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Slinger, Jill H.; Kothuis, Baukje Bee

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CHAPTER 28

# A specific transdisciplinary co-design workshop model to teach a multiple perspective problem approach for integrated nature-based design

**Jill H. Slinger[a,b] and Baukje Bee Kothuis[c,d]**
[a]Faculty of Technology, Policy and Management, Delft University of Technology, Delft, Netherlands
[b]Institute for Water Research, Rhodes University, Makhanda, South Africa
[c]Department of Hydraulic Engineering and Flood Risk, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands
[d]Netherlands Business Support Office, Houston, TX, United States

## Introduction

Interdisciplinary, place-based learning by international groups of students formed an integral component of the Partnerships for International Research and Education Coastal Flood Risk Reduction (PIRE-CFRR) program "Integrated, multiscale approaches for understanding how to reduce vulnerability to damaging events." The program aimed to create "authentic learning environments" that supported and benefitted from ongoing research efforts related to flood risk management. The challenges lay in designing such environments to accommodate the place-based and contextual nature of flood risk management, to integrate across multiple disciplinary fields, and to complement the diverse educational backgrounds and programs from which the staff and students in PIRE-CFRR were drawn. Moreover, the program sought to learn collectively about new approaches to flood risk reduction through innovative nature-based infrastructure design. Such nature-based solutions are characterized by disciplinary integration, including multiple perspectives in the determination of design requirements, and long-term time frames that balance the limitations of the Earth's natural systems and the socio-technical systems created by humans (Klaassen, Kothuis, & Slinger, 2021). The infrastructural artifacts reflect these characteristics in their form (Slinger & Vreugdenhil, 2020) and are sometimes designed to disappear over time, e.g., the Sand Engine in South Holland (Bontje & Slinger, 2017; Stive et al., 2013). The novelty of the nature-based solution concept presented an additional challenge to the design of an appropriate learning environment.

We report on two transdisciplinary workshops undertaken within the PIRE-CFRR program to teach a multiple perspective problem approach for integrated nature-based design, and examine their efficacy. The first workshop in May 2016 focused on the

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ebb-tidal delta offshore of the southwestern corner of Texel, an erosion hotspot on the Dutch coast, whereas the second workshop in June 2017 focused on the anticipated failure of the Hondsbossche Pettermer Sea Dike to continue to meet Dutch flood protection standards in the future (Fig. 1). The potential to apply nature-based solutions in managing these flood risks was a hot topic in the Netherlands at the time, making these cases attractive choices for teaching (see Pruyt, Slinger, van Daalen, Yucel, & Thissen, 2009).

Both workshops were convened and facilitated by the authors. The effects of these learning interventions are reported and analyzed in terms of (i) the co-design workshop process, (ii) the substantive outcomes, and (iii) evidence of learning at the individual level. The (shared) changes in understanding of (engineering) roles in a design team are reported in a publication by Klaassen et al. (2021). This chapter will not focus on the analysis of shifts in individual design roles nor on the design process followed by each of the student teams. Instead, the sequence of activities comprising the workshop process, the design outcomes of the transdisciplinary workshop, and the efficacy of the workshop method for achieving learning outcomes form the focus of the study.

First, we provide a theoretical background on problem-based learning and authentic learning pedagogies, on the design of participatory workshops within a policy process, and on nature-based solutions in hydraulic engineering (Section "Theoretical background"). After a brief description of the method (Section "Method"), we then describe the workshops in terms of the co-design process followed and their knowledge content (Section "Results"). The effects of the workshops are then evaluated in terms of the learning outcomes (Section "Learning outcomes") and the chapter concludes with a reflection.

**Fig. 1** The sandy southwestern coast of the island of Texel separated by a narrow channel from the ebb-tidal delta *(left)*, and the old Hondsbossche Pettermer Sea Dike and groynes *(right)*.

## Theoretical background

Standard teaching practices in traditional classroom environments focus on transferring formalized knowledge (textbooks, exercises) from the expert (the teacher) to novices (the students) and have long been criticized as lacking (i) the authentic problem contexts essential for effective learning (Schmidt, 1993) and (ii) the collaborative environment in which students can learn together by exploration (Duignan, 2012). Alternative forms of education have been developed and applied to address these issues. For instance, problem-based learning (Barrows, 1985, 1992) is a pedagogical approach in which students are challenged to solve an open-ended problem. The learning activity centers on realistic complex case study material associated with a particular local setting. The local setting can be a specific geographical area or biogeophysical environment or can encompass a specific social setting such as a community. The problem-based learning process does not focus on solving the case study problem via a preexisting or defined solution but encourages the development of skills such as critical appraisal, problem structuring, literature review, creative design, and iterative reflection and synthesis. The process involves working in small groups of learners. Students collaboratively identify what they know, what they need to know, and how to develop new knowledge to resolve the case study problem. The role of the teacher is envisaged as supporting, guiding, and monitoring the learning process. Problem-based learning originated in the medical sciences but has gained ground in the fields of design studies, engineering, and the natural sciences (Nicaise, Gibney, & Crane, 2000).

