Empathy Driving Performance

A study on the interaction between empathy, the integrated design process and the performance of civil engineering projects

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SUMMARY

Civil engineering projects are affected by increasing urbanisation and the transitions related to sustainability, such as climate change, energy and biodiversity. These transitions are interrelated, introduce new spatial claims, and herald a redesign of the built environment, which is the domain of civil engineering projects. New functions, stakeholders and disciplines are introduced into the projects and need to be integrated with traditional and enduring ones, such as the mobility function and its accompanying stakeholders and disciplines. Consequently, projects are becoming more complex and transforming from technology-driven to integration-driven challenges.

Additionally, the motivation for this research arose from the researcher's involvement in some poorly performing projects as a practitioner in the field of civil engineering. Generally, civil engineering projects worldwide are beset by underperformance, which is difficult to justify since these projects are mostly publicly funded. Moreover, poor cost performance threatens the healthy functioning of the private market. In summary, civil engineering projects show a history of precarious performance while simultaneously becoming increasingly complex. So, there is an urgent need to improve.

Therefore, this study aimed to understand better the factors dominating performance. Based on the developments in the sector mentioned above and the researcher's experiences, integration within the civil engineering design process was chosen as the perspective from which to evaluate the projects. Although the integrated design process has been identified as one of the many critical factors for performance, its detailed interaction with this performance has been scrutinised to a limited extent in the literature.

The research questions that guided this research focused on how the integrated design process affects performance and how it should be adjusted to improve the performance of civil engineering projects. The research used a constructivist approach and was based on elements of design inquiry, where theoretical knowledge and practical know-how are mutually instrumental and equal partners. The research method comprised multiple case studies using semi-structured interviews as the main data source. In addition, quantitative data were collected from surveys to enrich the qualitative data of the interviews. As such, the study was denoted as qualitative-driven mixed-method research.

The design process of civil engineering projects is defined as the course of all human activities transforming an existing situation into a plan for a new one to satisfy a need, including and balancing the interests of all parties and disciplines involved. As such, it is an overarching concept interacting with many other factors affecting performance. Given the integration assignment of today's projects, the process is integrative by definition and characterised as human and social, meaning it has limited predictability and rationality. This dynamic nature of design is recognised to a limited extent in the sector and conflicts with the project management and political need for controllability.

The study focused on the Dutch context, which is determined by a relatively high focus on collaboration and relationships. Another characteristic of the design practice in the Dutch situation is the transition from construct-only contracts to integrated contracts over the past decades. These contracts comprise a partial shift of the design scope and responsibility from the owner to the contractor. The understanding that these integrated contracts require the shared efforts of parties to tackle the social and dynamic design process and that the design problem definition (the design specification) cannot be fully settled contractually has grown slowly. The sector underestimated the impact of this transition, which negatively affected project performance.

The initial exploratory research confirmed a positive correlation between the performance of the integrated design process and project performance, where project performance is defined as the extent to which predefined goals related to cost, time, quality, safety and stakeholders' satisfaction are met. The study demonstrated that the extent to which project teams achieve an integrated approach of the design process is critical for performance. An integrated approach refers to integrating the interests of the stakeholders and the disciplines into the process and the solution. The project team participants' competencies to adopt and integrate the project context appear to be a dominant factor in arriving at such an integrated approach. However, the presence of competencies aimed at integration does not appear to be self-evident in today's civil engineering project teams.

Empathy emerged as an ability that contributes to an integrated approach. Empathy is a person's ability to feel and understand another person's mental world with self-other differentiation. It is often described as stepping into someone else's shoes to gain an understanding of the feelings and perspectives of that person. The empathic ability encompasses an affective and a cognitive dimension, which are intertwined. The growing need for integrating project context, functions, and the interests of the stakeholders and the disciplines links empathy to today's civil engineering project performance. This creates the research model shown in Figure 1.

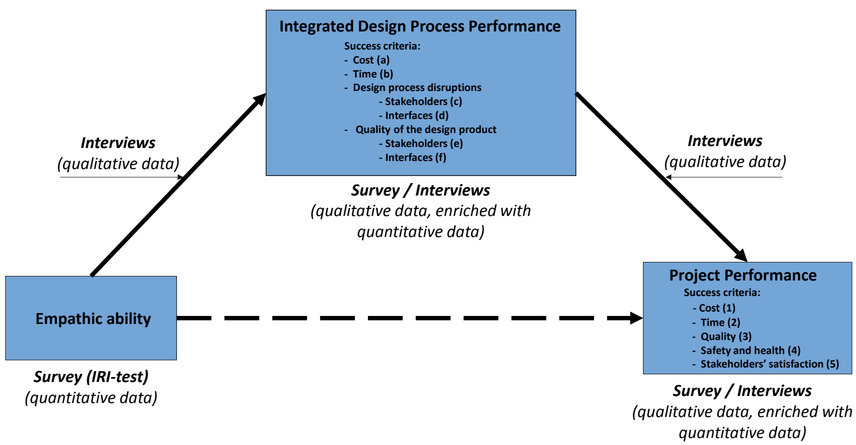


Figure 1: Research model and research methods.

The study demonstrates a positive correlation between the project participants' empathic abilities, the performance of the integrated design process and project performance of civil engineering projects. This interaction relates to projects dominated by integration, i.e. integration of stakeholders' and disciplines' interests. Given the global challenges related to sustainability transitions and building in more urbanised areas, this condition applies to many current and future civil engineering projects. The effects of empathy transcend the boundaries of the integrated design process and are more generally regarded as stimulating the collaboration between parties.

Integration is especially difficult when cultures between parties within the project team differ most. This study particularly revealed integration issues resulting from cultural differences between the design and construction disciplines, as well as between the owner and the contractor. Empathy can contribute to bridging these cultural gaps by entering the other actors' mental worlds, resulting in a more effective transfer of knowledge about the design problem and the provisional solution. Additionally, empathy is a basic ability interacting with other mediating and moderating human-related factors positively correlating with performance, such as collaboration, trust, and openness.

A literature study on the levels of empathic abilities revealed that the Dutch civil engineering industry scores relatively low compared to the average levels of a reference sample composed of participants from other study's control groups. This particularly applies to the affective empathic abilities of the civil engineering project teams' participants and implies room for performance improvement by focusing on empathy. First, empathic abilities can be enhanced by increasing the number of project participants with more empathic abilities. While women outscore men on empathic traits, particularly on affective empathic traits, this study concludes that performance improvement could be achieved by increasing gender diversity in project teams during the integrated design phase. Since the study results confirm the critical role of the management of the project, gender balance in technical and project management roles could be particularly effective.

Second, empathic abilities can be increased by focusing on situational skills and behaviour in projects. By increasing the identification with a group and group feelings, in-group empathy will increase, which could positively contribute to the effective transfer of knowledge and performance. Furthermore, empathic behaviour can be stimulated when project participants are made aware of the existence of yet unknown and implicit knowledge about the problem and the solution. Subsequently, they can be motivated and trained to adopt this knowledge better through functional empathic behaviour and thus achieve their project goals. On the other hand, the study suggests that empathy can be less effective or even counterproductive in less integrative project phases and roles.

The relationships between project performance, the integrated design process, an integrated approach and the project teams' empathic abilities are reflected in Figure 2.

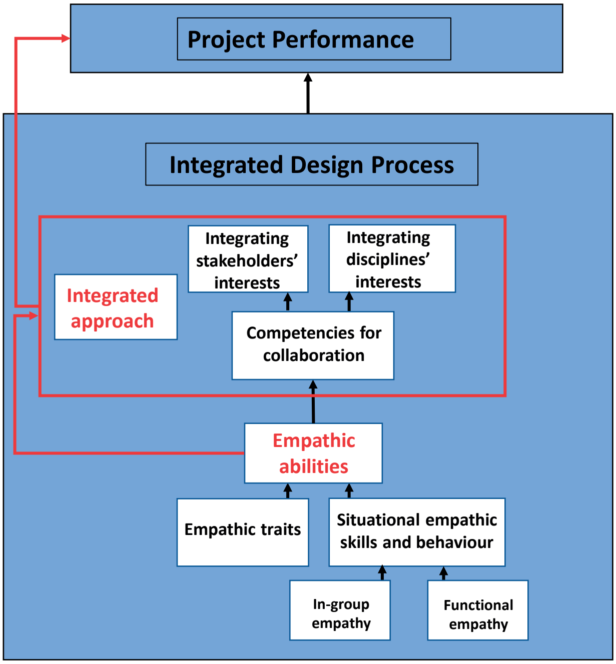


Figure 2: The relationships between project performance, the integrated design process, an integrated approach and empathic abilities.

As a result of the introduction of more and new stakeholders and disciplines, civil engineering projects could benefit from transformative design approaches at all levels of abstraction, meaning the design problem's context does not just provide the boundaries but becomes an inseparable, fluid, and natural part of the iterative process. In such a design process, all project members actively participate and collaborate. Empathic abilities could contribute to this process by bridging cultural gaps, facilitating the effective sharing of knowledge about the problem and the solution, and developing valuable, integrated solutions.

Being the first to investigate the role of empathy in civil engineering projects, more data collection from different cultures, contracts and countries is recommended to generalise the results further and gain more insights into the levels of empathic ability related to performance. Additionally, more insights are needed into the effectiveness of training methods focusing on empathic behaviour. Finally, given the essential role of project participants' competencies in projects, this study recommends more attention to competencies related to integration in education. This will contribute to creating a new civil engineer who plays a guiding role in the necessary transformative approach of the civil engineering design process and the interdependent global transitions.

SAMENVATTING

Civieltechnische projecten worden beïnvloed door een toenemende verstedelijking en de transities gerelateerd aan duurzaamheid, zoals de klimaatverandering, energie en biodiversiteit. Deze transities zijn aan elkaar gerelateerd, introduceren nieuwe ruimtelijke claims en luiden een herinrichting van de gebouwde omgeving in, hetgeen het domein is van civieltechnische projecten. Nieuwe functies, belanghebbenden en disciplines worden geïntroduceerd in deze projecten, die geïntegreerd moeten worden met bestaande en traditionele functies, zoals de mobiliteitsfunctie, met de bijbehorende belanghebbenden en disciplines. Als gevolg daarvan worden projecten complexer en veranderen ze van technisch-gedreven naar integratie-gedreven uitdagingen.

Daarnaast is de motivatie voor dit onderzoek voortgekomen uit de project betrokkenheid van de onderzoeker bij een aantal slecht presterende civieltechnische projecten. In zijn algemeenheid worden civieltechnische projecten wereldwijd geteisterd door matige prestaties. Dit is moeilijk te rechtvaardigen aangezien deze projecten grotendeels publiek gefinancierd worden. Bovendien bedreigen kostenoverschrijdingen een gezond functionerende markt. Kortom, civieltechnische projecten voldoen vandaag de dag vaak niet aan de verwachtingen, terwijl ze in de toekomst steeds complexer worden. Er is derhalve dringend behoefte aan een verbeterslag.

Het doel van dit onderzoek was daarom om een beter begrip te krijgen van de factoren die de prestaties van civieltechnische projecten domineren. Op basis van bovengenoemde ontwikkelingen in de sector en de ervaringen van de onderzoeker is de integratie binnen het civiel technische ontwerpproces als perspectief gekozen om projecten te evalueren. Hoewel het geïntegreerde ontwerpproces in de literatuur is geïdentificeerd als een kritieke factor, samen met vele andere factoren, is de interactie met de project prestaties tot op heden slechts beperkt onderzocht.

De onderzoeksvragen die leidend waren voor dit onderzoek richtten zich op hoe het geïntegreerde ontwerpproces de project prestaties beïnvloedt en hoe het proces moet worden aangepast om civieltechnische projecten te verbeteren. Het onderzoek volgde een constructivistische benadering en was gebaseerd op elementen van ontwerpend onderzoek, waarbij theoretische kennis en practische know-how wederzijds instrumentele en gelijkwaardige partners zijn. De onderzoeksmethode bestond uit case studies waarbij semi-gestructureerde interviews de belangrijkste bron voor de data waren. Daarnaast werden kwantitatieve data verzameld via enquêtes om de kwalitatieve data van de interviews te verrijken. Als zodanig kan het onderzoek worden geduid als een kwalitatief gedreven 'mixed-method' onderzoek.

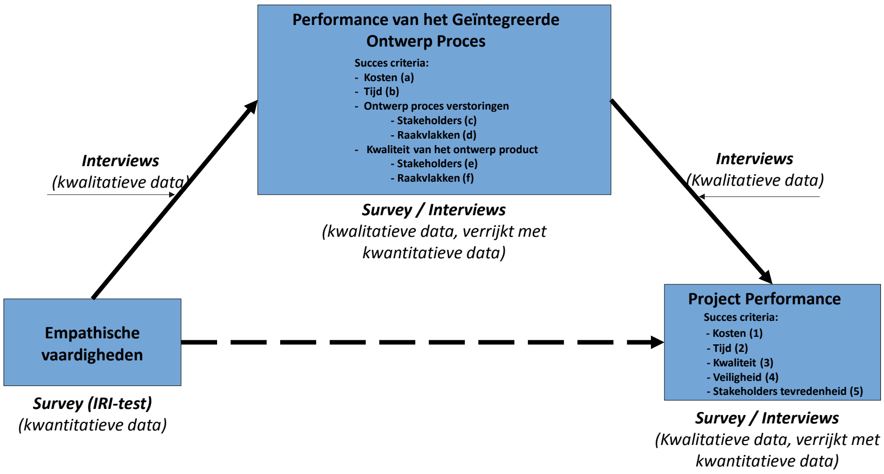
Het ontwerpproces van civieltechnische projecten is gedefinieerd als het verloop van alle menselijke activiteiten die een bestaande situatie vertalen naar een plan voor een nieuwe situatie teneinde te voldoen aan een behoefte, waarbij de belangen van alle betrokken partijen en disciplines worden betrokken en afgewogen. Als zodanig is het een overkoepelend concept dat interactie heeft met veel andere factoren die de project prestaties beïnvloeden. Gelet op de integratie-opgave van de hedendaagse projecten, is het proces per definitie geïntegreerd en

wordt het gekarakteriseerd als mens-gedreven en sociaal, hetgeen betekent dat het een beperkte voorspelbaarheid en rationaliteit heeft. Deze dynamische aard van het ontwerp wordt slechts in beperkte mate onderkend in de sector en staat op gespannen voet met de behoefte aan beheersbaarheid van het projectmanagement en de politiek.

Het onderzoek richtte zich op de Nederlandse context, die wordt gekenmerkt door een relatief sterke nadruk op samenwerking en relaties. Een ander kenmerk van de ontwerppraktijk in de Nederlandse situatie is de overgang van RAW-contracten naar geïntegreerde contracten in de afgelopen decennia. Deze contracten omvatten een gedeeltelijke verschuiving van de ontwerpscope en -verantwoordelijkheid van de opdrachtgever naar de opdrachtnemer. Het besef dat deze geïntegreerde contracten gezamenlijke inspanningen van partijen vereisen om het sociale en dynamische ontwerp proces te managen en dat de probleem definitie van het ontwerp (de ontwerp specificatie) vooraf niet volledig contractueel kan worden vastgelegd, is slechts langzaam gegroeid. De sector heeft de impact van deze transitie onderschat, hetgeen een negatieve invloed heeft gehad op de project prestaties.

Oriënterend onderzoek bevestigde een relatie tussen de prestaties van het geïntegreerde ontwerpproces en de project prestaties, waarbij project prestaties zijn gedefinieerd als de mate waarin vooraf bepaalde doelen met betrekking tot kosten, tijd, kwaliteit, veiligheid en tevredenheid van de belanghebbenden worden behaald. Het onderzoek toonde aan dat de mate waarin projectteams een geïntegreerde benadering van het ontwerpproces bereiken, cruciaal is voor de prestaties. Deze geïntegreerde benadering heeft betrekking op het integreren van de belangen van alle betrokken partijen en de disciplines in het proces en in de oplossing. De competenties van de project teamleden om de project context te adopteren en te integreren blijken een dominante factor te zijn om tot deze geïntegreerde benadering te komen. Echter, deze competenties blijken niet vanzelfsprekend aanwezig te zijn in de hedendaagse projectteams.

Empathie komt naar voren als een competentie die bijdraagt aan een geïntegreerde benadering. Empathie is het vermogen van een persoon om de mentale wereld van een ander te voelen en te begrijpen, waarbij onderscheid wordt gemaakt tussen deze persoon en de ander. Empathie wordt vaak omschreven als in de schoenen van de ander stappen om begrip te krijgen van de gevoelens en perspectieven van de ander. Het empathisch vermogen omvat een affectieve en een cognitieve dimensie, die met elkaar verweven zijn. De groeiende behoefte aan integratie van project context, functies en belangen van alle betrokken partijen en disciplines, verbindt empathie met de project prestaties van hedendaagse civieltechnische projecten. Dit creëert het onderzoeksmodel dat wordt weergegeven in Figuur 1.

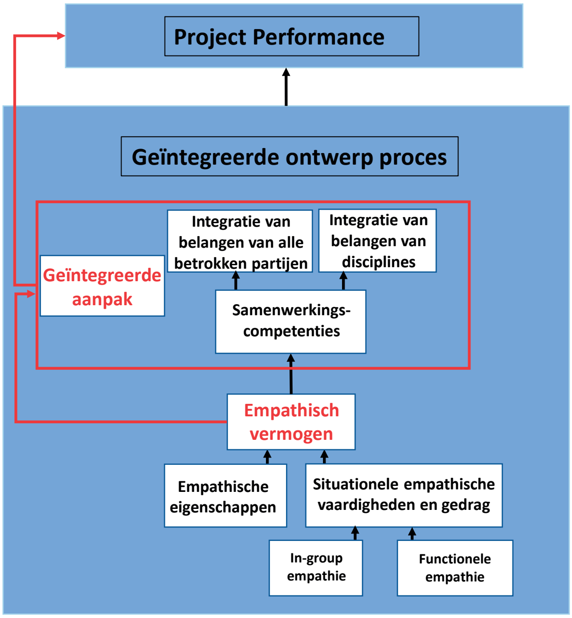


Figuur 1: Het onderzoeksmodel en de onderzoeksmethoden

Het onderzoek toont een relatie aan tussen de empathische vaardigheden van de project teamleden, de prestaties van het geïntegreerde ontwerpproces en de project prestaties van civieltechnische projecten. Deze interactie heeft betrekking op projecten die gedomineerd worden door integratie, dat wil zeggen de integratie van belangen van alle betrokken partijen en disciplines. Deze voorwaarde is van toepassing op veel civieltechnische projecten van nu en in de toekomst, gelet op de wereldwijde uitdagingen op het gebied van de duurzaamheidstransities en het bouwen in steeds meer verstedelijkte gebieden. De effecten van empathie blijken verder te reiken dan de grenzen van het geïntegreerde ontwerpproces en worden in zijn algemeenheid ook als stimulerend beschouwd voor de samenwerking tussen partijen.

Integratie is met name lastig als de culturen van partijen binnen het projectteam het meest verschillen. Deze studie bracht met name integratie problemen aan het licht die voortkomen uit cultuur verschillen tussen de ontwerp- en uitvoeringsdisciplines, en tussen opdrachtgevers en opdrachtnemers. Empathie kan bijdragen aan het overbruggen van deze cultuurverschillen door de mentale werelden van de andere actoren in het ontwerp proces binnen te dringen, hetgeen resulteert in een effectievere overdracht van kennis over het ontwerp probleem en de voorlopige oplossing. Bovendien is empathie een belangrijke vaardigheid die interactie heeft met andere mediërende en modererende menselijke factoren die positief correleren met prestaties, zoals samenwerking, vertrouwen en openheid.

Een literatuurstudie naar de niveaus van empathische vaardigheden maakte duidelijk dat de Nederlandse civieltechnische sector relatief laag scoort in vergelijking met de gemiddelde niveaus van een referentie sample, bestaande uit deelnemers van controle groepen van andere studies. Dit geldt met name voor de affectieve empathische vaardigheden en impliceert ruimte voor verbetering van prestaties door te focussen op empathie. Ten eerste kan het empathisch vermogen van teams worden versterkt door het aantal projectteamleden met meer empathische vaardigheden te vergroten. Aangezien vrouwen beter scoren op empathische eigenschappen dan mannen, met name op affectieve empathische eigenschappen, wordt geconcludeerd dat verbetering van project prestaties zou kunnen worden bereikt door de gender diversiteit in project teams te vergroten tijdens de geïntegreerde ontwerpfase. Aangezien de onderzoeksresultaten de cruciale rol van het management van het project bevestigen, kan met name genderbalans in technische en project management rollen effectief zijn.



Figuur 2: De relaties tussen de project prestaties, het geïntegreerde ontwerpproces, een geïntegreerde aanpak en empathische vaardigheden.

Ten tweede kunnen empathische vaardigheden worden vergroot door te focussen op situationele empathische vaardigheden en gedrag in projecten. Door het vergroten van de identificatie met de groep en het groepsgevoel in het projectteam, kan de in-group empathie toenemen, hetgeen positief zal bijdragen aan effectieve kennisoverdracht en de prestaties. Bovendien kan empathisch gedrag worden gestimuleerd wanneer projectteamleden zich bewust worden van het bestaan van nog onbekende en impliciete kennis over het probleem en de oplossing. Zij kunnen dan worden gemotiveerd en getraind om door middel van functioneel empathisch gedrag deze kennis beter te adopteren en zo hun projectdoelen te bereiken. Anderzijds suggereert de studie dat empathie minder effectief of zelfs contraproductief kan zijn in minder integratieve projectfasen en -rollen.

De relaties tussen de project prestaties, het geïntegreerde ontwerp proces, een geïntegreerde aanpak en de empathische vaardigheden van de projectteams zijn weergegeven in Figuur 2.

Als gevolg van de introductie van meer en nieuwe belanghebbenden en disciplines, zouden civieltechnische projecten gebaat kunnen zijn bij transformatieve ontwerpbenaderingen op alle abstractie niveaus van het ontwerpproces. Dit betekent dat de context van het ontwerp probleem niet alleen randvoorwaarden schept, maar een onafscheidelijk, vloeiend en natuurlijk onderdeel wordt van het iteratieve proces. In zo'n ontwerpproces nemen alle projectbetrokkenen actief deel en werken ze samen. Empathische vaardigheden kunnen bijdragen aan dit proces door culturele verschillen te overbruggen, het effectiever delen van kennis over het probleem en de oplossing en het ontwikkelen van waardevolle en geïntegreerde oplossingen.

Omdat in dit onderzoek voor het eerst de rol van empathie in civiele technische projecten is onderzocht, wordt aanbevolen om meer gegevens te verzamelen uit verschillende culturen, contractvormen en landen om de resultaten verder te kunnen generaliseren en meer inzicht te krijgen in de niveaus van empathisch vermogen gerelateerd aan de project prestaties. Daarnaast is meer inzicht nodig in de effectiviteit van training methodes die focussen op empathisch gedrag. Gelet op de essentiële rol van de competenties van teamleden in projecten, beveelt deze studie ook aan om in het onderwijs meer aandacht te besteden aan competenties gerelateerd aan integratie. Dit zal bijdragen aan het creëren van een nieuwe civiel ingenieur die een leidende rol speelt in de noodzakelijke, transformatieve benadering van de civieltechnische processen en in de onderling afhankelijke wereldwijde transities.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Introduction to the research

1.1 MOTIVATION FOR THE RESEARCH

The biblical narration of the construction of the Tower of Babel (Genesis 11:1-9) could be the oldest story of a failed project. The people came to the plains of Shinar to build a city and a tower from bricks and mortar that would reach the heavens and allow them to make a name for themselves. However, the Lord came down to earth to see the construction of the building and concluded that since they were one and spoke only one language, nothing they planned to do would be impossible for them. He decided to punish humanity for such haughtiness and confused their language so they could no longer understand one another's speech. Consequently, the people were forced to cease the construction and the tower remained unfinished forever.

The story of the Tower of Babel is beautifully reflected in a painting by Pieter Bruegel (dating from 1563). It is owned by the Kunsthistorisches Museum in Vienna, see Figure 1.1. The painting is based only in small part on the biblical passage in Genesis (Mannsbach, 1982). The Roman Colosseum probably inspired Bruegel to paint the tower. The figure on the left has been mainly recognised as King Nimrod, the principal of the great tower and the personification of human hubris. The right side of the painting shows the harbour facilitating barges to unload their building materials. In the middle, the construction of the tower is in full progress. The labourers use all kinds of mechanical devices, scaffoldings and engineering methods, making the scene easy to conceive as a contemporary project. They are carving the rocks, imagining the transformation of nature into a colossal structure through the arrogance of humankind. All in all, the story shows the failure of a haughty project due to the speaking of different languages and the ensuing confusion.

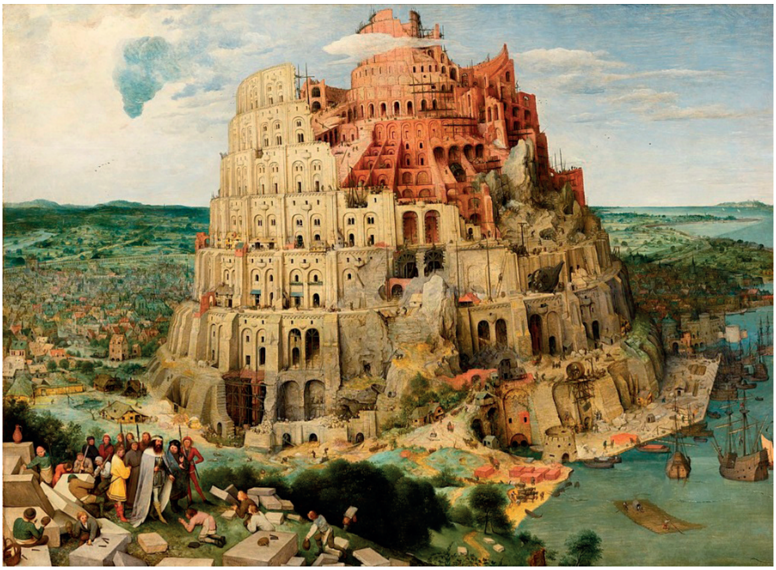

Figure 1.1: Tower of Babel, painted by Pieter Bruegel 1563 (Source: Mannsbach, 1982).

Unfortunately, more large unsuccessful projects followed after the Tower of Babel. Civil engineering projects, in particular, receive attention in this regard up to the present day because they are part of the public domain, are mainly publicly funded and encompass the built environment affecting many people and society. They show a long history of poor performance on a global scale, comprising budget overruns, time delays and social dissatisfaction (Flyvbjerg *et al.*, 2003; Cantarelli *et al.*, 2013; Love *et al.*, 2015). Even today, many major projects are affected by severe budget problems and delays, such as the reconstruction of the Afsluitdijk, the restructuring of the Zuidasdok in Amsterdam and the renovation and replacement of the Van Brienenoord Bridges in the Netherlands.

The social importance and the scale of the problem implied that project performance also became an important scientific topic subjected to extensive research. A broad body of knowledge on root causes for failures has been developed over the past decades. Nevertheless, projects turn out to be complex systems and hard to fathom. While the management of projects has improved over the years, the projects are confronted with increasing complexity, where the interaction between complexity and performance has been demonstrated in the literature (Bosch-Rekveldt, 2011).

Various causes can be identified as drivers for the increasing complexity of civil engineering projects, the most important of which are the interdependent global transitions related to sustainability, urbanisation, and the extensive rehabilitation assignment of existing civil engineering systems.

Interdependent global transitions related to sustainability

Climate change mitigation and adaptation will affect spatial claims, for instance by anticipating sea level rise, extreme rainfall, salinisation, drought and soil subsidence (IPCC, 2022). The energy transition, agriculture transition and biodiversity recovery will also change future land use (Opoku, 2019). These system transitions are interconnected and require an integrated approach (Leclère, 2020). Today, we notice the struggle for space resulting from these transitions, such as the local opposition to the construction of wind energy parks or the reduction of the agricultural sector in the Netherlands related to nitrogen emissions in favour of nature, housing and infrastructure. The impending conflict between liveability and climate change adaptation is a major challenge in the fertile and economically important deltas on a global scale. Civil engineering projects are involved in the built environment and aim to provide comfortable living spaces for humanity and technological solutions to spatial challenges. Therefore, civil engineering projects face a major task in the coming decades, given the threats of climate change and the interaction with other global transitions.

Urbanisation

Moreover, urbanisation has given rise to a growing need for infrastructure systems on a global scale. Where 30% of the population lived in urban settlements in 1950, this share is projected to be 68% by 2050. This is roughly the reverse of the global rural-urban population distribution of the mid-twentieth century (United Nations, 2019). This trend is also noticeable in the Netherlands, see Figure 1.2.

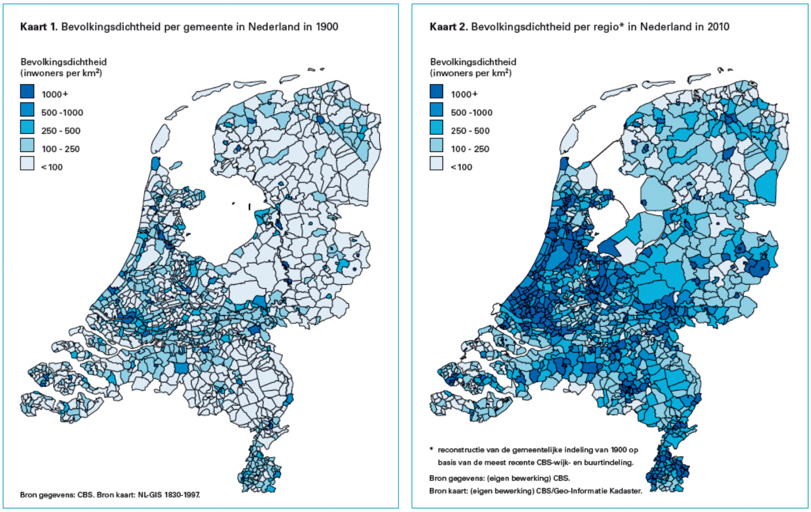

Figure 1.2: Urbanisation in in the Netherlands (Source: Ekamper, 2014).

This development necessitates expanding civil engineering systems in urbanised and densely populated areas. It requires a combination of functions to keep projects feasible (Hertogh, 2013). Projects combining mobility functions with ecological, water management or real estate functions have become common today. As a result, more elements, disciplines and stakeholders are introduced into the projects. Densification will continue as urbanisation grows, resulting in conflicting spatial claims in the cities and the deltas. Building in cities includes an increasing number of contradicting stakeholders' interests, again contributing to complexity. Urbanisation is thus an important factor for the increasing complexity of projects.

Extensive rehabilitation assignment

Additionally, project assignments are transforming from designing and building new objects into renovating and rehabilitating existing infrastructure systems since objects built in the post-war period are reaching the end of their functional or technical lifespan. An extensive rehabilitation assignment is imminent in North America and Western Europe (Lange, 2018). A new variable, i.e. the unknown status of the existing assets, complicates the projects. Furthermore, rehabilitation projects are more challenging because transport systems have to remain in operation during reconstruction as a result of the high demands on availability. Consequently, construction methods have become an essential variable when designing and planning projects.

These developments are interrelated and require an integrated approach. They unfold in a rapidly changing and unpredictable world. Although the climate is changing, it is yet unclear at what speed and with what effects. Resilient and adaptive solutions are needed, which is a new approach for the sector and further complicates solution finding in projects. Finally, there is increased awareness that civil engineering projects have social and economic impacts, especially on disadvantaged groups, either intentionally or unintentionally (Rodgers and O'Neill, 2012). As such, the inclusion of social inequality effects in civil engineering projects is another complicating factor.

Thus, in view of the significant assignments ahead, humanity will continue to realise challenging civil engineering projects. Perhaps they will be as challenging as the Tower of Babel project, whose construction failed due to the introduction of the speaking of different languages. '*Speaking different languages*' was also an often heard quote during the interviews of my research, referring to the cause of problems encountered in realising challenging projects. Although this issue did not initiate my research, the journey through the causes of project failures eventually led me to the project participants' competencies to understand each other and eventually to this ancient biblical story. One could easily conclude that nothing has changed after all these centuries.

Our world and projects have become an increasingly complex, inextricable tangle of interrelated objects, parties, people and interests. The better we can handle this complexity, the higher the quality of our projects will be and the better civil engineering projects can serve society. That is why we have a duty to allow for higher complexity and keep improving civil engineering projects. As a practioner in the field of civil engineering projects for approximately 35 years, I have been intrigued by these projects' complexity and willing to fathom the essence of the projects for the benefit of future projects and generations. Moreover, besides the failure to meet the project goals and the resulting unsatisfying social implications, I saw many companies, organisations, project teams and participants struggling with poorly performing projects, even leading to the downfall of companies and personal tragedies. I was involved in some of these projects myself. Organisations and those responsible often faced almost impossible assignments given the projects' complexity and high ambitions.

Therefore, this dissertation reflects an inquiry of a practitioner into the root causes of civil engineering project failures and aims to improve future civil engineering project performance to contribute to a sustainable and comfortable living environment for the next generations.

1.2 SUCCESS FACTORS FOR PROJECTS

An investigation of the causes of project failures immediately comes across a definition of successful or failed projects. Many scholars restrict the performance of civil engineering projects to financial success criteria. Even then, considerations on cost performance, definitions, and an objective reference in time are topics of discussion (Cantarelli, 2012; Love *et al.*, 2013). Although it is beyond doubt that the cost criterion dominates the project performance assessments, the literature agrees with today's view of performance which is much broader (Koops, 2017). The interpretation of performance used in this research will be discussed in Chapter 2.

The well-known and often cited research on cost overruns conducted by Flyvbjerg *et al.* (2003) presents inaccuracy in cost forecasts at an average of 44.7% for rail, 33.8% for bridges and tunnels, and 20.4% for road projects on a global scale. Moreover, they state that accuracy did not improve in the 70 years preceding the research, concluding that optimism bias and strategic misinterpretation are general drivers for cost overruns. However, their claim on the relationship with cost overruns is disputed (Osland and Strand, 2010) since their research actually lacks data on actors '*admitting lying*'.

