

EVALUATING THE DESIGN CHALLENGE NAVIGATOR IN BUILT ENVIRONMENT EDUCATION

ABSTRACT

In response to the increasing complexity of challenges in the built environment, this study evaluates the Design Challenge Navigator (DCN), board-game-like design toolkit created to develop future competencies among students in higher education to help them tackle the full spectrum of contemporary challenges. Developed within the ERASMUS+ sUser project, the DCN bridges conventional Design Thinking with a systems-thinking approach and structured methodologies applicable at varying levels of complexity. Using a mixed-methods approach, the DCN was tested across three educational contexts at Avans University of Applied Sciences in the Netherlands. This involved students from Construction Engineering, Civil Engineering, and Spatial Development. The findings indicate that the DCN encourages students to explore new methods, helps them structure and understand their process, and motivates them to follow a more user-driven approach. However, the study highlights the importance of tutor guidance, since the methodology can be complex to understand. And it highlights the importance of early integration into the curriculum to ensure the effectiveness of the DCN. Although the findings suggest that the DCN is a promising tool for educational purposes, further research is needed to validate its effectiveness amongst a larger student population and various project types.

Fenna Rooijackers

Avans University of Applied Sciences – Sustainable Built Environment
f.rooijackers1@avans.nl

Daniel Gotthardt

Avans University of Applied Sciences – Sustainable Built Environment
dc.gothardt@avans.nl

KEY WORDS

FUTURE COMPETENCES
DESIGN CHALLENGES
COMPLEXITY
BUILT ENVIRONMENT
TEACHING MATERIAL
HIGHER EDUCATION

1. INTRODUCTION

Education systems worldwide are increasingly challenged to prepare graduates for a rapidly evolving professional landscape (Groenier et al., 2025; Pelgrim et al., 2022). Beyond technical proficiency, students must cultivate adaptive expertise, resilience, and the ability to navigate uncertainty (Locklear & Fleener, 2022). This requires embedding pedagogical strategies that foster critical thinking, collaboration, and systemic awareness. For instance, integrating sustainability principles into design curricula ensures that learners consider the deep interconnectedness of environmental, social, and economic dimensions (Azmi, Wahid, Azman, & Jayus, 2024) (Ahmad et al., 2023). Moreover, the rise of digital transformation and globalisation amplifies the complexity of design challenges, demanding holistic approaches that transcend disciplinary silos (Bui & Nguyen, 2023) (Cowin, 2021).

As in many other industries, the built environment sector faces increasingly complex challenges. While less complex challenges can often be addressed through traditional problem-solving strategies such as Design Thinking, which have been widely integrated into curricula across disciplines, highly complex challenges require approaches grounded in systems thinking and complexity theory (Dorst, 2019) (Roth, Rau, Globocnik, & Neyer, 2022). Future professionals must therefore be able to characterise the type of challenge they face to apply an appropriate mindset and tailor a suitable problem-solving strategy (Gotthardt, Roth, & Kretschmer, 2024).

Since this is often a non-trivial task, Gotthardt, Roth, and Kretschmer (2024) introduced the *Design Challenge Navigator* (DCN) as part of the ERASMUS+ funded project sUser. The DCN is an innovative design toolkit for higher and professional education that playfully supports students in identifying the most suitable problem-solving strategy for the challenge at hand. This paper builds on initial trials conducted during a summer school in Tilburg (NL) with a diverse group of bachelor's and master's students, as well as a three-day innovation bootcamp with EMBA (Executive Master of Business Administration) participants. As part of this research, the effectiveness of the DCN was examined both qualitatively and quantitatively with students in the

built environment across three educational contexts at Avans University of Applied Sciences. The sample included bachelor's students from Construction Engineering, Spatial Development and Civil Engineering. The curriculum consists of compulsory modules and elective modules in which students tackle urgent issues relating to making the built environment more sustainable and future-proof, such as circularity, biobased materials, energy transition, flooding and drought, urban densification, and housing shortages. This study provides additional insights into the application of the Design Challenge Navigator across various educational contexts and academic disciplines, thereby contributing to ongoing research on how to make complex modern challenges in education more manageable and to empower students to identify their scope for action.

