarily defining the problem, developing solutions, experimenting and reflecting (Dewey, 1938/1986: pp.111-118). This means that both research and design activities are needed. Two essential aspects of Dewey's logic need to be highlighted for the purpose of a design inquiry.

First, as problem and solution co-evolve (see 4.2), research and design activities in a design inquiry *alternate* or even *coalesce*. For example, the conventional research activities in a design inquiry, named research *for* design (Frayling, 1993), serve to inspire design activities. However, possible solutions already flash upon us during these research activities. Likewise, artifacts are created and tested as you design, and new insights emerge that enable you to gain a better understanding of the problem or even reframe the problem. This is named research *through* design (Frayling, 1993; Gaver, 2012; Sanders & Stappers, 2012; Zimmerman et al., 2010), as the problem becomes known through designing and testing. Following Dewey's logic, students doing a design inquiry need to conduct both research *for* design and research *through* design.

Second, facts and ideas developed in an inquiry are verified and evaluated for their practical consequences (Dewey, 1938/1986: pp.116-118), that is: real-world consequences. Doing interventions and reflecting on the outcomes is pivotal for closing an inquiry. If anticipated outcomes are met, a doubtful situation ends, as we know how to act to achieve a goal. Thus, as Biesta and Burbules (2003: p.46) argued: "We need overt action to determine the worth and validity of our reflective considerations." The implication for a design inquiry is that the only way to verify ideas is putting them to the test!

3.4 Iterating

As an inquiry is progressive and cumulative, an inquirer needs to iterate so that facts and ideas become known. design thinking students have to alternate between defining the problem and developing solutions, between doing research and devising/testing designs. In educational programs, however, students often only iterate once (Liedtka & Bahr 2019; Lake et al., 2021) and wait to test prototypes until the very last moment. The derived insights can no longer be used to improve the design or to reframe the challenge, defying the nature of design.

To let design thinking students get acquainted with iterating, the 1-10-100 method was developed (Stompff, 2018: pp.89-99; van Turnhout et al., 2013). Students are 'forced' to conduct multiple iterations for a project, with each iteration consisting of all steps of the design thinking cycle (see Figure 1), including prototyping (see Figure 2).

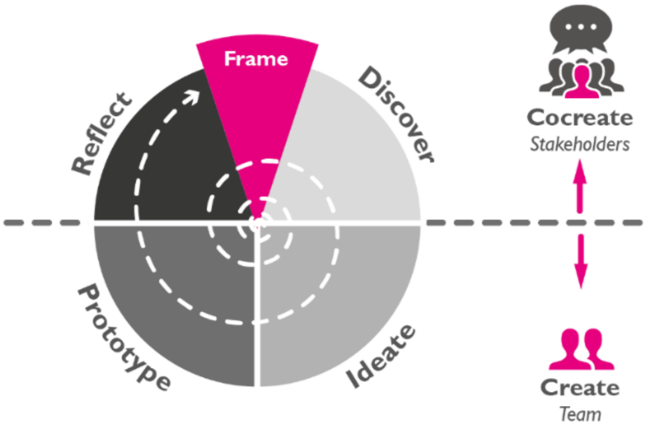

Figure 1. The 1-10-100 method is a design thinking approach as part of which several iterations need to be done for a project. Each iteration consists of naming a frame, conducting research, ideation, prototyping and reflecting (testing). The first iterations progress fast, the last requires much more time.

The name '1-10-100' refers to the relative time spent on one iteration. For the first iteration, students have only a few hours to develop and explore a frame. The rationale is that, in the beginning, much is unknown and ambiguity prevails, requiring exploration. By swiftly developing, presenting, and comparing *multiple* frames, students learn which frame is most 'productive', that is: has most practical value. Later in the project, when more research is done and ideas become concepts, an iteration requires several days and eventually even weeks to conduct proper research and design all the details. In this approach design and research activities genuinely alternate.

Figure 2. A prototype made by students already in the first days of their project on separating waste. They have to explore and prototype their ideas as soon as possible, using cardboard, foam, tape, etc.

4. Method and context

The method chosen is a design inquiry, whereby researchers and practitioners collectively deal with a challenge, by making designs, conducting experiments and critically reflecting on outcomes. It includes research for design and research through design and ongoingly the acquired insights are compared with known theories.

4.1 Method

In this study the researcher (first author) and practitioners collaborated to develop design thinking educational programs in different contexts (described below). In every case a design inquiry was conducted lasting years, following steps as depicted in figure 3.