Studies focusing on specific countries show widely varying figures but have substantial average budget overruns in common. Odeck (2014) reports a mean cost overrun of 8%, ranging from -59% to +183% for the Norwegian road sector. Love and Sing (2013) indicate a mean budget overrun of 12% for Australian construction and engineering projects using the contract award as the reference point. In the Netherlands, the cost performance of large-scale transport infrastructure projects shows an average cost overrun of 17%, although cost overruns are as common as cost underruns (Cantarelli *et al.*, 2013)

Cantarelli *et al.* (2013) categorised factors for cost overruns into *technical* (cost-related, such as forecasting errors, incomplete estimations, project design and scope changes), *economic* (underestimations), *psychological* (optimism bias) and *political* (cost underestimations or manipulation) causes. As such, projects are considered from a budgeting and cost-estimating perspective. Studies focusing on budget overruns as the dominant success criterion generally include frequently occurring project problem definition changes and the associated adjustments in project value over time to a limited extent. Therefore, these studies should be considered in a nuanced way.

Project complexity can be considered an overarching factor affecting performance, with the correlation usually suggested to be negative. The literature indicates consensus on the view that project complexity is, by all means, determined by the number of elements or participants and the extent to which they interact. Inferring their interaction is not a '*trivial*' matter, according to Simon (1996). The number of objects, disciplines, stages or participants involved in the project and the amount of overlap determine the complexity and affect performance (Akintoye, 2000; Vidal and Marle, 2008). On the other hand, Hertogh and Westerveld (2010) identified the dynamic complexity of projects related to the dynamic, non-rational and limited-predictable behaviour of the project's environment. Both types of complexity negatively influence performance if not well managed.

Project management frequently emerges as a general factor interacting with performance (Doloi, 2013). Project Management can be considered all activities described in the PMBoK (2021), i.e. managing integration, scope, time, cost, quality, human resources, communication, risks and procurement. Although this provides a broad and complete view of the management of projects, more detailed perspectives are needed to learn from project failures and successes. *Planning and control* play a significant role in project cost performance and delays (Doloi, 2013; Chan and Kumaraswamy, 1997). *Risk management* is another factor frequently appearing in the literature (Flyvbjerg, 2007).

A literature review of seven project management and construction management journals by Chan *et al.* (2004) divided the most frequently occurring factors affecting performance into four additional and more specific categories: *project-related* factors, *the external environment*, *procurement procedures* and *human-related* factors.

Project-related factors can be related to project complexity, as they attribute aspects, such as project size, number of objects, and type of project. Technically related factors might also be considered included in this category. Verweij (2015) defines technical problems as a factor related to changes in the physical or technical conditions under which the project is implemented and attributes cost overruns to this factor. Ground conditions and buildability are specific aspects raised in this respect (Akintoye, 2000; Chan and Kumaraswamy, 1997).

The external project influences are indicated as e*xternal environment*, including social and political systems. The stakeholders' interests and management belong to this important category and are often put forward as the effects of stakeholders' claims and dynamics are increasing (Verweij, 2015; De Schepper *et al.*, 2014). Political-economic factors, such as public opposition, inappropriate government policies and bureaucratic indecision regarding the decision to build, are also part of the field of external factors and are considered more impactful than technical explanations (Cantarelli, 2012; Moschouli, 2018).

Chan *et al*. (2004) refer to *procurement procedures* as the procurement and tendering methods aimed at selecting the organisation for the design and construction of the project. This also relates to the type and the quality of the contracts as a factor for performance. Deficiencies and omissions in the contract result in scope changes, which also emerge as an important factor inducing budget overruns and time delays (Verweij, 2014; Love *et al.*, 2015). Finally, since projects are based on human interaction, *human-related* factors cover a broad range of factors related to the project's participants, such as skills, competencies, experience, involvement, commitment, adaptability and relationships. The literature developed a broad body of knowledge related to this category (Bakker and de Kleijn, 2014; Loufrani-Fedida and Missonier, 2015).

Although the enumeration of factors affecting civil engineering projects' performance is not intended to be exhaustive, an inextricable tangle of interacting factors arises. Most studies consider factors related to performance separately, although usually factors mutually interact. For example, *stakeholder management* is a recurring, single factor affecting performance. However, managing the stakeholders in civil engineering projects will depend on the attention the project team members pay to the stakeholders, which relates to the *human factors* issue. In addition, it is important to include stakeholder management in *the risk management* and *planning procedures*. Then, the late integration of stakeholders' wishes and interests is an important cause of *design changes*, in turn affecting *scope management*, scope *omissions* and the *contract*. The contract might also include ambiguities regarding the responsibilities for managing the stakeholders. In summary, many factors are affected by the management of the stakeholders or influence the stakeholder management itself, meaning considering a single factor is limiting for research. Evaluations focused on isolated effects might not create a realistic understanding of poor performance causation (Verweij, 2015). Love *et al*. (2016) advocate a pluralistic approach considering the interdependencies of factors affecting performance. However, these research methods are not yet common.

1.3 DESIGN AS A PERSPECTIVE

The literature generally agrees on the dominant role of the early project stages in project performance, including the design phase (Bosch-Rekveldt, 2011; Cantarelli *et al*., 2012). Design, as an important part of the early project life cycle, also emerges as a factor affecting performance in the literature both as a process and as a product (Chan *et al*., 2004; Doloi, 2013; Love *et al*., 2015). From the aforementioned literature review, Chan *et al*. (2004) conclude that '*Designers play a vital role as their work is involved from inception to completion of a project*'. Chan and Kumaraswamy (1997) identified design team experience, project design complexity, and mistakes/delays in producing design documents as factors influencing performance. Doloi (2013) indicated '*Design efficiency*' as a factor affecting performance, which relates to all parties involved in the project. Clarity of the design at the initial stages of the project is considered highly necessary to produce realistic project time and cost plans. In addition, completeness of the detailed scope and design is crucial for the project to avoid discrepancies in contract documentation and the likelihood of mistakes during construction. Koutsikouri (2008) emphasises the importance of the collaborative design phase, especially in interdisciplinary projects. These conclusions correspond to my personal observations as a practitioner, i.e. that project failures often originate in the design phase of the projects.

A study by Love *et al*. (2015) visualises the role of the design process on contingencies that should have been included in cost estimates based on cost overruns experienced in 49 Australian road construction projects, see Figure 1.3. The figure schematically shows the decisive role of the design process in the contingencies and cost failures. Additionally, it indicates its highest impact in the early design stages.

An initial definition is needed to assess design as a possible valuable factor in evaluating civil engineering projects. Simon (1996) described design in general terms as the course of actions '*aiming at changing existing situations into preferred ones*'. As such, it encompasses the project phases from inception to the delivery of the design product, which is the description of the artefact to be built. It can be argued that this course of actions includes all project activities contributing to the arrival at the best possible solution. A common yet not precisely defined problem or need is the input for the process. The construction stage follows the design stage.

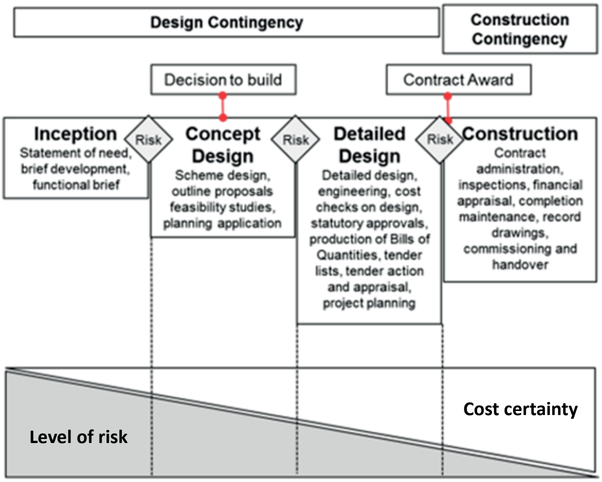

Figure 1.3: The role of the design process from inception to construction on the contingencies to be included in cost estimates derived from cost failures (Source: Love *et al*., 2015).

Simon (1996) distinguishes between an internal and an external environment, see Figure 1.4. The internal environment can be considered the creation process of the artefact itself (*'the substance'*), whereas the external environment is the setting in which the artefact operates. Simon (1996) states that '*the inner environment is appropriate to the outer environment and vice versa*.'

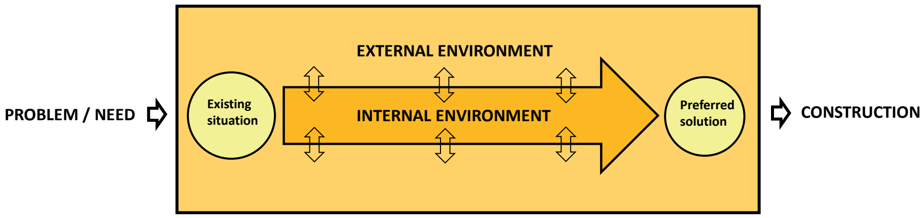

Figure 1.4: A visualisation of the design process after Simon (1996).

This broad interpretation of the design process interacts with a variety of factors influencing performance. First, referring to the literature review of Chan *et al.* (2004), the *external environment* is now part of the design process. Stakeholders' interests, political and political-economic factors, and physical environmental conditions interact with the design process and play an important role in determining the design solution. Integrating the external environment into the internal environment, i.e. the process and the design solution is critical for performance. In this way, stakeholders' management and the dynamic complexity of the stakeholders is an intrinsic part of designing.

The internal environment of the design process refers to the *project-related factors* categorised by Chan *et al*. (2004). The complexity of synthesising the elements of the artefact into an integrated solution interacts with project performance. Given the growing interdisciplinarity of civil engineering projects, this success factor has become increasingly relevant over the past decades (Koutsikouri, 2008).

The *procurement procedures* highly depend on the quality of the design product since it defines the scope of the product to be procured and the contract to be awarded. Poor quality of the design product and omissions will induce contract changes, budget overruns, time delays and consequently, poor performance. Moreover, the introduction of integrated contracts reflects a development from build-only contracts towards contracts in which the design scope is partly transferred from the owner to the contractor. Therefore, performance related to the integrated type of contracts often links to design processes (see Chapter 2).

Since the design process results in a description of the product to be built ("the design"), it interacts with several project management processes, if not considered a process in itself. The design problem definition determines the scope of the project and subsequently drives the scope management and the cost management process. Furthermore, it delivers crucial input for the planning process, risk management and quality management, and it affects the buildability in the construction phase.

Finally, design is eminently *human-related*. It is a process conducted by humans with different backgrounds and possibly opposing interests. It can be described as a social process (Bucciarelli, 1988) depending on human interactions and exchanging knowledge (Smulders *et al.*, 2008). In addition, it is partly creative and driven by subjective value judgements and bargaining powers (Archer, 1989). Project team participants from different parties have to collaborate to arrive at the best possible and most widely supported compromise (the design solution). This obviously requires, amongst other abilities, collaboration, communication, management and leadership competencies to achieve good performance. Additionally, technical experience and knowledge are needed to run a design process successfully.

In conclusion, the design process can be considered a broad overarching perspective interacting with several internal and external factors affecting project performance. Some of these factors depend on the input from the design process; others can even be considered part of the design process. Therefore, the design process is a valuable perspective for evaluating civil engineering projects. It is a non-isolated effect (Verweij, 2015), as its interdependencies are apparent and can be included in the research.

1.4 INTEGRATION AS A KEY FACTOR

The crucial role of the design process for project performance is confirmed by my own experience with civil engineering projects in the Netherlands over the past decades. Given the interpretation of design as the process that guides an initiative to a widely accepted solution, many project failures can be traced back to the design process. The efforts to include the (contradicting) interests of the stakeholders in a supported design solution are often underestimated, which is reflected in delays of permit procedures or discussions between the contractor, the owner and the stakeholders on interpretations of the requirements and the associated scope, causing budget overruns, delays or dissatisfied stakeholders. The same accounts for the lack of acknowledgement of the complexity of coordinating and synthesising the growing number of elements and aspects into a detailed design, also causing interface issues, budget overruns and delays, both on the side of the owner, the contractor and the subcontractors.

The civil engineering sector is used to siloed ways of working and is technologically driven. Until the end of the 20th century, building in green fields and technological challenges dominated civil engineering projects. These projects were interdisciplinary only to a limited extent. Project participants and designers could allow themselves to focus on their own expertise and discipline. The project context in the Netherlands was dominated by the rehabilitation assignment in the post-war period and the urgent need to protect the country from the sea after the devastating flooding in 1953 (see Chapter 2).

Diving into today's design process of civil engineering projects, my observation is that this process has been subjected to a comprehensive change over the past decades. From the late 20th century onwards, an introduction of an increasing number of assertive stakeholders and disciplines started and necessitated project participants to include new and yet unknown context, stakeholders and disciplines (Hertogh and Westerveld, 2010). The number of success criteria of the projects grew. Factors such as liveability, safety, availability, sustainability and minimising hindrance were introduced into the projects. Consequently, the number of disciplines and parties involved in the projects became numerous. This development introduced integration in the civil engineering industry as an important concept: integration of a growing number of system functions, assertive stakeholders, interests, aspects, disciplines and parties into the design process to arrive at supported design solutions. Two examples, observed in practice, demonstrate the crucial role of integration in today's civil engineering projects at several levels of abstraction.

Between 2000 and 2020, several tunnels were designed and built in the Netherlands, such as the Willem-Alexander Tunnel (Maastricht), the Leidsche Rijn Tunnel (Utrecht), the Westerschelde and the Sluiskil Tunnel (Zeeland) and the Salland-Twente Tunnel (Nijverdal). Following European legislation, tunnel safety had become a crucial success factor for these projects. Safety for the users of the tunnel is, apart from the tunnel layout, mainly determined by the technical installation and how it facilitates the users to safely escape from the tunnel in case of an emergency. Within the tunnel system, the technical installation is a complex system in itself. It consists of many sub-systems, such as the fans, the cameras, the detection systems, the intercom, and the traffic systems. Together, they have to provide a safe concept for escaping the tunnel. The high demands on safety implied new and high demands on the tunnel technical installation. As a consequence, the integration of the technical installation became a critical design aspect in tunnel projects (Hertogh *et al*., 2015; Hertogh *et al*., 2017).

New functions and requirements from the stakeholders regarding the safety concept had to be settled and integrated into the design of the tunnel system. New guidelines and stakeholders issuing safety-related permits were introduced, and rescue service departments gained increasing impact on the tunnel design and the process. Determining the design problem and the requirements was difficult to achieve, and the project teams struggled to integrate them timely into the design process. The complex tunnel technical installation system and the difficulty defining the design problem and requirements, also introduced issues in the testing and commissioning phase, which was naturally already on the project's critical path. While the tunnel technical installations used to be a relatively easily manageable, often subcontracted, part of the scope, it had now become critical for project success regarding budget, the time schedule, safety and stakeholder satisfaction.

Figure 1.5 Koning Willem Alexander Tunnel Maastricht (Source: Fred Berghmans).

Additionally, the technical installation discipline's characteristics and culture differed substantially from the traditional disciplines that ruled the tunnel projects. Where the technical installation design process is dominated by a systematic functional and requirements analysis resulting in design specifications and procurement of off-the-shelf products, the traditional structural engineering process of the tunnels was controlled by defining objects as a starting point of the design process and an extensive engineering process, resulting in the construction of customised, in-situ made elements. While the interfaces between the technical installation and civil process and objects are numerous, these differences, including literally different languages, caused several interface issues. Integrating the disciplines' ways of working, processes, time schedules, and geometrical aspects of the objects often failed, resulting in substantial time delays, budget overruns and extensive discussions with stakeholders. Today, the industry has managed to overcome these differences. The disciplines are now able to understand their critical interfaces and manage an integrated approach. However, it took some unsuccessful projects to arrive at this point.

An example of a successful integrated approach is the 'Room for the River' program in the Netherlands. The program was initiated after the near-miss floodings in 1993 and 1995 and comprised two objectives: increasing the capacity of the rivers to cope with future high water levels and improving the spatial quality of the riverine areas. In total, 34 projects were defined along the Rhine (Waal) River and its branches, centrally controlled to monitor the achievement of the program goals (Verweij *et al.*, 2021). Deviating from the traditional water management solutions, such as dyke strengthening, the 'Room for the River' program encompassed solutions highly affecting land use and spatial planning, such as dyke relocations, depoldering and the creation of additional flood channels. It thus required integrated river basin management facilitating the interplay between water and land use functions.

The program can be defined as a comprehensive water management approach that aligns multiple objectives such as providing safety against flooding, transport capacity, opportunities for recreation, enabling nature development, water supply, facilitating economics, safeguarding aesthetics and water quality (Zevenbergen *et al.*, 2015). Authorities integrated water management and urban and nature development policies on national, regional and local levels, see Figure 1.6. Moreover, the interdisciplinary projects synthesised and integrated water safety, planning, agricultural and nature elements into the design solutions. Compared to other large projects in the water and infrastructure sectors, the 'Room for the River' program performed well in terms of achieving project objectives and the overall process of delivery (Zevenbergen *et al.*, 2015) and substantiates the value of integration in today's projects. The integrated approach has delivered more value than would have been achieved with a monodisciplinary approach.

Figure 1.6: The Room for the Waal project in Nijmegen, showing the flood by-pass (left), urban, and recreation development (Source: Siebe Swart).

The examples demonstrate that integration manifests itself at several levels of abstraction within projects.

Integration of authorities' policies and strategies

Civil engineering projects usually are comprehensive, meaning they affect several fields of policy at various administrative levels, such as infrastructure, water management, urban development, and nature development. Integrating the authorities' policies and the requirements derived from them in the early design phases is necessary to avoid contradicting specifications, discussions during the design or delays in permit procedures. Within infrastructure projects, lack of integration frequently occurs, for instance between the infrastructure owners and the water board authorities or architectural authorities. Issues occur as a result of conflicting interests or non-aligned procedures. On the other hand, the 'Room for the River' example showed the added value an appropriate integration can provide for projects.

Integration of stakeholders' interests

The extensive character of civil engineering projects implies the involvement of many stakeholders affecting or affected by the project. Appropriate integration of their interests, wishes and requirements in the design process and the design solution is essential for performance. However, stakeholders' interests turn out hard to fathom, as was the case with the tunnel technical installation. Projects frequently face incomplete inventories of stakeholders' interests. Additionally, really understanding the stakeholders' concerns, interests or problems seems hard to achieve. Then, translating a stakeholder's interest into a (written) specification, often in a contractual setting, is difficult and frequently causes misinterpretations between parties. As a result, designs do not meet the stakeholder's interests, redesigns are necessary, contractual discussions arise, and the stakeholders are dissatisfied. Again, on the other hand, thorough investigation of the stakeholders' interests and real involvement of stakeholders, for instance, through participatory processes, can provide project value that exceeds expectations.

Integration of owner–contractor interests, processes and cultures

Depending on the type of contract, the owner and the contractor will have shared and contradicting interests. Naturally, they have their own stakeholders to satisfy and their own budgets and associated struggle not to exceed them. Additionally, their cultures and processes differ and need, at least partly, to be aligned. The rise of integrated contracts over the past decades introduced a partial shift of design responsibilities from the owner to the contractor. Consequently, their design processes became interdependent and needed tuning and integration. However, projects lacked recognition of the different cultures, processes and interests in the design process, introducing, among others, disputes on interpretations of design specifications and validation, and misalignment of decision-making procedures, causing delays.

Integration of disciplines

Today's civil engineering projects are highly interdisciplinary. Each discipline is characterised by its expertise, culture, way of working, process, and interests. Understanding and integrating mutual interests is crucial, since best-for-project solutions often require reciprocity and mutual granting between disciplines. As demonstrated in the example of the Dutch tunnel projects, disciplines have specific ways of working, culture and processes, and, even language. Since the disciplines work together in an integrated project and depend on their mutual exchange of information, integrating their processes, ways of working and cultures is, to some extent, necessary. Interacting disciplines appear in several guises and can be related to expertise (for example civil, technical installation, roads, architectural, landscaping), the project organisation (for example design, construction, procurement) and parties outside the project organisation (subcontractors, suppliers, consultants). As all of these disciplines play their role in the design process, many disciplines need integration and interactions are at stake. Lack of integration manifests itself in delays (for instance due to misunderstanding of mutual information needs), budget overruns (as a result of lack of integration of design input during tender phase on the side of the contractor) or unsafe designs (for instance due to lack of integration of construction knowledge in the design).

Apparently, the transition towards more integrated approaches in projects is slow and difficult to achieve. Obviously, the industry has learned from past mistakes. For instance, the integration of the technical installation in tunnels has become less critical in projects today due to more integrated approaches, as discussed. However, where integration assignments are becoming increasingly challenging, the sector struggles to adapt to new levels of integration. It seems the project participants prefer to stay within their discipline or expertise, rather than proactively encounter others to settle interfaces or conflicting interests. Integration frequently requires participants to act on the edge of their expertise and responsibilities and, sometimes, to adjust policies or governance (Visser, 2020). Possibly, the pressure of challenging time schedules and budgets leads to choosing the short-term successes of siloed solutions.

The literature confirms the above delineated observation of integration as a crucial factor for performance. However, different definitions of integration are used among scholars. Baiden and Price (2011) use a broad interpretation of integration '*where different disciplines or organisations* *with different goals, needs and cultures merge into a single cohesive and mutually supporting unit (Baiden et al., 2006) with collaborative alignment of processes and cultures (Ochieng and Price, 2009).* This definition covers the integration and alignment of disciplines, organisations, goals, needs, cultures and processes, and reflects the broad interpretation of the concept of integration. Studies argue the positive effects of integration on team effectiveness (Koutsikouri, 2019) and project management performance (Demirkesen and Ozorhon, 2017). Although the body of knowledge on integration management and its effects on performance is growing, little is known about the drivers of integration and how it can be supported.

From a design perspective, integration can be considered from different viewpoints. First, integration can be projected at different levels of abstraction of the project. At the highest level, the artefacts' goals or values (frames) can be integrated, creating new solutions or typologies. This is the level where policies are connected, which was the case at the 'Room for the River' program. Also, the advocated integration of strategies to mitigate and adapt to climate change refers to this level (Leclerc, 2021). If the artefacts' goals are determined, a more technical interpretation of integrated design applies, referring to, for instance, the integration of the technical installation system into the tunnel system (Visser, 2020). This is the integration level of the artefact's disciplines or the components.

Secondly, integration applies to different aspects of integration. Parties' or disicplines' interests (goals, needs) need to be integrated to arrive at a common and shared set of functions and specification for the system. Additionally, parties' or disciplines' processes need (at least to a certain extent) integration in order to manage interfaces related to the system. Processes include ways of working, culture and organisation. Both interests and processes apply to any level of abstraction of the project. As such, four areas of integration in design processes appear: integration of interests and processes at the policy (strategy) level and integration of interests and processes at the disciplines' level of the project.

It can be concluded that the design process of civil engineering projects is integrative by definition (see Chapter 2). Therefore, in this study, the term "integrated design" will be used when referring to design, to emphasise the essence of integration when designing civil engineering objects and systems. However, as described, integration is not self-evident in civil engineering. Neither can it be considered an all-or-nothing phenomenon. The extent to which integration is achieved depends on the artefacts' compatibility (Visser, 2020), i.e. the extent to which artefacts or their frames can be aligned. More precisely, it depends on the compatibility of the parties' processes and interests. It seems that the extent to which the project teams manage to overcome the differences determines to what extent integration is achieved. The concept of integrated design will be further discussed in Chapter 2.

It can be concluded that contemporary civil engineering projects are facing a major integration challenge, which is the footing for many project failures as well as successes. It is assumed that the need for increasing integration, observed in recent decades, will continue, or even accelerate, in the future. Section 1.1 already discussed the future challenges of civil engineering projects, including the need to adopt strategies to mitigate and adapt climate change and the loss of biodiversity. In addition, the projects need to include design and construction methods that fit the rehabilitation assignment and its availability requirements and account for the social-economic effects. Consequently, an increasing number of interests, processes and cultures of new authorities, stakeholders, owners and disciplines will need integration in the future. Therefore, based on the observations from practice, there is reason to improve the integrated design process of our projects to anticipate future developments regarding the increasing complexity following from integration.

1.5 PROBLEM STATEMENT

Civil engineering projects show a history of difficulty meeting predefined goals, mainly referring to cost overruns, delays and dissatisfied stakeholders. Meanwhile, the transitions related to sustainability will affect spatial claims and land use. Since civil engineering projects are involved in the built environment and aim to provide technological solutions for a comfortable living environment for humanity and spatial challenges, these projects play a crucial role in facilitating these transitions. Furthermore, they need to anticipate uncertainties by including resilience and adaptivity. The inclusion of these transitions will continue to increase the complexity of these projects, since new aspects will be introduced in the civil engineering industry. So, civil engineering projects are facing challenges to improve today but will be increasingly complex tomorrow.

Design is a crucial process covering project activities from inception to construction. It interacts with several factors that are related to project performance. As such, it is considered a valuable perspective to evaluate projects. The researcher's observations point in the direction of integration, i.e. integration of the project's policies, stakeholders, disciplines, cultures and objects into the design process and the design solution, as a crucial factor for success. A broad spectrum of issues observed in projects can be traced back to integration deficiencies of processes and parties' interests from the policy level to the discipline level. However, while design processes of civil engineering projects are integrative by definition, integration in the design process is not self-evident. Although it has become increasingly decisive for civil engineering project performance, integration is hard to accomplish in a sector used to siloed ways of working.

Little is known about the drivers for integration and the integrated design process and how it affects performance. Therefore, this study investigates the interaction between the integrated design process and the performance of civil engineering projects. In addition, it aims to propose adjustments to the process to improve performance.

1.6 RESEARCH QUESTIONS

The previous sections delineated a problematic situation observed by a practitioner: projects are struggling with performance today, while the integrated design process, being a crucial factor for performance, will face increasing integration challenges in the future. This research is an investigative journey of a practitioner, merging theory and practice, to discover how the integrated design process interacts with performance and how it can be adjusted to improve project performance. Therefore, the main research question for the study is:

> *"How can the performance of civil engineering projects be improved through the integrated design process?"*

This research is based on the researcher's observation that the extent to which an integrated approach is achieved in the design process and the design solution is critical for project performance. This initiated an open-minded inquiry for the dominant factors affecting the integration of the design process, i.e. the integrated design process, and ways to contribute to an improvement of project success. As such, two research subquestions guided the research:

> Subquestion 1:
> *'What are the dominant variables affecting the integration of the design process and the performance of civil engineering projects?'*

> Subquestion 2:
> *'How do the dominant variables of the integrated design process influence the performance of civil engineering projects, and how can the variables contribute to improving performance?'*

1.7 RESEARCH APPROACH AND METHODS

1.7.1 Research approach

The purpose of the research is to understand the interaction between the integrated design process and project performance of civil engineering projects. Subsequently, the research aims to provide guidelines for improving the integrated design process and the project. The literature stipulates that the integrated design process and its interaction with performance are complex, not obvious and encompasses many interdependent factors. Moreover, the variables are highly dependent on human interaction and behaviour, a complex context and interpretation. Therefore, a constructivist worldview governs the research.

The constructivist paradigm grew out of the philosophy of Edmund Husserl's and German philosophers' studies called hermeneutics, meaning the study of interpretive understanding or meaning (Mertens, 2019). The basic principle is that knowledge is socially constructed by people active in the research process. Human beings construct meanings as they engage with the world they are interpreting. Constructivist researchers look for the understanding of these interpretations, the context or the setting and give meaning to what they find (Crotty, 1998). Meanwhile, they rely on the individuals' views (Creswell and Creswell, 2018). Part of constructivist research is that the researcher and the participants are interlocked in an interactive process influencing each other (Mertens, 2019). Therefore, a more individual, interactive mode of data collection applies to this research. Rather than starting with a theory, constructivist researchers intend to develop (construct) a theory, suggesting inductively-based research. However, since theory also needs verification, this research ranged between the inductive and deductive sides of the empirical cycle, converging towards theory-building

The researcher of this study is well embedded in practice. Therefore, the interactive process with the participants of his research objects can be easily accomplished and provides the opportunity to interweave practice and theory. As such, the research approach encompasses elements of design research, where knowledge development evolves from practice. Knowledge, according to Dewey (a pragmatist philosopher), is knowing what to do in an evolving situation to attain a goal (Stompff *et al.*, 2022). Knowing is something we do and is embedded in our activities and practice. It implies that, in design research, the researcher is not a neutral 'spectator' observing the world 'out there', but someone who is in and engages with the world he is investigating (Stompff *et al.*, 2022). Consequently, theoretical knowledge and practical know-how are mutually instrumental and equal partners.

Dewey advocated a pattern of design inquiry merging theory and practice comprising six steps, see Figure 1.7.

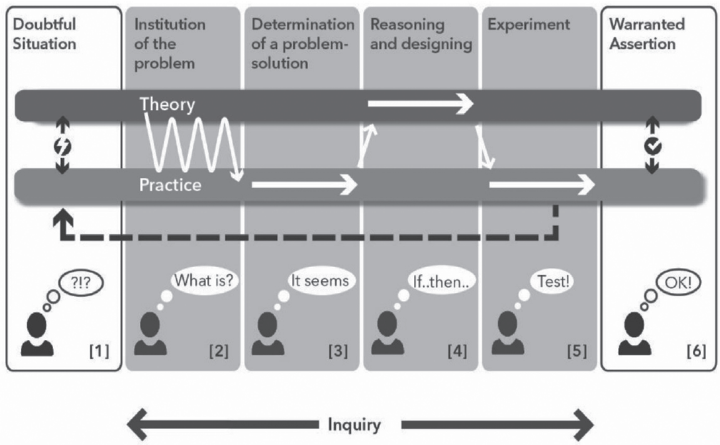

Figure 1.7: Dewey's pattern of Design inquiry (Source: Stompff *et al.*, 2022).

Although the pattern suggests a sequential coherence, it may be iterative in nature. The inquiry starts with a 'Doubtful situation', which can be a problem experienced in practice where people no longer know how to act. The situation might be "*troubled, ambiguous, confused, full of conflicting tendencies, obscure*" (Dixon, 2019). For this study, the doubtful situation was discussed in Section 1.5, being the problematic integration in design processes of civil engineering projects. Next, this problem needs to be clearly instituted (step 2). Theory and practice enhance the understanding of the problem, its constituents and their interrelations. The next step (3) concerns the process of coming to a possible problem-solution pair. The problem and the solution co-emerge resulting in a deeper understanding of the problem and a provisional solution and its effects. This practice-based and iterative process is followed by a more theoretical and intelligent interpretation (step 4) resulting in propositions that need testing by experiments in practice (step 5). Given that the results of the experiment align with the anticipated effects, the inquiry ends, and transferable knowledge can be developed (step 6). Dewey avoids the concept of truth and introduces the notion of 'Warranted Assertion' recognising the value of a claim resulting from a set of reasonable conclusions given a certain, well-defined context and allowing for future research (Stompff *et al.*, 2022; Dixon, 2019).

This study embraced elements of this practice-led research approach. The opportunity to include solid access and experiences of practice into a theoretical investigation has been considered of specific added value. An investigative journey unfolded into the drivers of the integrated design process and performance, where theory and practice reinforced each other, see Table 1.1. Integration of the design process was considered a starting point, however, the journey was open-minded and left room for unforeseen destinations.

Following the problem definition (the doubtful situation) and based on the literature and observations from practice, the essence of today's integrated design process will be defined and problematised, investigating its constituents and their interactions (step 2). Step 3 explores the interaction between the integrated design process and project performance and investigates its dominant drivers (subquestion 1). This phase of the study has an explorative and qualitative character. The results of this study confirmed the critical role of the participants' competencies as a dominant variable for the integrated design process and performance. More specifically, the team's empathic ability was broadly theorised and proposed as a critical factor for the integrated design process and performance (step 4). Then, the experimental step has an explanatory character and comprises qualitative and quantitative research methods and focuses on the understanding of the interaction between participants' competencies, the integrated design process and performance and ways to improve performance (answering subquestion 2).

Table 1.1: Research Design and Methods.

Dewey's Design Inquiry			Research Approach			Chapter	Sub-question
	Step	Theory / Practice	Design		Methods		
1	Doubtful Situation	Practice				1	
2	Institution of the Problem	Theory / Practice	Literature review and observations on the integrated design process			2	1
3a	Determination Problem - Solution	Practice	Exploratory	Qualitative	Non-structured Interviews	3, 4	
3b			Exploratory	Qualitative	Multiple Case Study: - Semi-structured interviews		
4	Reasoning and Designing	Theory	Literature review empathy			5	
5a	Experiment	Practice	Explanatory	Mixed Method	- Semi-structured interviews - Survey	6, 7	2
5b			Explanatory	Mixed Method	Multiple Case Study: - Semi-structured interviews - Survey	8, 9	
6	Warranted Assertion	Theory				10	

1.7.2 Methods

Qualitative research methods are closely related to the research topic and the constructivist approach, given the complex subject, the context dependency and the importance of data interpretation. However, quantitative methods are also included in this study. The mixed-methods provided the opportunity to enrich the qualitative and interpretative data with quantitative data to gain a more complete understanding. Databases could be mutually verified and explained. Where the research is mainly characterised as qualitative, the mixed-methods are exploratory sequential, meaning that the quantitative analysis follows the qualitative analysis (Creswell and Creswell, 2018). The quantitative data are mainly used to support, enrich and nuance the interpretations from the qualitative data.

The exploratory research conducted in step 3 initially used non-structured interviews and open-ended questions exploring the participants' views to get an initial impression of the interaction between the integrated design process and project performance to verify the design process' relevance for performance. This research step used interview data recorded in interview reports. Then, based on the initial findings of the exploratory interviews, a multiple case study was conducted, aiming to identify the dominant variables of the integrated design process affecting performance. The case study research used semi-structured interviews and open-ended questions as a research method, supported by document reviews and the researcher's observations. The analysed data consisted of interview data recorded in interview reports, project-related documents and field notes.