1.1. The Design Challenge Navigator

The Design Challenge Navigator (DCN) is a board-game-like design toolkit that bridges conventional Design Thinking with systems approaches, making it applicable to a wide range of design challenges in education. It aims to support professionals in designing roles across disciplines in choosing suitable tools and methods for the problem they are facing. Thereby, the material distinguishes between four levels of complexity for which it provides two design processes. Lower-complexity challenges (Levels 1 and 2) are addressed with the “hike”, and higher-complexity challenges (Levels 3 and 4) are tackled with the “expedition”. While the “hike” follows an established design thinking structure, the “expedition” adopts a systemic design perspective, requiring greater investment in analysing and visualising complex systems before thinking of solutions (Gotthardt, Roth, & Kretschmer, 2024).

The central component of the DCN, the Navigation Map, is where users place selected methods and gradually build their design process throughout the innovation journey. The DCN includes forty method cards outlining each method's steps, required time and resources, related methods, and suitability for either the “hike” or “expedition” process. Furthermore, the thirteen writable statement cards encourage innovation and help teams discuss ideas and agree on decisions during key moments of their process. The application of the learning toolkit is visualised in Figure 1. The entire set is available both physically and virtually (Gotthardt, Roth, & Kretschmer, 2024).

The first application in 2024 targeted eighteen bachelor's and master's degree students with diverse backgrounds during an international summer

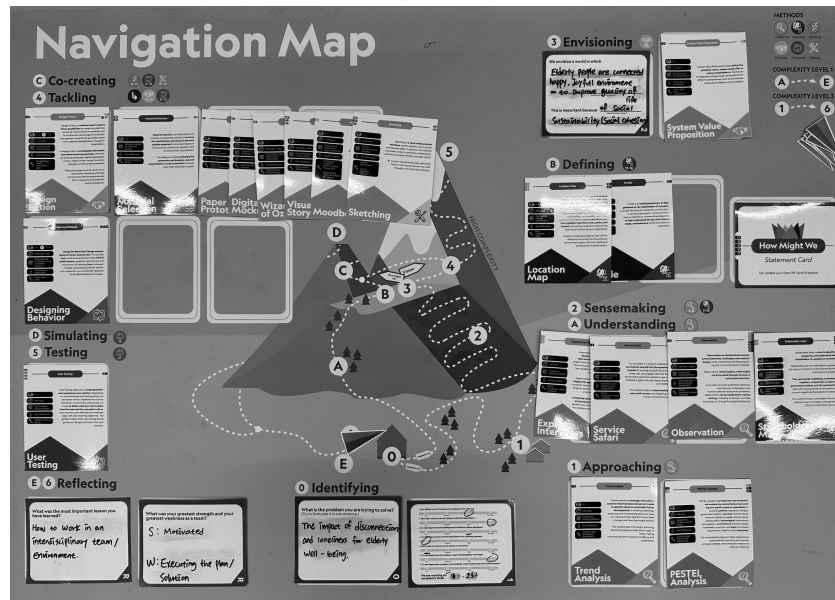


FIGURE 1. The Design Challenge Navigator during application. Method and statement cards are placed on the Navigation Map. (Source: Author)

school in Tilburg and fourteen EMBA students at an innovation boot camp. These initial applications identified several valuable insights into the use of the Design Challenge Navigator (DCN) in these two educational settings. First, the integration of physical learning aids, such as a tangible card set, significantly enhanced student engagement and enjoyment by making the learning process more interactive and game-like. This aligns with similar research that highlighted the positive effects of physical, playful teaching materials (Su, Cheng, & Lin, 2014). Second, the DCN improved team communication by providing a shared framework that structured discussions, aligned priorities, and thereby saved time. Third, it effectively supported students in planning and executing their design processes, empowering them to break complex challenges into manageable steps and boosting their confidence. Fourth, while the DCN provided valuable structure, more experienced students and professionals found it somewhat restrictive, highlighting the need for greater flexibility and a clearer emphasis on the iterative nature of the design process. Finally, the DCN fostered critical innovation skills, helping students to analyse challenges more deeply, reflect before ideating, engage meaningfully with stakeholder feedback, and adopt a more experimental mindset toward problem-solving (Gotthardt, Roth, & Kretschmer, 2024).