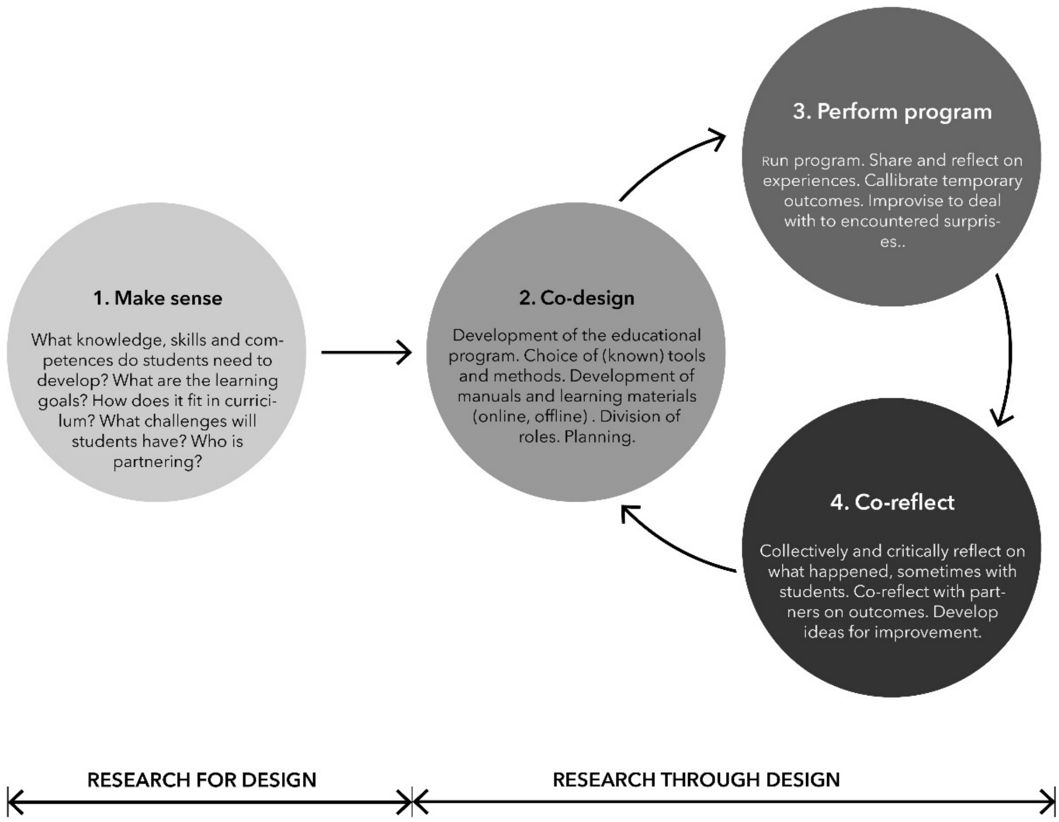

Figure 3 Steps of the design inquiry. In each case, these steps were followed and several design iterations performed.

In each case, the research started with a sensemaking step, in which educators and the researcher established what the situation was, e.g., what competences and knowledge students already had. In step 2, a dedicated educational program was co-designed and the coaches prepared. In step 3, the programs were run, leading to many observations that were reflected on with educators and stakeholders in step 4. These reflections offered valuable insights for adapting and improving the program, resulting in another cycle. All programs for the cases were run the next semester or a year later and improved multiple times. The researcher participated in all cases and shared insights across cases. As two cases were conducted simultaneously, they informed and inspired each other.

4.2 Context

The three cases are presented in Table 1. As the design thinking programs had to fit different educational courses, they varied considerably (duration, level, individual or team, complexity).