Since the case study indicated people's competencies and, more specifically, empathy as the dominant variable for the integrated design process performance, the experimental step of the inquiry comprised explanatory research on the interaction between the empathic abilities of the project team participants and performance using semi-structured interviews and a survey. As such, the initial part of this step was characterised as mixed-method research, combining qualitative data from the interviews and quantitative data from a survey on a project team's empathic abilities. The results of this study suggested a positive correlation between the team's empathic abilities and performance. Therefore, a more extensive test was conducted, comprising a mixed-method multiple case study, including eight projects. This part of the study aimed to verify the hypothesised positive correlation between the team's empathic abilities and performance. An extensive survey aimed at obtaining quantitative data on the empathic abilities of eight project teams and was combined with semi-structured interviews to enlarge the understanding of how empathy interacts with the performance of projects, to find out whether empathy is a dominant variable affecting performance and identify measures for improving performance by focusing on empathy.

The research comprised two multiple case studies, including four and eight real-life projects respectively. A case study is an empirical inquiry that investigates a contemporary phenomenon in its real-world context, especially when the boundaries between the phenomenon and the context are not evident. Case studies are an appropriate method when "How" questions need to be answered. In addition, case studies are preferred when examining contemporary events (projects), and the relevant behaviour cannot be adjusted (Yin, 2014). All these aspects apply to the study.

Flyvbjerg (2006) considers a case study an appropriate method because '*it is important for the development of a nuanced view of reality, including the view that human behaviour cannot be meaningfully understood as simply the rule-governed acts found at the lowest levels of the learning process, and in much theory.*' The phenomenon under study is complex, since the integrated design process and project performance are affected by many interacting variables. Therefore, case studies on projects offer the possibility to conduct in-depth investigations in the real-world context. Furthermore, since the process is dominated by human interaction and behaviour, interviews as part of the case study offer good possibilities for gathering data on this important aspect. This makes case studies a favourable research method for the subject under study.

Furthermore, interviews were the main source of data. In total, 73 interviews were conducted, mainly semi-structured interviews using open-ended questions. All interviews were recorded, transcribed and validated by the interviewees. The interviews were experienced as open and transparent, providing an atmosphere to sincerely share the course of the project. Elements of grounded theory were used for analysing the interview data. This is a valid method when analysing complex matters (Corbin and Strauss, 2014), which applies to this study. The analysis unfolded while the data were being collected, resulting in an iterative process. The raw data were the quotes of events reported during the interviews, such as incidents, activities, examples or statements. Quotes referring to the same phenomena were coded as concepts and, subsequently, as concept groups, being potentially relevant phenomena for theory-building. By aggregating concept groups, a theory could be constructed, which in turn was verified with quotes from the interviewees.

1.7.3 The role of the researcher

Qualitative research is interpretative research; the researcher is involved in a sustained and intensive experience with the participants. Moreover, the design inquiry approach implies that the researcher acts in a familiar environment. This introduces various strategic, ethical and personal issues (Creswell and Creswell, 2018). Qualitative researchers collect data themselves, interview participants, observe behaviour and examine documents. They then interpret the data gathered. Where the participant's view is an individual construct of reality, the researcher gives meaning to that view by using his own experiences and interpretation. This particularly applies to constructivist researchers building a theory.

In the current study, the researcher is a construction industry practitioner with a broad experience in civil engineering projects. Being familiar with the subject under study implies advantages. The researcher has easy access to projects and data. He can easily give meaning to the data and observations collected. Furthermore, the researcher will have the opportunity and capability to translate scientific knowledge to practice and findings from practice to science, thereby enriching science and practice and mutual learning.

On the other hand, an experienced practitioner conducting research in his own field implies risks (Ruijter, 2019). The researcher will have his view on the subject and the problem based on experiences from the past. Given the constructivist and qualitative character of the research, the data gathered from interviews, conversations and documents need interpretation, and the researcher can easily shape his interpretation from his past experiences and biased reasoning, even unconsciously. In addition, he might influence the data collection, for example, through the projects and participants he chooses and the questions he asks during the interviews. Since the research aims for understanding, it is important to incorporate all views, whether they correspond with the view of the researcher or not. New or opposite insights might complicate the research but will, above all, enrich it. This raises ethical issues such as bias, validity and the reliability of the research. Acknowledgement of this risk is crucial for valid and reliable research results.

Reflexivity and transparency are essential for the constructivist researcher to overcome these risks (Mertens, 2019; Schwartz-Shea and Yanow, 2012). In the case of interpretive research, generated knowledge does not directly lead to generic knowledge (Ruijter, 2019). The researcher must be aware of a reflexive and transparent attitude, and alertness should prevail above ignoring opposite insights. The researcher should be able to reflect on the context and acknowledge his role in the interpretation. Furthermore, he must be transparent and alert when data analysis turns into interpretation, and his role and experiences start influencing the research. This is where his reflexivity starts. Transparency helps the researcher and the reader recognise this moment in the analysis. The effects of the researcher's role in this study will be further discussed in Section 10.4.3.

1.8 RESEARCH DEMARCATION

This study has a number of demarcations to manage the research scope. Firstly, the study considers civil engineering projects. Generally, "civil engineering" is defined as the design and construction works serving the public domain. The projects involved in the research mainly comprised infrastructure transportation and high-water protection works. Objects linked to these projects are bridges, tunnels, roads, railways, water systems and dykes. Characteristic of these projects is that they serve and affect a broad variety of stakeholders. This highly affects the projects but also limits generalisation.

Furthermore, the study is limited to the Dutch context. All projects studied were located in the Netherlands, and the interviewees were mainly involved in the Dutch civil engineering sector. As a result, the study results are determined by the Dutch culture, types of contracts and project characteristics. Chapter 9 discusses the consequences for the generalisation of the results and the conclusions.

Finally, the study only considered integrated contracts, which are generally used for large projects in the Dutch civil engineering sector. Although the integrated design process of integrated contracts does not basically differ from build-only contracts, the partial shift of the design scope and responsibilities from the owner to the contractor affects the design process. Section 2.10 discusses the consequences of the integrated contracts for the design process. The study considers both the owner's and the contractor's perspectives on performance.

1.9 DISSERTATION OUTLINE

In this chapter, the complexity of arriving at an integrated approach of the design process of civil engineering projects was described as a critical factor for performance. The unfamiliarity with the main drivers for integration was defined as the problem that initiated the main research question. Since this study uses the integrated design process as a perspective to evaluate projects, Chapter 2 delineates the general design process, institutes its characteristics and investigates its constituents and their interactions. In addition, the effects of the Dutch contracts, culture and project complexity of the design process are considered. Since the problem definition and the research question link the integrated design process to performance, a definition for performance used in this this study will also be determined.

Chapter 3 explores the relationship between the design process and performance and aims to identify the determining variables of the integrated design process that affect project performance. From this exploration, the project participants' competencies were confirmed as a dominant variable, and particularly empathy emerged as a variable that could affect performance through the integrated design process. Therefore, Chapter 4 deepens and reflects on these study results, further exploring the role of empathic abilities in projects and the pairing of problem and solution from a practical perspective. In Chapter 5, the concept of empathy is broadly elaborated on from a theoretical perspective and a proposition is defined. Chapters 3, 4 and 5 are mainly concerned with research subquestion 1, referring to investigating the main drivers for the integrated design process, see Table 1.1.

Chapter 6 comprises an initial exploration of the proposition, i.e. the interaction between empathy, the integrated design process and performance. Chapter 7 reflects on the results, elaborates on its practical implications and prepares further experimentation. Chapter 8 describes a broad experiment, testing the hypothesis concerning the relationship between empathic abilities and performance and how the variables interact. Then, Chapter 9 reflects on the outcomes of the extended experiment and defines the context for the study and its analysis. Finally, Chapter 10 transfers the results of the study to general knowledge. The overall research results will be discussed from a broader perspective, and its implications for future civil engineering projects will be contemplated. In addition, the validity and reliability of the study will be considered. Chapters 6, 7, 8, 9 and 10 test the hypothesis and mainly relate to subquestion 2, delving into how the empathic abilities interact with the integrated design and how the process could be adjusted to improve performance. This subquestion was refined, after establishing empathy as a hypothesised relevant variable for integration and performance. The studies' conclusions and recommendations are described in Chapter 11.

This dissertation is partly based on three papers that were produced with the help of others (see Chapters 3, 6 and 8). The author wrote all papers included in this dissertation. The (co)promotors had supervisory roles for the papers. Chapter 6 uses the results of a master study by Mrs. Batelaan, which was initiated and supervised by the researcher of this study. Mrs. Batelaan contributed to the paper of this chapter. Mrs. Sleeswijk-Visser also supervised this master study and the paper.

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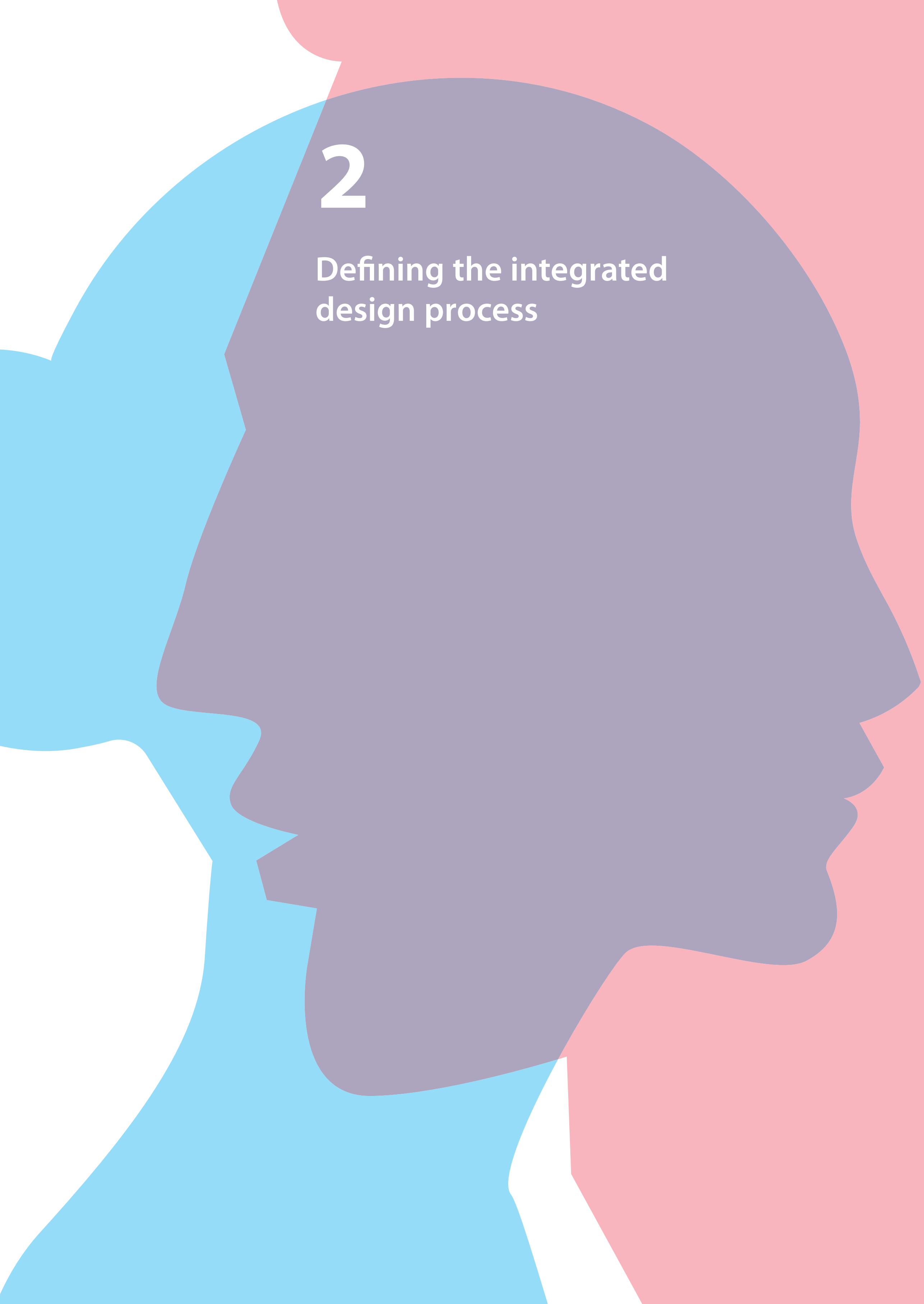

2

Defining the integrated design process

2.1 INTRODUCTION

This study uses the integrated design process as a perspective to evaluate civil engineering projects. Therefore, a thorough and explicit understanding of the design process is essential. Design as a process is a broad concept that can be defined in various ways. This chapter describes the interpretation of the design process used in this study. The analysis will focus on civil engineering practice based on general design process principles and today's practice. Additionally, since this study evaluates projects in the Netherlands, developments regarding design processes and project performance in the civil engineering industry are described from the Dutch perspective to account for the study's context and to be able to generalise the research results appropriately. While the research considers the interaction between the design process and project performance, this chapter also discusses and establishes the definition of performance used in this study.

2.2 THE BASIC DESIGN CYCLE

Design may be considered as a process and as a product. The design product is defined as the description of the artefact to be manufactured. In a civil engineering context, the artefact is usually a system, an assembly of different objects that perform the desired functions in their mutual coherence. The design process is the course of all actions contributing to the delivery of the description of the design product or system. A method is a specific, rational, general and observable way of working (Roozenburg and Eekels, 1995) and is as context-independent as possible. So, a design method is a generally defined way of working to arrive at the description of artefacts. In this study, the term process will be used for a generally accepted design method, in this case, in civil engineering.

A methodology is defined as the research of methods. A methodology describes (How does the process work?) and prescribes (How should the process work?). Extensive research has been conducted on design methodology since the 1960s (Visser, 2020). Simon (1996) describes a design process in general terms as the course of all actions '*aiming at changing existing situations into preferred ones*'. Voorendt (2017) adds the purpose of the design in his definition by defining the process as '*... creating an optimal plan or convention for realising an object or system that is required to satisfy a need*'. Zwart (2019) describes the challenge to adopt this need advocating that engineering design is closely related to psychological and social phenomena, as the final and ultimate goal of their endeavours is the production of artefacts that serve useful purposes in society without causing all sorts of collateral damage. Trustworthy knowledge about the use, role, reception and possible harm of these artefacts can only be acquired by systematic research into these psychological and social phenomena. He describes this process as '*the almost magical action of bridging the ontological and linguistic gap between the functional constraints of the design brief and the factual description of the artefact's blueprint*', adding the ontological and linguistic descriptive aspect of design. Another relevant aspect discussed by Luckman (1967) is the principle that '*some creativity or originality must enter into the process for it to be called design*', implying that a design process is conducted by human beings and always includes several possible solutions. The best possible solution cannot be automatically derived from a defined set of specifications. In general and to start, these perspectives define a design process as transforming an existing situation into a plan for a new one through creative acts of human beings and by acknowledging the social impact in order to satisfy a need. Although design processes have been approached from different perspectives, different methods have been developed and quite some debate on the usefulness of methods has been going on, there is a common denominator in design methods. For this study, the method presented by Roozenburg and Eekels (1995) will be used as a general starting point. The steps described in their method cover the various methods discussed in the literature. In addition, the method is recognisable in the civil engineering context, although the focus of the method was product design. Basically, four steps are distinguished in the design process as shown in Figure 2.1: Analyse, Synthesise, Simulate and Evaluate.

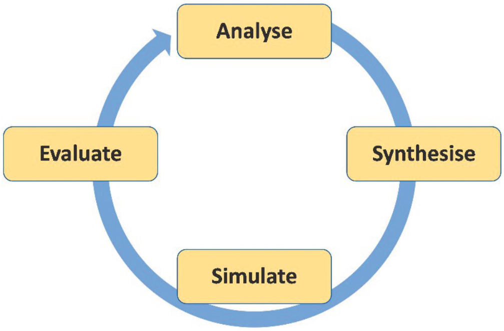

Figure 2.1: Basic design method, after Roozenburg and Eekels (1995).

Analyse

The analysis phase starts with analysing the design problem, which comprises understanding the values and needs related to the design problem. From values and needs, functions can be derived. The functions form the design process' foundation. However, they cannot be separated from their context, i.e. the values and needs. Subsequently, the specifications can be defined from the functions in this phase. Roozenburg and Eekels (1995) argue that these specifications cannot be unambiguously deduced from values, needs and functions since they are part of the designer's and stakeholder's perception of the problem and the goal. So, different specifications can be composed of a design problem, demonstrating the human interactive and social character of this part of the design process.

Synthesise

In the synthesis phase, driven by human creativity, a provisional design solution is transformed from ideas and composed of mutually related components. It can be considered the inductive part of the design concerning '*externalising and describing ideas*', often described as brainstorming and generating ideas. In contemporary civil engineering practice, trade-off matrices structure variant choices based on the values and needs defined in the analysis phase.

Simulate

The simulation phase is the deductive part of the design cycle. In this phase, the provisional design is tested. Using technological reasoning and experimentation, properties and behaviour are added to the design solution. Several design disciplines, such as product design and architecture, often use test models in this phase. The large-scale and expensive nature of civil engineering artefacts means that test models are usually not feasible. However, recent developments in the field of digitisation, such as 3D-, 4D-, 5D-modelling and virtual reality, have given an important impulse to the simulation phase.

Evaluate

Finally, an evaluation takes place to determine whether the design satisfies the requirements, the needs and values, and a decision has to be made on how the design process should continue. Today's civil engineering projects include extensive verification and validation procedures with the stakeholders to ensure that artefacts meet the values and needs. Permit procedures can also be considered part of this phase and are important to a civil engineering design process.

In the analysis phase, the design method starts with the determination of functions. Although this step is preceded by determining the values and needs, Roozenburg and Eekels (1995) consider these activities as not part of the design process and method itself. Since the values and needs are inextricably linked with the design process, this is debatable. This also applies to civil engineering projects while they influence the public domain. Societal values affect the design problem and solutions, which is becoming increasingly apparent with the introduction of functions resulting from sustainability, ecological or liveability values in civil engineering projects in the past decades. These values and related functions might compete with more traditional ones, such as mobility and economic growth. Compromising on these values, needs and design solutions is complicated, which will be further discussed.

Roozenburg and Eekels (1995) demonstrate the similarity of the design cycle with the classical empirical cycle: Observe, Induce, Deduce, and Test. Zwart and de Vries (2016) also stress the differences, mainly coming down to the fact that in contrast to the empirical circle, designs '*being functional and intentional objects for societal use, ... are inherently normative and value-laden*', whereas the empirical cycle results in '*true*' or '*false*' conclusions.

2.3 DESIGN PROCESS CHARACTERISTICS

2.3.1 Cognitive design aspects

The question arises as to whether a design method is effective and to what extent the design method presented is followed by the designers. Van Dooren *et al.* (2014) and Schön (1983) describe the design process as '*not split up in separate steps and actions but…an undivided whole with automatic, unconscious steps, actions based on common practice or routine, and moments of reflection and exploration*'. Designs are made by (teams of) human beings. Apart from the prescriptive design processes, design activities take place in the minds of humans. Roozenburg and Eekels (1995) depict a virtual design process encompassing the creation and imagination of several states of mental designs apart from the material reality. Participants of the design team virtually value these mental designs. As a result, given a team of several participants in civil engineering designs, such as the owner, the designers, the contractor and stakeholders, different expectations on the design outcome will affect the process. Cross (2001) reviewed studies on design cognition and found several mental mechanisms introducing deviations from the basic design cycle. Relevant phenomena indicated are: Design problems are ill-defined (see Section 2.3.2), Solution-led behaviour (jumping into solutions), Co-evolution of problem and solution, Fixation on existing solutions, Attachment to early solution concepts, Opportunistic behaviour, and Switching types of cognitive activity.

In particular, the co-evolution of problem definition and solution finding in creative processes is discussed in the literature and considered inevitable and valuable (Dorst and Cross, 2001; Smulders *et al*., 2008). Design involves a period of exploration in which problem and solution spaces evolve in parallel, contributing to better fulfilling the user's need. Since many actors participate in a design process, each making their virtual interpretation of the problem and the solution, the process becomes highly social. In this respect, the ethnographic studies of Bucciarelli (1988) are interesting. He described the design as a social process, not lawful, deterministic or causal in a mechanical sense and introduced the term '*Object worlds*,' meaning *'a world of technical specialisation, with its own dialect, system of symbols, metaphors and models, instruments and craft sensitivities'.* Design teams involve many actors having their own object worlds. Based on these different perceptions, a non-rational, partly unstructured social process of negotiation and agreements unrolls, where the different problem-solution spaces belonging to the different object worlds are, to some extent, mutually influential. The prescribed processes become overruled by human and subjective value judgements about goals and the bargaining powers of the participants in the design team (Archer, 1989).

A process appears which is highly dominated by human interaction. Smulders *et al.* (2008) describe this interaction as transferring factual knowledge of the solution and perceptual knowledge of the problem from the designing actor to the client and vice versa, factual knowledge of the problem and perceptual knowledge of the solution from the client to the designer. The actors should be concerned with acknowledging the existence of perceptual knowledge and decreasing it by explicating implicitly held knowledge, understanding and information to arrive at satisfying problem-solution pairs.

Although a structured process helps to order the design process, designers inevitably choose their own strategy and decide on how to follow the design cycle. Studies show that too rigid adherence to a structured process as well as very un-systematic approaches will result in poor solutions, advocating balancing between diverging and converging (Fricke, 1996). It can be concluded that although the basic design cycle shown in Figure 2.1 describes all necessary design steps in a logical way, the steps are not always followed subsequently or consciously. Steps can reinforce each other through mutual interaction. Sometimes, events can lead to the necessity of a step back. Therefore, the design method is an iterative process by nature. Wynn and Eckert (2017) distinguish two categories of iterations from a literature review study. First, they identified the progressive type of iterations. From new insights, the design progresses to a higher level, i.e. it better meets the values, needs or requirements. This type of iteration is considered inevitable and positively affects the design process results. The corrective type of iterations is related to complexity and does not necessarily contribute to a better product but reduces imperfections. This type of iterations is unplanned and negatively affects the process.

2.3.2 Ill-defined design problems

The first step of the design process, the analyse-phase, encompasses the definition of the design problem, resulting in a description of the functions and specifications, which is defined as '*a list of normative statements about the properties a new product should have, which sets limits to the solution space and indicates which solutions are the preferred ones*' (Roozenburg and Eekels, 1995). The design problem definition and the specification do not prescribe the solution but provide the designer with the criteria by which the value of the design product is to be judged.

Defining the design problem is a difficult activity. The description of design as the co-evolution of the problem and the solution implies that we cannot presuppose that there is something like a fixed design problem at any point early on in the creative design process, nor can we describe the design process as running from problem to solution (Smulders, 2008). Studies argue that design problems are ill-defined. Archer (1979) defines an ill-defined design problem as '*one in which the requirements do not contain sufficient information to arrive at a means of meeting these requirements simply by transforming, reducing, optimizing or superimposing the given information alone.*' He describes the interdependence and interactive process of emerging requirements and developing provisions, implying the impossibility of defining a fixed set of requirements at the start of the design process. From a study review, Cross (2001) concludes that '*In a design project it is often not at all clear what 'the problem' is; it may have been only loosely defined by the client, many constraints and criteria may be un-defined, and everyone involved in the project may know that goals may be re-defined during the project.*' In addition, he found that when the design goals and constraints are known, designers do not seem to consider them sacrosanct. Whelton and Ballard (2002) define the problem definition as a learning process aiming to match intentions and outcomes and include solution generation in the problem definition.

The already introduced cognitive co-evolution of the problem definition and solution finding is a consequence of ill-defined problems. From solution generation, new insights into the problem are gained and new specifications emerge, or previously defined specifications turn out to be conflicting or wrong. Apparently, humans cannot completely envision the implications of their demands and wishes in advance. Additionally, in the case of civil engineering projects, functions and specifications often originate from users and stakeholders unfamiliar with formulating smart and solution-free functions and requirements. These are often formulated based on mental solutions (Roozenburg and Eekels, 1995; Cross, 2001): a goal envisioned in human minds before a concrete solution is visualised. The designed solution based on these requirements might not correspond to the mental solution and not fulfil the expectations. This will result in a revision of the requirements or the provisional design.

Moreover, functions are considered to be normative. However, it is difficult to give objective normative meaning to several functions. For instance, esthetical or safety-related functions are hard to make objectively normative in civil engineering. In addition, functions that need to be mutually valued and rated remain '*essentially human and largely subjective*' (Archer, 1979). Finally, the gap between cognitive modelling and sketching on the one hand and the verbal system and notation on the other hand complicates design problem definition (Archer, 1979). As such, transferring design problems through scripts or even written contracts can be another source of misalignments between specifications and provisional solutions.

In conclusion, design problem definitions reveal themselves through partly non-normative, conflicting, unclear or mutually subjectively rated function descriptions and specifications, contributing to the iterative character of the design process. This phenomenon is inherently incorporated into the design process. Having established this, the inevitability of these design problem characteristics makes it arguable to denote the problem as "ill", given its negative connotation.

2.3.3 Interaction between the design process and project context

The complications in defining the design problem call for close interaction between the design process and the stakeholders involved in the needs and values that encompass the design assignment. As discussed in Chapter 1, Simon (1996) distinguishes an internal and an external environment. The internal environment can be considered the design process of the artefact itself (*'the substance')*, while the external environment comprises the environment in which the artefact operates. Kroes and Van de Poel (2009) interpret the term 'external environment' through the project '*context*'. The context of something is '*its environment, setting or background that contains all elements that are somehow relevant for the thing involved in the sense that they condition its being or occurrence*'. The term 'context' covers the entire set of aspects affecting the design process. The civil engineering projects' context is extensive given its public and large-scale nature. It comprises societal values, such as sustainability and economic or socio-economic values. On a lower level of abstract, the project context includes aspects such as the liveability and safety of individuals.

According to Simon (1996), the internal and external environment interact: '*The inner environment is appropriate to the outer environment and vice versa.*' Kroes and Van de Poel (2009) advocate that '*independent of whether technology is interpreted as a process or a product, … it is not possible to draw a demarcation line with technology on the one side and its social (intentional) context on the other*.' They consider social context '*definitive and constitutive for technology.*' Conversely, technology can move social context, which is most clearly demonstrated by the development of the internet in the 21st century. So, the design process is guided by context, but the design can also influence context. An example of the reciprocal effects of design and context in civil engineering is the construction of the Koning Willem-Alexander tunnel in Maastricht in the Netherlands, see Figure 2.2. Where real estate development initially launched the construction of the tunnel in the A2 highway, the liveability improved after the realisation of the tunnel, and, consequently, also the value of the existing real estate increased in a considerable radius around the tunnel (Schultink, 2017).

Figure 2.2: Urban development on top of the Willem Alexander tunnel in Maastricht, the Netherlands.

In a design process as a '*transformation process*', the context becomes a fluid, natural part of the iterative design process, see Figure 2.3. Through interaction between context and the design process outcomes, boundaries between internal and external environment or context fade. These are the participatory types of design processes, embracing context in the process. Kroes and Van de Poel (2009) distinguish reproductive processes on one side of the spectrum, where the context is input for an unidirectional process. On the other side of the spectrum, in transformative processes, the context is an inseparable part of the iterative process and the process outcomes. In civil engineering projects, we noticed the development from technocratic, reproductive processes towards more participatory processes in the past decades (see Section 2.10). A parallel can be drawn between the deterministic perspective (a reproduction process) and the complexity perspective (transformation process) of Hertogh and Westerveld (2010).

Zwart and Kroes (2015) show that the boundaries do play a role in design practices, although a distinction between the design process '*core*' and context is not possible. Designers tend not to own influences outside the technical core of the design brief, being the procedural context of the process and the substantive context of the design product. They prefer to remain aloof from the environmental context.

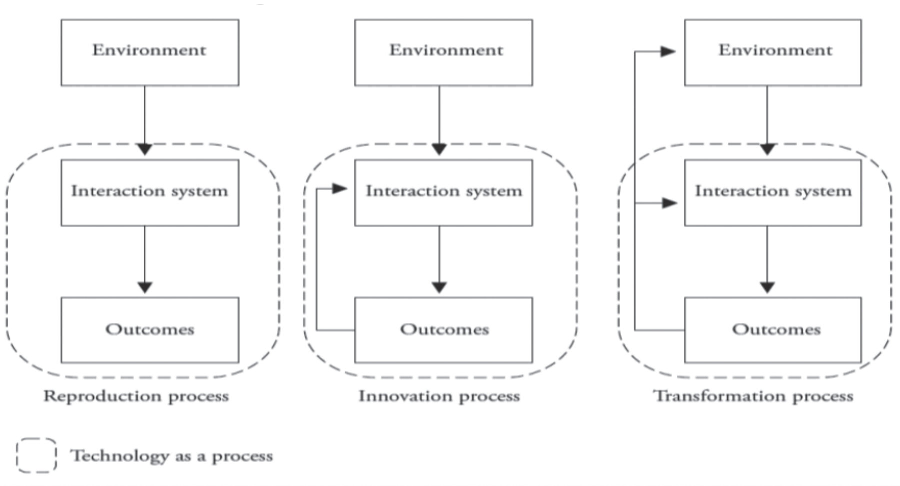

Figure 2.3: Types of technology processes and increasing inclusion of context (Source: Kroes and Van de Poel, 2009).

Values and needs are the basis for the design problem (Roozenburg and Eekels, 1995). These values and needs can be regarded as the context of the design process in terms of the definition defined by Kroes and Van de Poel (2009). Assuming an inseparable link between the design process and the context, adopting the context becomes a necessary step of a design method. The explicit incorporation of the context in the problem definition will bring values and needs closer to the iterative design process. The method shown in Figure 2.4 emerges. The cycle now shows the explicit inclusion of the ill-defined problem definition in the iterative process. If the context is influenced by the design process outcome (the artefact), the context will even become part of the iterative cycle and be affected by the design process and its outcome.

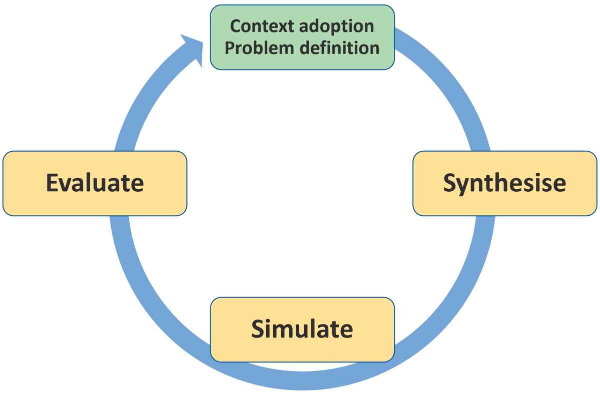

Figure 2.4: Design method explicitly incorporating context adoption in the design problem definition.

The Introduction chapter delineated the development of the increasing impact of context for civil engineering projects due to the growing need to include sustainability aspects, building in more urbanised areas, the rehabilitative nature of the design assignment and the increasing assertiveness of the stakeholders. Given the increasing impact of context in civil engineering projects over the past decades and the expected further increase in the future, the method shown in Figure 2.4 can be projected on today's civil engineering projects to anticipate the growing interwovenness between the design process and the project context. Alignment of the cognitive designs of the design process' participants, embracing the ill-defined design problem and the challenge of incorporating the project context into the process are represented in the green labelled analysis step of the design process.

2.4 VARIATIONS OF DESIGN METHODS AND CULTURE

The cognitive aspects, the issue of tackling an ill-defined design problem, and the fusion of the project context and the design process cause the design steps to intermingle in context-dependent design assignments. The design process no longer follows a logical order and becomes more reflective, as shown by Schön (1983). The design thinking approach from Rowe (1991) is an example of a method that makes the design problem definition more explicitly part of the iterative process. The same accounts for the double-diamond method, which places problem definition as equal to solution-finding to arrive at decision-making, with a similar approach of diverging and converging (Kochanowska *et al.,* 2021).

Architectural design schools embrace these design methods (Van Dooren *et al.*, 2014). They focus on context by questioning the framework or making the framework part of their assignment. Solutions evolve while determining the design problem. Architectural artefacts act in their (physical) context. The interaction with the context determines the artefact's experience and functions. Therefore, the focus on context and interweaving in the design process is self-evident in this discipline's culture. Civil engineering design processes do not have this tradition because the context used to be less dominant, which made this process more technocratic and technically driven and consequently more structured than the architecture processes. As discussed, these characteristics are changing due to the increasing impact of the context of civil engineering projects.

Technical installations became more integrated into civil engineering systems. These installation systems are characterised by compositions of (mainly) off-the-shelf products. Where civil and architectural design processes result in descriptions of objects or products, the installation design results in more functional descriptions, specifications for product purchase and software development. Although basically the same steps of the design cycle are followed, compared to civil engineering design, the technical installation discipline's culture puts more emphasis on function analysis and testing (simulation). This also causes a different interpretation of the design phasing, a different language and a different design planning compared to civil and architectural design processes, causing issues in integrated designs if they are not acknowledged.

The construction or manufacturing of the artefact is another aspect that can affect the design process. For instance, in mechanical engineering, manufacturing can seriously affect the design of the product and requires close attention. The method of Krooneburg and Siers (1992) explicitly includes a design phase for the determination of manufacturing aspects of the product. Although this is not yet common in the civil engineering design process, construction methods and phasing are increasingly impacting the design assignment given the development in which building in green fields is changing to reconstructing objects and systems that must remain in operation. The high demands on the availability of the systems result in additional requirements related to construction methods that affect the design outcome and that need to be implemented in the process.