In a parallel development, the authentic learning pedagogy concentrated on teaching students to undertake complex and realistic tasks through situated cognition. The aim is for students to develop problem-solving skills and robust knowledge that transfers to real-world practice in a particular field of study (Herrington, Reeves, & Oliver, 2014). The design of an authentic learning environment in which the student is placed centrally and the teacher acts to facilitate learning became a core focus of authentic learning endeavors. Learning environments are the physical or virtual settings in which learning takes place. Their design is not simply a matter of following a recipe (Bransford, Brown, & Cocking, 2000). Instead, it requires crafting to weave the activities, the (collaborative) interactions, and the tasks into a set of conditions that resemble the real-world situation sufficiently for the learning goals to be achieved (Boettcher, 2007).

Indeed, Yadav, Subedi, Lundeberg, and Bunting (2011) and Warren, Dondlinger, McLeod, and Bigenho (2012) established that involving students in authentic and meaningful work enhances their engagement and performance. By combining problem-based learning and authentic learning approaches, students can be offered opportunities to produce rather than solely consume knowledge, teachers can act as learning facilitators rather than simply as instructors, and groups can work together to develop designs and strategies to address an actual problem. In such situations, students regulate their learning process internally and are encouraged to become more reflective practitioners (Duignan, 2012; Slinger, Kwakkel, & van der Niet, 2008).

The emphasis placed on teaching students to become reflective practitioners aligns with the work by Schon (2011) in the field of policy analysis. Indeed, in their book on new developments in public policy analysis, Thissen and Walker (2013) emphasize the necessity for iterative and reflective processes in decision-making on complex problems. McEvoy et al. (McEvoy, 2019; McEvoy, van de Ven, Blind, & Slinger, 2018; McEvoy, van de Ven, Brolsma, & Slinger, 2020) draw on policy analysis work by Thissen and Twaalfhoven (2001) in distinguishing process and content in evaluating the efficacy of participatory planning workshops for the design and selection of flood mitigation measures in urban environments. They conceptualize these workshops as "policy analytic activities" or interventions nested within ongoing planning processes and explore how process and content choices within the workshops affect the overall process. A significant finding is that the effect of a half-day workshop in which participants learned about the different perspectives of representatives from other departments within a city authority could be traced one and a half years later. This emphasizes the learning impact of participatory workshops and signifies their potential value as procedural and substantive learning environments within the context of flood risk management.

The field of flood risk management has undergone significant developments in the last decade. Most notable is the insurgence of new concepts such as "Building with Nature" (EcoShape, 2020; Waterman, 2010), "Working with Nature" (PIANC, 2011), and "Engineering with Nature" (Bridges, Banks, & Chasten, 2016). Building with Nature specifically seeks to use natural materials and interactions in the design, realization, operation, and maintenance of hydraulic infrastructures (Waterman, 2010), striving for more ecosystem-based hydraulic engineering, while acknowledging social complexity (Slinger & Vreugdenhil, 2020). New types of nature-based hydraulic infrastructure have resulted. For instance, in the coastal area of North Holland, the Hondsbossche Dunes now offer protection from flooding where previously the oldest Dutch stone dike was located (RWS, 2015). On the Wadden Sea coast tidal marshes on the dike foreshore aid in protecting the hinterland from flooding, while permeable bamboo fences retain sediment and promote mangrove forest regrowth, preventing part of the Indonesian coast from eroding further (EcoShape, 2020). Such innovations in flood protection infrastructure design require the integration of knowledge from the fields of ecology and geomorphology with planning and engineering. They also require a broad consideration of the perspectives of multiple actors whose lives the infrastructure will affect over its whole lifecycle (Slinger & Vreugdenhil, 2020). Clearly, new methods for teaching the transdisciplinary, collaborative design skills necessary to develop integrated nature-based solutions for flood risk reduction are required.

## Method

Two learning interventions were designed in the form of transdisciplinary co-design workshops—"Building with Nature" Living Labs—between international groups of students and faculty members drawn from three Texan universities and four Dutch universities. The Texan universities included Texas A&M, Rice University, and Jackson State University, while the involved Dutch universities included the Delft University of Technology, the University of Twente, Wageningen University, and the Vrije Universiteit Amsterdam.

The first workshop took place on May 31, 2016 and was attended by a total of 20 master and doctoral students, 10 from Texas, and 10 from the Netherlands. The Texan participants spanned a wide range of disciplines associated with flood risk reduction including civil, chemical, and environmental engineering, urban and regional planning, geography and environmental science. Students from a similarly wide range of disciplinary backgrounds were recruited to attend by Dutch faculty, namely civil engineering, architecture, policy analysis, and environmental science. Key to the workshop design is the combined problem-based learning and authentic learning environment pedagogy. Accordingly, four additional local experts were invited to share their deep situated knowledge with participants in formal presentations and to act together with the faculty members as "service desks" for knowledge sharing during the entire workshop. The local experts were drawn from public authorities, such as the water authority Heemraadschap Hollandsnoorderkwartier (HHNK), from nongovernmental organizations, and from knowledge institutes located in the Netherlands such as UNESCO-IHE and Deltares. The first workshop spanned a day and took place in a large open space within the Science Museum on the campus of the Delft University of Technology. The schedule of activities comprising the workshop is listed in Box 1.