Previous results are promising but do not sufficiently cover different educational contexts or a wide spectrum of disciplines. This research addresses this gap. As part of this study, the DCN was applied and evaluated in three different educational contexts in the field of the Built environment at the Avans University of Applied Sciences.

2. METHODOLOGY

This study employed a mixed-methods approach, combining quantitative and qualitative data to provide comprehensive insights into the effectiveness of the Design Challenge Navigator (DCN) at Avans University of Applied Sciences, Academy for Sustainable Built Environment. Quantitative measures reveal general patterns, while qualitative feedback captures learners' nuanced experiences of the methodology. This combination of these methods is especially valuable in design education, where outcomes often include emotional engagement and self-reflective aspects that cannot be reduced to numbers. Future research could build on this work by incorporating longitudinal designs to examine the sustained impact of DCN integration on professional competencies methodology (Creswell & Plano Clark, 2017) (Dawadi, Shrestha, & Giri, 2021).

The DCN was implemented and assessed across three distinct educational contexts within Avans University of Applied Sciences:

2.1. Interdisciplinary Minor: Drowning Cities

The first evaluation took place within the interdisciplinary and international minor program Drowning Cities. This program aims to teach students about the interconnectedness of cultural and socio-economic factors in flood-prone areas. Students developed innovative design solutions for water-related challenges in Ho Chi Minh City from construction engineering and civil engineering perspectives. The DCN was used as a practical toolkit to support the students' design processes and to help them choose methodologies that fit the steps of the process and that they had not used earlier in their studies. A survey, adapted from a previous instrument used during the Erasmus+ Summer School in Tilburg (Gotthardt, Roth, & Kretschmer, 2024), was distributed to 16 students, with 4 responses collected ($N = 4$). Additional feedback was collected in a regular annual evaluation of the course where the DCN was implemented. Some students ($N = 7$) mentioned the DCN specifically in the annual evaluation.

2.2. Multidisciplinary Bachelor Project

The second evaluation was conducted during a 20-week multidisciplinary project involving third-year bachelor students working on a spatial development challenge. The aim of the project was for students to redevelop an urban area which was perceived as unattractive and uncomfortable by the municipality of 's Hertogenbosch and residents of the surrounding buildings. In week seven, students participated in a three-hour workshop using the DCN as a reflective tool to assess their design process thus far and plan forward using the methodologies embedded in the DCN. A focus group discussion (N = 8) was held to evaluate the workshop and gather in-depth student perceptions. This qualitative method was chosen to uncover nuanced insights and validate the relevance of the survey instrument (Mansell, Bennett, Northway, Mead, & Moseley, 2004) (Zhou, Zhou, & Machtmes). Following the workshop, students were asked additional questions regarding their continued use of the DCN methodologies throughout the remainder of the course (N=2).

2.3. Minor Program: Disruptive Events

Based on findings from the focus group in the Multidisciplinary Bachelor Project, an adapted survey was developed and administered in a third context: the interdisciplinary minor *Disruptive Events*, where students conducted research projects on migration and climate change. Although the DCN was not used during the research phase, it was introduced in a reflective workshop at the end of the course. Students used the DCN's digital canvas and method cards to evaluate their research process and gain insight into what they would do differently when initiating another iteration. The survey was distributed to 28 students, with 15 responses collected (N = 15).

3. RESULTS

The evaluation of the Design Challenge Navigator (DCN) across three educational contexts revealed a positive reception among students, particularly regarding its card-based methodology, its role in supporting complex problem-solving and design thinking and the collaboration between students from different backgrounds.

3.1. Perceived Usefulness of the DCN Cards

Survey responses indicated that the majority of students (N = 13) found the DCN cards to be a valuable medium for gaining knowledge on complex

problem-solving. Most students (N = 9) reported that the cards enhanced their understanding of the design process and the steps to take. Furthermore, the majority of students (N = 11) agreed that the methodological explanations provided on the cards were clear. However, some students (N = 8) reported understanding the theoretical intent of the cards but required further guidance to apply them effectively, for example, from tutors, particularly during short workshops.