2.5 A PHASED DESIGN PROCESS

When the scope of the design assignment increases, it becomes advisable to split the process into phases. The design cycle is then followed several times while the design evolves from coarse to fine. Zeiler (2019) considers subdividing the process necessary because it structures the process and breaks down the complexity into better manageable tasks. This can be considered a managerial interference; it makes the design process more controllable. At the phase transitions, explicit moments are introduced to verify the status of the design process. If the evaluation shows that the defined problem is not being solved as desired, timely action can be taken and the unnecessary spending of time and costs is prevented. Each design step starts with an analysis of the assignment and requirements for the upcoming phase, tuned to the level of the design development, and ends with an evaluation of the design results (a stage gate). The extent to which the results meet the prescribed requirements determines whether the next phase can start. So, the basic design cycle is repeated several times at increasing levels of detail.

Several methods of phasing have been developed. Figure 2.5 shows the method inspired by Pahl *et al.* (2007), which is also known in civil engineering projects.

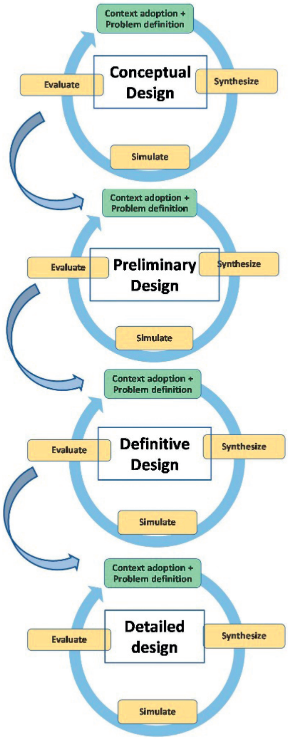

Figure 2.5: A phased design method, after Pahl *et al*. (2007).

2.6 THE DESIGN PROCESS OF A SYSTEM

Civil engineering projects and design assignments have become more complex over the past decades. The combination of functions introduced new disciplines and technologies that needed integration into the system. For example, today, mobility functions of infrastructural objects are combined with other functions such as ecological, water management, real estate and recreational functions.

So, today's civil engineering artefacts are not mono-functional products or objects but complex systems consisting of many objects that fulfil the system's functions in their mutual coherence. The literature indicates consensus on the view that project or design complexity is, by all means, determined by the number of elements or participants and the extent to which they interact (Vidal and Marle, 2008). Inferring their interaction is not a 'trivial' matter (Simon, 1996). Hertogh and Westerveld (2010) add the dynamic complexity perspective from the stakeholders for large infrastructure projects and conclude that complexity is mainly social, meaning that it is strongly related to the dynamics of the stakeholders' system. In line with this approach, Maier *et al.* (2016) state that design is complex and emphasises the non-rational interaction between the designer, user and artefact. Bosch-Rekveldt (2011) focuses on the concepts of uncertainty and risks related to complexity.

The design process of such a complex system requires structuring. Simon (1996) advocates a hierarchic, decomposed structure for complex systems: '*Decomposability also simplifies the description of complex systems and makes it easier to understand how the information needed for the development or reproduction of the system can be stored in a reasonable compass.*' Decomposing a system into sub-systems, elements and components introduces interfaces. The extent to which systems are decomposed (aiming for simplification) and the manageability of the interfaces introduced (causing complexity) must be balanced. Ideally, interfaces only occur between elements within the sub-system. However, in complex systems interfaces between elements of different sub-systems might also arise since pure decomposition is hard to achieve. The complexity of the process is increased by the different design approaches and cultures of the disciplines, as described in Section 2.4. Although civil engineering, technical installation and architectural disciplines have different processes and views on design (referring to the '*Object worlds*' introduced by Buciarelli (1988)), they have to manage an integrated process collaboratively given their interfaces (both physically and process-wise). Since components at the lowest design level might be connected to components and elements of any other sub-system, conducting the process of all sub-systems from coarse to fine at approximately the same pace is important.

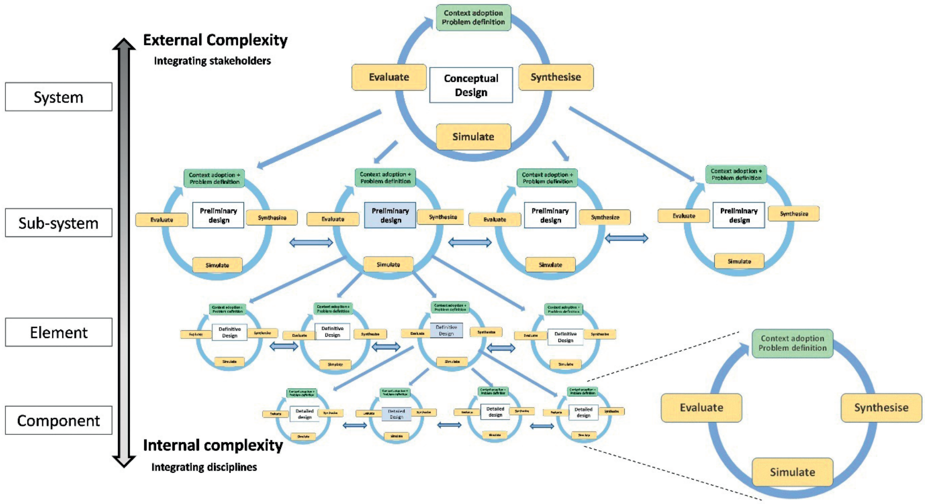

Figure 2.6: Phased design process of a complex system.

Adding the decomposition of complex systems to the design phasing shown in Figure 2.5, the process presented in Figure 2.6 evolves. The model indicates the classical design cycle at any level within any discipline or sub-system, element and component. The challenge of the cognitive design aspects of all participants, the ill-defined design problems and the adoption of the design problem context applies to any design cycle shown. Moreover, these iterative design cycles interact, indicating a process of exchanging information between the design teams of all decomposed sub-systems, elements and components. These teams are part of different organisations, such as the owner, the contractor, the designer and the sub-contractor. As such, the model reflects a challenging and complex network of exchanging and adopting the context, functions and specifications at the right time between all interrelated sub-systems, elements and components.

In civil engineering projects, the context at the system's level mainly refers to the stakeholders' interests and the integration of their values and needs into the process, the problem definition and the solution on the level of the concept design. At the component level, design problems and solutions will affect the stakeholders to a lesser extent. At this level, the design problem context mainly refers to the values and needs of the interacting disciplines and components. Integrating their mutual interfaces is crucial in the detailed design phases of the process.

2.7 INTEGRATED DESIGN PROCESSES

Section 1.4 described integration as critical in contemporary civil engineering projects and design processes. Observations from practice indicated integration as a key factor at the policy and the disciplinary level, and at any intermediate level. Integration reveals itself when aligning the parties' interests and processes at any project level. Projecting these observations on the delineated design methods, integration can be defined as adopting and including the project's context at the system level (referring to authorities policies and stakeholders affecting or affected by the project) and at the component level (referring to the disciplines). As such, the design method underlines the fundamental role of integration in the design processes of civil engineering projects. Integration is definitive for designing; designing is integrating. Therefore, this study uses the term integrated design process for the design method in civil engineering projects.

Stock and Burton (2011) consider integrated as a collective term for all kinds of interactive activities: multidisciplinary, interdisciplinary and transdisciplinary. Multidisciplinarity, being thematically organised, is considered the lowest level of integration, if there is integration at all. The next level, interdisciplinarity, '*bridges disciplinary viewpoints and potentially enables the examination of existing accumulated knowledge from the perspective of a neighbouring discipline*'. Given a design problem in an interdisciplinary setting, disciplines depend on each other and cannot solve the problem without exchanging information. Transdisciplinarity is considered the highest level of integration, not only integrating disciplines involved but also participants interests related to the project. This type of integration requires participatory approaches, involving all participants in the project and balancing their interests in the solution. All participants become part of the process. Incose (2015) states that '*a transdisciplinary approach is needed when the problem cannot readily be "solved" and the best that can likely be achieved is a "resolution" instead.*' Such an approach needs participants to '*transcend*' their disciplinary approaches to arrive at a synergistic understanding that the disciplines cannot independently achieve. As discussed in Section 2.3, Kroes and Van de Poel (2009) interpret this process as transformative, the highest level of a technological process, where context is merged in the design process. Dorst (1997) interprets designing in an integrated matter '… *as building up a network of decisions concerning a topic (problem or solution) while taking account of different contexts*…'. This implies the possibility of looking at the problem and the solution in an integrated way.

The integrated design process described in this study (Figure 2.6) reasons from these transdisciplinary or transformative approaches (Stock and Burton, 2011; Kroes and Van de Poel, 2009; Incose, 2015). That assumes the inclusion of context in the design processes and the co-evolution of problem and solution at all levels of the design process and with all system's components. Naturally, it is illusory to arrive at such a level of integration in the case of large civil engineering systems consisting of many sub-systems and elements and with many parties involved. Projects arrive at certain levels of integration but will never achieve the normative description of transformative integrated design contemplated in this chapter. Where the correlation between the integrated design process and project performance was established (Section 1.4), the design process' degree of integration achieved thus appears to be an important factor for project performance.

2.8 TERMS OF DEFINITION

This chapter described a general design process projected on civil engineering projects. This process can be characterised by complexity driven by (see Figure 2.6):

- Integration of stakeholders' context, since these projects are projected in the public domain and are concerned with societal values and needs.
- Integration of the disciplinary's context, since the artefacts consist of complex systems of many interacting elements, each having their disciplinary context.

Reasoning from this essence of designing and elaborating on the initial definition established in Section 2.2, the definition of the integrated design process used in this study is:

> *'The course of all human activities transforming an existing situation into a plan for a new one to satisfy a need, including and balancing the interests of all parties and disciplines involved'.*

This definition includes human activities related to the problem-solution co-evolution, which will be partly creative. The reference to 'the interests of all parties and disciplines involved' covers the integration of the context at the system and the component level. This also includes acknowledgement of social impact as put forward in Section 2.3 since parties involved in the project will insert societal aspects. The integrated design process, as defined in this study, covers the project phase that starts with the inception (the Statement of Need or the Functional Brief as described by Love *et al.* (2015)) and ends with the delivery of the design product, i.e. the description of the system to be built.

The analysis in the previous sections outlines a design process of civil engineering projects as a partly rational, dynamic, limited structured and format-free process aimed at achieving the best possible compromise between an ill-defined design problem and the solution space. Moreover, the process involves many interacting sub-systems, elements and components, each subjected to different disciplinary perspectives and individual cognitive perceptions. A network of interconnected, iterative design cycles emerges. This human and dynamic nature of the process implies limited predictability and rationality. Meanwhile, civil engineering projects strive for manageability and predictability. When the important role of the integrated design process for project performance has been recognised, the tension between design and performance and the struggle to control the design process becomes apparent. This interaction is the topic of this study.

2.9 INTEGRATED DESIGN IN CIVIL ENGINEERING PROJECTS

How can the integrated design process be projected on contemporary civil engineering projects? The integration practice and challenges of a typical Dutch infrastructure design process including the relationship with performance are elaborated hereafter.

A road system of several kilometres, typically including sub-systems, such as a road, several bridges, a tunnel, a water management system and ecological objects, is a typical infrastructure civil engineering system, see Figure 2.7. Usually, the motivations for these projects are traffic congestion, road safety issues and liveability for the environment, which also induce the main system functions. For a national highway system, regional and local policies and strategies need alignment here, when interfaces or opportunities with local urban development, economic development and traffic planning arise. The same accounts for water management planning, given today's attention to adapting the effects of climate change. The authorities (possibly) involved in the project must align their processes, integrate their interests, optimise the project's goals and define the system's boundaries and functions.

Meanwhile, the stakeholders, i.e. all parties that affect or are affected by the project, need to be involved since their input can highly affect the system's functions and requirements, and their support is crucial. Possible stakeholders are, apart from the initiating authorities, politics, local residents, interest groups, asset management authorities and approving authorities associated with permits. Based on the systems functions, requirements development starts with the stakeholders, following the V-model and the systems engineering approach. The co-evolution of problem and solutions develops, since the inclusion of the requirements and wishes from the stakeholders and their imagination mutually influence each other. Participation of the stakeholders in the process is crucial (and legally required) and ends with a provisional set of specifications for the conceptual design.

Figure 2.7: A Typical infrastructure system, Junction Princeville, The Netherlands.

The design process continues by increasing the level of detail of the specifications and the design objects. Sub-systems, elements and components gradually develop by running through the design cycles of analysing, generating, simulating and evaluating. Since determining objects and specifications continuously requires compromising, involving the stakeholders remains crucial during the process. While most of the large infrastructure projects in the Netherlands are tendered via integrated contracts, somewhere in this process, the responsibilities for the design process are divided between the owner and the contractor. Usually, and simply put, the contractor becomes responsible for the preliminary or final design, while the owner remains, at least partly, responsible for the stakeholders and requirements. The specifications get a contractual status, and their interpretation becomes a precarious design activity. Referring to the cognitive aspects of designing (Section 2.3), misinterpretations of design specifications can easily occur, and now introduce contractual discussions on scope and budget and possibly issues with the stakeholders. Moreover, the stakeholders' wishes and requirements develop over time, causing scope changes. Given the long lead time of civil engineering projects, this is a common phenomenon.

As the design process evolves, the integration focus shifts from the stakeholders to the disciplines. As the number of components introduced in the design process grows, the number of disciplines and their mutual interfaces also increase. The road system interacts with the bridges, tunnel, water management system and traffic installations. Within the road system, there are numerous elements, such as the asphalt structure, its foundation, the cables and ducts, the guide rail, the road marking, the signage and the lighting. Often, a different designing subcontractor or supplier is associated with each element. Consequently, numerous parties appear in the design process, each with their own interests and processes. Since they share several physical and process interfaces, integration into a common process is essential. Although the focus during the final and detailed design phase might be on the integration of the disciplines, coordination and validation of the design solutions with the stakeholders remains a significant challenge.

As described in the example, several project failures can be attributed to performance issues in the integrated design process. Issues related to the integration of the stakeholders' interests (mainly in the owners' domain) and the disciplines' interests (mainly in the contractors' domain in the case of integrated contracts) are distinguished. The possible issues are not limited to the list below.

Issues related to integration of stakeholders' interests:

- Scope changes: a lack of proper integration of the stakeholders' interests or developing stakeholders' requirements over time hinder the validation of the design late in the process. Design changes need to be made, resulting in additional design costs, possibly additional scope and associated costs, delays, and unsatisfied stakeholders.
- Delays in permit procedures: a lack of coordination with the requirements from permit authorities introduces rejection of permit applications, resulting in delays, possible design changes, and extra costs.
- Discussions with stakeholders: inappropriate integration of the stakeholders' interests results in incomplete sets of specifications, imperfect specifications, incorrect translations of wishes into written specifications or misinterpretations of specifications. These are common problems within design processes and are partly inherent to the design process. Consequently, design changes need to be made resulting in delays, extra scope, budget overruns and possibly unsatisfied stakeholders.

Issues related to integration of disciplines' interests:

- Lack of constructability: a lack of integration between the interests of design and construction departments and its subcontractors frequently results in a design solution lacking constructability. This introduces safety issues, redesigns, delays and possibly cost overruns if provisions must be made to account for a constructable design.
- Interface issues with subcontractors and suppliers: more broadly, lack of integration of interests of (designing) subcontractors or coordination of interfaces results in redesigns, delays and unforeseen costs on the side of the contractor or the subcontractors.
- Budget overruns of staffing; underestimation of the efforts needed to manage interfaces and to integrate the numerous interests of the disciplines frequently introduces budget overruns and delays on the side of the contractor.

2.10 THE DUTCH CONTEXT

2.10.1 Introduction

This study was conducted in the Netherlands. The data collected through interviews and case studies concerned participants and projects from the Dutch civil engineering industry. Therefore, it is important to delineate the Dutch context. The research data and results have to be considered within the types of contract, the prevailing culture of collaboration between parties and the current way of working In the Netherlands. Furthermore, acknowledgement of the context is necessary when generalising the research results. Three topics are elaborated in this respect, i.e. the development from construct-only to integrated contracts, the Dutch culture and the increasing complexity of the design assignment. The analysis is based on the literature, explorative interviews as further detailed in Chapter 3 and own observations.

2.10.2 From construct-only to integrated contracts

Construct-only contracts concern the construction of an asset managed, designed and maintained by the owner. Integrated contracts are defined by the integration of more than one project phase in one contract (Lenferink *et al.*, 2013; Regan *et al*., 2015; Alleman *et al*., 2017*)*. This often concerns the integration of the design and construction scope in the case of civil engineering projects. In addition, integration of the maintenance, finance and operational scope of projects occurs. There are several reasons for owners to consider integrated contracts. First, the neo-liberalism governmental paradigm advocated the mobilisation of private market expertise and competition to create more innovative design and construction outcomes based on functional specifications (Regan *et al*., 2015). Furthermore, the integration of project stages (design, construction and potentially maintenance and finance) leads to more sustainable infrastructure development because of the life cycle optimisation incentives (Lenferink *et al*., 2013). Finally, the perception and intention can be that outsourcing the design (and maintenance) scope and associated risks increases the manageability of the owner's budget and planning, given the growing project complexity (Regan *et al.*, 2015; Alleman *et al.*, 2017).

Focusing on design and construct contracts, the extent to which the design is elaborated at the owner's responsibility at the time of the contractor's bid can vary between a description of functions and a basic design. In the case of a functional description, the partial elaboration of the problem definition becomes part of the contractor's scope and includes the adoption of the project context, the inclusion of the stakeholders' interests and the definition of the project specifications. However, given the public environment of civil engineering projects, the owner cannot remain aloof from this scope. In the case of a fixed basic design of the owner, only the responsibility of the detailed design rests with the contractor. These contracts are often referred to as engineering and construct contracts. Many intermediate variants occur. In all cases, the partial shift of the design scope and responsibility from the owner to the contractor is characteristic of design and construct contracts. This also includes a partial shift of design-related risks, such as timely granting of the permits, stakeholders' satisfaction and dealing with incomplete information for the design. The implications of the introduction of design and construct contracts within the theory of the integrated design processes are visualised in Figure 2.8. The figure visualises the process of the integrated design as a typical design cycle comprising the problem definition, synthesising a provisional solution, simulating, and evaluating whether the chosen solution meets the specifications. The red bar indicates the contractual split of the design-related responsibilities between the owner and the contractor. In the case of construct-only contracts, the design scope and responsibility rest with the owner. Usually, only minor detailed design activities are the contractor's responsibility and do not affect the problem definition, the chosen design solutions or the evaluation. In the case of integrated contracts combining design and construct, a substantial part of the design responsibility rests with the contractor. When the design problem is functionally defined by the owner to provide optimum possibilities to include the private market expertise and creativity, these responsibilities can comprise partially defining the design problem (i.e. the design specifications), generating solutions, simulating the best possible solution and evaluating whether this solution meets the owner's functional requirements through verification and validation.

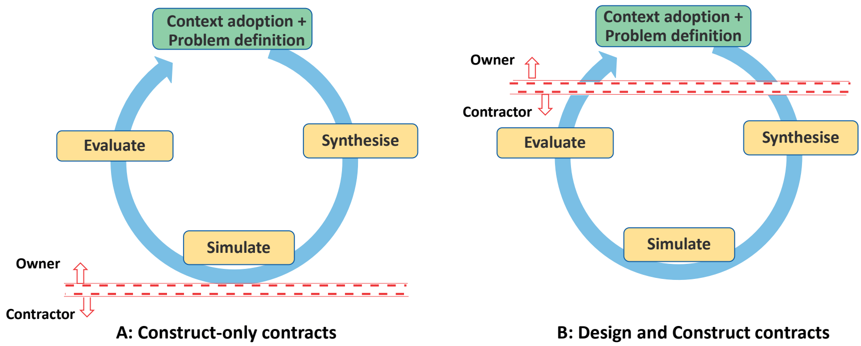

Figure 2.8: Implications of integrated contracts for the iterative integrated design.

At the system or sub-system levels, the iterative design cycle concerns the integration of the project context and the stakeholders' interests in the design problem definition, see Figure 2.6. It was concluded that this problem definition is an ill-defined problem, subjected to cognitive, individual perceptions and interpretations. Moreover, the problem definition co-evolves with solution finding. This co-evolution was defined as iterative, social, partly rational and complex given the interconnectedness between sub-systems, elements and components. Figure 2.8 indicates a contractual split across this iterative process, separating problem definition from the other design steps. Given that problem definitions evolve and change, and project context, functions and specifications will be imagined or interpreted differently by participants and parties involved, contractual issues related to scope, and consequently budget and time, can easily occur. The essence of a design process is iterative and only partly rational by nature, implying design changes and contractual changes in the case of design and construct contracts. The owner's and contractor's teams have to acknowledge this and deal with it to arrive at successful projects. This requires collaboration and efforts for mutual understanding of perceptions of the design problem and solutions. The essence of design and its effects on contracts and collaboration is only recognised to a limited extent in the civil engineering industry (own observation, based on involvement in many civil engineering projects and the associated disputes resulting the iterative design process). The same applies at the component level, where problem definitions of specific elements or components cannot be entirely settled in advance, possibly resulting in design changes for adjacent disciplines and failure costs. These disruptions and failure costs occur between disciplines of the same organisations but also between parties involved in the integrated design process, such as the contractor, sub-contractors and engineering parties.

The transition to integrated contracts in the Netherlands will be considered given the interaction between the integrated design process and integrated contracts. The origins of this transition lead us back to a major flood disaster in the middle of the 20th century.

In 1953, a storm surge caused 67 dyke breaches in the southwestern part of the Netherlands. As a result, 1863 people perished, 72,000 individuals had to be evacuated, and the economic losses amounted to 1.5 billion guilders (Voorendt, 2017). Immediately afterwards, the Ministry of Transport, Public Works and Water Management appointed the Delta Committee to advise the minister on measures to prevent future flood disasters. The committee's advice resulted in the well-known Dutch Delta Works, comprising 13 flood defences, such as barriers, dams and locks. The design and construction of the Delta Works between 1956 and 1997 contain some important moments regarding design and contracting.

At the time, construct-only contracts were the common way of contracting civil engineering projects. The designs were initiated, drafted and managed by governmental agencies. A prominent design authority was the 'Bouwdienst' of Rijkswaterstaat, the executive agency of the Ministry of Transport, Public Works and Water Management. Rijkswaterstaat was responsible for the entire design and supervision of the Dutch highway network and the sea flood protection and issued construct-only contracts for construction works. The same applied to railway, infrastructure and flood protection works on a more local level.

From 1956 on, the Delta Works were contracted in this way based on the designs of Rijkswaterstaat. This also included the closing of the Oosterschelde estuary. Rijkswaterstaat had designed a dam, a usual solution to prevent the land behind from flooding. The construction had already started in 1974. However, opposition from fishermen, shellfish farmers, sea yachtsmen and environmental organisations forced the government and Rijkswaterstaat to design a barrier with closable openings to preserve saltwater intrusion and tidal currents (Voorendt, 2017). Consequently, the Oosterschelde Barrier was designed and built between 1976 and 1986 and became an icon in Dutch civil engineering history. It was the first time that wishes from the environment were integrated into a design with major consequences for the design outcome. Although Rijkswaterstaat designed this barrier, the highly innovative character of the structure forced the designers to consult market parties to obtain all the necessary expertise. So, although the design responsibility remained with Rijkswaterstaat, it was the first time that market parties were involved in designing a large civil engineering project based on hiring expertise (Ruijter, 2019).

A tipping point regarding the collaboration between the government and the private market would be reached at the completion of the final part of the Delta Works, the Maeslantkering, see Figure 2.9. Influenced by the neo-liberal agenda of the 1980s and the wish to exploit the creativity and competition of the market, the Ministry of Transport, Public Works and Water Management decided to launch a competition for the design of a storm surge barrier in the busy Nieuwe Waterweg near the port of Rotterdam. The winner would be responsible for the design and construction of the barrier, based on highly functionally defined requirements of Rijkswaterstaat. During the design and construction phases, Rijkswaterstaat only had a supervising role. It was the first design and construct contract of any size (including five years of maintenance) in the Netherlands and, moreover, a highly innovative and large civil engineering project. The barrier was commissioned in 1997, marking the completion of the Delta Works. The project was considered successful, given the innovative solution and minimal budget overruns, despite the opposition of the Rijkswaterstaat organisation to the innovative type of contract and the unfamiliarity with the new division of roles between owner and contractor (Ruijter, 2019).

Figure 2.9: The Maeslantkering, The Netherlands; the first major civil engineering works contracted based on functional requirements (Source: Siebe Swart).

The design and construct contracting of the Maeslantkering was a major exception in the 1990s, particularly given the innovative character, the high level of functionality of the problem definition and the size of the project. The success of the project and the continuing focus on privatisation, outsourcing of public services and public budget cuts caused an upswing of integrated contracts from the late 1990s in the Netherlands (Lenferink *et al.*, 2013; Hertogh, 2013). The Betuweroute, a railway track for freight transport, was constructed between approximately 1995 and 2000 and was primarily contracted using integrated contracts (10 billion Dutch guilders (Algemene Rekenkamer, 2000)). The design specifications were yet rather detailed, leaving little room for design on the side of the private market. The civil works of the High-Speed Track Zuid (HSL-Zuid) between Schiphol Airport and the Belgium border were constructed between approximately 2000 and 2007 and were contracted via design and construct contracts, see Figure 2.10. The rail superstructure works also included the maintenance component. These contracts left more room for design optimisations of the owner's reference designs. Additionally, system engineering aspects, such as verification and validation, were introduced to demonstrate that the designs met the owner's specifications. The complete work reached 7,3 billion euros (Algemene Rekenkamer, 2014). Smaller-scale integrated contracts also started to emerge. Today, most civil engineering projects from national or provincial public agencies are contracted via integrated contracts (CROW, 2016).

Figure 2.10: High-Speed Track South (HSL-Zuid), Bridge crossing the Hollands Diep at Moerdijk, The Netherlands.

The growing deal flow of integrated contracts from the early 2000s onwards introduced issues resulting from the contractual split shown in Figure 2.8. These issues were mainly driven by different interpretations of the problem definition, i.e. the design specifications, by the stakeholders, the owners and the contractors. The contractor's design solutions based on his interpretations of the specifications frequently failed to match the expectations of the owner or the stakeholders, resulting in contractual discussions between parties. Furthermore, incomplete and incorrect information, such as information on utilities, soil and existing assets, caused conflicts. These disputes easily escalated (own experience in several projects in the past).

Fraud affair

In 2001, an extensive system of prohibited price agreements and mutual cost settlement in the Dutch construction sector came to light. This so-called 'Bouwfraude' was further exposed in a parliamentary inquiry in 2003. In a closed system and within a predictable lowest-price award process, the construction sector could apparently easily have maintained a risk reduction mechanism (Doree, 2004). As such, construction fraud could be seen both as a cause and a consequence of an imperfectly functioning market (Ruijter, 2019). The 'Bouwfraude' resulted in a loss of trust, estrangement between owners and contractors and a more business-like relationship based on transparency and accountability. Since the emerging design and construct contracts in particular required closer coordination and mutual understanding between owners and contractors, their removal was particularly counterproductive in the projects with integrated contracts.

A shift of design-related competencies
The essence of design and construct contracts is the partial shift of design scope and responsibilities from the owners to the contractors. This also implied a shift of design-related competencies from the owners to the contractors. These competencies included technological expertise and, moreover, knowledge of design processes, stakeholder management, permits, and understanding of its effects on construction risks, budgets and planning.

On the side of the owners (mainly public agencies), the reduction of the design competencies was driven by governmental budget cuts and the management's perception that the owner's efforts in the design could be minimal now that the design scope was mainly transferred to the contractor. The transition was managed top-down despite opposition from the organisations (Rijkswaterstaat, 2004, 2008). The attitude of limiting the owner's efforts to define the design specifications and verifying the design results at the end of the process was cynically referred to as the 'Bahama-model', where the owner had no active role in the process. However, Chapter 2 showed the important role of the owner in the iterative process of defining and evaluating the problem definition and the design solutions. This requires substantial effort and expertise. The lack of this expertise negatively affected the design process and the integrated contracts (own observation, based on involvement in many D&C-projects since 2000, lacking effective discussions on the design problem definition).

On the other hand, the development of the design-related expertise on the contractors' side developed slowly. Acknowledging the far-reaching effects of the design scope and design processes on the contractors' risks and performance was limited. Furthermore, incorporating a new discipline and its deviating culture in the contractors' organisations was challenging to achieve. The iterative design process was hard to grasp and embrace in organisations focusing on optimal linear processes. It was difficult for contractors, who preferred acting and doing, to collaborate with designers, who focused on contemplating and thinking (own observation, based on practicing in the design assignments and being employed at contracting companies).

The result was a design competency void both at the owners' and the contractors' organisation, caused by misunderstanding the essence of the design process and its impact and the project performance.

Design in a price-driven market
While the design scope and design-related risks transferred from the owner to the contractor, the construction sector was highly price-driven. Although owners started to include qualitative aspects in their tenders, such as minimising construction hindrance, optimising traffic flows during construction and process procedures (EIB, 2013), the lowest price remained decisive in awarding integrated contracts (EIB, 2015). Since design had become part of the contractor's scope, it could be a distinguishing aspect in price-driven tenders. Minimising quantities, developing innovative

solutions and sharply interpreting the design specifications of the contract could lower the bid price. As a result, the pressure on drafting challenging, innovative and competitive tender designs grew. After awarding the contract, often, not all assumptions could be fulfilled, negatively affecting the project results (Koenen, 2015). Additionally, the insight that the owners could not stabilise the problem definition introduced opportunistic mechanisms on the contractors' side during tenders and contractual changes after awarding the contract.

In the context of poor collaboration and distance between the owners and the contractors, a lack of design competencies and misunderstanding of the impact of design on project performance, and the creation of highly optimised and challenging tender designs in a price-driven market, the design process could easily negatively affect project performance when integrated contracts were introduced. Referring to costs and planning, several integrated contracts performed poorly both from the perspective of the owner and the contractor (Koenen, 2015; Cantarelli, 2013). This was exacerbated by the 2008 financial crisis, putting even more pressure on budgets. In the late 2000s, a flow of Design, Build, Finance and Maintenance (DBFM) projects was introduced, aiming for more cost control and better life cycle solutions. These contracts showed a nuanced picture. They performed on average slightly better than design and construct projects on the aspects of availability, cost control on the owners' side, time, process innovations and life cycle optimisations (Koppenjan *et al.*, 2020). On the other hand, the pressure on timely delivery (also introducing opportunistic behaviour in a price-driven competition) and lack of flexibility are considered detrimental. Moreover, the high risks and complexity of the large projects caused severe financial problems for several contractors, even threatening the continuity of several companies, resulting in DBFM contracts already being abandoned as a type of contract for new projects in the Dutch civil engineering market (FD, 2014).

Altogether, the introduction of integrated contracts delivered mixed results regarding project performance. On the one hand, there is a common belief that integrating the project phases aligns the interests of actors, stimulates integrated designs and seems a logical step towards sustainable performance in the lifecycle (Koppenjan *et al.*, 2019; Lenferink *et al.*, 2013; Eversdijk and Korsten, 2009). The explorative interviews of this study (Chapter 3) confirm the creation of more innovative solutions, particularly regarding construction methods, minimising hindrances and planning. On the other hand, the cost performance of several projects was inferior, both on the side of the owner and the contractor (Koenen, 2015).

The analysis shows the important effects of the introduction of integrated contracts in the Netherlands on the integrated design process and project performance. The transition had a rather top-down implementation, while organisations both on the side of the owner and the contractor had difficulties managing this considerable change for the participants involved in the integrated design. The toughness of the transition has been underestimated. In addition, misunderstanding of the essence of the integrated design process and lack of acknowledgement of the effects of the design process on performance introduced poor-performing projects. Understanding slowly grew that integrated contracts and the integrated design process require shared efforts of the owner and the contractor and that the design problem definition and the design process outcomes cannot be fully contractually settled. The rapid rise of 2-phase contracts in the civil engineering sector reflects this awareness. The cases investigated in this study were subjected to this context of a yet incomplete transition to recognition of the need for collaboration and clear division of roles in the integrated design process.

2.10.3 Culture

Every human group forms a culture, as does the Dutch civil engineering sector. Culture is defined as the shared and transferable perceptions, values or practices of the group (Hofstede, 2015). Kotter and Hesket (1992) distinguish culture into two levels; the deeper cultural level refers to shared values and tends to persist over time, whereas the more visible level represents the behavioural patterns and practices of the group, being less resistant to change. Cultures are stable, although not static, and hard to change purposely. It just seems to happen to groups (Hofstede, 2015; Kotter and Hesket, 1992).

Culture can be assigned to different group configurations. Here, the civil engineering sector in the Netherlands is considered. While the Dutch civil engineering culture is influenced by its national culture, the sector also influences the culture at the project level. However, different nuances in project cultures and between parties, such as the owner and the contractor, can be observed (see Section 10.2.1).

Based on Hofstede's model of five cultural dimensions at the societal level (Hofstede, 2001), Hofstede *et al.* (2010) described an agent-based model for bargaining in the context of trade. The Dutch and Anglo-Saxon cultures of bargaining are considered very similar in three dimensions, i.e. tending to individualism (instead of collectivism), small power and equality (instead of large power), and uncertainty tolerance (instead of uncertainty avoidance). However, contrary to the Anglo-Saxon, Dutch culture is feminine (instead of masculine) and long-term (instead of short-term) oriented. This is reflected in an attitude of valuing quality above quantity, intention above result, a broader focus on the future above a momentary snapshot and context-sensitivity (Hofstede, 2015; Hofstede *et al*., 2010). In line with this, the Dutch prefer trust over certified quality and third-party testing (Meyer *et al*., 2006).