The second workshop took place on June 9, 2017, in Petten at the Beach Pavillion Zee&Zo near the Hondsbossche Dunes on the coast of North-Holland. This meant that the participating 26 students (16 from Texas and 10 from the Netherlands) from a wide range of disciplinary backgrounds were able to experience the actual location of an innovative nature-based flood defense for themselves. Four experts drawn from the water board Heemraadschap Hollandsnoorderkwartier (HHNK), and from a local citizens initiative, as well as from knowledge institutes, provided situated knowledge in the form of presentations and "service desk" advice, together with faculty members. The schedule of activities (Box 1) of the second workshop spanned a full day.

Data used in this analysis comprise (i) detailed "shooting scripts" prepared by the organizers detailing the choices made regarding the activities and their intended outputs, (ii) the presentations by local and disciplinary experts, (iii) photographs and notes on the designs made by the students, (iv) notes taken during the plenary feedback sessions, (v) proceedings of the workshops, and (vi) questionnaires completed by the Texan students on their return journey as part of the PIRE-CFRR exchange program.

**Box 1: The eight activities making up the transdisciplinary co-design workshop method**

The **transdisciplinary co-design workshop method** comprises a specific sequence of eight activities:

– Activity 1. Getting acquainted with each other
– Activity 2. Getting acquainted with the problem context
– Activity 3. Identifying key stakeholders and characterizing the biogeophysical system
– Activity 4. Acquiring the nature-based infrastructure design concept and the design assignment
– Activity 5. Collaboratively designing nature-based infrastructure
– Activity 6. Communicating the nature-based infrastructure designs
– Activity 7. Reflecting on learning
– Activity 8. Receiving expert feedback on the nature-based infrastructure design.

Throughout such a workshop, diverse disciplinary and situated, experience-based knowledge is offered to the small groups of students undertaking the design challenge. The effort is directed to ensuring an open, friendly atmosphere in which experts can easily be consulted and where documentary and visual information is freely accessible. Each student manages their own process of inquiry and discovery, although this takes place within the context of a small team of students from diverse backgrounds within the larger workshop setting

## Results

### The co-design process of the workshop

The purpose of the workshops was specified as "teaching integrated nature-based design for a specific coastal and societal context." The contexts were (i) the dynamic area on the southwestern coast of the island of Texel, and (ii) the sandy coast of Petten, the location of the oldest stone sea dike constructed in the Netherlands (Fig. 1), as these areas were either regarded as a potential site for nature-based solutions (Wijnberg, Mulder, Slinger, van der Wegen, & van der Spek, 2015) or were experiencing such interventions (EcoShape, 2020).

Earlier work on game-structuring approaches to complex environmental management problems in coastal communities (Cunningham, Hermans, & Slinger, 2014; Kothuis, Slinger, & Cunningham, 2014; Slinger, Cunningham, Hermans, Linnane, & Palmer, 2014) built an understanding of the problem by first identifying the key players, next gathering information on the system from the situated experience of participants, and then discussing and defining future outcomes. In essence, participants answered the questions (i) Who cares? (ii) Why we care? and (iii) What do we care about? before proceeding to define payoffs, identify future moves, and then negotiate with each other regarding the potential resolution of the problem. The success of this approach in creating an environment within which participants felt safe to discuss deeply contested issues and start to collaborate to address flood risk reduction issues (see Kothuis et al., 2014), led us to include similar steps in the teaching workshops. Clearly, the students were not familiar with the case study environment. This meant that they first needed information on the local bio-geomorphological and social environment and its current use and management. Accordingly, after a formal welcome and short getting acquainted exercise (*Activity 1*), disciplinary experts provided information on the hydro-geomorphology and ecology of the case study. This was followed by information on the local community, their uses of the area and their concerns, provided by a local resident or representative. Information on Dutch flood risk management practices and details applicable to the specific location was provided by a representative from the water board HHNK. At the close of this activity, many perspectives of the case study location and its natural and social dynamics had been communicated to the students. The presentations occurred in a theatre setting with opportunities for questions and discussion in the plenary. However, the experts were present throughout the workshop and were available for bilateral discussion and questions as and when needed. The provision of the contextual information formed *Activity 2* of the workshop method. The information was complemented by preprepared fact sheets designed to give an impression of the problem location, such as colorful photographs, tourist information, types of ecosystem, biodiversity importance, conservation status, employment, and human uses of the area. Aerial images and maps were also available for study as were the annual reports on the position of the Dutch coastline and sand nourishment volumes.

In *Activity 3*, the students are tasked with understanding the system by identifying the key stakeholders (Who cares?) and engaging with the biogeophysical and use components of the problem situation (Why they care?). This was undertaken using brainstorming techniques followed by clustering and grouping to come to a shared understanding of the key actors and the issues at play in the natural environment. The students undertook this task in small groups standing around a number of central tables and were free to consult the available information and the experts present.

## Box 2: Design assignments for the 2016 and 2017 workshops

### Texel Design Assignment

Design alternative coastal management strategies (or improve the current strategy) for the coast of southwestern Texel using the natural channel-shoal dynamics of the ebb-tidal delta to ensure safety from flooding and serve other functions.