This need for support was echoed in the group discussion, where most participants (N = 6) stated that they would not have been able to effectively use the DCN during a short workshop without tutor guidance. These outcomes point to the critical role of guided instruction in ensuring students can meaningfully engage with the unfamiliar design methodologies the DCN provides.

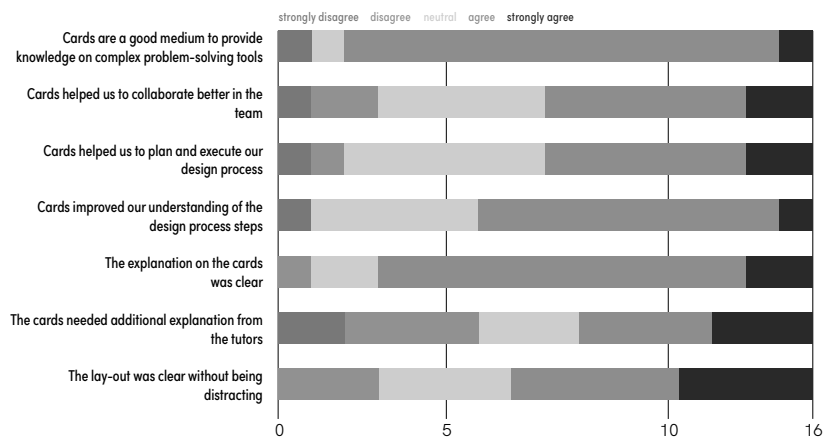


FIGURE. 2. Survey responses on the DCN cards (Source: Author)

3.2. Collaboration and Process Structuring

All participants in the group discussion (N = 8) agreed that the DCN facilitated a more constructive and collaborative design process. However, survey responses were more varied: while seven students agreed or strongly agreed that the DCN improved collaboration, five remained neutral, and three expressed disagreements in this manner. This divergence suggests that the perceived impact of the DCN on teamwork may be context-dependent or influenced by individual preferences and existing group dynamics.

Additional feedback from students in the *Drowning Cities* and *Multidisciplinary Bachelor Project* programs emphasised the DCN’s role in promoting an iterative approach to the design process rather than a linear progression. These reflections suggest that the DCN may support deeper engagement with design thinking principles when integrated into longer-term projects.

3.3. Digital Environment and Usability

All students from the *Disruptive Events* program and four participants from the *Drowning Cities* program engaged with the DCN via a digital Miro canvas. While the concept of a digital environment was well-received (N = 14), technical limitations significantly affected usability. Students reported difficulties in copying and editing the canvas, which led to confusion (N = 6) and hindered their design process (N = 4). Two of the students from the Disruptive Events minor program mentioned the explanatory videos embedded in the digital canvas specifically as helpful (N=2). These findings underscore the importance of reliable digital infrastructure and intuitive interface design when implementing online learning tools.

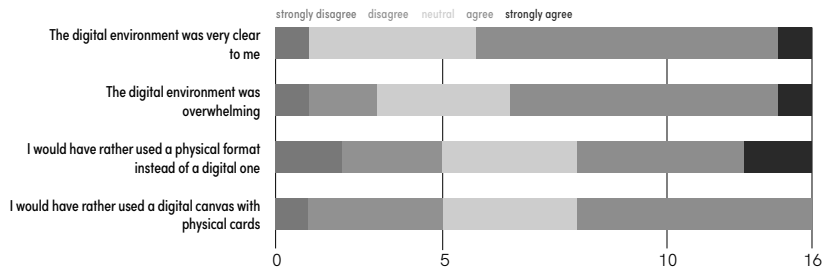


FIGURE 3. Survey responses on the digital environment (Source: Author)

3.4. Contextual Fit and Methodological Relevance

For some students (N = 4), the DCN methodology did not align well with their specific assignments, limiting its applicability in their design process. This suggests that while the DCN offers a flexible framework, its effectiveness may depend on careful alignment with course objectives and project scopes.