A feminine culture focuses on collaboration and prioritises the relationship with the partner and building trust. The relationship has a long-term focus since it might pay off in the future. Negotiations are considered a small step in a long process (Hofstede *et al*., 2010). Furthermore, Dutch leadership is characterised as transformational. Transformational leaders motivate their followers by inspiring them, offering challenges, and encouraging individual development. They focus on relationships, common ground, shared values and ideas, and greater meaning to activities (Ozorovskaja *et al*., 2007). Contrary to transactional leaders, they are less concerned with the role and task requirements of employees and structure.

In this culture, the fraud affair, as described in Section 2.10.2, was exposed in 2002. The sector was confronted with a lack of mutual trust between the government and the private market and confusion about the culture on which the contracts and collaboration should be based (Veenswijk *et al.*, 2010). The emergence of several initiatives and task forces to restore mutual trust, such as the Regieraad Bouw, PSI Bouw and PIB (Veenswijk *et al*., 2010), demonstrates the efforts the sector made to restore trust between parties and is a reflection of the high value Dutch culture attaches to collaboration and relationships. The collision of Anglo-Saxon and Rhineland cultures sparked the development of an institutional bricolage (Koppenjan and De Jong, 2017). Collaboration, trust and relationships have been main topics on projects over the past decades and have often been indicated as important success factors for Dutch civil engineering projects (Van Marrewijk *et al.*, 2008). This culture, the institutional bricolage and the search for new concepts of contract and collaborations was this study's setting.

2.10.4 Increasing complexity

Chapter 1 described the development of the growing complexity of civil engineering projects. While the integrated contracts developed between 2000 and 2020, in the Netherlands, civil engineering projects were also subjected to this increasing complexity. On the system level, the increasing need for mobility (KIM, 2021) and the migration towards the urban regions (PBL, CBS, 2019) introduced projects in more densely populated areas. The resulting necessary combination of functions and accompanying complexity is already visible in projects such as Zuidasdok in Amsterdam, the Koning Willem-Alexander Tunnel in Maastricht and the Gaasperdammertunnel in Amsterdam (DIMI, BNA, 2017). An integrated mobility analysis (Ministry of Infrastructure and Water Management, 2021) delineates the challenges of accommodating future traffic in the cities and the metropolitan areas in the centre of the Netherlands, resulting in further infrastructure infill, see Figure 2.11. Sustainability challenges (Delta Programme, 2015) and social inequality aspects (RLI, 2018) also apply to Dutch projects. Climate adaptation and mitigation in particular are crucial in the Dutch delta, where developments such as rising sea level, drought, heavy rainfall, salinisation and soil subsidence threaten liveability. Finally, the rehabilitation assignment of civil engineering systems built in the post-war period is current and complicates projects (Bleijenberg, 2021).

Figure 2.11: Urban densification by buildings crossing the A12 highway in The Hague, The Netherlands.

On the component level, disciplinary complexity increased through the growing size of projects (more elements and components) and the introduction of new disciplines. The introduction of integrated contracts in infrastructure projects coincided with the combination of civil and roadway works in the early 2000s. The construction of several tunnels in the 2000s and the growing demands on the availability of the infrastructure systems caused close attention to the installation works. Since these works were highly interdisciplinary in themselves and interacted with the civil works and several stakeholders, this discipline became dominant in infrastructure projects (Hertogh *et al.*, 2015; 2017). Furthermore, the inclusion of ecological aspects is increasing in today's projects.

2.10.5 Conclusion

This research was conducted in the context delineated in this section: a culture of valuing collaboration and relationships, an as yet undetailed transition towards integrated contracts, a variety of types of contracts affecting collaboration between parties during the integrated design process, and organisations having difficulties adapting top-down imposed changes. Additionally, parties are facing an increasing complexity of the design assignment. This was the starting point to investigate the effects of the integrated design process on the performance of civil engineering projects.

2.11 THE DEFINITION OF PERFORMANCE

Performance is the dependent variable of this study. Therefore, a proper definition of performance is also required. This research investigates the variables that affect the integration of the design process. Therefore, the project performance and the performance of the integrated design process are distinguished. In the next sections, performance and performance criteria are defined. Chapters 3, 6, and 8 will further elaborate on the performance criteria.

2.11.1 Project performance

Generally, performance is defined as the extent to which predefined project goals are met. From a literature study, Silva *et al.* (2016) concluded that project performance can be defined as '*The perceived degree of achievement of predetermined performance objectives and participants' expectations of the execution of a construction facility or a service*'. The indication '*perceived*' refers to the project participants' perceptions of the extent to which goals or objectives are met. Baker *et al*. (2008) suggest that there is no such thing as absolute success in a project, and there is only perceived success. This implies that participants have different, partly subjective, perceptions of performance.

This study focuses on the owner and the contractor as the main actors in a project. Additionally, the stakeholders are considered crucial actors in a project, referring to (but not limited to) the users of the civil engineering artefact and the people affected by or benefitting from a civil engineering system or service (or their representative organisations). Obviously, the owner, the contractor and the stakeholders might have contrary interests and different perceptions of performance given their different organisational purposes, missions and roles in the project. Shared project objectives are often compromised. Moreover, it is difficult to assign objective meaning to goals, such as stakeholders' satisfaction, nature development, economic development and design quality. Consequently, performance, i.e. the extent to which the success criteria are met, can be judged differently, making performance a complex concept.

Various success criteria can be attributed to projects. These criteria can be categorised as per result area, time frame (short, medium and long-term goals) or actor (owner, contractor, client/ stakeholder) (Koops, 2016; Westerveld, 2003). A dominant category of short-term success criteria is the area of project management, which traditionally includes the budget, time, and quality success criteria. Although subjected to discussions on objective references in time, the project actors' perception of performance is highly affected by the budget and time success criterion. The quality criterion refers to the extent to which project requirements and specifications are met. Health and safety during construction and the total project life cycle are other short-term, project-related success criteria that have gained significant attention over the past decades in the civil engineering construction industry (Silva *et al*., 2019).

The development of building in urbanised and densely populated areas introduced the satisfaction of the stakeholders as a crucial success criterion. This development was accelerated by a growing assertiveness of the stakeholders and tools to easily and immediately influence opinions regarding the project's satisfaction (social media). As discussed, the stakeholders of civil engineering projects come in several guises. Focusing on the stakeholders outside the owners' and contractors' organisations, the users of the artefact (e.g. infrastructure systems), local residents affected by the project, residents benefitting from the artefact (e.g. a high water protection), interest groups and approving or permit issuing authorities can be distinguished. Given the sustainability challenges, today, even non-human stakeholders, such as nature and "Mother Earth", are considered stakeholders. Referring to the owners' and contractors' organisations, sponsors, public authorities, politicians and private shareholders can also be indicated as stakeholders relevant to the project. This study will focus on the satisfaction of the stakeholders outside the organisations of the owner and the contractor.

Success criteria that refer to long-term objectives transcending the limits of the project are satisfaction and personal development of the project participants, the achievements of learning objectives in project programs, the development of technology, and the reputation, market share or competitive advantage of a private party. Although human-related aspects, such as collaboration and communication, are often identified as a success criterion in itself, in this study they are considered success factors, i.e. means to arrive at success, rather than success criteria.

This study adopted the success criteria commonly used in contemporary Dutch civil engineering projects. First, the iron triangle criteria, costs, time and quality are considered the main drivers for project success. Next, stakeholders' satisfaction was chosen as a critical success criterion, given the major impact the stakeholders have on project success. Finally, safety is now widely accepted as crucial for project success. These criteria (costs, time, quality, safety and stakeholders' satisfaction) correspond to the EMAT criteria (Economically Most Advantages Tender) that dominate today's tenders in the Netherlands (EIB, 2013, 2015). The owners' policy and strategy are reflected in these criteria. Besides the budget and time criterion, most EMAT tenders include criteria relating to the availability of the system and hindrance to the environment, referring to stakeholders' satisfaction. Other often appearing criteria relate to the functionality of the system, referring to the quality and stakeholders' satisfaction criteria, and risk management, referring to managing the costs and time criteria. Today, the importance of sustainability for project success is rapidly growing. Since this criterion was hardly an issue during data collection of this study (2019 – 2022), the sustainability criterion was not included in this research.

While performance is shaped by the perception of humans, in this study, performance is mainly based on data derived from interviews rather than documentation. More precisely, since the interviews were mainly conducted with the project managers, technical managers and contract managers of the projects, the performance perception is framed by the management of the project. This also accounts for the stakeholders' satisfaction criterion, which was assessed by the owners' and contractors' interviewees. This is considered a limitation of the study.

In the explorative part, the study investigated the satisfaction of the participants with performance related to the chosen success criteria (see Table 1.1). This type of investigation meets the explorative and qualitative character of this stage of the research. In the explanatory part, the mixed method research implied a quantitative (survey) and a qualitative (interviews) investigation of the performance. The success criteria were made as objectively assessable as possible. Nevertheless, the assessments of the success criteria remained subject to the subjective interpretation (perception) of the project participants to some extent. The interviewees were influenced by their role in the project and their organisational background and culture. Moreover, consciously or unconsciously, they include factors outside their sphere of influence differently and chose different references in time related to the cost and time criteria. These personal perceptions and interpretations emphasise the qualitative character of determining performance and the research, also considering the limited number of cases investigated.

2.11.2 The performance of the integrated design process

The study investigates the success factors affecting the performance of the integrated design process. Consequently, also a definition of the success criteria of the integrated design process is needed. The considerations on performance and perceptions made for project performance are also applicable to the performance of the integrated design process. Thus, the performance of the integrated design process is related to the extent to which predefined goals are met and, in the case of this study, based on the perceptions and interpretations of the projects' management.

The literature does not provide guidance on the success criteria of the integrated design process. Based on the analysis of the integrated design process in this chapter, the process is successful if the context and associated requirements and specifications are adequately adopted in the design process and the design solution. Thus, the success criteria can be related to the design process and the design solution, referring to context integration. This accounts for the stakeholders' context and the disciplines' context. Furthermore, the design process serves the project and its objectives and is not an end in itself. Therefore, the success criteria of the design process must be related to the project objectives and success criteria.

Process related criteria

The analysis of the integrated design process demonstrated the difficulty of adopting the context and the translation into a set of requirements, resulting in the iterative and unpredictable nature of designing. Where iterations related to progressive optimisations of the design solutions are considered inevitable and positively affecting performance, iterations are also introduced by imperfections that negatively affect performance (Wynn and Eckert, 2017). The latter are introduced by incomplete or misinterpretations of specifications on the stakeholders and discipline level or deficiencies in interface management between disciplines. These iterations are considered evitable disruptions, causing design changes and associated re-engineering efforts, indicating poor performance of the process and negatively affecting project performance.

Based on own observations and experiences from practice, the design process of civil engineering projects is seriously subject to evitable disruptions and iterations resulting from imperfections in the design process. The re-engineering efforts resulting from these iterations cause unforeseen overruns of costs budgeted for the integrated design process and delays for the project. So, the success criteria cost and time budgeted for the integrated design process are indicators and success criteria for the design process. Costs and time overruns of the design process directly affect the project success criteria cost and time, where time overruns of the design process usually have the most significant negative leverage on the project success criteria (since the costs of the design process are usually a relatively small part of the project costs).

Next, minimising the number of evitable disruptions of the design process is an important objective for the design process and the project. Following the difference in levels of abstraction made in this chapter, success criteria for the disruptions from integrating the stakeholders' context and the disciplines' context are applicable. The number of disruptions indicates the accuracy by which the project context and the disciplines' context are adopted in the design process. Disruptions introduce budget overruns and time delays for the design process and the project. Moreover, they introduce discussions with stakeholders and between disciplines, possibly affecting the stakeholders' satisfaction.

Product related criteria

Finally, the quality of the design product, being the result of the design process, is considered a crucial success factor for projects and, consequently, a success criterion for the design process. Again, a difference is made between the quality at the stakeholders' level and at the disciplines' level. At the stakeholders' level, the quality of the product refers to the extent to which the stakeholders' context is integrated into the design product. This will relate to the stakeholders' satisfaction of the project. At the disciplines' level, the quality of the product refers to the extent to which the disciplinary context is integrated into the integrated design product. This success criterion relates to failure costs, budget overruns, time delays during construction, and safety and quality issues of the project.

In summary, the performance of the integrated design process in this study is defined as the project participants' perception to which extent the goals related to 1) cost and 2) time (related to the integrated design process), the number of disruptions related to the 3) integration of stakeholders' context and 4) disciplines context, and the quality of the design product related to the integration of 5) the stakeholders' context and 6) the disciplines' context are met.

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BROOKLYN

3

An exploration of the dominant variables of the integrated design process affecting performance

This chapter reflects a manuscript published in the *Journal of Engineering, Design and Technology* titled "Improving the performance of civil engineering projects through the integrated design process", by Guus Keusters, Hans Bakker, Erik-Jan Houwing, 27 January 2022, Vol. 22 No. 2, pp. 344-364. https://doi.org/10.1108/JEDT-10-2021-0519

It comprises an exploration of the dominant variables affecting the integrated design process and performance, and refers to the problem-solution pairing step of the design inquiry presented in Section 1.7. Sections 3.2 through 3.4 describe abbreviated versions of the problem statement and the definitions of the integrated design process and performance used in this study. As such, these sections contain repetitions of topics discussed in Chapters 1 and 2. For the sake of completeness, these sections have been included in this dissertation anyway.

3.1 ABSTRACT

Purpose

Civil engineering projects around the world have been underperforming for a long time. While the complexity of these projects will continue to increase, there is an urgent need to perform better. Although the integrated design process is critical for project success, the literature lacks studies describing the link to project performance. Therefore, this study investigates the dominant variables that affect the integrated design process and consequently project performance.

Design/Methodology/Approach

A multiple case study was conducted to determine the dominant variables that affect the integrated design process and project performance. The research included four projects. Semi-structured interviews were the main source of data.

Findings

The cases indicated that the extent to which an integrated approach is achieved in the design process is essential for project performance. This applies to the integration of stakeholders' interests as well as the integration of disciplines. Above all, it was concluded that the project team participants' competencies for integration are a dominant factor for project performance, as the integrated design process has changed from a technical challenge to an integrative one.

Originality

This study provides insights into the dominant variable of the integrated design process that affects project performance, which is underexposed in the literature. The study results reveal the importance of competencies related to integration and adoption of the design problem context, which are not yet included in civil engineering design methods. In this respect, empathy is introduced as a new and critical competence for the civil engineering industry, which needs further research.

3.2 INTRODUCTION

The problem of underperforming civil engineering projects has been extensively studied, where performance is mainly defined as the extent to which goals are met, related to cost and time. Budgeted project costs show a substantial, average overrun (Flyvbjerg *et al*., 2013; Odeck, 2014; Locatelli *et al*., 2017). This is difficult to justify socially, since these projects are mainly publicly funded. The literature identifies many interrelated factors that affect project performance (Doloi, 2013; Moschouli *et al*., 2018; Shane *et al*., 2009). The front-end development phase or the preconstruction phase have been acknowledged as essential factors of the project life cycle (Gibson *et al*., 2006; Bosch-Rekveldt, 2011; Cantarelli *et al*., 2012). The design process is a substantial part of these phases, as it covers critical stages such as concept development, feasability and scope defintion (Bosch-Rekveldt, 2011; Turner, 2008; PMI, 2017). Additionally, the outcome of the design process defines the project scope, which in turn forms the basis for essential project processes, such as cost estimation, stakeholder management and risk management.

The integrated design process can be defined as the process that delivers the artefact's description and integrates the interests of all parties involved (Stock and Burton, 2011). This process is related to many variables affecting performance, such as stakeholder management, scope definition, contract changes and technical management. A network of inextricably linked variables affecting project performance appears (Love *et al*., 2016), of which the integrated design process is a relevant part. Therefore, the design process can provide a valuable perspective to evaluate and improve civil engineering projects. Observations from practice reinforce this assumption. Over the past decades, the integrated design process has been influenced by two important developments that affected projects: an increasing complexity of the design assignment and a transition to integrated contracts.

The design process is strongly affected by complexity (Benabdellah, 2020). While many aspects determining complexity emerge from research (Bosch-Rekveldt, 2011), it is commonly understood that the complexity of civil engineering projects is influenced by internal and external aspects anyway. Internal aspects are often defined as the number of elements and participants within the project system and the extent to which they interact (Simon, 1996; Vidal and Marle, 2008). External aspects refer to the project context (Vidal and Marle, 2008). In this respect, Hertogh and Westerveld (2010) and Maier and Fadel (2006) identify dynamic complexity of projects, which is mainly related to the dynamic and non-rational character of the stakeholders' behaviour. Both types of complexity apply to civil engineering projects and the integrated design process due to their interdisciplinary nature and significant environmental impact. Over the past decades, both types of complexity have increased, and this trend will inevitably continue.

First, civil engineering projects play a key role in anticipating climate change, especially in the urbanised deltas. Therefore, projects will have to accelerate climate adaptation and circularity and stimulate biodiversity (Global Centre of Adaptation, 2020; World Wide Fund, 2020). Second, the need for mobility and urbanisation will further increase (Eurostat, 2016). An increasing number of functions and disciplines will have to be integrated into the projects when urbanisation and mobility merge. Additionally, a growing number of stakeholders' interests need to be considered when building in more urbanised areas. Third, infrastructure objects built in the post-war period reach the end of their functional or technical lifespan. As a result, extensive rehabilitation is imminent (Lange, 2018). Rehabilitation projects are more complicated because transport systems have to remain in operation during reconstruction, considering the high demands on availability. Fourth, infrastructure systems have social and economic impacts, especially on disadvantaged groups, either intentional, or unintentional (Rodgers and O'Neil, 2012). The impact has both quantitative and qualitative appearances (Wilkinson, 2019). The inclusion of all of these aspects will further increase both internal and external complexity of the design assignment of civil engineering projects and consequently affect their performance.

Another development that has influenced the integrated design process and project performance over the past decades is the transition from construct-only contracts to integrated contracts (Regan *et al*., 2015; Alleman *et al*., 2017). The use of output specifications, and a partial shift of the design responsibility and risks from the owner to the contractor are characteristic aspects of integrated contracts. As a result of this transition, design competencies have slowly shifted from the owner to the contractor. Meanwhile, projects were still, at least partly, traditionally awarded based on competitive, low-bid contracting principles. Consequently, contractors were enticed into challenging and risky tender designs as design became a differentiator for winning lowest bid contracts (Alleman *et al*., 2017; Koppenjan *et al*., 2020). The convergence of these aspects might have affected design-related project failures over the past decades.

It is concluded that the integrated design process is an important part of a network of variables that affect civil engineering projects' performance and that the complexity of this process is growing. However, the body of literature on critical success factors for project performance lacks studies related to collaborative and integrated design processes (Koutsikouri *et al*., 2008). Thus, the question is how the integrated design process interacts with project performance and by extension how that process should be adjusted to improve the civil engineering industry's performance. This study aimed to identify the determining variables of the integrated design process that affect project performance.

Although the problem of poor-performing projects manifests itself globally, this paper focuses on the Dutch practice, where underperformance has also been identified (Cantarelli *et al*., 2012; Verweij *et al*., 2015). Recent examples of large projects with considerable cost and time overruns show the problem's topicality, such as the Sealock IJmuiden and the Zuidasdok in Amsterdam (Clahsen, 2019). Furthermore, since the Netherlands can be characterised as a densely populated delta, the development of increasing complexity is manifest (Delta Commissioner, 2014; KiM, 2020; Bleijenberg, 2021; RLI, 2020). To that can be added the transition of contracts (Koppenjan *et al*., 2020).

The study needs proper definitions of the integrated design process and project performance, which will be discussed in Sections 3.3 and 3.4. After this, the research method and the method of data analysis are described in Section 3.5. The study results, as discussed in Section 3.6, provide insights into the dominant variables affecting the performance of the civil engineering industry. The implications of the results for the industry are concluded in Section 3.7.

3.3 INTEGRATED DESIGN PROCESS

Design may be considered as a process or as a product. Design as a product is the description of the artefact to be manufactured. In a civil engineering context, the artefact usually is a system, being an assembly of different objects that perform the desired functions in their mutual coherence. Design as a process is the course of all actions that contribute to the delivery of the design product or system and has been subject to research since the '60s (Visser, 2020). In general terms, Simon (1996) describes the process as the course of actions aiming at changing existing situations into preferred ones. In this study, the process principles of Roozenburg and Eekels (1995) will be followed (see Figure 3.1). The application of these principles is common in the civil engineering industry (Visser, 2020). The four steps of the iterative design cycle are somehow recognisable in any design method: analysing and defining the design problem (*Analyse*), externalising and describing ideas (*Synthesise*), technological reasoning and testing (*Simulate*) and evaluating whether the solution meets the requirements and satisfies the needs (*Evaluate*).

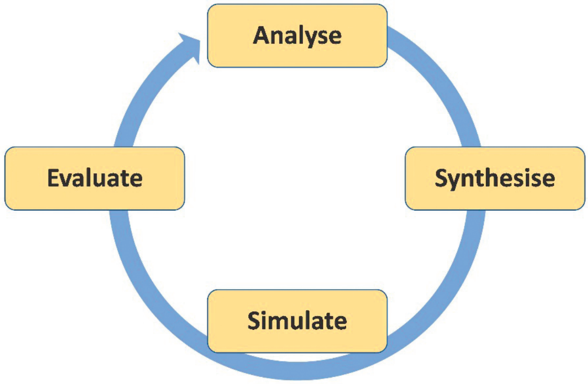

Figure 3.1: The basic design cycle, after Roozenburg and Eekels (1995).

Although the method seems to represent a logical set of sequential steps, this does not reflect a practical design process. Schön (1983) describes the design process as an '*undivided whole with automatic, unconscious steps, actions based on common practice or routine, and moments of reflection and exploration*.' Human and subjective value judgements and the creation and imagination of several mental design states dominate the process (Roozenburg and Eekels, 1995).

The problem definition in the analysing step initiates the non-sequential and iterative character of the process. Functions and requirements of the design problem are often formulated based on mental solutions (Roozenburg and Eekels, 1995; Cross, 2001); a goal envisioned in human minds before a concrete solution has been visualised. However, problem definitions based on mental solutions will not automatically induce the desired artefact, resulting in adapting the requirements or the solution. A co-evolution of problem definition and solution-finding, and an iterative process result. Moreover, design problems are ill-defined or even wicked, implying that they cannot prescribe the end or goal due to unknowns anyhow. Problem definitions are a function of the complexity of project context variables and associated stakeholder needs and values (Whelton and Ballard, 2002). Drost (2019) argues that the increased complexity of the problem definition, combined with the solution space, has led to the achievement of human cognitive capacities to find solutions using conventional design methodologies. He advocates a more explorative, reflective, practice approach to designing, repeatedly framing the problem situation.

The complexity of defining the design problem depends on the number of elements and the extent to which they affect the problem, where technological elements have been accompanied by elements from the societal and human domain in recent decades. This is the context of the design problem. Kroes and v.d. Poel (2009) define the context as '*its environment, setting or background that contains all elements that are somehow relevant for the thing involved in the sense that they condition its being or occurrence.*' Technology and social, intentional context are inseparable (Kroes and v.d. Poel, 2009; Witmer, 2018) and should be mutually matched (Simon, 1996). Context guides the design process, but the process can also influence context. In a design process as a transformation process, the context becomes a fluid, natural part of the cyclic design process.

The increasing complexity of civil engineering projects, as discussed in Section 3.2, is driven by an increase of the design problem's context. More and more aspects need to be included in today's design problem definitions and solutions. Recognising the importance of understanding and adopting the context in the analysing step of the design cycle has become more critical. Therefore, it is necessary to identify two activities in the analysing step; 1) understanding and adopting the context of the design problem and 2) establishing the problem definition (see Figure 3.2).

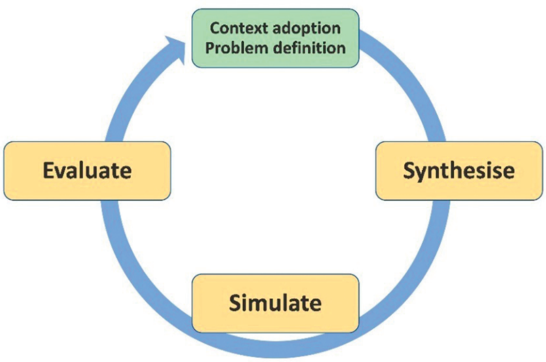

Figure 3.2: The basic design cycle after Roozenburg and Eekels (1995), in which the analysing step is split into context adoption and problem definition.

Architectural design schools embrace focusing on context by questioning the framework or making the framework part of their assignment (Dooren *et al*., 2013; Dorst, 2019; Holmes, 2020; Leon and Laing, 2021). The British Design Councils' double diamond approach reflects the emphasis on problem definition in the design process. Civil engineering design methods do not yet explicitly include such an approach.

When the design assignment's scope increases, it becomes advisable to split up the process into phases. The design cycle is then conducted several times sequentially while the design evolves from coarse to fine. At the phase transitions, explicit moments are introduced to verify the status of the design process. Subdividing the process is necessary because it structures and breaks down the complexity into more manageable tasks (Zeiler, 2019). This can be considered a managerial interference; it makes the design process more controllable. Several methods of phasing have been developed. Figure 3.3 shows the method inspired by (Pahl *et al*., 2007), which is familiar in civil engineering projects.

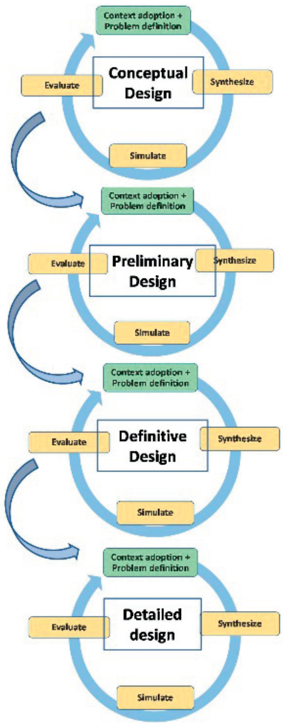

Figure 3.3: A phased design process after Pahl *et al*. (2007).

The design process of a complex system requires structuring through a hierarchic, decomposed structure because doing so simplifies the description of a complex system and makes it easier to manage information for the development of the system (Simon, 1996). Decomposing civil engineering systems into sub-systems, elements and components using the system engineering approach is a common method in large civil engineering projects to manage complexity. By combining the typical design cycle, a phased approach, and the decomposition of the system, the design process can be visualised, as shown in Figure 3.4. An interdisciplinary process emerges, which requires attention to socio-political aspects in addition to the formal project management methods (Koutsikouri *et al*., 2008)

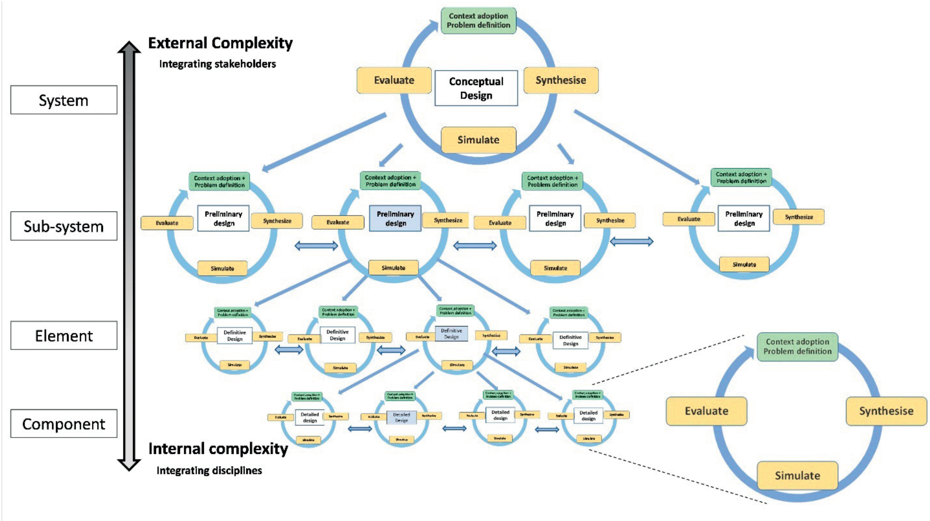

Figure 3.4: Phased design process of a complex civil engineering system, comprising the typical design cycle at any level of design.

The model shown in Figure 3.4 indicates the presence of the typical design cycle at any level of detail within any sub-system, element or component. At any cycle, the design process is about adopting the context of the design problem and including it in an optimum design solution through an iterative process of problem definition and solution-finding. The context, the problem definition and the solution are unique in any cycle. Referring to the complexity of the design assignment, internal and external complexity can be distinguished (see Section 3.2). The system level mainly involves integrating stakeholders' interests, which refers to external complexity. The process is governed by evolution and limited predictability and understanding of stakeholders (Hertogh and Westerveld, 2010). The component level is mainly about integrating disciplines, referring to internal complexity. Now, the number of elements and the extent to which they interact dominate the process. The type of complexity of the design assignment gradually shifts from external to internal as the level of detail of the design increases. In integrated contracts of civil engineering projects, the (public) owner normally is responsible for the process at the system level, while the contractor bears the responsibility at the component level. The responsibility gradually shifts, depending on the type of integrated contract.

With respect to a design process, the term "integrated" refers to the highest level of interactivity, referred to as transdisciplinary (Stock and Burton, 2011) or transformative (Kroes and v.d. Poel, 2009). An integrated process accumulates knowledge from the participants' perspective or the neighbouring discipline to merge the context in the design process. This type of integration requires participatory approaches, involving all participants in the project and balancing their interests to arrive at the best useful overall compromise for the benefit of the whole. As visualised in Figure 3.4, integration, i.e., merging the context in the design cycle, is present throughout the whole design process and at any level.

This analysis leads to the definition of the integrated design process of civil engineering projects for this study, based on Simon's (1996) basic principle: An integrated design process is the course of all human activities transforming an existing situation into a plan for a new one to satisfy needs, including and balancing all parties' interests and disciplines involved.

The increasing impact and assertiveness of stakeholders and the increasing number of aspects that affect the civil engineering design assignment, as referred to in Section 3.2, can be considered an increase of context over the past decades. Expanding infrastructural networks in green fields in the post-war period has evolved into integrating infrastructure into the existing urban environment. As discussed, this development is set to continue in the coming decades. This complicates the analysing step of the design cycle, aiming to establish the context and define the design problem, as well as running the iterative cycle as a whole.

3.4 PROJECT PERFORMANCE

Project performance can be defined in many ways and depends on the participant's perspective (Koops, 2017; Kylindri *et al*., 2012). Costs, time and quality are well-known criteria and are dominant in any civil engineering project. These criteria are often referred to as 'the iron triangle'. Cost and time are considered in relation to predetermined goals. Quality is what the project or the deliverable must do and the extent to which this is achieved (Nicholas *et al*., 2017) and can be assessed by considering the degree to which the product or the process meets the specified requirements.

In recent decades, the emphasis has shifted from the project manager's perception to evaluating project success by multiple stakeholder groups when determining project success (Davis, 2014). In the case of civil engineering projects, usually public owners are involved, being responsible for the social performance and representing the stakeholders. These stakeholders can be grouped into an economic, political and cultural system, each having their specific needs and interests (Doloi, 2012). Their satisfaction is an important criterion for the performance of contemporary projects.

In the civil engineering construction industry, safety has lagged compared to other industries. However, safety is considered an important performance criterion by both the owner and the contractor in today's projects. The literature confirms health and safety aspects among the critical criteria for project success (Silva *et al*., 2019; Ali and Rahmat, 2010). Bakker *et al*. (2010) defined the success criteria as costs, time, quality, safety, client satisfaction and start-up. The relevance of start-up in infrastructure projects has increased since the importance of technical installation and software has risen. In recent years, the delivery of systems with a dominant installation component, such as tunnels, has shown poor performance due to start-up problems. In this research, this aspect has been incorporated in the stakeholders' satisfaction criterion, since it affects the users and owners of the transport systems.

To summarise, in this research, the criteria cost, time, quality, safety and stakeholder satisfaction will be considered to determine project performance. These criteria cannot be mutually compared or weighed. Therefore, satisfaction with each criterion and its interaction with the integrated design process were considered separately. The criteria rule today's civil engineering projects in the Netherlands and correspond with the EMAT-criteria (Economically Most Advantages Tender) of today's tenders (EIB, 2015). In integrated contracts, the owner representing the clients but also the contractor have a strong influence on the performance criteria (Westerveld, 2003). Therefore, the perspectives of both the owner and the contractor were considered, imposing the constraint that the stakeholders' satisfaction is assessed from the owner's and contractor's perspectives.

3.5 RESEARCH METHOD

The research aims to find the dominant variables of the integrated design process and understand how they interact with project performance. Exploratory research was carried out, followed by a multiple case study.

The exploratory research included a literature study and ten non-structured interviews with key actors of the Dutch civil engineering industry, such as representatives from owners, contractors and consultants. After ten interviews, it was concluded that the data was saturated. The interviews were non-structured using open-ended questions to investigate whether the integrated design process was identified among the most relevant variables affecting project performance. Additionally, it was explored which variables dominate the integrated design process. All interviews were recorded and transcribed. The data analysis was conducted using elements of grounded theory (Corbin and Strauss, 2014).

Subsequently, a multiple case study was conducted based on the results of the exploratory research to get a deeper understanding of the interaction between the variables. A case study is an appropriate method when "how" questions need to be answered when examining contemporary events, and the relevant behaviour cannot be adjusted (Yin, 2014). Furthermore, *'the closeness to real-life situations obtained from case study research is necessary to understand the human behaviour, as it cannot be captured by rule-governed acts'* (Flyvbjerg, 2006). These conditions applied to the study since the integrated design process is a course of activities governed by humans.

A proper definition of the study's context is required to generalise from a case study. The context is to a high extent determined by the case selection. Therefore, the selection of the cases was driven by the widest possible range of project characteristics (see Table 3.1). While literal replication requires a minimum of two or three cases (Yin, 2014), in this study, the data converged to shared views and conclusions after conducting four cases, and further research would not have contributed to new insights.