### *Hondsbossche Pettemer Sea Defense*

The Hondsbossche Pettemer Sea Defense no longer meets the required safety standards. Design alternative coastal protection strategies (or improve the current strategy) so as to comply with required safety standards both now and in 2050, taking compatibility with the biophysical, social, and institutional environment into account in your integrated design.

In *Activity 4*, the design assignments were explained (Box 2). The instructions given regarding the design assignments were intended to stimulate creativity and indicate to students that they should not be limited by considerations of whether their solution is financially or institutionally viable. So, for instance, they need not consider legal feasibility but should consider physical feasibility. So, "turning the sea red" was infeasible, but designing a flood risk reduction option that did not conform to the then legally required flood protection level of 1 in 10,000, was feasible. This explanation occurred in an informal plenary setting, with the assignment projected on a central board and the first author, as workshop lead, emphasizing the core thinking of nature-based infrastructure design and reiterating the particular place-based challenge. In the second workshop, the explanation of the design assignment commenced with the students still standing around in groups after completing the previous step. They then adjusted their position in order to be able to hear and see clearly, contributing to the open atmosphere. In both workshops, a task relating to each student's role in a design team formed an additional component of the design assignment and is fully reported in Klaassen et al. (2021).

At the close of *Activity 4*, each student was asked to look on the back of their name badge to find a picture of a bird. They were then tasked with finding all the other students with the same bird, to form their small design team. Each team was handed a pail with a variety of equipment potentially useful for making their design—coloring pens, tacks, colored paper, markers, post-its, and flip-overs. They were encouraged to eat lunch together, provided in picnic form in the first workshop and as a buffet in the second workshop, and to begin to design. Each small group then set about making their own integrated, nature-based solution for the problem situation (*Activity 5*). Students made full use of the space available to them. Some sat outside to develop their design, others spread themselves liberally across the available space, some worked very neatly and quietly, and still others employed their artistic talents in the service of the group. The students were in charge of their process of inquiry, discovery, and design, learning to translate their understanding of the system and the actors into an integrated design with their small group. According to Klaassen et al. (2021), the early, divergent way of looking at the design problem and the search for common ground across the diverse perspectives of the team members, each bringing different disciplinary backgrounds to the design table, supported the realization of integrated nature-based solutions.

In *Activity 6* each of the small groups presented their designs. Participants asked questions of other groups to clarify their understanding and also questioned the reasoning behind specific design choices. The jury, comprising the experts who had presented information earlier in the day supplemented by faculty members with a sound understanding of "Building with Nature," then went into a separate room to deliberate.

The students then reflected together on their roles in the design team and how this had influenced the collaborative design process of their small group (*Activity 7*). Finally, the jury returned to give feedback on the integrated, nature-based infrastructure designs. This formed the final formal component of the workshop (*Activity 8*). In the time remaining before the departure of the bus, most students explored their surroundings and made plans to meet up again.

Overall, the collaborative design workshop focused first on allowing the students to formulate a picture of the real, complex design (solution) space of the problem (Activities 1–3) before tasking them with a design assignment (Activities 4–6), and reflection (Activities 7 and 8). Furthermore, the atmosphere in both workshops shifted from some discomfort at the beginning, to a more relaxed atmosphere during the day, and finally to an informal, open atmosphere in which students and faculty interacted freely and binational network contacts were formed.

## The substantive outcomes of the workshop

In 2016, there were four design teams with five students. In 2017 there were four design teams with five students and one design team with six students. The design assignments are specified in Box 2. This is followed by a detail of each of the designs produced in the first workshop (Figs. 2–4) and a summary of the designs produced in the second workshop. The observations of the expert jury are included in the analysis of the range and character of the students' designs.

The design of group 1 was entitled the Wadden Sea Education Research Center (TWERC) and focused on educating people (tourists, locals, authorities) about the dynamic, transient nature of features of the ebb-tidal delta like the "Razende Bol" (Fig. 2). This design shows that the students were able to acquire and use knowledge on the real problem situation in producing their multifunctional, adaptive design. When they were asked whether educating people really contributed to flood defense, they responded that the ebb-tidal delta would over time coalesce with the southwestern corner of Texel. This would mean that sand nourishment would no longer be needed for quite some time.

The design of group 2 envisaged the Razende Bol as a recreational sand engine (Fig. 2). They sought to give free reign to the natural processes of erosion and accretion that lead to the migration of this part of the ebb-tidal delta. They also envisaged constructing a vegetated dune ridge and erecting seasonal structures (demobilized in winter) to support recreational activities and enhance economic value. The Razende Bol would be accessible only by boat. In responding to questions the group explained their motivation as tackling the erosion problems, while simultaneously trying to realize a new