3.5. Skill Development and Methodological Exploration

The majority of respondents (N = 8) reported that the DCN helped them critically examine the status quo and reflect on their own values and perceptions. Additionally, nine students indicated that the tool supported their ability to identify and communicate potential points for intervention. Notably, students in both the group discussion from the Multidisciplinary project and post-course evaluations from the Drowning Cities course (N = 13) stated that the DCN encouraged them to explore unfamiliar methodologies, with four specifically noting an increased use of user-driven approaches. These outcomes suggest that the DCN fosters methodological diversity and supports the development of reflective design practices.

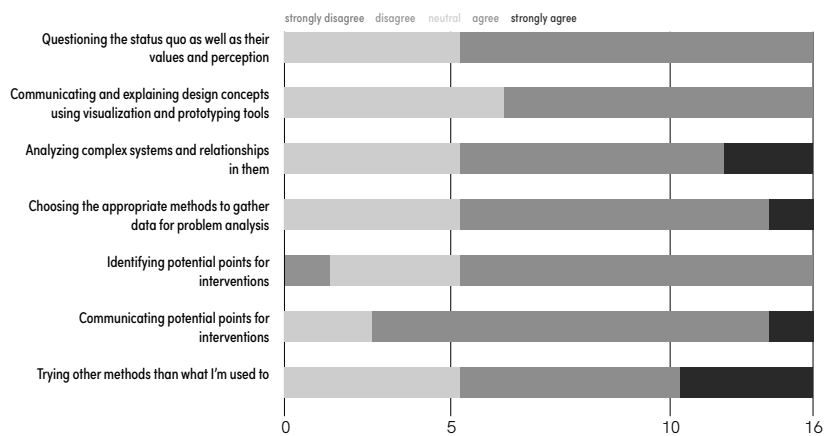


FIGURE 4. Survey responses on improved skills (Source: Author)

4. CONCLUSION AND DISCUSSION

Integrating the DCN into the curriculum of higher education programs helps to operationalise the combination of the principles of systems thinking and design thinking together (Meadows, 2008) (National Academies of Sciences, Engineering and Medicine; Health and Medicine Division; Board on Global Health; Global Forum on Innovation in Health Professional Education, 2018). This combination should help students address wicked problems from different disciplines. However, scaling these efforts remains challenging and requires strong institutional support for faculty training and infrastructure. Looking ahead, co-creating localised DCN versions with industry partners could enhance relevance and authenticity.”

This study evaluated the implementation of the Design Challenge Navigator (DCN) across three educational contexts at Avans University of Applied Sciences, Academy of the Sustainable Built Environment. The findings suggest that the DCN has the potential to enhance student learning in complex, multidisciplinary design challenges, for multiple-week courses, as well as short workshops. Findings suggest that it fosters reflective thinking and collaborative problem-solving. Furthermore, it motivates students to implement more iterative design principles and a more user-driven approach.

The majority of students responded positively to the DCN’s card-based methodology. The survey and group discussions reported improved understanding of the design process and increased ability to identify and communicate intervention points. The cards were perceived as clear and useful, though nearly half of the respondents indicated a need for additional explanation, highlighting the importance of tutor guidance, especially in short workshops.

Student feedback on the digital environment was mixed. While the concept of a digital canvas and the tool’s layout were appreciated, technical limitations emerged during the workshops, including the inability to edit or copy the tool. These technical limitations negatively impacted usability and perceived effectiveness.

Importantly, students reported that the DCN encouraged them to explore unfamiliar methods and adopt more user-centred approaches. This aligns with the pedagogical goals of the programs involved, which emphasise sustainability, interdisciplinarity, and real-world engagement.

Overall, the DCN appears to be a promising tool for supporting design education in higher education settings. However, its effectiveness depends on thoughtful integration into the curriculum, adequate tutor support, and reliable digital platforms.

The findings of this study suggest that the Design Challenge Navigator (DCN) holds promise as a pedagogical tool for supporting design thinking and collaborative problem-solving in higher education. Students responded positively to the DCN's card-based methodology, reporting improvements in their understanding of design processes and increased engagement with unfamiliar and user-driven methods. However, the interpretation of these results must be situated within the methodological constraints and potential biases inherent in the study design.