Table 3.1: Project characteristics of the cases.

Case nr	Project	Contract type	Contract size [mio euros]	Project Scope
1	Spatial development and high water protection project	D&C	116	High water protection, spatial area develoment, infrastructural works (roads bridges)
2	Tunnel project	DBFM	700	Infrastructure; tunnel, roads, viaducts
3	Infrastructure project	PDC	415	Infrastructure; roads, viaducts
4	Infrastructure reconstruction project	D&C	43	Infrastructure: roads, movable bridges

The cases covered involvement of nine different owners, eight different contractors (in joint ventures), and represented all current contract types, i.e., Design-Construct (D&C), Design-Build-Finance-Maintain (DBFM) and Plan-Design-Construct (PDC), which also included the spatial planning design in the scope of the contractor. The contract size varied between 43 and 700 million euros. Finally, the scope of the projects was representative of contemporary civil engineering projects and comprised a tunnel, roadworks, bridges, viaducts, high-water protection works, and reconstruction works. The projects were situated in urban or more rural areas.

Interviews were the most important data source because they provided insights into the backgrounds of people's acts and behaviour and their effects on the process. The selection of the interviewees was driven by the condition that they should have a good understanding of the project performance, the integrated design process, and their interaction. Therefore, in all cases, at least the Project Manager and the Technical Manager of both the owner and the contractor were interviewed. The Technical Manager is responsible for the design management and the construction management. In two cases, we also interviewed the Design Manager to get more detailed data of the design process. In one case, the contractor's Tender Manager was interviewed, who became a steering committee member after the contract was awarded. This respondent provided extra data regarding the tender process and its impact on the design phase. Complementary to the interviews, documents were reviewed to better understand the process (e.g., contract documents, tender documents, and design documents). Finally, field notes were registered of observations made during data collection and site visits.

The interviews were semi-structured, using open-ended questions to gain the widest views on the variables affecting project performance. They were experienced as open and transparent.

The interviewees were motivated to participate in the study because they wanted to learn from the projects. Altogether, 19 interviews were conducted, recorded and reported. The interviewees validated the reports. Case analysis reports were made for each case based on the interview reports, reviewed documents, and field notes. The project managers of both the owner and the contractor validated their project case analysis report. Only validated data were used for the analysis.

The data were analysed based on elements of grounded theory. The analysis unfolded as the data were being collected. The quotes of events reported during the interviews, such as incidents, activities, examples or statements, were the raw data. In this research, quotes were built up from one or more sentences in such a way that the event could be understood independently (DeCuir-Gunby *et al*., 2011). Quotes referring to the same phenomena were coded as concepts, potentially relevant phenomena for theory-building. The concepts required precise definitions. New insights during data collection resulted in adjusted definitions and new concepts, making it necessary to recode the data. Thus, an iterative process unfolded.

When the data collection of the last case was completed, the cross-case analysis was updated and finalised. Then, related concepts were aggregated into concept groups representing more abstract phenomena. Finally, concept groups were developed into a theory describing the dominant variables of the integrated design process. Verification of the theory proceeded in the reverse direction from theory to quotes. Atlas TI software was used for structuring and analysing the data.

3.6 RESULTS AND DISCUSSION

3.6.1 Exploratory study

All interviewees from the exploratory study indicated the integrated design process as an essential factor for project performance. Furthermore, a broad range of variables that affect the design process emerged from this study. Complexity appeared as a central theme, which could be decomposed into three dominant variables: *Stakeholder Management, Multidisciplinarity* and *Planning*, representing the time available for the integrated design process. *Stakeholder Management* is linked to external complexity, while *Multidisciplinarity* refers to integrating disciplines and internal complexity, as discussed in Section 3.3 (see Figure 3.4). Figure 3.5 shows the breakdown of the variables and how they relate to project performance.

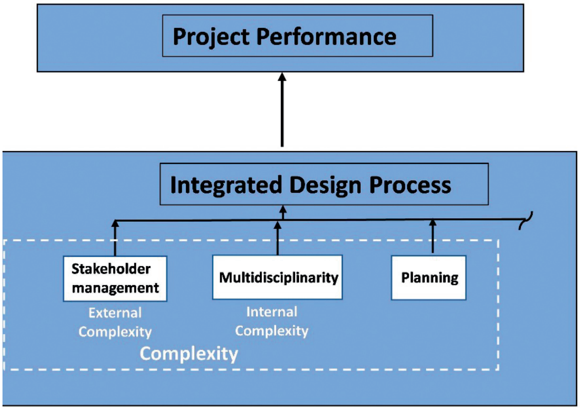

Figure 3.5: Results of exploratory research: variables of the integrated design process interacting with project performance.

Stakeholder Management was mainly emphasised by the interviewees representing the owners, and *Multidisciplinarity* and *Planning* were mainly nominated by the interviewees representing the contractors. This arrangement corresponds to what one would expect as a result of the division of responsibilities in integrated contracts, where the public owner mainly bears the responsibility for stakeholder integration, while the contractor bears the responsibility for the integration regarding multidisciplinarity.

3.6.2 Multiple case study

The variables shown in Figure 3.5 were the starting concepts for the analysis of the case study data. In the end, coding the data of the four cases resulted in 575 quotes and 52 concepts. Table 3.2 shows the ten most grounded concepts, including their definition, groundedness, and density, indicating the number of relationships with other concepts. When comparing Table 3.2 and Figure 3.5, it can be concluded that the multiple case study confirmed the relevance of the three main concepts from the exploratory study in the top ten and that new, relevant concepts emerged.

Table 3.2: Top ten concepts based on groundedness.

Nr.	Concept	Definition	Grounded	Density
1	Integrated approach	The design approach of integrating all parties' interests and all disciplines in a design solution in a balanced way for the benefit of the whole.	194	4
2	Stakeholder management	Integrating the stakeholders' interests in the design	120	5
3	Problem definition	The description of the the design problem from function thruogh design specifications.	114	7
4	Context adoption	Context is the total environment in which something gets meaning or that gives meaning to something, (Kroes and vd Poel, 2009). Context adoption is understanding the context and its relevance and taking care of the coherence between the context and the artefact; integrating context in the design solution.	113	10
5	Design process	The course of all human activities transforming an existing situation into a new one to satisfy needs	101	0
6	Multidisciplinarity	>1 discipline within the artefact, interacting to a certain extent	93	4
7	Level of detail	Level of detail of the description of the artifact	74	0
8	Planning	Course of design activities set out along a timeline defining the time available for the design process activities	73	1
9	Contract	Contract between the owner and the contractor	63	2
10	Design changes	Adjustments of a (conceptual) design already issued, resulting in additional activities not initially foreseen	57	4

Integrated Approach was clearly the most coded concept, meaning that it is important for theory-building. Altogether, 194 quotes related to this concept.

Concepts that frequently co-occur in quotes will be related and might converge to concept groups contributing to theory-building. Figure 3.6 shows an overview of related concepts grouped with the same colour. The figure indicates the concept co-occurrence coefficient, a number between 0 and 1 indicating the degree of co-occurrence related to both concepts' groundedness. A high coefficient indicates a high co-occurrence and a comparable groundedness. The figure also includes concepts that were relevant for the group but were not in the top 10 grounded concepts shown in Table 3.2, as well as the concepts that resulted from the exploratory study and were not part of a group (indicated white). For purposes of clarity, only co-occurrence coefficients equal to or higher than 0,10 are presented.

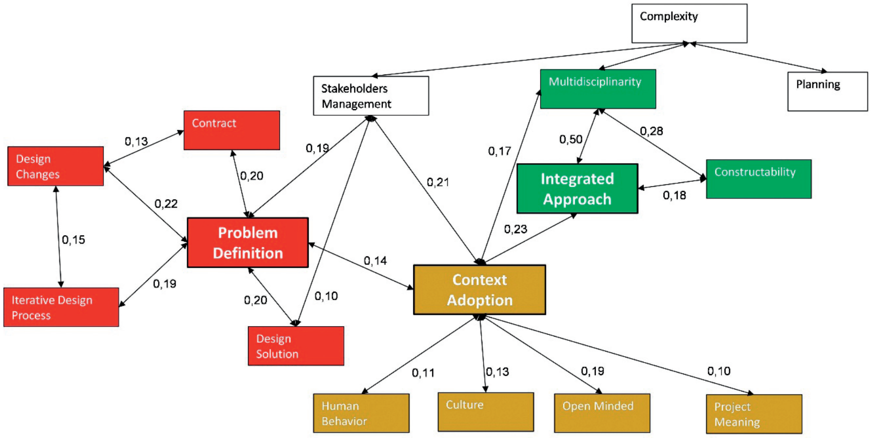

Figure 3.6: Overview of the most relevant concepts, co-occurrence coefficients ≥ 0,10 and concept groups.

Through aggregating, three concept groups appeared, which again were interrelated. First, a concept group related to the *Integrated Approach* emerged (indicated green). *Multidisciplinarity* and *Constructability* showed a relationship with this concept, referring to the relevance of integrating disciplines and specifically constructability aspects in the design. Furthermore, *Context Adoption* had a relatively strong relationship with this concept group.

Second, a group related to *Problem Definition* turned up (indicated red). This concept group referred to the definition of the design problem, which is considered part of the iterative design cycle. The data showed relations with the *Iterative Design Process*, *Design Changes*, *Contract*, *Design Solution*, *Stakeholder Management*, and *Context Adoption*, which would be expected from the definition of the integrated design process discussed in Section 3.3.

Third, *Context Adoption* (indicated yellow) showed a relatively high groundedness and a high density indicating many relations with other concepts. The interaction with *Human Behaviour*, *Culture*, *Open Minded* and *Ownership* designated a broad interpretation of this concept. This concept group was interrelated to the groups *Integrated Approach* and *Problem Definition*.

From the definition used in this study, an integrated approach refers to both integration at the component level, which links to *Multidisciplinarity* and *Constructability*, and the integration at the system level, which links to the integration of stakeholders' interests (see Figure 3.4). Therefore, a relationship between *Integrated Approach* and *Stakeholder Management* would be expected as well. However, this interaction did not dominantly emerge from the data, which was explained by the observation that the interviewees did not link stakeholders' integration to the definition of the *Integrated Approach*. Nevertheless, the high groundedness of *Stakeholder Management* demonstrated the importance that the interviewees attached to integrating stakeholders' interests.

Finally, *Complexity* and *Planning* are presented in Figure 3.6 since they were the starting concepts of the analysis. After aggregating, they were not part of concept groups.

The following discusses the identified concept groups in more detail.

3.6.3 Integrated Approach

All cases demonstrated a clear relationship between an integrated approach of the design process and project performance. At the system level, the project teams of all cases focused on adopting the stakeholders' context and integrating their interests in the design. This positively affected the satisfaction with project performance criteria, especially quality and stakeholder satisfaction. At the component level, awareness of integrating disciplines was noticed. However, the cases showed differences in the extent to which integration between disciplines was truly successful, even within the same project. In particular, integrating construction aspects in the design process was challenging in all cases and negatively affected the cost criterion of the project performance on the contractors' side. The interviewees indicated the project participants' ability to adopt context as a necessary condition for an integrated approach.

3.6.4 Problem Definition

The concept group *Problem Definition* referred to the ill-defined design problem and the iterative process of problem definition and solution-finding. Section 3.3 showed that this iterative process can be applied at any level of the design process. The data confirmed the importance of the process of problem definition for project performance given the high groundedness and density, see Table 3.2 and Figure 3.6.

At the system level, all cases showed a relation between proper interaction with stakeholders and adoption of the project context on the one hand and satisfaction with project performance criteria on the other. Furthermore, the cases showed that awareness of the interaction between problem definition and the contract affected performance positively. Recognition by the participants that solution-finding might result in modifying the problem definition due to the iterative nature of the design process, and consequently the contract specifications, contributed to a better-integrated design process and finding best for project solutions. *Collaboration* and *Trust* between parties turned out to be conditional for such an iterative process (groundedness 52 and 17 respectively, code co-occurrence with *Problem Definition* 0,10 and 0,06). The awareness of parties that problem definition related to the contract fostered a robust process of verification and validation of the design specifications. This process contributed to the proper integration of stakeholders' interests and the definition of the design problem.

On the other hand, in all cases, limited awareness of the issue of problem definition at the component level was observed. Adopting the context of adjacent disciplines and defining the design problem through an iterative process was not anchored in the process. This observation seemed to be related to the failures of integration between disciplines that were indicated in Section 3.6.3.

3.6.5 Context Adoption

The concept group *Context Adoption* was tied to achieving an integrated approach and determining the problem definition through an iterative process. In Section 3.3, the importance of this concept was outlined from a theoretical perspective. The case study confirmed the relevance of a mutual understanding of the context by parties and disciplines. However, all cases reported that mutual adoption of context was hard to achieve. In particular, poor interaction between the design and construction disciplines caused problems with project performance in all cases.

A more detailed analysis of the concept of *Context Adoption* was conducted by analysing the related quotes. Each quote was matched with an act that reflected the interpretation of adopting context. When possible, the acts were taken literally from the quotes; in other cases, they were derived. The acts represented the behaviour that the participant should exhibit to adopt and include context in the design process. Since the quotes were in Dutch, a translation into English was required. Table 3.3 shows the results of this analysis and indicates how often the act appeared in the interviews. In total, 133 acts related to context adoption were reported during the interviews, 56 of which were different.

Table 3.3: Interpretation of acts related to Context Adoption, derived from interview quotes, including the number of times the act was indicated.

Act	no.	Act	no.	Act	no.
Understand	17	Think	2	Consult	1
Be involved	8	Be interested	2	Take time	1
Speak the same language	6	Change perspectives	2	Think along with	1
Watch along with	6	Talk with eachother	2	Experience	1
Create acceptance	5	Sit together	2	Have contact	1
Interact	5	Interfere	2	Be together	1
Explain	4	Find integrality	2	Communicate	1
Weigh interests	4	Exchanging views	2	Find each other	1
Adopt	3	Stay in touch	1	Stay close	1
Pay attention	3	Listen	1	Play chess	1
Be open	3	Be curious	1	Take responsibility for context	1
Share	3	Have affinity	1	Anticipate	1
Collaborate	3	Want to know	1	Analyse	1
Know eachother	3	Respect	1	Have a broad vision	1
Translate problems	3	Be proactive	1	Translate knowledge	1
Connect knowledge	3	Have ownership	1	Act beyond ones discipline	1
Align	3	Be the same worlds	1	Have shared views	1
Ask questions	3	Create trust	1	Combine	1
Meet eachother	3	Come together	1		

A broad interpretation of *Context Adoption* appeared. The interviewees indicated a wide range of competencies and behaviour that the participants of the project teams should exhibit to understand and adopt the interests of the stakeholders or the adjacent disciplines. The essence is a mode of interaction that leads to understanding and internalising the other and its anticipation.

The data presented in Table 3.3 seem to point toward empathy as a relevant competence for context adoption since it is interpreted as identifying with and understanding the other's feelings or thoughts (Kouprie and Sleeswijk Visser, 2009). Empathy comprises both cognitive and affective aspects (Davis, 1994). The importance of empathy in design processes has been recognised in product design (Devecchi and Guerrini, 2017; Postma *et al*., 2012) and to some extent in architecture and landscape design (Van der Ryn, 2013). It has even been considered conditional for ethics in design in general (Vallero and Vesilind, 2006). Furthermore, empathising is an essential step in design thinking, a problem-solving method that gained ground in recent decades (Köppen and Meinel, 2015). A relationship between emotional intelligence, which also includes aspects of empathy, and team performance and project performance has already been demonstrated by Rezvani (2019) and Khosravi *et al*. (2020).

3.6.6 Aggregating the concept groups

The cases showed that an integrated approach of the design process is critical for project performance. Moreover, the ability of the participants of the design teams to adopt the context of the design problem and integrate it into the design process is a dominant variable that is conditional for an integrated approach and, subsequently, project performance. This interaction is visualised in Figure 3.7. When comparing Figure 3.7 and Figure 3.5 from the exploratory study, it is concluded that *Planning* does not appear as a dominant variable after conducting the case study. Generally, a short lead time of the design process contributed to project complexity and negatively affected project performance in most cases. However, in this study, *Stakeholder Management* and *Multidisciplinarity*, together determining an integrated approach, appeared more critical.

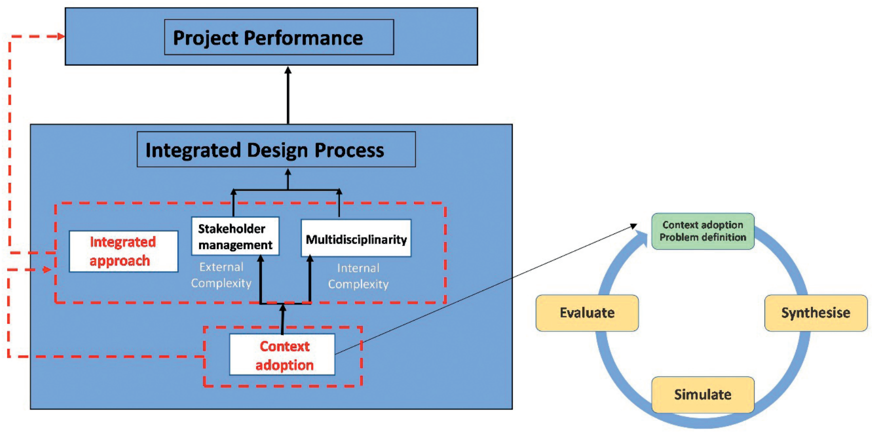

Figure 3.7: Overview of the dominant variables of the integrated design process affecting project performance, indicating the dominant variables in red.

Adopting the design problem's context applies at any level of design. It is necessary to integrate the stakeholders' interests at the system level (referring to stakeholder management and external complexity), as well as the adjacent disciplines at the component level (referring to multidisciplinarity and internal complexity). The importance of context adoption and problem definition in the typical iterative design cycle can be recognised, as stated in the literature and discussed in Section 3.3. The study confirms this importance. Furthermore, the study shows that proper context adoption is not obvious in civil engineering projects and that lack of context adoption negatively affects project performance.

Integrating the context of the design problem in the process is more common in architecture, spatial planning design and landscape design, as their interface with the environment has been more intense by nature. However, context has also become an essential part of the design process in civil engineering projects, and its relevance will grow. Civil engineers play an important role in managing the challenges resulting from climate change, urbanisation, and mobility. The growing impact of the design problem's context and multidisciplinarity of civil engineering projects requires competencies of the participants of the design team that have been only called upon to a limited extent to date. This comprises a shift from the technological to the human perspective and from a problem-solving to a more problem exploration-oriented design approach (Drost, 2019) and a contextual engineering approach (Witmer, 2019).

3.6.7 Other relevant variables

The project size emerged from the study as a relevant variable. It might be connected to stakeholders and multidisciplinarity because large projects will often imply many stakeholders and disciplines. Trust between parties and collaboration turned up as conditional variables for the design process, as its iterative character inevitably introduces modifications of the problem definition and, consequently, contract changes. Furthermore, opportunism on the contractor's side appeared as a variable affecting the design process and project performance, since it resulted in opportunistic designs during tender stages that could not be realised after the contract was awarded. On the other hand, technology did not appear as a dominant variable. Apparently, the project teams master the technical challenges of today's civil engineering projects, and other variables dominate project success. Finally, the cases did not show any distinction in the interaction with project performance related to the type of integrated contract.

3.6.8 Project performance

The interviewees were asked to reflect on the interaction between the integrated design process and each project performance criterion, as discussed in Section 3.4. Although they could not always detail each criterion's interaction, and the figures should be considered subjective judgements, analysing the data for all cases provided additional insights into the interaction. Table 3.4 shows the number of times the interviewees indicated a direct relationship between the integrated design process and the specific project performance criterion and whether the design process positively or negatively affected the project performance aspect.

Table 3.4: Confirmed numbers of interactions between the integrated design process and project performance, negatively or positively.

		Case 1	Case 2	Case 3	Case 4	Subtotal	Total	Percentage of maximum score (=19)
Cost	effects on cost neg	0	3,5	5	1,5	10	16	84%
	effects on costs pos	2	1,5	0	2,5	6		
Time	effects on time neg	1	1	3	0	5	10	53%
	effects on time pos	0	1	0	4	5		
Quality	effects on quality neg	0	0	0	1,5	1,5	18	95%
	effects on quality pos	5	4	5	2,5	16,5		
Safety	effects on safety neg	0	1	0	1	2	11	58%
	effects on safety pos	2	2	4	1	9		
Stakeholders' Satisfaction	effects on stakeholders neg	0	0	1	0	1	19	100%
	effects on stakeholders pos	5	5	4	4	18		

In case no interaction with the performance criterion was noticed, a 0-score was appointed. A score of 1 point was awarded in case a positive or negative interaction was indicated. Finally, if the interviewee explained that the integrated design process affected performance both positively and negatively, a score of 0,5 was appointed to both the positive and negative effects. By doing so, the interviewees could award in total 0 or 1 points to the interaction with each performance criterion. Since 19 interviewees were asked to consider the interaction, a maximum score of 19 could be obtained for each criterion.

The table indicates that the integrated design process mainly affected the performance criteria cost, quality, and stakeholders' satisfaction, which were confirmed in 84%, 95%, and 100% of the cases respectively. Furthermore, the table shows that interviewees almost unanimously confirmed that the integrated design process positively affected quality and stakeholders' satisfaction, while costs and time were affected both negatively and positively. The results indicate that the interaction with time and safety performance criteria were the lowest. The relatively high scores on stakeholders' satisfaction and quality could be explained by the fact that stakeholders' participation is legally defined. This implies that projects are de facto not permittable if stakeholders are not adequately consulted. In fact, the stakeholder satisfaction criterion is prioritised in this way in the design process.

3.6.9 Limitations of the study

The cross-case analysis revealed an integrated approach and adoption of the problem context as the dominant variables. It indicates that the results and conclusions of the study apply to projects that are dominated by integration challenges related to stakeholders' interests and multidisciplinarity. The selected cases represent this type of project, and they can be considered representative of contemporary projects in the Netherlands. Generally, the study results will be applicable for multidisciplinary civil engineering projects in complex, urban environments.

3.7 CONCLUSIONS

Although the integrated design process is considered an important phase in the civil engineering project life cycle, its interaction with project performance has been researched to a limited extent. Therefore, this study aimed to investigate this interaction and identify the dominant variables of the integrated design process that affect project performance, considering the poor performance of the projects today and the increasing complexity of the design assignment in the future.

A multiple case study was conducted to investigate the interaction between the integrated design process and project performance. We conclude that the integrated design process is essential for project performance and that an integrated approach of the process is critical. This applies to integrating stakeholders' interests at the system level and integrating disciplines at the component level of the design process. Above all, the project team participants' abilities to adopt and integrate the context of the design problem is the dominant variable to achieve an integrated approach at any level of design and improve project performance. The study reveals that competencies focusing on integration are not obvious in civil engineering projects and that a lack of these competencies negatively affects project performance.

The complexity of civil engineering projects is increasing, while those projects have been facing poor performance for a long time already. Project teams need to integrate a growing number of stakeholders' interests and aspects, a process which is driven by growing urbanisation, the need for mobility, climate adaptation, biodiversity, circularity and the renovation of the existing infrastructure systems. Where projects used to be technically driven, integration challenges dominate today; integration of civil engineering objects in their increasingly complex context and integration of a growing number of disciplines. Therefore, design teams of civil engineering projects should stimulate the development of competencies focusing on integration to improve performance. This also implies a shift from a solution-driven design attitude to a more problem exploration-oriented design approach. Empathy seems to be a competence of the design team participants that fosters problem orientation and subsequently an integrated approach and project performance. While empathy has been acknowledged as a relevant competence in disciplines that have been affected by problem context by nature, there is reason to further investigate the role of empathy in civil engineering projects.

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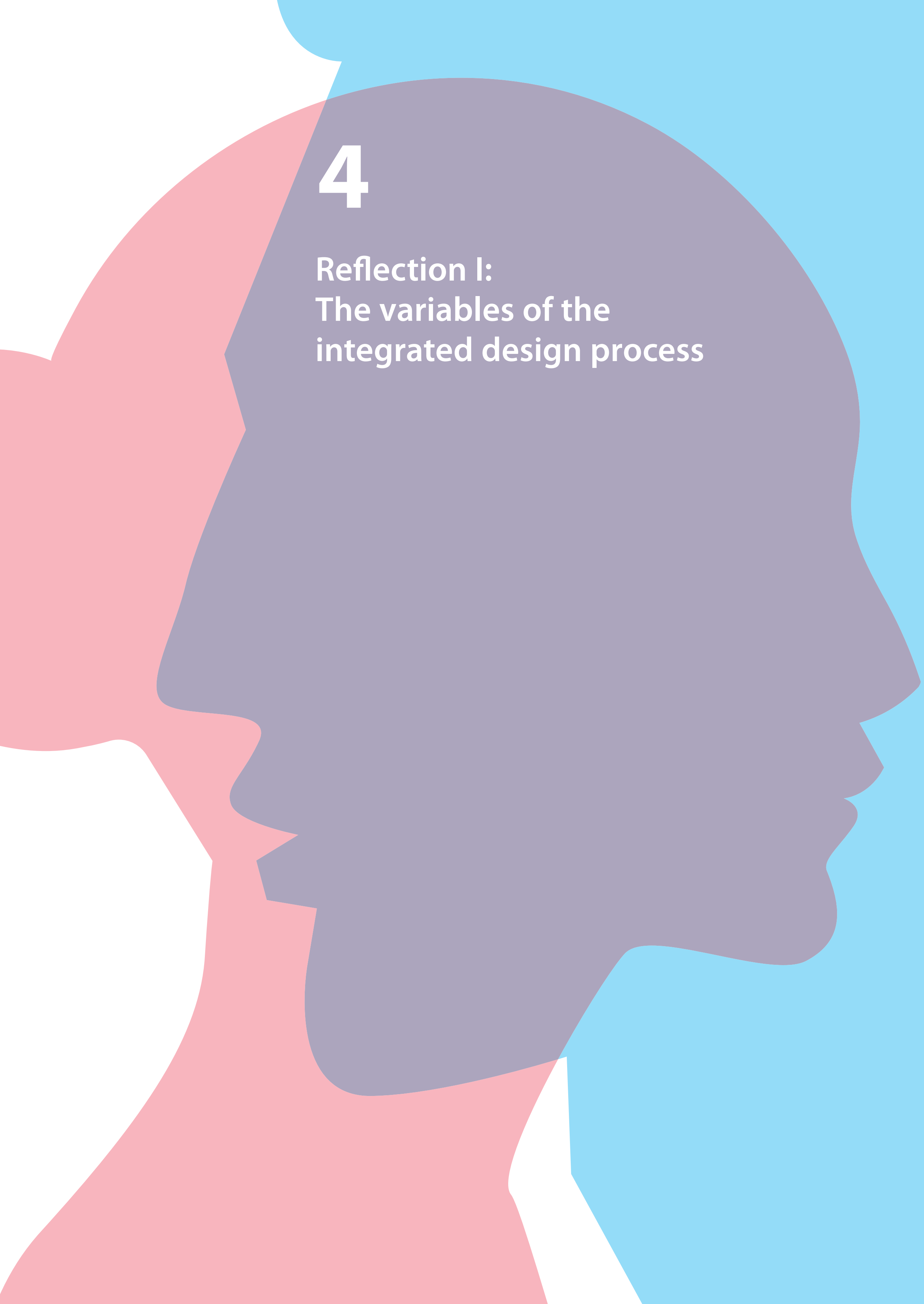

4

Reflection I: The variables of the integrated design process

4.1 INTRODUCTION

Chapter 1 discussed the essential role of integration in the design process and its importance for performance. Chapter 2 further developed integration into adopting the project context and integrating it into the design process and the solution. Adoption and integration of the project context reveal themselves at the project's system and the component level (see Figure 2.6 and 3.7). This interpretation of integration and its importance was evident in the cases investigated in Chapter 3. It was concluded that the design process is essential for project performance and that an integrated approach of this process is critical. The project team participants' abilities to adopt and integrate the context of the design problem emerged as a dominant variable to achieve an integrated approach at any level of the design process and improve project performance.

This chapter reflects on the study's outcomes presented in Chapter 3 and analyses the practical integration issues and successes of the four cases investigated in the study, aiming for a deeper understanding of the competencies needed for integration, therewith pairing the research problem and a potential solution. These reflections are only based on the researcher's analysis of the data and deepen the analysis made in Chapter 3. Finally, the potential of empathy as a competence contributing to integration is discussed. The quotes in this chapter are shown in '*italics*' and translated from Dutch to English. Some quotes were slightly adjusted for the sake of anonymity.

4.2 THE IMPORTANCE OF AN INTEGRATED APPROACH AND PEOPLES' COMPETENCIES

This section examines the drivers for integration within the four cases examined in Chapter 3 successively in more depth and substantiated by the interviewees' quotes.

Case 1

A striking example of integration as a success factor for performance is demonstrated in Case 1. The project success of this case is attributed to an integrated approach from the initiation to the construction phase. Initially, the project only comprised a high-water flood protection. However, '*the project became really feasible by the ambition of a Provincial executive who advocated an integrated solution for the various problems within the area. This meant that not only the high-water problem had to be solved, but that several problems within the area had to be tackled within an integrated solution*.' The parties involved in the area decided to integrate other projects to arrive at an integrated area development programme. Room for new economic development, increasing the area's liveability, and development of nature became the project goals in addition to flood protection. Parties managed to align their strategies and interests into shared project objectives. The project scope now included infrastructure works, harbour works, and nature reserve works, in addition to dyke reinforcement works.

An integrated design and construct contract was awarded after determining the requirements for the design, with the design being the contractor's responsibility. The owners considered it *'important that the contractor adopted an integrated approach and involved the stakeholders in his design process. It was important that the contractor clearly understood the multidisciplinarity and the stakeholders and that they recognised that the project was not just about technology and money. It was about content and context.'*

The advantages of combining and integrating the projects at the system level were numerous. For example, the integrated approach facilitated the development of an innovative dyke solution, deviating from the traditional dyke profile, which is characteristic of the Dutch situation. The solution required an intensive process of testing and approval. However, it offered a number of benefits compared to a standard dyke profile. Better landscape integration of the flood defences could be achieved with the support of the environment. The spatial claims on nature and agricultural land were limited, and the construction was more sustainable and cost-efficient by using local materials and limiting transportation. Additionally, new nature areas could be developed:

- *'The solution scored very well because of its good environmental integration. It was very well supported by the stakeholders. ... The solution provided benefits for the client regarding the acquisition of land and prevented the purchase and transport of soil, which had financial benefits.'* (Project Manager, contractor)
- *'The integral collaboration within the team and the creativity were important factors that contributed to this success. It was acknowledged that the design was more than just making a drawing. There was a proper and integrated assessment of costs and benefits.'* (Project Manager, owner)

The project team adopted an integrated design approach from the system level (integrating project goals) to the component level (e.g. the innovative dyke solution). *'The integrated approach was the most decisive factor for the design process. Integrality has a technical aspect, but it also includes integrated considerations of stakeholder interests. All in all, this factor has been well addressed within the project.'*

The case underlines the important role of people for the project's integrated approach and success: '*A success factor that influenced the design process was the right people in the team that understood that the assignment was about constructability, landscaping and technology and how these interact.'* However, the case also shows the project participants' difficulty acting integrally. An integrated approach implies interactions between many parties and people and, as a consequence, many interfaces. '*These interfaces are diffuse. A lot of information needs to be shared. This requires proactive coordination. This is difficult for many people. Ownership, controlled adopting and sharing, is a very important characteristic in such a design process that not everyone possesses.'* At the disciplinary level, the abilities required to work integrally differed. It was hard to manage costs in one discipline, because '*designing was not a joint activity. There was no experience within the construction department to participate early in the design phase to optimise the design*.' In another discipline, '*the interaction … was very good from the start, so that a good design was made. The reason it worked better was that the team already knew each other from a previous project and sought each other out from day one.*' Apparently, different levels of integration were achieved within the same project.

Case 2

In the second case, the design scope and responsibility also mainly rested with the contractor, while the owner was responsible for the requirements. Based on lessons learned from earlier projects, the project team identified an integrated approach as essential for project success.

- *'We wanted an integrated and phased design approach. That was a strong philosophy within the design organisation. So, not a planning-driven design approach, but an approach with integral baselines.' (*Design Manager, contractor).
- *'This integral design management approach was a conscious choice. We wanted to put much emphasis on the integrated design organisation. That was the lesson of a previous project. There, the decision was made to divide and outsource the design. This went wrong because construction started before the design was ready and because the disciplines operated separately, not in an integrated way.'* Technical Manager, contractor).
- *'The contractor very well followed a process of passing the designs of the disciplines simultaneously, so "through the gate together". They acted more integrally from the design than I had seen on other projects.'* (Project Manager, owner).
- *'The contractor made a considerable effort achieving integrality; it made them resilient for problems they faced later on.'* (Project Manager, owner).

In addition to the integrated baseline approach, the contractor introduced a conceptual design phase at the beginning of the process to enhance integrality. This phase intended to share and adopt the mutual interests of parties at the critical project aspects on a high level. This was considered a successful intervention at the system level.

- *'Working with concepts introduced by the contractor was impressive. It was a different way of thinking, which made it clear to each other what they stood for. This made it clear to everyone what his/her contribution to the project was. It became more difficult as more people entered the organisation, but there was a strong focus on this.'* (Project Manager, owner).
- *'Through the concept phase, the contractor has truly opted for an integrated preliminary design. The concept phase was intended to share the tender solution with a larger group and also to explore the interfaces and dependencies. It has been a good step.'* (Technical Manager, owner).

After the conceptual design phase, the willingness to understand the design problem at the project's system level is reflected in how the owner and contractor managed the (contractual) requirements together: '*The attitude was not to think in terms of requirements but in terms of what the stakeholders wanted. We were also looking for a contractor who understood this, … The contractor has really invested in understanding the stakeholders, for example, during the requirements analysis and at the gate reviews.*' At the system level, this approach positively contributed to the project performance in terms of acceptance and support for the design solutions by the stakeholders.