Table 1: An overview of case studies, in chronological order

	Case 1 ***Residence program for DT in design lab***	**Case 2** ***Integrating DT in first-/second-year curricula***	**Case 3** ***Design-based graduation projects***
Organization	Cube design museum	Zuyd University of Applied Sciences	Inholland University of Applied Sciences
Involved studies	Residents program involving multiple (international) students	Communication & Multimedia Design	Communication; Tourism Management, Media & Entertainment Management, Creative Business
Education level	Secondary vocational up to Master	Bachelor	Bachelor
Location	Kerkrade (NL)	Maastricht (NL)	Amsterdam; Rotterdam; The Hague; Haarlem (NL)
Aim	Co-development of a program for residents (students) working on societal challenges	Co-development of UX Design (first year) and Design Research (second year) courses	Co-development of educational & coaching programs for design-based graduation
In cooperation with	Program manager and 2 coaches	Program manager, 5 lecturers/coaches	3 program managers, 2 researchers, approx.. 20 coaches
# students involved	Approx. 80	Approx. 200–250	Approx. 80, scaling up to 500 (2022)
Description of course(s)	Half-year program to co-design solutions for societal challenges in multidisciplinary student teams	Distinctive courses to develop design skills; courses are cumulative (both 15 credits)	Empowering coaches and students to use design-based research in graduation projects (30 credits)
Main challenge for developers	Innovative educational environment, lack of examples	Adapting running programs, redesigning several courses on the curriculum	Most students and coaches lack basic design skills
Available materials	Course how to practice design thinking: https://teach.dariah.eu/	Book: *Design Thinking* (Stompff, 2018)	Manual, online courses and movies (provided by Inholland)
Development period	2015-2020	2016-2019	2020-2022
State of affairs	Discontinued due to COVID-19	Part of regular program	Part of larger transition to integrate DT in curricula

The first case concerned the co-development of a program for ‘residents’ in the design lab of a design museum. Residents are international students who work in teams at the museum amidst visitors for several months on societal challenges, such as an ageing society. Most were product or interaction design students, but students from art schools or social sciences also participated. Interestingly, the education level of students varied considerably, from secondary vocational level up to master level.

The second case concerned the co-development of a program for design thinking for a bachelor degree program (Communication and Multimedia Design). The design lab program (case 1) was adapted, split in two and embedded as part of the curriculum. In the first year, the design thinking program was integrated into the User Centered Design course, and in the second year into the Design Research course. Whilst the programs were running and improved, the alignment with other courses was also fine-tuned to offer a more coherent curriculum.

The third (ongoing) case concerns the co-development of materials, masterclasses and train-the-coaches programs at a university of applied sciences for design-based graduation at bachelor level. The challenges are that it concerns non-design students and that most coaches, having an academic background in the sciences or the humanities, lack basic design skills. Several pilots with a limited number of students were conducted to learn and prepare for the large number of students that will graduate using design thinking in 2022.

5. Findings: Lack of solid ground and coping mechanisms

The human-centric and solution-oriented approach of design thinking was appreciated by (most) coaches, students and clients. Above all, coaches and assessors applauded the framing activities which teach students that many perspectives co-exist. The impact can best be demonstrated by the scaling: pilots with few students became extensive programs for hundreds.

Even so, conducting a design inquiry based on Dewey's logic proved to be an acquired taste. In this paper, we focus on one problematic issue that was consistent across cases: students and coaches struggled with the indeterminacy and experienced anxiety as result of doubt. They could not settle on the problem definition once and for all, but had to rephrase it due to emerging insights when testing designs, just like they were unable to formulate ends without considering available means (e.g., budget). They had to formulate problems and create solutions, define ends and decide on means 'simultaneously'. This co-evolution proved to be difficult for students and coaches alike as they searched for solid ground.

A conceptual abductive leap was required. This required courage, as much was unknown and ambiguous, as well as imagination to envision what might be. It will come as no surprise that not every student (and coach) could deal well with the inherent doubt. Four coping mechanisms were observed, each with a specific strategy to deal with the doubt, often evolving into pitfalls. These are summarized in Table 2 and discussed below.

Table 2. Overview of observed coping mechanisms

	Focus on analyzing the problem	Focus on creative problem-solving	Focus on developing means	Focus on future ends
Assumption	The problem must be understood ahead of the design stage	The problem is simple, finding a solution is not	There is a clear idea that needs to be developed	Design involves envisioning possible futures
Behavior	Focus on conducting research, trying to analyze their way out	Focus on ideation, relying on ctheir creative capabilities	Focus on making an early idea 'work' rather than exploring alternatives	Focus on creating futuristic concepts, less on making it 'real'
Pitfall	Analysis paralysis, postponing creative parts of the inquiry	Unsubstantiated design without an understanding of the situation	Fixation, sticking to (poor) ideas even when it is clear other ideas are better	Hanging on to a dream, developing concepts that are not feasible

5.1 Focus on analyzing the problem

Many students cope with doubt by focusing on research *for* design, spending ample time on conducting interviews and the like. They hope the research outcomes will offer guidance for the design. Due to ambiguity, however, they inevitably encounter stakeholders with opposing opinions. The issue is that ambiguity cannot be resolved by conducting more research (Weick, 1996: p.27).