4.1. Sample Size and Generalizability

The small sample size ($N = 24$) limits the statistical power and generalizability of the findings. While the mixed-methods approach provided rich qualitative insights, the quantitative data should be interpreted with caution. Future studies with larger and more diverse cohorts are needed to validate these preliminary findings and explore variations across disciplines and learning contexts. Comparing the results of this study with those of other studies on the implementation of the DCN in other contexts might yield different results.

4.2. Self-Selection Bias

Participation in the survey was voluntary, introducing the possibility of self-selection bias. Students with strong positive or negative may have been more inclined to respond, potentially skewing the data. This bias may have amplified both enthusiasm and criticism and should be considered when assessing the overall effectiveness of the DCN.

4.3. Timing of Implementation

In the Disruptive Events program, the DCN was introduced late in the course, which may have constrained its impact. Students reported that the tool was helpful for reflection and structuring their process, but its late introduction limited opportunities for iterative use. This suggests that the timing of implementation is critical to maximising the DCN's pedagogical value. Embedding the DCN earlier in the curriculum may allow students to engage more deeply with its methodologies and integrate them into their workflow..

4.4. Technical Constraints and Platform Usability

The digital environment used to host the DCN, Miro, was a source of frustration for many students. Technical limitations, such as restricted editing capabilities, negatively influenced user experience and may have confounded perceptions of the DCN itself. These issues highlight the importance of reliable and intuitive digital platforms when using design tools in educational settings. Without adequate technical support, even well-designed pedagogical frameworks may fail to achieve their intended outcomes.

4.5. Contextual Fit and Adaptability

Some students reported that the DCN methodology did not align well with their specific assignments, suggesting that contextual fit is a key determinant of effectiveness. While the DCN offers a flexible framework, its successful implementation requires thoughtful adaptation to the learning objectives, project scope, and disciplinary context. This finding underscores the need for educators to critically assess when and how to integrate such tools into their teaching practice.

5. RECOMMENDATIONS

To optimise the educational impact of the DCN, additional reflective components could help. The integrated reflection cards could be a first way to do this, but should then be integrated between the step phases of the methodology. The digital environment might facilitate analytic purposes that would provide opportunities to be more responsive to users' needs. Additional research on how to arrange the analytics and adaptivity of the digital tool would be helpful. Based on the findings of this study, and the studies that have been done at the other sUser project partners, several recommendations can be made to enhance the implementation and effectiveness of the Design Challenge Navigator (DCN) in higher education settings:

Introducing the DCN at the beginning of a course or project cycle would allow students to engage with its methodologies more iteratively and meaningfully. Early integration can support deeper learning and provide students with a structured framework for navigating complex design challenges throughout their process. The DCN was first tested during a week-long summer school (Gotthardt, Roth, & Kretschmer, 2024), which shows more effective engagement with the tool. This was also the case for the students who were allowed time to work on their projects after they were introduced to the DCN.

The need for additional clarification reported by students could be more easily addressed if more time is allowed to work with the DCN. During a short workshop, the guidance and clarification needed to understand the tool could take up time that would otherwise be available to work with the methodologies the DCN offers. When working on longer courses and introducing the DCN early, the time needed to get to know the tool would be less of a problem.

To maximise the relevance and impact of the DCN, the objectives of the course should be well-aligned with the methodologies in the tool. The first aim of the DCN was to help students design Sustainable Elderly Service Housing. However, it was developed to improve agile and user-driven methodologies and systems thinking for students in a broad spectrum of complex challenges. The DCN was tested at Avans in courses where students were addressing complex challenges, however, the original aim, to help students design Sustainable Elderly Service Housing was not tested within Avans. To understand if the DCN works for courses with this objective within Avans, additional research would be needed. .

Additional research should be conducted among larger, more diverse student populations. It was now only tested among third- and fourth-year bachelor students but should be evaluated among first- and second-year students as well to gain deeper insight into the DCN's effectiveness and adaptability.

Acknowledgement

This work was made possible through the generous financial support of the Erasmus+ program. The research presented in this paper is part of the sUser project, which was funded by Erasmus+. We gratefully acknowledge their contribution in enabling collaborative, user-centred research aimed at fostering inclusive and sustainable design practices.

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