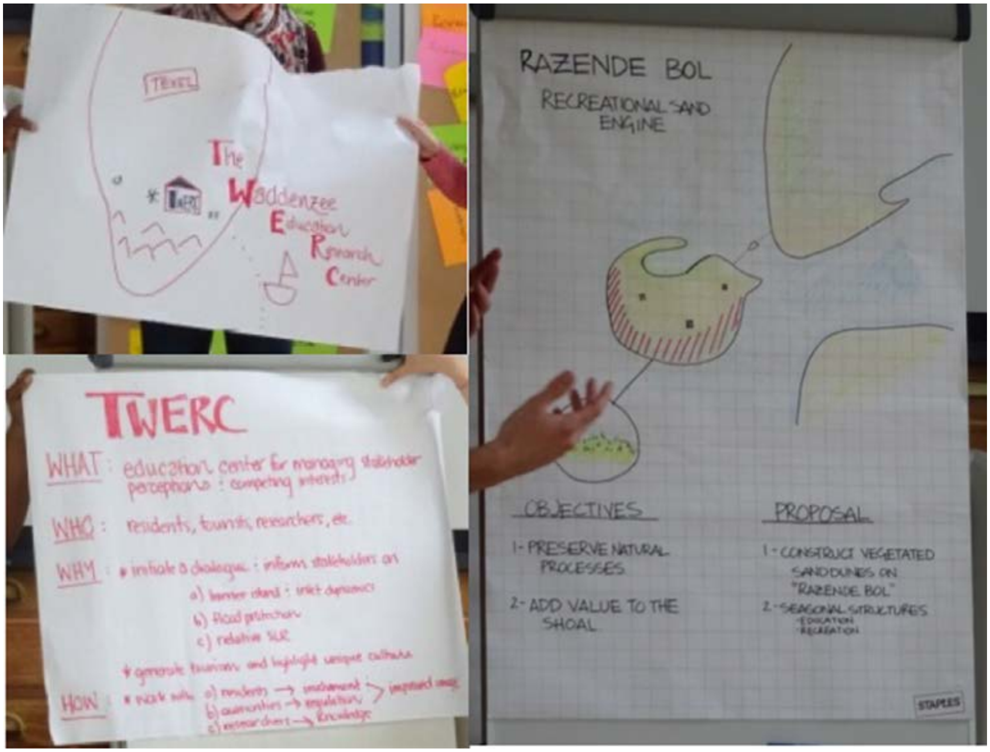


**Fig. 2** The integrated nature-based solution envisaged by group 1 *(left)* and group 2 *(right)*. Both of these solutions considered education regarding the transient and dynamic character of the Razende Bol an important aspect of their designs.

recreational function for the area. They used the analogy of the Sand Engine, as here the sand migrates along the coast as well as strengthening the dunes, and recreational use diversifies and intensifies over time. Again, their design reveals that the students were able to acquire and use problem-based knowledge to produce a creative design alternative.

Group 3 took a different approach, focusing on the problem of erosion on southwest Texel and the navigation channel between the Razende Bol and the island of Texel (Fig. 3). There are many uncertainties that this group took into account using scenarios. They explored business as usual—Scenario Zero in which the present erosion hotspot remains, there is sand nourishment each year, and the sand from the Razende Bol slowly silts up the navigational channel. There are no additional risks. Next, they explored the Full Stop scenario in which all intervention is halted. This means the ebb-tidal delta will continue to migrate and Texel will continue to erode. It is the most risky in terms of flooding danger. Then, they considered expanding the current dredging program to include the navigational channel, concluding that the ecological consequences of this would be severe. They advised following the business as usual approach as the problem

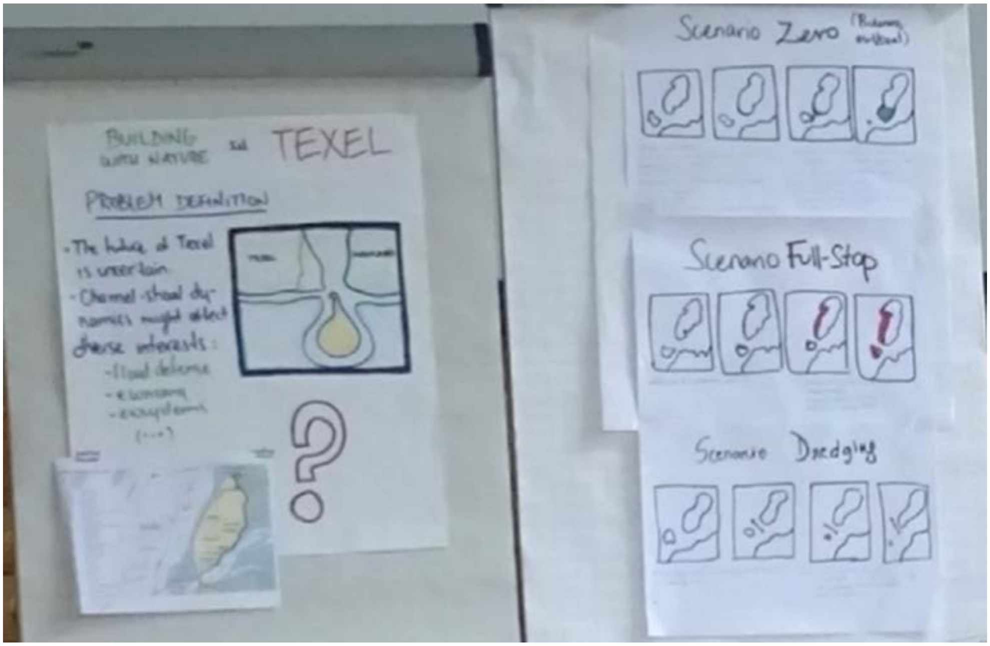


**Fig. 3** The integrated nature-based solution envisaged by group 3 takes uncertainty into account. They advised buying time by proceeding as usual and waiting for the Razende Bol to adhere to the island of Texel.

will disappear when the ebb-tidal delta joins to the island, and in the meantime encouraging a dialogue with all stakeholders. The design of this group reflects the integrative character of the authentic, problem-based learning environment by combining both procedural and substantive elements.