The students risk stumbling into the *analysis paralysis* pitfall, whereby they postpone the creative parts of the design inquiry. When time runs out, they feel stressed and present shallow advice or, at best, 'jump to solutions'. We observed that introducing methods that are embraced by the design research community, such as contextual inquiry (Karen & Sandra, 2017) or design probes (Mattelmäki, 2006), hardly mitigated the analysis paralysis. These time-consuming methods offer rich insights for design, but gave students a false sense of security. They felt they were doing the 'right' things, yet effectively postponed design activities until the point of no return: great insights, no designs.

The paralysis is intensified by introducing 'thresholds' to safeguard the quality of interim deliverables. In case 3, for example, some students were not allowed to start their graduation project without a concise problem definition, severely restricting the solution space. Other students could not start design activities because the number of conducted interviews did not meet the standards of their coaches. This 'gatekeeping' defies the co-evolution of the problem and solution space and has a profound impact on activities and planning.

5.2 Focus on creative problem-solving

A different coping mechanism is to focus on ideation and creation. Some students consider the design inquiry a legitimate way to skip the 'boring' research parts, assuming it is about creativity and artistry. The complex situation with many interrelated issues and opposing interests is not studied well and students develop ideas based on how they experience the world. As an example, students working on ‘loneliness among the elderly’ explored Tinder-like ideas, projecting their own lived experience rather than immersing themselves into the world of the elderly. They risked producing *unsubstantiated designs* that may seem creative, but lack an understanding of the situation.

Interestingly, we observed that coaches with design experience unwittingly strengthened this coping mechanism. Seasoned designers often quickly understand the situation adequately enough to start designing. They allocate most of their time to developing concepts and rely on experimentation (Schön, 1983: pp.102-104). Their experience enables them to rely on developing and testing designs to validate their assumptions quickly. These experienced coaches expect students to do the same, yet students lack their experience and are unable to grasp the situation at hand quickly, producing poor designs. Students need to conduct research more systematically than professional designers.

5.3 Focus on developing means

A third coping mechanism manifests when students promptly settle on a promising idea. They spend most of their time on the realization of this idea, rather than exploring alternative ideas. Often this idea is derived from the knowledge base of the students, which is shaped by prior education. For example, communication students see every problem as a communication problem, so they quickly opt for ideas like ‘improve the website’ and spend most of their time on ‘making it work’. They hardly question whether a website is appropriate, even when it is clear to others that a website most likely will not do. This easily becomes a pitfall that is named *fixation* (Jansson et al., 1991), whereby designers stick to ideas and ignore the fact that other ideas are more elegant, have more impact or are less costly.

Fixation is a well-studied topic (e.g., Crilly, 2019; Youman et al., 2014), but what surprised us was that fixation was also introduced by coaches and clients. In order to help students forward, coaches suggested methods or gave an idea that became a lifeline for insecure students. Clients had pre-existing about on what they needed and introduced a guiding frame that most students did not dare to question, even when it became obvious that it was unsuitable. Coaches and clients reduced ambiguity in order to help students, yet unwittingly turned the design inquiry into a simple checklist of activities that led to poor learning outcomes.

5.4 Focus on future ends

A fourth coping mechanism of students is to interpret the design inquiry as a method to envision an ideal world. ‘Dreaming’ is undeniably needed in a design process in order to set inspiring goals that are beautiful, sustainable and/or inclusive, but some students seem to forget to develop plans to make it real (see Figure 3). In a dream world, your budget is unlimited, everything is possible and potential conflicts can be circumvented. However, the essence of design is to develop ideas that transform opposing interests and are tested for their real-world consequences. Dreaming of a beautiful future offers a safe haven for students to deal with ambiguity, but lets them escape the ‘hard’ choices that must be made. This pitfall can be described as *hanging on to a dream*.