However, at the disciplinary or component level, the contractor faced serious issues managing integrality, mainly concerning the design and construction disciplines: '*Although the contractor made an enormous effort to reach an integrated approach, they did not succeed at one part of the project.*' '*The contractor made a real difference to achieve integrality in the organisation. Nevertheless, it is remarkable that the interaction between design and construction has been insufficient.*' So, where this relatively large project was split up into two geographically oriented teams, using similar processes and focusing on integrality, one team did not achieve an integrated design solution, highly and negatively affecting the performance.

The interviewees were clear in identifying different cultures and the lack of competencies to bridge the differences as the main cause for the problems, which is substantiated by several quotes:

- '*There are good and bad examples within the same project. So it has nothing to do with processes, but with people.*' (Design Manager, contractor).
- '*I was very surprised that good experienced managers were not able to work together; different cultures, not used to collaborate, no openness, no togetherness, focusing on improvisation.*' (Project Manager, contractor).
- '*A lack of integrated approach was caused by people's characters: lack of openness, curiosity, willingness to collaborate. Insufficient awareness that it was a shared challenge.*' (Project Manager, contractor).
- '*Despite the enormous effort in integration, the contractor did not succeed in one part of the project. It proves how hard it is to achieve. Different words, values, a different way of viewing the world.*' (Technical Manager, owner).
- '*Ultimately, this problem was caused by people's personalities: people did not want to open themselves up to other people's ideas, did not ask questions and made their own plans.*' (Technical Manager, contractor).
- *Design, preparation and construction were different worlds; they did not speak each other's language, they came one after the other. Only a few managed to make the combination. You need T-shape employees, but there are very few of them. People who make the connection.*' (Project Manager, owner).

Case 3

At the third case, the owner also acknowledged the importance of an integrated approach. It was decided to include the contractor's construction and costs expertise early in the process, by awarding a Planning, Design and Construction contract. Consequently, already during the project's spatial planning phase, the contractor was involved in the project and was responsible for the (spatial planning) design and construction. This necessitated a close interaction in the spatial planning design phase between the stakeholders, the owner and the contractor, to which parties were not accustomed. Moreover interests needed alignment and integration at the project's system level, which seriously affected the performance perspectives of parties.

In terms of the quality of the design product, safety and stakeholders' satisfaction, the integration is considered successful:

- '*Better considerations have been made regarding costs, which has led to better use of money for society.*' (Project Manager, contractor).
- *'We are very satisfied with the quality of the design. … Basically, the construction aspects have now also been properly taken into account and considered in the spatial planning design.'* (Tender Manager, contractor).
- *'I believe that the quality of the design is better. I don't know of any traditional spatial planning design in which not something has been forgotten, for instance, the logistics and where the contractor's construction experience is included. We managed to do so.'* (Contract Manager, owner).

However, in terms of costs and time, the project was not considered successful because the parties faced difficulties to manage an integrated design process and bridge the opposing interests. Parties encountered severe budget overruns and delays. The owner and the contractor jointly had to manage the spatial planning design, but they encountered different cultures: where the owner was '*contemplative, process-oriented, striving for acceptance*, …', the contractor was '*striving for practical solutions, doing instead of thinking, working in a straight line, …*'. Although these competencies could be considered complementary, parties struggled to bring them together. One of the owner's interviewees classified the difference '*as big as the Grand Canyon.' 'You have to consider the different dynamics of the spatial planning study and a D&C phase, but also the dynamics of a governmental organisation and a private company: how do you bring these together?'*

In addition to the differences between the owner and the contractor, the contractor also faced issues integrating the construction aspects in the spatial planning design. This integration issue at the component level was also observed in Case 2 and, to a lesser extent, in Case 1. However, it was perceived more strongly in this case given the higher level of abstraction of the spatial planning design, which apparently made it even more challenging to bring disciplines together.

The difficulties with the interaction resulted in designs lacking constructability, often related to the phasing of the construction.

At the level of abstraction of the spatial planning design (the system level), the interests of parties substantially affected the scope of the project and, consequently, also the cost and time performance criteria. The dynamics of this phase are driven by flexibility, iterations and searching for consensus, where the contracting parties also required predictability in terms of costs and time. The difficulties of bringing parties (owner-contractor, design-construction) and interests together were attributed to a lack of people being able to bridge the different cultures. The project team was aware of the differences and tried to overcome this issue but did not succeed

More specifically, competencies to connect worlds were considered essential and lacking in the team:

- *'"Pre-thinkers", people who think about what could happen. … Who can seek integrality beyond their own discipline. … We don't have many people like that.'* (Project Manager, contractor).
- *'When it was successful, it was possible to translate the raw knowledge of the construction and the designer into the spatial planning phase and make it presentable for the stakeholders and the client so that they could form an opinion about it. People with a broader vision of the project and speaking the language of the planning study.'* (Project Manager, contractor).
- *'An example was the design manager. He has made his mark in design, but his added value was that he could find the integrality and translate a problem of the construction into a subject in the planning study so that it was understood. You have to be able to speak in a different way to be heard.'* (Project Manager, contractor).
- *'… in the spatial planning phase, you need people who speak the language of the construction. It is difficult to explain clearly; it is about competencies to be able to work integrally.'* (Contract Manager, owner).
- *'It is a different type of person that is able to perform in both worlds. I haven't seen many people who master both.'* (Project Manager, owner).

The integration challenges between the construction and the design departments were also attributed to people's competencies, comparable to Case 2: '*Including construction knowledge in the design is also difficult …. It is caused by different cultures, different thoughts, different perspectives, speaking different languages, different characters too: the designer is calm, strives for thoroughness, while the construction manager strives for speed and cheap solutions. This is where tension and miscommunication arise.*'

Case 4

The final case concerns a relatively small project, however highly interdisciplinary. In this case, issues between the owner and the contractor were raised due to different interpretations of the requirements as a part of the contract. Parties lacked acknowledging the difficulty of adopting and integrating the project context in the de problem definition and the need for a shared effort to arrive at a common understanding of the project context: '*It requires trust. And clearly describing what you want. The focus was on general regulations and guidelines …., which is not what you want. The client received something while he expected something different. We* [the contractor] *had attached something to it that we thought was correct. You want to know what they want from the very beginning - knowing for sure that everything is right. That it is validated.'*

A taskforce, including a limited number of project team members, was established to solve the problems. The interviewees observed a remarkable change in the project participants' attitude after the taskforce, resulting in better integration of project context in the design solutions. Possibly, the different composition of the taskforce compared to the project team made the difference.

- '*After the taskforce we* [the contractor] *were more in the lead, the agreements were clear. An example was the issue with the available height of a bridge underpass: there was a contradiction in the requirements. You have to admit that first. When that happened we could have a look: What do you really want? Then we solved it. If you do it together you can achieve a lot. We started looking at what was best for the project.'* (Project Manager, contractor).
- *'After the introduction of the taskforce, there was togetherness; the designers sat together to solve the issues. Before, it was the owner against the contractor.* (Project Manager, contractor).

At the component level, managing the multidisciplinarity was challenging: '*The design process became difficult: all the interaction, bringing all these lines together, trying to get all parties into the same flow. You also have to deal with a short construction time, so your suppliers, the traffic, …: you need many parties at all these interfaces; that is quite difficult. In addition, all these parties have their own budgets.'* The maintenance discipline in particular was difficult to integrate into the process, resulting in issues when delivering the project.

The contractor faced a lack of integrality issues during the tender stage. For instance the planning was not a result of an integrated effort: '*When you gather pieces of information and you let one person combine it, it doesn't mean you have an integrated approach. You have to work together in an integral way.'* It resulted in a very tight time schedule, lacking time for proper preparation of the works and procurement. This negatively affected the cost performance. On the contrary, after contract awarding, integration is considered a success factor for the project: '*You have to make it together, the people responsible for the construction must be included in the design process. Then, all their knowledge can be reflected in the drawings. That worked out well.'* The underlying success factor indicated is '*sitting together and good communication, listening to each other… This made it easy for them to monitor each other, and the interaction was good, including the suppliers and all disciplines.'*

Case 4 indicates peoples' competencies more broadly as a success factor for integration and performance:

- *'The people of the preparation took an interest in the design, got involved, and I liked it too; It's about people… the success factor is an intrinsic motivation to be curious in the other discipline, wanting to know how they do it and why. It meant that you were also forced to think carefully about others. Just by asking questions.'* (Design Manager, contractor).
- *'I think it has to do with how people are wired. Whether they have interests and want to coordinate, share information, go to the other person. If you want to tune in, you can always do so.'* (Design Manager, contractor).

A final observation was that the craftsmanship of the team was indicated as a success factor for performance: *'My observation is that the contractor's team had skilled people, eager to make it a success. They made no assumptions, did not despise the details. They were on top of it. Sharp on constructability. There was involvement until the end. This made an important contribution to the project.'* Experienced and skilled teams of interdisciplinary projects will recognise mutual interests and interfaces. They act on routine, mutually knowing which information they have to share between disicplines. Consequently, they will know how to proactively prevent interface issues they experienced in the past. Then, craftmanship can be created related to state-of-the-art artefacts.

4.3 THE POTENTIAL OF EMPATHY AS A CRITICAL FACTOR FOR PERFORMANCE

The project teams at all four cases recognise and underpin the essential role of integration in the design process for performance. They anticipated an integrated approach in advance by establishing an integrated contract, process or way of working. Nevertheless, the extent to which they achieved an integrated approach differed substantially and affected performance. At the system level, parties coordinated and determined processes to integrate the interests of authorities and stakeholders rather explicitly, probably encouraged by legally required procedures or contractual obligations between the owner and the contractor. However, differences in the parties' cultures complicated these processes, obstructed real connection and hindered exchanging, understanding and aligning interests. At the component level, mutual interests and requirements were determined less explicitly, possibly because the coordination occurs (partly) within organisations and is relatively informal. Since there were also significant cultural differences between disciplines within organisations, the disciplines' interests seemed also difficult to exchange and determine. This complicated establishing a proper problem definition and, consequently, an integrated solution.

The analysis provides a process of integration where the project team participants' abilities to bridge cultural differences, processes and ways of working is an essential and initial step to be able to fathom the project context and understand the interests of parties involved in the design problem. This process applies at any level of abstraction of the project. Only when interests are understood, adopted, and aligned a complete and integrated design problem definition can be established, which in turn is the base for the development of an integrated design solution enhancing project performance, see Figure 4.1.

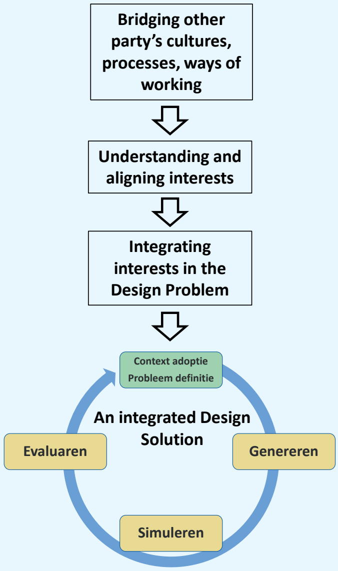

Figure 4.1: The process of integration.

The first steps of integration, i.e. bridging to unfamiliar cultures, parties, and disciplines and understanding the others' interests, emerged as an essential success factor for the integrated design process. The behaviour corresponding to this ability was described in Table 3.3 and seemed to point in the direction of empathy, which is often described as stepping imaginatively into the other's shoes. When project team members would be able to easily gain an understanding of the feelings and perspectives of other, unfamiliar participants involved in the project, it would be likely that they are better able to bridge to and immerse in other cultures and processes, understand their interests and take this into account when identifying a problem and the accompanying solution. Therefore, the next chapter will delve into the concept of empathy to theorise the problem-solution pairing of this study.

5

The concept of empathy

5.1 THE ORIGINS OF EMPATHY

Adam Smith (1723-1790) is identified as the first scientist to outline the basics of empathy. A big question at that time was whether people were solely selfish by nature or capable of selfless behaviour. Smith responded to the image of man portrayed by Thomas Hobbes (1588-1679), namely, man as a selfish being. In his book *Leviathan* (1651), Hobbes concluded that '*inherently and self-seeking creatures such as ourselves needed an authoritarian government to keep ourselves in check*' (Krznaric, 2014). Smith, on the other hand, argued that maximising one's personal interest promotes the best interest of the community as a whole. Therefore, based on this book the *Wealth of Nations* (1776), he is recognised as one of the first economists and founder of capitalism or laissez-faire economics. However, in addition, he focused on another big question: whether human morality should be grounded in reason (cognition) or in our feelings (affection). Smith sought the basic principles that make peaceful coexistence and fruitful cooperation possible (Karssing, 2022). So, although Smith is considered a founder of capitalism, his ideas run with a strong sense of community, morality, sympathy, and justice.

In his first book, *The Theory of Moral Sentiments* (dated 1759), he replied to Hobbes's pessimistic view of man by stating that *'How selfishly soever man be supposed, there are evidently some principles in his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it, except pleasure seeing it'.* His insights laid the foundation for the concept of empathy, although, in his book, he rather describes the concept as sympathy and imagination. Karssing (2022) elaborates on Smith's interpretation that people empathise with another's situation '*not by "feeling" his or her feelings—we can only feel others' feelings to a limited degree—but by using imagination to put ourselves in the other person's situation and imagine what feelings we would have in that situation. Imagination requires an effort, an investigative attitude, not only listening and observing but also asking emphatic questions to gain a better understanding of the situation*'. For Smith, sympathy and the imagination of the other's perspective are the foundation for developing one's moral compass and a peaceful society.

Hereafter, the body of knowledge on empathy developed. The German philosopher Theodore Lipps began applying the word '*Einfühlung'* to explain our experience and knowledge of other people's mental states (Nillson, 2003). '*Einfühlung'* can be translated literally as '*feel into*' (English) or '*inleven*' (Dutch). In 1909, the American psychologist Edward Titchener transformed the word '*Einfühlung*' into the English word empathy, based on the Greek word '*empatheia',* which is composed of the words '*em*', meaning 'into' and '*pathos*', meaning '*passion, feeling*' (Kouprie and Sleeswijk-Visser, 2009).

Although the current knowledge on empathy still leaves unexplored aspects, the psychological perspective of empathy can be described as the human's nature to enjoy the other's fortune without self-interest, which requires the ability to put ourselves in the other person's situation and imagine what feelings we would have in that situation. Our intrinsic need for empathy causes us to a) make an effort to use our imagination as best we can to assess the other's situation, and b) to adjust our feelings and behaviour to an intersubjective measure of appropriateness. Empathising with the feelings of the other person in this way produces a pleasant feeling (Karssing, 2022). Empathy enables us to act beyond our self-interest and allow others to serve their interests.

Besides the psychological perspective, empathy can be viewed from a biological and evolutionary perspective (Sorrell, 2014). From the early 20th century on, a theory gained attention that, counter to social Darwinian ideas, cooperation and mutual aid were just as important as competition in an evolutionary process. Although Charles Darwin's theory on the struggle for existence seemed to put competition rather than cooperation as a driver for men's evolutionary history, he gained the insight that cooperation and reciprocity are also essential for humans (Rifkin, 2009). Evolutionary biologists have shown how animal species exhibit cooperative tendencies, share food and protect one another from predators (Krznaric, 2014). After decades of studying primates, De Waal (2019) concluded that mutual assistance and effective collaboration are essential for individual and group survival, requiring being exquisitely in tune with the emotional states and goals of others. He argued, for instance, that empathy is essential to respond appropriately to our offspring. Mammalian evolution showed that females responding to their child's needs '*out-produced those who were cold and distant'*. In line with this, the fact that females, rather than males, nurture babies unable to express themselves could explain why they outscore males in empathic abilities, which is cross-culturally determined (Feingold, 1994). Today, the evolutionists' claim, i.e., the existence of empathy in humans simply proves its importance in societies and groups, is widely recognised.

Finally, the neurological perspective on empathy has gained attention in the past two decades. This perspective is built around the existence of mirror neurons, which are activated when we experience something but also when we perceive the same experience in someone else. The fact that we start yawning by seeing someone else's yawn, shows that we can feel and copy the other's experience. It generally demonstrates the operation of exemplary behaviour. Mirror neurons are activated when we experience someone else's emotions. They enable us to experience the feelings of others by simulation (Paradiso *et al*., 2021). Consequently, the empathiser "feels it" instead of looking at an abstract image. The other's emotion affects us. It explains why we are socially wired and tightly interwoven with other people. Neurological studies demonstrate that this neural activity is to some extent under people's control. People can deliberately choose how deeply they allow their own emotions to resonate with those of others, indicating that empathy is not a fixed concept and can be influenced (Keysers, 2022). The functioning of mirror neurons as part of a complex yet undiscovered empathic system in the human brain affects our empathic abilities.

5.2 DEFINING EMPATHY

Today, empathy is subject to different views and interpretations, and reassessments of claims on human social interactions are ongoing (Mezzenzana and Peluso, 2023). It can be described as a set of psychological mechanisms (e.g., 'identifying with'), as an ability, as a process ('stepping in and out of the other's situation') and as a set of various components (e.g., 'affective and cognitive').

Authors agree that there is limited consistency in how the concept of empathy is defined (Kouprie and Sleeswijk Visser, 2009; Gerdes *et al*, 2010; Batson, 2009).

On the other hand, there is a considerable common denominator in the interpretation of the concept of empathy. Generally, empathy is defined as a person's ability to feel, understand and share another person's world with self-other differentiation (Hakkanson Eklund and Summer Meranius, 2021). It is often described as stepping imaginatively into the other's shoes to gain an understanding of feelings and perspectives. Kohut (1959) defines empathy as '*the capacity to think and feel oneself into the inner life of another person*'. This involves mechanisms such as creating awareness, imagining, perspective-taking, understanding, relating, connecting and identifying with the other person.

Different aspects of the concept of empathy include cognitive and affective components. Scholars agree that empathy is the ability to have an emotional response to another's emotional state and reflect on that by perspective-taking (Rijnders *et al.*, 2021). De Waal (2012) considers cognitive perspective-taking a secondary development built around more elementary mechanisms, such as state-matching and emotional contagion. Affection refers to feeling an emotion as a reaction to someone else's emotion, and cognition refers to understanding someone else's feelings (Baron-Cohen and Wheelwright, 2004). The affective and cognitive components of empathy are strongly interrelated. They must both be present for empathy to exist (Gerdes *et al*., 2010; Davis, 1980). Kouprie and Sleeswijk Visser (2009) conclude: '*Having an emotional response to another's emotional state (affection) and being able to reflect on that by perspective taking (cognition) seems to be the core mechanism of empathy.*'

Empathy cannot be considered an all-or-nothing phenomenon, although it is considered an evolutionary developed trait. Emotional contagion can be considered the trait's core. From there, the mammalian line added layers to it, such as concern, consolation, perspective taking, and intelligence, like a Russian doll (De Waal, 2009). Human beings (and apes) reach the highest empathic levels of feeling and understanding others. However, different development of empathy layers is also identified within humans, which is shown from the empathy measurements (also used in this study as will be discussed in the next chapters). Someone's empathic trait also depends on one's empathic horizon, which can be defined as the individual's range of understanding of and empathy for the other's experiences in different contexts, such as background, culture, age and gender. McDonagh-Philp and Denton (2000) argue that expanding one's horizon is a never-ending process if actively considered, implying an expanding ability to empathise with increasing age.

Next, the literature has demonstrated that empathy is affected by in-group bias, which means that it is easier to empathise with group members or familiar individuals (De Waal, 2012; Decety and Lamm, 2006). Identification (through, for instance, values, culture or shared goals) is the main portal for empathy. As an example, the higher willingness in Europe to accept Ukrainian refugees after the Russian conflict started in 2022 compared to refugees from the Middle East or Africa shows higher identification and empathic feelings towards the in-group of European citizens than citizens outside Europe (De Coninck, 2023). Although this implies a lack of empathy for out-group individuals, it can be activated by outsiders or even non-human stakeholders, such as nature or Mother Earth (Talgorn and Ullerup, 2023).

Finally, someone's emotional state, engagement in or commitment to the other person can also affect someone's level of empathy (Kouprie and Sleeswijk-Visser, 2009; Rijnders *et al*., 2021)). Keysers and Gazzola (2018) also consider fairness, responsibility, and voluntary empathy to the category of factors affecting empathic tendencies. Their studies demonstrate the activation of mirror neurons only when people are motivated to empathise with others. Singer *et al.* (2006) demonstrated similar effects when fairness and justice were at stake. Competition is another relevant factor affecting empathic tendencies. Where humans are empathic partners in a collaborative setting, they exhibit the opposite behaviour, or even hostility, towards competitors (Lanzetta and Englis, 1989). The more competitive nature of men compared to women is therefore suggested as a factor contributing to men's lower empathic abilities. The latter factors indicate that people are able to regulate their empathic activities depending on the situation and personal preferences.

Although the positive effects of empathy have been widely endorsed, some limitations have also been raised. A commonly shared limitation of empathy is its individually focused character. Since empathy occurs mainly between individuals and is affected by in-group bias, it involves the risk of prioritising individual over group interests and, consequently, best-for-project. Bloom (2018) attributes rational competencies to humanity above all. Therefore, he considers empathy-based and individual-oriented decision-making in the here and now inferior to human rational decision-making. In the wake of this, it could hinder an attitude of decisiveness and determination, which is also critical in project management. In conclusion, the downside effects or possible overrepresentation of empathy also need consideration.

In summary, this study considers different dimensions of empathy:

- Empathy as a trait, comprising psychological and evolutionary aspects. This trait-dimension of empathy is difficult to influence. The male-female empathy distinction exemplifies this dimension. Nevertheless, expanding an empathic horizon is possible in a lifetime and depends on someone's experiences. Empathy as a trait is a measurable dimension, which will be discussed in Chapter 6 and 9.
- Situational empathic skills or behaviour, which can temporarily vary and depend on the environment and circumstances. The in-group aspect exemplifies varying empathic feelings and behaviour attributed to the same person and depending on the group to which the other person belongs to. Moreover, aspects such as willingness, commitment, or motivation affect and regulate the empathic tendencies of a person. People can acquire functional empathic behaviour if they or motivated.

It is noted that when this study refers to 'empathy', it should be interpreted as a multidimensional catch-all concept of an individual empathic ability, including the aforementioned aspects, since the concept of empathy is broadly interpreted in the literature. This also includes a commonly accepted interpretation of empathy as the ability to have an emotional response to another's emotional state and to reflect on that by perspective-taking in order to take appropriate action, while retaining self-other differentiation.

5.3 EMPATHY VERSUS SYMPATHY

Empathy is often confused with sympathy or compassion. However, the self–other distinction is an important and distinctive aspect of empathy. Although the process of empathising induces similarities between the feelings one experiences oneself and those expressed by others, Decety and Lamm (2006) stress the importance of avoiding self-other confusion. Empathy is predominantly other-oriented, which is where it differs from sympathy. Sympathy concerns the other's well-being, whereas the goal of empathy is to understand and feel the other person's experiences (Wispe, 1986). Sympathy refers to 'relating' and allows the observer to have his own emotion as a response to the other's emotion, while empathy relates to 'knowing' and does not allow the observer to develop his personal emotion. Contrary to sympathy, empathy is when one does not feel the desire to take away someone's suffering. The interpretation of empathy is limited to the feeling and understanding of the other's emotion or interest. It provides the basis for an appropriate response, but the response itself is not part of empathy. The empathiser's response will depend on his/her goals, but he/she will consider the adopted feelings and understanding of the other's interests. Therefore, the self-other differentiation promotes empathy to an applicable concept in a professional and competitive setting.

5.4 THE ROLE OF EMPATHY IN PROJECTS

The role of empathy in projects is generally debated in the literature, where the correlation between empathy and performance is predominately positive. In this section, the relationship between empathy and project management aspects and design processes are discussed.

5.4.1 Empathy in project management

Empathy is related to the project manager's tasks and competencies essential for project success, such as communication, collaboration, and trust (Solares Menegazzo *et al*., 2015). Empathy supports the performance of a group or team with the same characteristics and interests by fostering collaboration and creating an emotionally safe working atmosphere where people feel free to share their ideas and concerns (Miyashiro, 2011; Roberge, 2013). The relationship between high-performing teams and transformative leadership and the mediating role of empathy is demonstrated in the literature (Toor and Ofori, 2008; Socas, 2018; Solares Menagazzo *et al*., 2015). Moreover, the literature relates empathy to other factors essential for project management and success, such as communication, collaboration, trust and human interaction (Valente, 2016; Köppen and Meinel, 2015; Moradi *et al*., 2020). Thus, empathy could be part of a tangle of mutually dependent, human-related factors affecting team performance, project management, leadership, and project performance.

The literature also indicates a positive connection between the team's emotional intelligence (EI) and project performance in large-scale infrastructure projects (Khosravi *et al*., 2019; Rezvani *et al*., 2018). EI is defined as a cognitive ability to 1) perceive emotions, 2) use emotions to facilitate thinking, 3) understand emotions, and 4) manage emotions in oneself and others (Mayer *et al*., 2004; Clarke, 2008). As such, EI is considered related to the cognitive aspects of empathy. Butler and Chinowsky (2006) examined the relationship between EI factors and transformational leadership for the construction industry specifically. They found that construction managers scored particularly low on empathy, with empathy identified as a factor of EI. Therefore, they called for additional attention to be paid to this competence specifically.

5.4.2 Empathy in design processes

Empathising in a design process comprises entering, discovering and immersing in the user's world, connecting to resonate with the user and finally detaching to take appropriate action. Kouprie and Sleeswijk-Visser (2009) described a process of "wandering around" in the user's world, stepping in to gain a deep understanding and stepping back to take competent action. In this process, empathic behaviour manifests itself by connecting, listening, openness and willingness to feel and understand the other or even non-human stakeholders. Empathy is acknowledged as an important ability to adopt the needs and emotions of the user in the design process and to foster performance (Heylighen and Dong, 2019), especially in product design and architecture. These disciplines are characterised by high human interaction and context integration by nature. Furthermore, empathising is an essential step in design thinking (Köppen and Meinel, 2015).

As discussed in the previous chapters, a sound design problem definition is essential (Cross, 2001). This requires a deep understanding of the project's context. It is suggested that the designer's ability to feel and understand the other's interests and concerns about the project will enhance adopting the project context, accurately defining a design problem definition, and finding solutions. The understanding of context applies at different levels of abstraction of the design process, see Figure 2.6. At the higher levels of abstraction, the project context is mainly dominated by the stakeholders affected by the project. At this system level, feeling and understanding their concerns and interests is crucial and has become a key challenge (Unterhitzenberger *et al*., 2021; Witmer, 2019). At the lower levels of abstraction, the integration of disciplines governs the design process. The empathic ability of the project participants to feel and understand the concerns and interests of the participants of the adjacent disciplines or parties could help define the design problem at the component level and consequently find the best solutions (Baiden and Price, 2011). So, empathy could support mutual understanding and the adoption of interests and perspectives at any level of the integrated design process.

5.4.3 The research gap, hypothesis and refined research subquestion

The theoretical underpinnings in this chapter indicate the potential positive correlation between the design and project team participants' empathic abilities and project performance. Although the literature generally elaborates on the role of empathy, no exploration of the appropriate levels of empathic ability or the downside effects of the overrepresentation of empathy is available. Moreover, the role of empathy in civil engineering projects is yet unexplored, nor has it been investigated how empathy interacts and what impact it can have on performance in practice. Therefore, it is worth exploring the relationship between empathy, the integrated design process and project performance in the context of civil engineering projects. It was discussed that civil engineering projects are changing from technical to integrative challenges, which could introduce the need for other critical success factors and competencies.

The 'Problem-Solution Pairing' and 'Reasoning and Designing' steps from Dewey's process of design inquiry (see Figure 1.7) accumulate to the hypothesised relationship between the project team's empathic abilities, the integrated design process and the project performance, see Figure 5.1.

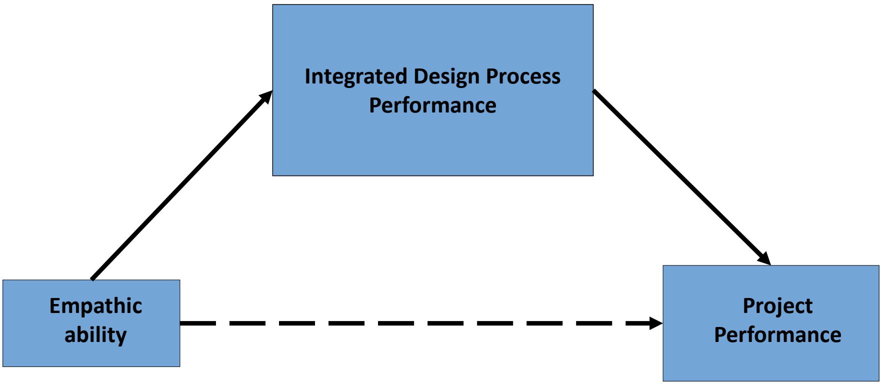

Figure 5.1 Visualised hypothesis indicating the relationship between the empathic abilities, the integrated design process and project performance.

This hypothesis needs testing. Chapter 6 comprises an initial experiment exploring the interaction between empathy, the integrated design process and the performance in a representative Dutch civil engineering project. Based on the insights of the previous chapters and the indication of empathy as a potential dominant factor for integration in the design process and project performance, subquestion 2 (see Section 1.6) has been refined to:

> *"How does empathy influence the performance of the integrated design process, and how can empathy contribute to an improvement of the performance of civil engineering projects?"*

The answers to this refined research question will be developed through the following research steps and analyses.

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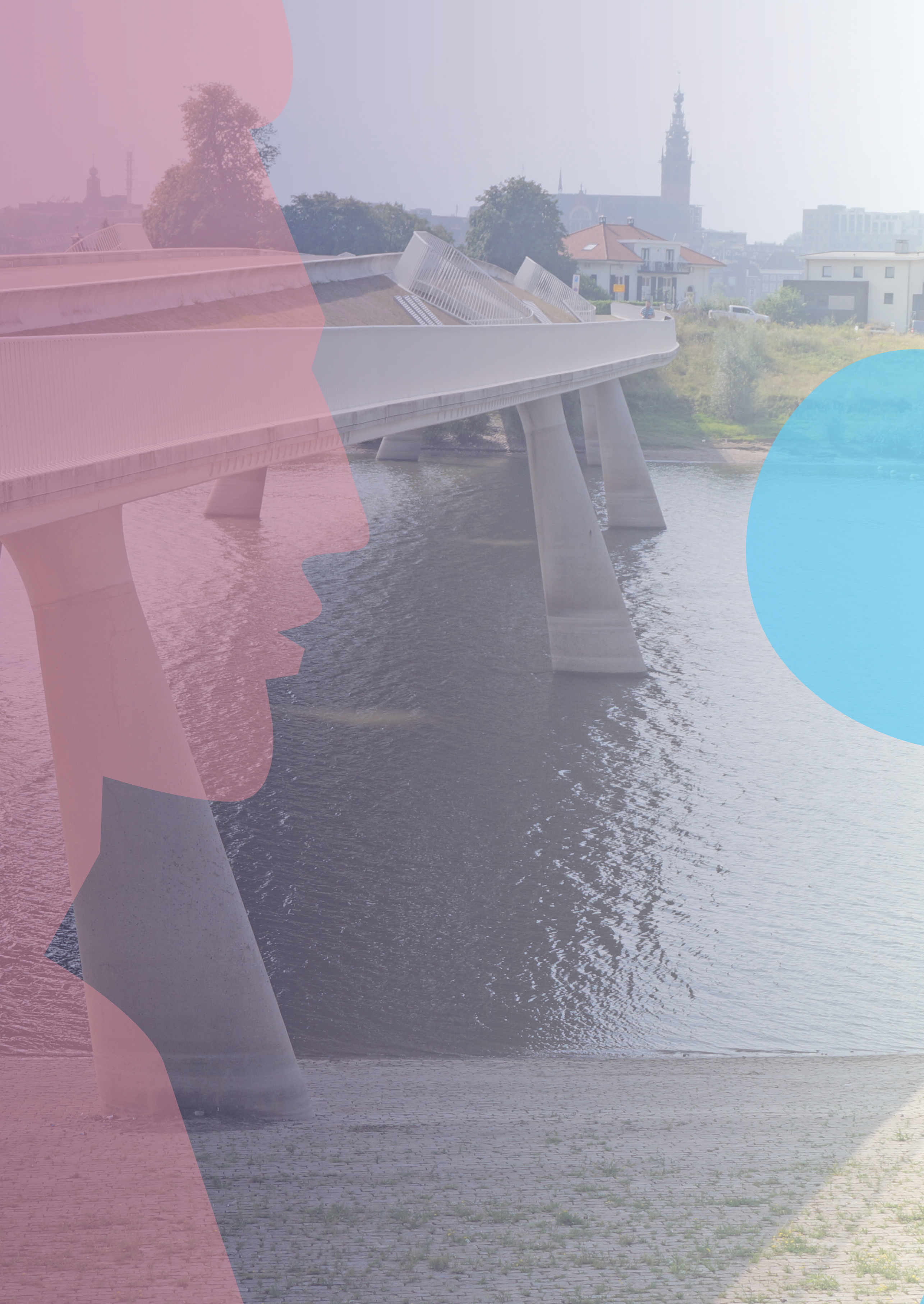

6

An exploration of the relationship between empathy and project performance

This chapter reflects a manuscript published in the *Journal of Engineering, Design and Technology* titled "The Potential of the Empathic Ability for the Performance of Civil Engineering Projects", by Guus Keusters, Frederique Batelaan, Froukje Sleeswijk-Visser, Erik-Jan Houwing and Hans Bakker, DOI 10.1108/JEDT-08-2022-0431, published in 2023.