Group 4 proposed a staged approach (Fig. 4). First, they envisage using vegetation to stabilize the sand on the northwestern edge of the Razende Bol and on the southwestern edge of Texel. Next, they proposed dredging the channel to induce offshore migration (by disposing sediment on the Texel side to create shallow and steep slopes) and finally using mussel beds to attenuate waves. The mussel beds offer more natural value, serve to trap sediment, and increase flood protection. The plan is that the increased natural value will lead to enhanced use by nature lovers, birdwatchers, etc. In response to questioning, this group acknowledged a high level of uncertainty about the time frames for mussel beds to become established but indicated that this is likely to provide a truly sustainable solution or at least build evidence of what can be achieved using nature-based measures. This design revealed that the students could effectively integrate a wide range of knowledge of the real problem situation into an adaptive "Building with Nature" solution within a 1-day workshop.

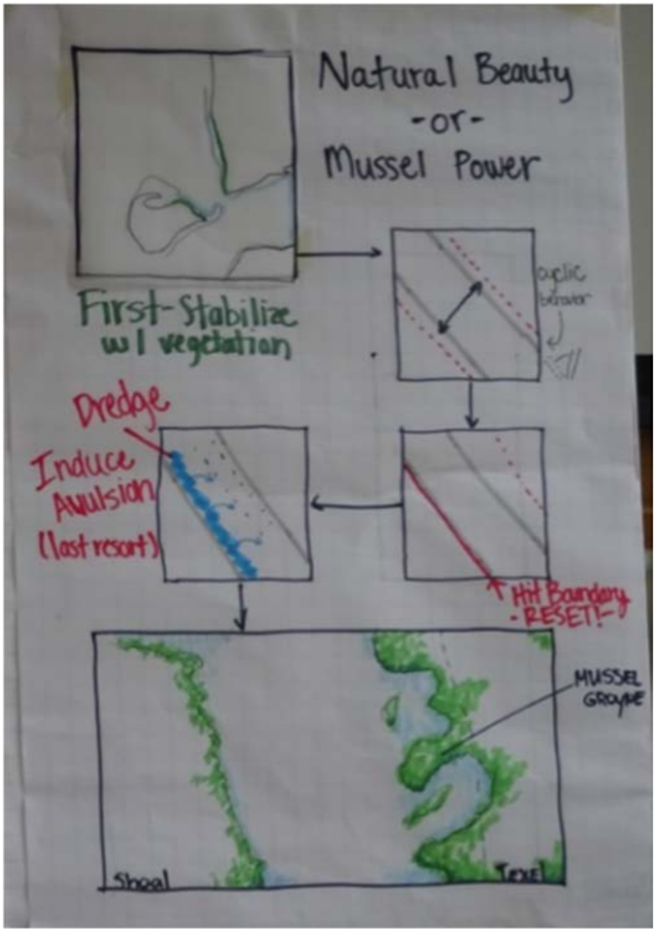


**Fig. 4** The integrated nature-based solution envisaged by group 4 employs vegetation, dredging, and finally mussel beds to realize flood protection for the island of Texel.

The expert jury (*Activity 8*) considered that all the designs showed evidence of an understanding of dynamic natural processes and an appreciation for the range of uses and perspectives held by stakeholders. It was slightly surprising that such a strong focus on education and awareness building appeared in two of the groups. However, the serious consideration given to uncertainties by group 3 was acknowledged, while group 4 was awarded the prize (an apple pie) for their integration of dynamic aspects of erosion and sedimentation with the natural feature of mussel beds.

Of all the groups, only group 3 took into account the degree to which their design affected flood protection standards. The absence of elements of conventional engineering and the degree to which the students embraced the concept of using natural dynamics were noteworthy. All designs revealed that the student groups were able to acquire and use diverse problem-based knowledge to achieve integrated nature-based solutions.

The design assignment of 2017 specified that the designs had to meet flood protection standards in the future. This requirement, and the fact that the Texan students had already been to the Sand Engine in South Holland, meant that the wide range of designed solutions for the HPZ case was still narrower than that for the Texel case. The manner of depicting the solutions was more varied, as more diverse crafting materials were available to the students. This included clay, wool, and matchsticks so some groups constructed maquettes of their designs. All of the designs took local interests into account, primarily tourism and recreational interests. There was also an emphasis on dune landscapes and their ecological and flood protection value. All of the designs focused on placing large volumes of sand at the Pettemer coast. The major differences in the designs lay in how quickly and where the sand volumes were placed. One team included the construction of wetlands inland of the position of the old HPZ dike as wetlands have ecological and tourism value. This group was awarded the prize by the expert jury (*Activity 8*). The designs of 2017 consistently exhibited multidisciplinary integration and a strong "Building with Nature" philosophy in that they integrated ecological and engineering knowledge, included multiple perspectives in the design requirements, considered the full lifecycle of the infrastructure, and designed artifacts different from conventional flood defenses (see Slinger & Vreugdenhil, 2020).