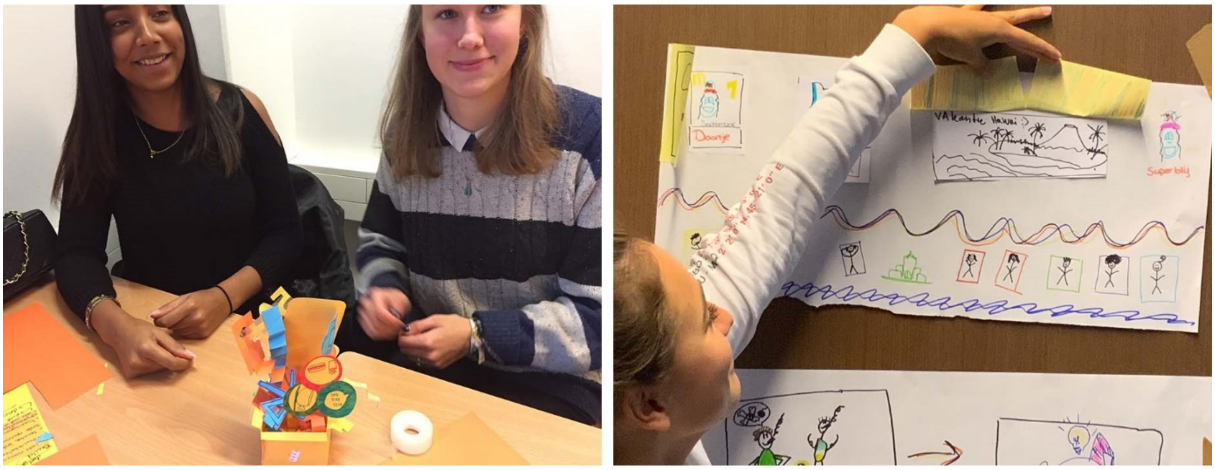

Figure 3. ‘Prototypes’ of ideas showing a dream, lacking the realism needed to test the ideas. It represents what might be, but not how to get there.

We observed that coaches who lacked design expertise often strengthened this coping mechanism. They were swept along by the exposed idealism of students and lacked the expertise to judge what the real-world consequences were or how much time and money was needed to develop something feasible.

6. Improving the inquiry: Establishing solid ground

These findings show that the doubt inherent in the design inquiry poses an educational challenge. Many interventions were conducted to offer students guidance without spelling out what to do. Interventions aimed at constructing a joint practice with a ‘community of learners’ (Dewey, 1929/1966) proved to be exceptionally effective. This insight arose in case 1, where students had to work in a museum amidst visitors. It was difficult for students to meet the professional standards of the museum, but the focus on visual, tangible or even interactive representations paid off. Through the artifacts, students learned from each other and from visitors what was ‘good’, reducing the doubt. In the other cases, *show-and-share* sessions (Figure 4) were introduced where students presented their work. Rather than describing what they had done (activities), students presented what they had created (artifacts), and rather than telling what they planned to do, they showed what they planned to produce.

At first, these show-and-share sessions were held every week week, involving the students themselves and coaches. They made movies to show what respondents said in their research; photos of what they observed; posters explaining what frameworks they were exploring; low-fidelity prototypes of futuristic concepts; and functional prototypes demonstrating how something works. Students both gave and received feedback in these sessions as well.

Figure 4. Show-and-share sessions in which students present their findings and ideas to other students and coaches, receive feedback and give feedback.

Later, these sessions were taken to another level when students invited other students, partners and users, albeit on a less frequent basis (Figure 5). We quickly learned that the artefacts of design activities, such as the objects and posters used in these presentations, functioned as *boundary objects* (Star & Griesemer, 1989; Carlile, 2002). These are objects that are observable by many and have boundary-spanning capabilities: plastic enough to adapt to use in different contexts, yet robust enough to maintain a common identity. Through these objects, students learned what other students were doing and reflected whether they themselves were doing the ‘right’ things:

- Students with a tendency to focus on analysis observed how stakeholders instantly liked the immature, daring ideas of others.
- Students who tended to rely on their creative powers discovered that their designs were based on clichés when confronted with the rich insights of other students as a result of research.
- Students who got fixated on an early idea and tried hard to ‘make it work’ were confronted with more elegant, inspiring ideas that required far less work.
- Students who tended to stick to dreaming a perfect world got a wake-up call when other students presented business cases showing realistic cost estimations.

Also, these objects helped to establish intersubjective standards between students, coaches and clients on what can be considered ‘good’ and why. This included ‘what is good enough research’; what ideas are ‘inspiring’; how ideas can be presented ‘well’; and what narratives ‘justify’ the choices made. These objects became even more meaningful when used to conduct tests with users. Experiencing the *real-world consequences* of their designs gave students insight into whether the assumptions underlying their designs were justified. This also helped them to convince clients (see Figure 5).

Figure 5. Students test concepts at a show-and-share afternoon with clients, users, stakeholders and coaches.