In summary, the design outcomes of 2016 and 2017 revealed that the problem-based, authentic learning pedagogy embodied in the 1-day transdisciplinary workshop method provided an effective procedural and substantive environment for acquiring transdisciplinary, nature-based design skills.

## Learning outcomes

In the reflection activity (*Activity 7*) during the workshop, only positive remarks were made about the authenticity of the design challenge (see also Klaassen et al., 2021). This indicates that the students recognized and enjoyed the case studies chosen and the way they were able to engage with the material—an important factor in learning and acquiring new skills. However, we were specifically interested in the knowledge acquisition of the Texan students and their opinions on the codesign workshop, particularly, as they previously had limited exposure to nature-based design concepts. In their responses to the confidential survey administered on the return journey, the majority of the Texan students could explain the "Building with Nature" concept after the workshop (Table 1). They were enthusiastic about the idea as captured in the quotes: "I was not aware of this concept until coming to the Netherlands. I am very impressed on their innovative creation and engineering" and "Building with nature works with natural processes instead of against them. Building with nature in the context of flood mitigation includes strategies such as dunes, permeable surfaces etc." In 2017, a student was even able to express their knowledge gap in relation to the concept, namely "I know the goals of engineering with nature and its benefits, but I don't know how its design process differs from traditional design." This anticipates upon the type of learning about design that occurred through the 1-day workshop method.

**Table 1** Responses of Texan students to the survey question: "What do you know about the concept 'Building with Nature'?."

| What do you know about the concept "Building with Nature"? | |
|---|---|
| **2016** | **2017** |
| – How the natural processes play the major role in transporting sediment<br>– Build with Nature" mainly makes things look natural, but it is actually a man-made structure for flood mitigation. I am interested in solid core dunes, but they are robbed of the sediment transport processes that natural dunes have, i.e., migration patterns, flood response to climatic regimes, and this bums me out, but I think they work. It is something we should strive for from a process-based understanding. I like the sand engine, actually<br>– That it's awesome! For example, the sand engine utilizes natural processes (currents and waves) to transport sediment along the shoreface in an economical fashion. The Dutch are trying to utilize natural processes to minimize coastal risk from flood impacts<br>– Building using naturally occurring processes<br>– The only thing I know is to use what's in nature to build a conceptual design<br>– The basic idea and process<br>– It's a pretty big deal in the Netherlands, and becoming more so in the rest of the developed (and developing) world. It is a wide-ranging concept that includes multiple kinds of interventions and noninterventions all with careful consideration<br>– I was not aware of this concept until coming to the Netherlands. I am very impressed on their innovative creation and engineering<br>– Sand engine—building for defense with what nature provides | – Building with Nature; applying certain amount of sand to let it do its flooding/coastline protection job<br>– This is a recent concept with both pro's and con's depending on personal opinion, experiences, project requirements<br>– Building with Nature should be a major requirement where applicable for proposed flood infrastructure<br>– Building with nature works with natural processes instead of against them. Building with nature in the context of flood mitigation includes strategies such as: dunes, permeable surfaces, etc.<br>– Let the nature do (most of the work). Integrated design with existing/prior ecosystems<br>– I know the goals of engineering with nature and its benefits, but I do not know how its design process differs from traditional design<br>– This is basically integrating nature aspects in designing solutions for flood protection<br>– Building with Nature is incorporating designs that allow natural processes to work for you instead of against you<br>– I know that is finding ways to use nature or work with it for designs. I still do not know a lot about design processes, but I learned a lot more here<br>– I mostly know about "biophilic" design in the area of architecture. Respecting nature and integrating it into design instead of working against it<br>– Human inputs are involved at the initial stage, and let it build its adaptive capacity by nature without any artificial approach<br>– Building with Nature is working with the natural system to increase the safety and resiliency of a region<br>– Need to consider input from many stakeholders. Need to design multifunctional solutions. High emphasis on spatial quality<br>– Building with nature is letting nature "do the work for you" |

The Texan students' responses to the broadly formulated question "What are the main things you have acquired from the design workshop?" (Table 2) focused primarily on the different ways of working and the acquisition or deepening of transdisciplinary collaboration skills. This is exemplified in the following quotes: "I learned how to work with others from another country to solve a problem," and "The biggest skills I gained were about bonding with a team and coming to an agreement of a design; We needed to work together." A number of students indicated explicitly that they worked outside their knowledge boundaries, e.g., "Working outside of your natural ability could be valuable as it helps you bridge knowledge between the different field, however one always fall back to their natural profile." Only one of the 46 students complained that the time was too rushed to learn adequately.

The overwhelming majority of enthusiastic and positive responses to the workshop method, and the integrated nature-based designs that were produced validate this learning intervention as a means of teaching transdisciplinary collaborative skills.