Thanks to these boundary objects and the collective show-and-share sessions, most students could deal with the doubt they experienced and were able to make the creative leap required to grasp the problem at hand and develop inspiring concepts at the same time. They developed a *joint* practice, in which it became clear what was expected of them; what the problem was; what ‘good’ solutions were and why; and how to progress. Note that we use the word ‘joint’ and not ‘shared’. ‘Joint’ highlights that every student and coach adds parts: posters, objects, sketches, prototypes, examples. Their individual contributions may vary considerably, but together they decide what is inspirational, what is good and what is an adequate justification of the choices made. Together they construct a meaningful practice.

The boundary-spanning qualities of these objects exceeded the community of learners: the work of students of one year proved to be highly informative for students in the next. Most surprisingly, the work of students of one degree program (e.g., communication) proved to be meaningful to students of another (e.g., social sciences): showing examples had more impact on activities than well-prepared lectures, such as on framing. The lectures did not result in observable changes of behavior, but according to assessors, showing posters of other students depicting different frames with different lenses were rapidly understood and improved learning outcomes considerably. The objects offered a sense of direction on *how* to do things, leaving ample room on *what* was needed.

7. Conclusion

design thinking is often taught as a process, whereby problems are defined before solutions are developed. These, in turn, are tested as a last step. This perspective overlooks that problems and solutions co-evolve and that design knowing resides in practices. Dewey's inquiry offers an epistemological basis for a design inquiry that resolves these issues, as it is remarkably similar to design. In a design inquiry, the problem is defined temporarily while solutions are devised and tested, resulting into adjustments to the problem definition and until a plausible and justified narrative is developed as to what to do. Research and design activities alternate or even coalesce and design artifacts are the driver for arriving at new insights.

However, it became clear that students struggled with the lack of solid ground they experienced as a result of the ambiguity and uncertainty they faced: they had to interpret the situation and develop solutions 'simultaneously'. The co-evolution of problem and solution and of means and ends requires a conceptual abductive leap, which is challenging. Four coping mechanisms were observed, a visual overview of which is provided in Figure 6. Each coping mechanism focuses on a specific aspect of the design inquiry. Some students focused on understanding problems (risking analysis paralysis), whereas others relied on their creative skills to create solutions (risking unsubstantiated claims). Some promptly embraced an idea and tried to make it real (risking fixation), whereas others focused on developing aspirational ends (risking hanging on to an unrealistic dream).

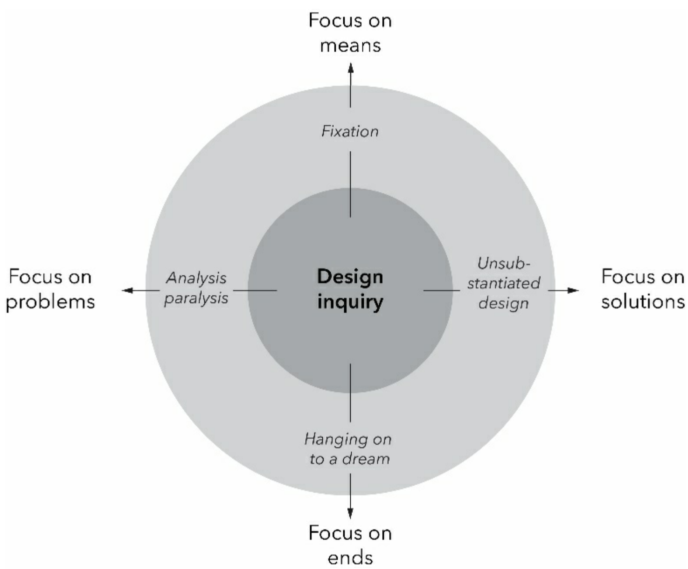

Figure 6. A framework for explaining the observed coping mechanisms. In a design inquiry, problems and solutions co-evolve, just as means and ends. Students need to balance these (the inner circle). When they focus too much on one of these aspects, pitfalls occur (outer circle).

Logical reasoning and step-by-step processes do not offer a way out from the swamps of uncertainty and ambiguity. Most students established solid ground by means of a jointly developed practice in a community of learners. Observable and/or tangible representations facilitated collective reflections. Collectively, students established what issues were considered most problematic; which ideas were inspirational; what designs were feasible; and what the real-world consequences were of the choices made. In short: designs were evaluated for their practical value in a social context by a community of learners, thus justifying the choices made. By putting artifacts at the heart of the program students by creating a community of learners in which students, coaches, users and clients learn what is expected and establish standards on what is good, so that they can finally touch ground.

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