**Table 2** Responses of Texan students to the survey question: "What are the main things you have acquired from the design workshop?."

| What are the main things you have acquired from the design workshop? | |
|---|---|
| **2016** | **2017** |
| – Understanding the engineering role in each group. 2. Applying my role in the group was very interesting because I found that the engineer can play any role based on his/her experience. 3. Thinking for innovative solution for building with nature<br>– I learned how Dutch students organize group work and attack problems—I will use this method<br>– I found from the design workshop that Dutch students are (1) extremely practical and organized in problem solving, and (2) are very humble! Their approach to flood risk reduction is refreshing. In the US, we consider living on the coast (with an ocean view) an inherent right ("you can build whatever you want if it's your property" or "it's my loss if my property gets destroyed"). We have to juggle individual property rights and flood risk reduction when designing protection structures. It seems simpler in the Netherlands…as if the entire nation understands flood risk and has bought into living with a modified coast | – Brainstorm; Itemize the goals of design; strategies can be reasonable and creative<br>– I learned how research questions are formulated along with the process required to answer; Working with new people outside my core group allowed me to work with even more views and knowledge (expanded my thoughts)<br>– Working with engineers and assuming a non-natural role<br>– Diversity of issues that need to be addressed when planning; Stakeholders<br>– Collaborative work; Building with nature (had very little knowledge before)<br>– I learned a ton about the Dutch political system and Dutch culture from talking to Dutch students on the bus<br>– The interaction with experts, students in different fields that helped a lot<br>– The biggest skills I gained were about bonding with a team and coming to an agreement of a design; we needed to work together<br>– I learned from the Dutch students on a public knowledge / student level; Simple |

*Continued*

**Table 2** Responses of Texan students to the survey question: "What are the main things you have acquired from the design workshop?."—cont'd

| What are the main things you have acquired from the design workshop? | |
|---|---|
| **2016** | **2017** |
| – The design workshop validated the fact that Dutch students and American students approach problems differently<br>– I learned how to work with others from another country to solve a problem<br>– I did not gain much in terms of knowledge since the workshop way completely out of my discipline. However, it was a good experience to see the perspectives of different groups and working in a multidisciplinary group<br>– Collaboration between Dutch students was very helpful by understanding their approach<br>– I learned to think more critically and look at a larger range of things<br>– Within short frame of time, I was able to address the problem and work on finding a creative solution<br>– Again, Dutch approach to organizing goals + decide<br>– There are many approaches to solving coastal engineering problems and there are lots of stakeholders to consider<br>– Working outside of your natural ability could be valuable as it helps you bridge knowledge between the different field, however one always fall back to their natural profile<br>– Being able to work with others and try to understand what role I play<br>– I do have experience with multidisciplinary research. The workshop only reinforced my experiences<br>– The design workshop was an interesting experience, and I am glad I had the chance to participate, but I didn't acquire much additional knowledge, as far as I can tell. I've experienced such workshops before<br>– I am a "anonymized." I work on process improvement from mechanical standpoint. I have applied a few strategy of mechanics into civil engineering, especially in whole system design and problem solving<br>– I learned to think more critically and look at a larger range of things | explanations from people my age / education level helped me grasp complex concepts better<br>– The Dutch students were much familiar to the Petten's condition that they helped us get into the main problems and possible strategies efficiently<br>– I enjoyed meeting the Dutch students and sharing our perspectives on flood risk mitigation design and planning<br>– Main skills I acquired was learning how to work in team with multiple backgrounds and experience levels<br>– Felt like I didn't gain much because it was rushed and not explained too well |

## Concluding remarks

Informed by problem-based and authentic learning pedagogies, the game-structuring approach, and nature-based design concepts, an eight-step transdisciplinary collaborative design workshop method was developed. The effects of the method, in the form of two learning interventions—"Building with Nature" Living Labs—are evaluated in this chapter. Specifically, two workshops were conducted in 2016 and 2017. The participants were international students and faculty members drawn from three Texan universities and four Dutch universities, supplemented by local experts familiar with the problem situations. The authentic problem contexts were provided by (i) the erosion hotspot of the southwest coast of Texel island and (ii) the future noncompliance of the old Hondsbossche Pettermer Sea Dike with Dutch flood defense standards. The effects of the workshops are evaluated in terms of the process of co-design, the substantive outcomes, and the learning outcomes. The collaborative design process created an open and authentic environment in which the students could experience undertaking integrated, nature-based design. Each student managed their own process of inquiry and discovery, although this took place within the context of a small team of students from diverse backgrounds tasked with designing together, within the larger workshop setting. Overall, a wide range of integrated nature-based designs was produced and diverse biogeophysical and social aspects were included in all designs. This indicated that the students were able to work collaboratively to produce novel designs that incorporated multiple perspectives from the problem situations. They were exposed to information beyond their own disciplinary fields and learned to synthesize relevant aspects into a coherent nature-based design by collaborating with other students. The overriding enthusiastic and positive responses of the Texan students to survey questions on their learning experiences affirm the success of the transdisciplinary co-design workshop method as a means of teaching integrated, nature-based infrastructure design.

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