It comprises an initial experiment testing the hypothesis in practice, i.e. the existence of relationships between empathy, the integrated design process and project performance of civil engineering projects. Additionally, it explores how these variables interact. Sections 6.2 and 6.3 comprise the study's problem statement and a theoretical description of the concept of empathy, which were more broadly discussed earlier in Chapters 1 and 5 respectively. Consequently, these sections contain repetitions. For the sake of completeness, these sections are included in this chapter anyway.

6.1 ABSTRACT

Purpose
The increasing complexity of civil engineering projects necessitates focusing on new competencies of project participants. Based on research on team performance and design processes that are more closely linked to the relevance of the project context, it is hypothesised that empathic abilities could play an important role in the performance of civil engineering projects. Therefore, this research investigates whether performance can be improved by focusing on empathic abilities during the integrated design phase.

Design/methodology/approach
Semi-structured in-depth interviews with experts were conducted to explore the relevance of empathic abilities and their interaction with performance in a real-life infrastructure project. The project team's empathy level was measured by means of a survey using Davis' IRI-method. Finally, differences between expected and measured levels of empathy were analysed.

Findings
The results provide insights into how empathic abilities interact with performance. The measurement indicates that, on average, professionals in the civil engineering industry score relatively low on empathy. In addition, differences were identified between the expected distribution and the measured empathy levels of the team, implying a potential for improvement, in particular by increasing the empathic abilities of the project management and increasing gender diversity.

Originality/value
This study is the first to investigate a relationship between empathy and the performance of civil engineering projects. The results provide initial insights into the empathic ability of civil engineering project teams and the potential of empathy to improve performance. Furthermore, from an empathy perspective, the study advocates increasing the gender diversity of project teams to improve performance.

6.2 INTRODUCTION

Civil engineering projects have become increasingly complex in recent decades. This is driven by a growing need for mobility and urbanisation (Eurostat, 2016), inducing the need to combine functions to make projects feasible (Hertogh, 2013). Today, combinations of mobility functions with ecological, water management or real estate functions are common. Consequently, new aspects - such as ecology, technical installations, architecture and landscaping - need to be integrated or play a more dominant role in the projects. In addition, the impact of stakeholders has increased as a result of building in more urbanised areas and stakeholders becoming more assertive (Maddaloni and Davis, 2017; Mashali *et al.,* 2022). As a result, project complexity has increased due to a growing number of elements in projects (Vidal and Marle, 2008) and an increasingly dynamic impact of stakeholders (Hertogh and Westerveld, 2010; Maier and Fadel, 2006)). Dorst (2019) argues that the increased complexity of the problem definition and the solution space has led to the achievement of human cognitive capacities to find solutions using conventional design methods.

The trend of integrating an increasing number of aspects, and thus the increasing complexity of projects, will continue in the coming decades. Civil engineering projects face major challenges, such as the inclusion of climate adaptation, biodiversity, circularity and social inequality (IPCC, 2021; Wilkinson, 2019). The adoption and integration of these aspects has become dominant in civil engineering projects (Demirkesen and Ozorhon, 2017), with the integration of stakeholder interests and disciplines becoming particularly challenging (Keusters *et al*., 2022).

Meanwhile, civil engineering projects are beset by poor performance, which is often described in terms of 'the iron triangle' criteria of project management: cost, time and quality (Nicholas and Steyn, 2017). Today, however, criteria such as stakeholder satisfaction and safety have also grown in importance (Davis, 2014; Silva *et al*., 2019). In this study project performance is defined as the extent to which the project meets its predefined goals related to cost, time, quality, safety and stakeholders' satisfaction. It is broadly concluded that the predefined goals of civil engineering projects are hard to meet (Flyvbjerg, 2013; Locatelli *et al*., 2017).

The question arises as to whether the transition to integration challenges affects the team's competencies to deliver more successful projects, given the relationship between team participants' competencies and project performance that has been demonstrated in the literature (Bakker and de Kleijn, 2014). The literature indicates a positive connection between the team's emotional intelligence (EI) and project performance in large-scale infrastructure projects (Khosravi *et al*., 2019; Rezvani *et al*., 2018). EI is defined as a cognitive ability to 1) perceive emotions, 2) use emotions to facilitate thinking, 3) understand emotions and 4) manage emotions in oneself and others (Mayer *et al*., 2004; Clarke, 2008). Butler and Chinowsky (2006) examined the relationship between EI factors and transformational leadership for the construction industry specifically. They found that construction managers scored particularly low on empathy, with empathy identified as a factor of EI. Therefore, they called for additional attention to be paid to this competence specifically.

Empathy is defined as the ability to experience and understand the feelings of another (Decety and Lamm, 2006; Krznaric, 2014). While overlapping with aspects of EI, it is distinguished by a focus on affective dimensions, in addition to the cognitive ones. The positive effects of empathy on team performance have been demonstrated (Miyashiro, 2011). Considering design processes as social processes (Bucciarelli, 1988) and taking empathy as a driver for social cohesion (Roberge, 2013), openness to other's perspectives on the project and empathic communication could contribute to a better working atmosphere and collaboration in general. Moreover, people with high empathic abilities are better able to understand and feel other people's interests and emotions. As such, empathy has been identified as an important personal and team competence to improve project performance through design disciplines such as product design, architecture and landscape design (Devecchi and Guerrini, 2017; Postma *et al*., 2012; Van der Ryn, 2013). These disciplines are characterised by a close interaction with the project context by nature and the need for context integration to achieve successful projects.

The ongoing development from technological to integration-driven civil engineering projects, includes the increasing need of adoption of project context, as is already common in product design, architecture and landscaping. If stakeholders have an increasing impact on processes and outcome of civil engineering projects, project participants' skills contributing to understanding and adopting stakeholders' interests will become more relevant (Witmer, 2019). Likewise, if more and new disciplines are to be integrated into a design solution, competencies appealing to the involvement of unfamiliar areas of knowledge will become more critical.

The increasing need for context integration justifies the proposition that the relevance of empathic abilities has also increased in civil engineering projects, as empathy can promote feeling and understanding the design problem's context. These abilities will be especially relevant during the integrated design phase, where integration is crucial and where the decisions taken are important for project performance (Koutsikouri *et al*., 2008; Leon and Laing, 2022). In this study, the integrated design process is defined as the course of all human activities whereby an existing situation is transformed into a new one in to satisfy needs, including and balancing the interests of all parties and disciplines involved (Keusters *et al.,* 2022).

Since the connection between empathy and performance of civil engineering projects is virtually unexplored in literature, this study investigates whether the performance of civil engineering projects can be improved by focusing on the project team's empathy during the integrated design phase. While empathy encompasses cognitive and affective dimensions, this research can provide additional insights compared to previous studies on EI and performance. First, this paper outlines the concept of empathy in general and describes a model of the interaction between empathy and performance in civil engineering projects, followed by a description of the research method. The data were collected from a large infrastructure project in The Netherlands. The analysis and the discussion of the results focus on the gaps between the expected and the actual level of the project team's empathic ability, which in turn leads to conclusions regarding the interaction between empathy and project performance.

6.3 THE CONCEPT OF EMPATHY

When diving into the literature on empathy, it is easy to get carried away by the many different understandings, interpretations and applications across different disciplines. Authors agree that there is little consistency on how the concept of empathy is defined (Kouprie and Sleeswijk Visser, 2009; Gerdes *et al*, 2010; Batson, 2009). Empathy can be described as a set of psychological mechanisms (e.g., 'identifying with'), as a trait (e.g., 'an ability'), as a process ('stepping in and out of the other's situation') and as a set of various components (e.g., 'affective and cognitive'). For example, Kohut (1959) defines empathy as '*the capacity to think and feel oneself into the inner life of another person*'. This involves psychological mechanisms such as creating awareness, imagining, perspective-taking, understanding, relating, connecting and identifying with the other person. Also, Baron-Cohen and Wheelwright (2004) explain that empathy allows people to interact with others by understanding their intentions, predicting their behaviour and feeling an emotion as a reaction to this. Such definitions regard empathy as a capacity or ability of psychological mechanisms. The differences with related concepts, such as sympathy or compassion, are also highlighted, since they are often confused with each other (Baron-Cohen and Wheelwright, 2004; Batson, 2009, Köppen and Meinel, 2015). Contrary to sympathy, empathy is when one does not feel the desire to take away someone's suffering. Where the goal of empathy is understanding the other person's experiences, sympathy concerns the other's well-being (Kouprie and Sleeswijk Visser, 2009).

Furthermore, the degree to which a person can be empathic is bounded by someone's ability and willingness. The ability of an individual refers to the extent to which someone can empathise beyond the specific characteristics of his or her group. This is bounded by someone's 'empathic horizon' such as gender, education, age, etc. (McDonagh-Philp and Denton, 2000). Willingness to be empathic with another refers to someone's personal engagement with another person, which can be influenced by someone's connection to the other, commitment, or someone's emotional state.

Different aspects of the concept of empathy include cognitive and affective components. Cognition refers to understanding someone else's feelings, and affection refers to feeling an emotion as a reaction to someone else's emotion (Baron-Cohen and Wheelwright, 2004). The affective and cognitive components of empathy are strongly interrelated (Gerdes *et al*., 2010; Davis, 1980). Kouprie and Sleeswijk Visser (2009) conclude: '*Having an emotional response (affective) to another's emotional state and being able to reflect on that by perspective taking (cognitive) seems to be the core mechanism of empathy*.'

It should be noted that when this study refers to 'empathy', it should be interpreted as a multidimensional catch-all concept of individual empathic ability, including the aforementioned aspects, since the concept of empathy is broadly interpreted in the literature. When projected onto the integrated design phase of civil engineering projects, this concept of empathy could enhance the designer's ability to sense and understand the other person's emotion, interest or problem, referring to 'the other' as the stakeholder or another colleague in the project organisation. In this way, empathy could contribute to managing the integration challenges of today's projects.

6.4 EMPATHY AS A DRIVER FOR PROJECT PERFORMANCE

In general, the positive effect of empathy on team performance has been widely discussed (Roberge, 2013;). Empathy increases people's concern for the welfare of another and the team. As a result, team members become able to overcome conflicts and collaborate efficiently with each other, which increases team effectiveness and productivity. In addition, feeling understood by others may lead team members to open up and disclose valuable information that would otherwise not be shared (Roberge, 2013). Furthermore, the literature elaborates on the interaction between empathy and performance through leadership skills. Leadership on the part of the project manager is about leading, directing, guiding, influencing and managing the project team, stakeholders and other participants to achieve the project objectives (Burke and Barron, 2014). There are different leadership styles for doing this. Project managers should have the skills to sense and understand which leadership style is needed (Toor and Ofori, 2008). Empathy is proposed as an important competence supporting this ability (Duff, 2017; Socas, 2018).

The literature also suggests an interaction between empathy and project performance through empathising with the user in a design process (user-centred design). Devecchi and Guerrini (2017) and Postma *et al*. (2012) elaborate on the essential role that empathy plays in this process. Koskinen *et al*. (2003) introduce 'Empathic Design' as a method where designers get closer to the lives and experiences of users to increase the likelihood that the product meets the user's needs. The importance of the integrated design process links empathy to the performance of projects.

This study distinguishes between internal and external empathy (Köppen and Meinel, 2015). Internal empathy is interpreted as empathy between people within a certain group or team with the same characteristics and interests to support collaboration and create an emotionally safe working atmosphere that fosters performance (Roberge, 2013). External empathy is defined as empathy between people from different groups with different interests or perspectives, e.g., between the owner (client), contractor and stakeholders. These participants often have different backgrounds and interests. They need to cooperate and integrate working processes and information to successfully deliver the project (Demirkesen and Ozorhon, 2017). In this case, empathy aims to feel and understand mutual perspectives and interests (Baiden and Price, 2011). Both internal and external empathy seem relevant to civil engineering projects where disciplinary teams need to collaborate in a safe and pleasant atmosphere, and where conflicting interests and wishes between parties need to be overcome.

Based on the literature review, three categories of empathy are identified for the purpose of structuring the investigation into the role of empathy in performance. This follows Köppen and Meinel's (2015) distinction between internal and external empathy. This categorisation can be applied to the integrated design process as follows:

1. Team empathy - internal empathy

Empathy may contribute to a good working atmosphere and better collaboration within disciplinary teams, which will in turn lead to improved performance. Here, internal empathy focuses on personal relationships and job satisfaction.

2. Interdisciplinary empathy - internal + external empathy

Participants of disciplinary teams in a civil engineering project have different interests, processes and cultures. Here, external empathy might contribute to a better understanding each other's challenges or interests, leading to better designs, processes and performance. Additionally, in an integrated process, disciplinary teams may also be part of a joint group or project organisation. Therefore, internal empathy may also strengthen interdisciplinary relationships, as described under (1). Interdisciplinary empathy can therefore comprise aspects of both internal and external empathy.

3. Interorganisational empathy - external empathy

Considering integrated civil engineering contracts, the owner, the contractor and the stakeholders have different interests during the integrated design phase that need to be merged into one integrated solution. Therefore, feeling and understanding each other's emotions, wishes and interests might contribute to a better process and integrated solution and performance.

The research model in Figure 6.1 provided a structure for this study and visualises the hypothesised relationship between the categories of empathy, project performance and the integrated design process.

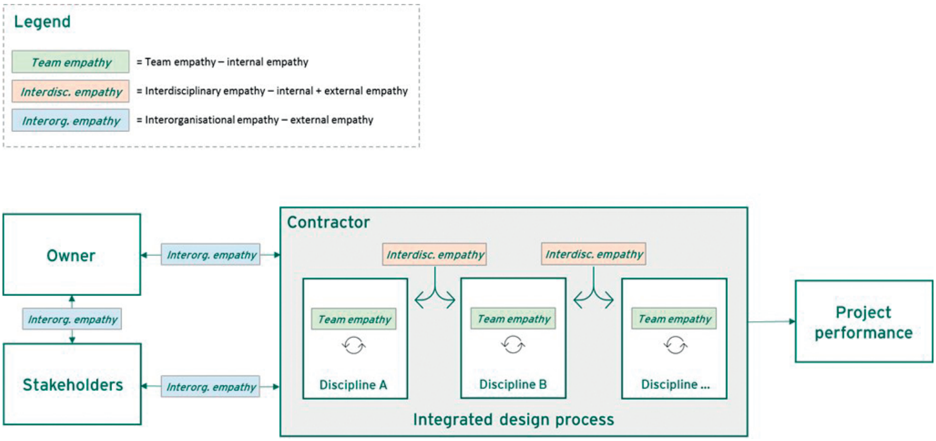

Figure 6.1: Research model.

This study considers integrated contracts, where the responsibility for the integrated design scope mainly rests with the contractor. The importance of the integrated design process for performance has been demonstrated in the literature and was discussed in Section 6.2 (Koutsikouri *et al.*, 2008; Keusters *et al.*, 2022; Leon and Laing, 2022).

6.5 RESEARCH METHOD

Data collection.

The research was exploratory to investigate whether relationships between empathy and the performance of civil engineering projects can be identified. The data were collected in February and March 2021 from a real-life, large infrastructure project in the Netherlands that was contracted via a Design, Build, Finance and Maintain contract. The contractor was a joint venture of several companies. They had contracted various engineering firms for the design assignment. The client was a public owner representing various public agencies (province and municipalities). The project scope comprised bridges, viaducts, tunnels, roadworks, earthworks, ecological works and landscaping. As such, the case was considered a representative infrastructure project.

Ethics.

Generally, all data was retrieved according to the guidelines of the Delft University of Technology ethics committee. Initially, the entire project team was informed about the research through a short presentation without mentioning empathy as a subject of study or the hypothesis. The voluntary nature of the data collection was explained. Then, prior to the interviews and the survey, the interviewees and participants were informed about the research goals, the interview and survey procedures, data collection, voluntariness, confidentiality and anonymity of the project, interviewees and survey participants, whereupon their informed consent was requested for the use of the collected data. The interviewees, being experienced and highly educated professionals, provided consent, asked no questions nor raised any risks regarding their participation. The analysed sub-groups were chosen such that individuals could not be traced.

Interviews.

Part I of the research aimed to investigate the dominant factors for performance and to explore their interaction with empathy. Eleven semi-structured in-depth interviews were conducted with experts from the owner's and contractors' organisations with project roles: project director, project managers, stakeholder managers, technical design managers and contract managers. Two interviewees were female; nine were male. The interviewees had between 7 and 31 years of experience in the civil engineering sector. The interviews followed a predetermined questionnaire based on five main questions and were conducted individually and online due to Covid-19 restrictions.

In the first part of the interview, success factors were examined to explore whether empathy interacted with performance. The interviewees were asked open-ended questions to identify 1) the most critical success factor for civil engineering projects and 2) which improvements could contribute to better performance. The interviewer did not mention empathy in this part of the interview to prevent biased answers. Only if connections with empathy-like competencies emerged the interaction with performance was explored more in detail. After an introduction of the concept of empathy, the second part of the interview focused on 3) the role of empathy in the integrated design phase, 4) when and where empathy might be important in the organisation, and 5) how it might affect the performance criteria costs, time, quality, safety or stakeholder satisfaction.

Data analysis
The interviews were transcribed and reported. The raw data were the quotes of events reported during the interviews, such as incidents, activities, examples or statements. The interview reports were analysed by highlighting all quotes related to empathy-touching topics. Quotes referring to the same success factors were clustered by theme (thematic concept coding). Open coding was used to optimally facilitate gaining insights into success factors, although *Integration* and *Team competencies* were the initial provisional concepts based on the theory described in Section 6.2. The comparison of quotes supported the accumulation of concept substantiation or the emergence of new concepts (Corbin and Strauss, 1990). The concepts required precise definitions. New insights during the analysis resulted in adjusted definitions and new (sub)concepts. Consequently, an iterative process unfolded. For the second part of the interviews, the empathy-related quotes were clustered along the three empathy categories introduced in Section 6.4 (see Figure 6.1) and sub-clustered along specific roles in the project organisation. Based on this clustering and the accompanying quotes, the researchers could verify the research model of Figure 6.1 and analyse how empathy interacts with performance.

Empathy survey
Part II of the research consisted of a survey to measure the project participants' empathic ability and to investigate how this ability is distributed throughout the team. Several methods are available for measuring individual empathic ability, for example observation methods and neurological scans. A self-report tool was chosen for this study because it is the most commonly used method and it provides valuable data that can be easily accessed.

In this study, the widely used IRI-test developed by Davis (1980) was used. One major advantage of this test is the availability of a validated Dutch version by De Corte *et al.* (2007). Furthermore, the IRI-test provides insights into the affective and cognitive abilities of the participants by measuring a total empathy score that is composed of four sub-scale scores: Fantasy (FS), Perspective-taking (PT), Empathic concern (EC) and Personal distress (PD). Categories PD and EC assess the affective dimension of empathy, while PT represents the cognitive dimension. FS is assigned to both the cognitive construct (Ewin *et al*., 2021) and the affective construct (Corte *et al*., 2007) and is thus more difficult to characterise along the cognitive-affective dimension (Baron-Cohen and Weelwright, 2004). Each sub-scale is measured by seven questions.

As the project was in the integrated design phase at the time the research was being carried out, and it was assumed that each participant was somehow involved in the design process, all participants working on the project received an invitation to participate in the survey. In total, 514 construction professionals received the questionnaire; 219 people responded, representing a response rate of 43% (25 respondents from the owner's side, 194 from the contractor's side). Participants were asked to answer the questions on a five-point scale, from 0 (does not describe me well) to 4 (describes me very well), see Appendix A.2. Additionally, personal characteristics of the respondents were collected, such as age, gender, discipline, role in the project and the number of team participants they supervised. The data were analysed by using statistical analysis software and comparing different (mean) empathy scores with each other.

While the interviews in Part I of the research provided qualitative insights into the interaction between empathy and project performance, the measurements in Part II had a quantitative character. The combination of the results of Parts I and II creates a mixed-method study and permits an analyse as to whether empathy can provide potential to improve performance.

6.6 RESULTS AND DISCUSSION

6.6.1 Part I: Interviews

The first part of the interviews explored the critical success factors for civil engineering projects and whether they interact with empathic abilities. During the analysis, the initial provisional concept of *Integration* appeared to unravel into *Integration of stakeholders' interests* and *Integration of disciplines*, see Table 6.1. Then, the initial provisional concept of *Team competencies* was broken down into the concepts of 1) O*penness* (referring to an attitude and atmosphere of speaking freely about what is on one's mind), 2) *Mutual understanding of interests*, and 3) *Communication*. Finally, by open coding, a new concept of *Collaboration* emerged, which turned to be broken down into *Collaboration between owner-contractor* and *Team collaboration* as the analysis progressed. The interviewees indicated the concepts of *Mutual understanding of interests* and *Communication* as supportive of the *Integration* and *Collaboration* concepts. As such, these concepts were not regarded as success factors in themselves. The literature review of Section 6.4 demonstrated empathy positively correlating with *Mutual understanding of interests* and *Communication*. In Table 6.1, parts of the quotes referring to these concepts are indicated in bold and underlined respectively, showing the broad support of the success factors. On the other hand, the concept of *Openness* was indicated as an independent concept by the interviewees and, for that reason, interpreted as a concept for success.

Thus, the analysis resulted in five main concepts considered essential for performance, see Table 6.1. The concepts are supported by a selection of quotes from the interviewees representing actions that foster project success and refer to empathy-related behaviour. It should be noted that the quotes used in this analysis were translated from Dutch into English. The overview indicates that empathy-related aspects broadly support success factors for performance. Generally, factors referring to collaboration-related skills were mentioned most frequently. The success factors align with the empathy categories from the research model (Figure 6.1): Team empathy aligns with *Team collaboration*, Interdisciplinary empathy corresponds with *Integration of disciplines* and Interorganisational empathy with *Collaboration owner-contractor* and *Integration of stakeholders' interests*. *Openness* was not included in the research model as a success factor. However, the positive correlation between openness and empathy has been demonstrated in the literature (Roberge, 2013; Kouprie and Sleeswijk Visser, 2009). In conclusion, the critical success factors for project performance are, to some extent, conditioned by the empathic abilities of the team's participants in the integrated design phase.

Table 6.1: Concepts of success factors derived from the interviews and substantiated by the interviewees' quotes.

Concepts → *Interviewees ↓*	**Collaboration owner - contractor**	**Integration of disciplines**	**Team collaboration**	**Integration of stakeholder's interests**	**Openness**
Interviewee 1	*"that the contractor and the owner **understand what each other's interests are**"; "that the contractor is sufficiently skilled to <u>communicate</u> what is needed for a constractual change, such that it is clear for the owner, and that he **understands what the owner needs** as substantiation"*	*"both teams should feel along with each other and <u>be able to talk to each other</u>"; "the construction team needs to be able to think along with the design team" "that you have a good collaboration between the design team and the execution team"*			
Interviewee 2	*"that **the contractor better envisions what the owner wants** in the design"; "by <u>communicating</u> getting a better vision of what you expect from each other"; "that **the owner creates understanding** for how we did certain things"*	*"It is important to **delve into what's going on**"; "<u>start the conversation</u> with project participants to hear the story behind certain choices"; "They need to look at other layers in the organisation and **think about why this person did this**"; "**To see why** certain choices are made and how things are integrated"; "That the director or project board is open to signals in the organisation"*	*"if you have a good team, with good dynamics and solidarity, where people know how to find each other, then you have <u>good communication</u>, which is essential"*		*"Be more open with each other and talk more to each other"*
Interviewee 3		*"I need to be able to <u>communicate interests</u> and involve people in why we go a certain way"*	*"If people are not able to find each other, everything will fail"; "people need to be proud and enjoy their work"; "if you can respect each other and the other's personality you can build together"; "you need to see that you can not change someone else but you can adapt to someone, then you can connect further and talk about the content"*		*"There needs to be openness"*

Table 6.1: Continued

Concepts → Interviewees ↓	**Collaboration owner - contractor**	**Integration of disciplines**	**Team collaboration**	**Integration of stakeholder's interests**	**Openness**
Interviewee 4	*"**empathising with the interests of the other** in the collaboration between owner and contractor"; "it is about **interests** and being able to take perspective"; "the owner has not enough perspective for the effect of his decisions"; "that the owner realises how you need to communicate his request to the market parties"; "that **a market party fathoms the owner's wishes**"*			*"we need to think about the image towards stakeholders"*	
Interviewee 5	*"on a management level it is about **thinking about the interests** of the project and not only individual interests"*		*"daring to ask for help in a collaboration"; "It is about how do I function in a team?"; "to be able to get the right culture and values within the team"; "you can say anything as long as it is in a respectful way"; "take a different perspective and help each other more. This supports more interaction, knowledge sharing, a high engagement of people and people feel more heard and welcome"*		*"openness is also very important"*
Interviewee 6	*"when you find dilemma's you need to be able to find each other and collaborate"; "It's important there's trust and **seeing each other's interests**"; "The owner needs to be involved in the project"; "operate in **a triangle of the interests of the contractor, the owner, and the stakeholders**"*			*"operate in **a triangle between the interests of the contractor, the owner, and stakeholders**"*	

Interviewee 7	*"Dare to act vulnerable and tell what's wrong"; "That the contractor sees that the owner envisioned something"; "Start the conversation together and feel comfortable to say what holds you back"; "You need to get to know each other"*			*"Start the conversation together and feel comfortable to say what holds you back"*
Interviewee 8	*"that, together as a team from the client and contractor, you share ideas and discuss risks"; "It is about acting vulnerable, openness, sharing problems and dare to speak"; "it is about choosing people on competences instead of technical knowledge only"; "also on the personal side we need to connect"*			*"always tell what's on your mind so we can talk about it together"; "it is extra important to put energy in openness"*
Interviewee 9		*"it is essential you are **open to the different interests** and disciplines and that you deliver the project together"; "you need to look broader and stay on speaking terms"*		*"you need to be open and transparantly make clear what's going on"*
Interviewee 10	*"it is important you can have informal meetings where you can speak freely, specifically between owner and contractor"*	*"it is important you **consider all different interests**, requirements and processes in a project"; "don't look at matters seperately but have a more broad perspective and look at relationships between matters"; "it is about the interference between other processes and interfaces"*		*"it is important you can have an informal meeting where you can speak freely"*
Interviewee 11	*"it is about the collaboration and the attitude of both parties when unforseen circumstances take place"*			*"when you collaborate, you should be open and direct from the beginning"*

After introducing the concept of empathy, in the second part of the interview the interviewees indicated how, when and for whom empathy might be important during the integrated design phase. The interviewees' statements are clustered in Table 6.2 along with the three empathy categories: (1) team empathy, (2) interdisciplinary empathy and (3) interorganisational empathy.

Table 6.2: For whom is empathy important during the integrated design process and for project performance.

Interviewee	Empathy is most important during the integrated design phase to foster project performance …	1	2	3
1	Between participants from the design team and construction team to support good collaboration and integration between these disciplines.	x		
2	Within teams to support job satisfaction of participants in the project organization. Participants who enjoy their work and their colleagues are more productive, which supports project performance.		x	
3	Within teams to involve participants and towards stakeholders.		x	x
4	(I) For the project management, (II) towards the owner, (III) for stakeholder manager and towards stakeholders, and (IV) for contract management	x		x
5	(I) Within teams and towards the owner, and (II) between participants from the design team and construction team to support a good collaboration and integration between these disciplines.	x	x	x
6	Between the owner and contractor.			x
7	Between the owner and contractor in the tender phase because that is where good collaboration starts.			x
8	Between the owner and contractor.			x
9	(I) Between the owner and contractor (especially during the tender phase), and (II) between participants from different disciplines	x		x
10	Between the owner and contractor.			x
11	Between the owner and contractor.			x

Table 6.2 shows that empathy is considered necessary at every level. However, external interorganisational empathy between the owner and the contractor was scored as the most relevant. Delving deeper into the interview data, we observe the following about how, when and for whom empathy is relevant to support performance. The arrows indicate the empathic interaction. Verbatim quotes from the interviewees are indicated in *italics* and placed between quote marks.

1. Team empathy – Internal empathy
   - *Team members ↔ Team members*

   The interviewees elaborated on the contribution of empathy in the entire team to a productive and successful project organisation in which the participants are '*happy and satisfied with their job*'. When team members are more empathic towards each other, '*trust and a certain level of solidarity is created*'. Consequently, '*team members are more satisfied with their job and colleagues*', which improves productivity and involvement. Then, by being empathic, '*team members understand how to communicate with each other, which contributes to collaboration within the team*'.

- *Project Managers ↔ Team members*

Team members need to be empathic towards each other, but it is their managers in particular who should '*stimulate and facilitate this by leading by example*'. Managers should know how to '*involve and stimulate team members and be aware of the personalities and behaviour of the participants to encourage them to share their ideas so that the project can benefit from them*'. Furthermore, managers should be empathic '*to understand how to communicate plans to their team members'* so that they '*feel more involved, welcome and heard*', making them more productive as a result.

2. Interdisciplinary empathy – Internal + external empathy

- *Participants from discipline A ↔ Participants from discipline B*

Interviewees explained that empathic abilities are needed to '*acknowledge the other's different expertise and personality'* and to '*empathise with someone else's way of thinking and working, and with their interests and problems'*. Being empathic can support a good project outcome by '*understanding how to communicate with someone from another discipline and creating trust. It is about understanding each other*', '*understanding how to communicate information between disciplines'*, and '*being able to share ideas with the other person to support collaboration and integration between the disciplines'* and '*to achieve a joint success'*.

- *Team members of the design team ↔ Team members of the execution team; Managers and Team Leaders of the design team ↔ Managers and Team Leaders of the execution team*

The interviewees stated that participants from the design and construction teams in particular not only have different expertise, but also '*have different characters and communicate in different ways'*. Empathy promotes '*listening to each other, instead of pushing your own opinion*'. It is needed '*to understand and sense what kind of communication is needed'* when working with someone from a different discipline and '*to understand the other's process and challenges'*, since collaboration between the design and construction team is considered crucial for performance in today's projects. This is considered primarily the responsibility of the managers and team leaders.

- *Project Managers and Team Leaders of disciplines ↔ Participants from other disciplines*

In particular, the interviewees allocated a role to the Project Managers and the Team Leaders of the disciplines to be empathic towards each other and to stimulate empathy between the disciplines. They should understand how to communicate '*the interests of the project as well as the specific disciplines, and how to involve people*'. The interviewees also mentioned the importance of the Project Manager leading by example when it comes to empathy to create a '*culture of openness in the organisation*'.

3. Interorganisational empathy – External empathy
   - *Owner ↔ Contractor (mainly the Project Managers of the two)*

   Most interviewees mentioned that the owner and the contractor should be mutually open and willing. This was mainly seen as the responsibility of the Project Managers. They should '*understand each other's interests*' and know how to communicate with each other, '*to be aware of how my comments and questions are perceived by my counterpart*'. A lack of empathy towards the other to understand what is possible, feasible or reasonable for the other party leads to '*unrealistic expectations, resulting in changes to plans and budget and time overruns*'. It was stressed that, especially at the beginning of the project, empathy plays an important role in building '*mutual trust and understanding of each other's perspective*' to prevent the project from getting off to the wrong start. Therefore, empathy between the owner and the contractor is already crucial at the tender stage to understand each other's needs and challenges.

   - *Contract Managers owner ↔ Contract Managers contractor*

   The interviewees also indicated that Contract Managers should empathise in order to '*understand how to communicate contractual issues*', '*understand what language to use in the contract*' and '*to avoid their statements offending the owner*'.

   - *Stakeholder Managers ↔ Stakeholders*

The interviewees indicated that it is essential for Stakeholder Managers to be empathic towards stakeholders to '*identify and respect their expectations, wishes, concerns and thoughts about the project*', so that they can decide how to involve them and incorporate their interests in the design process. Interviewees pointed out that this should be on the agenda in the early stages of the integrated design process. '*For most stakeholders who oppose a project, simply feeling heard and understood can be enough*'. In case the project lacks empathy towards external stakeholders, the interviewees explained that resistance to the project would grow, permits might not be granted, the project might receive negative media coverage, processes would be disrupted and, ultimately, the project might overrun budgets and time schedules.

It was concluded that, to a certain extent, empathy is essential for every team participant to function well in a team (Team empathy). However, empathy is considered most important for Project Managers, Team Leaders of the disciplines, Contract Managers and Stakeholder Managers. These project roles have in common that they have a lot of contact with external parties (Interorganisational empathy). Empathy was considered less important for participants from the Project Control - Finance team and participants lower down in the organisational structure, especially participants from the Technical Management team. This could be explained by the less integrative character of their tasks and fewer external contacts.

In summary, the analysis of the interview data shows that empathic abilities support performance and that empathic abilities are considered most important for participants with integrative tasks, although empathic abilities are to some extent important for any project participant.

6.6.2 Part II: Empathy measurement

In addition to measuring the team's empathy, a literature review was conducted of studies on empathy using the IRI method to gain a broader picture of empathy levels and to be able to put the project team measurement in a broader context. The IRI-method is widely used in the fields of psychology and sociology. However, studies often focus on groups with specific characteristics (e.g., schizophrenia, autism) or samples from psychology and medicine students or academics. For this study, only samples without specific characteristics (e.g., control groups) were used so that a reasonable comparison could be made with the project team used in this study. Table 6.3 presents the IRI measurements found in the literature and the empathy measurements of this study. Only the samples highlighted in green in the table were used for the analysis (4,184 participants, 58% of whom were female). The literature review indicates an average level of empathy of 63.6, with a significant difference between the genders (females 67.5; males 59.1). An equal ratio of females to males would result in an average level of empathy of 63.3 in the literature. Although an extensive literature review is beyond the scope of this research, some noteworthy observations can be made.

The project team in this study had an average empathy level of 57.2 (females 66.2; males 55.5), which is 10% lower than the average in the literature. This gap can be explained by the overrepresentation of men in the project team (34 females, 185 males), which is typical for the civil engineering industry. However, it is also noted that the average empathy level of the males in the project team is lower than the average found in the literature (literature 59.1; project team 55.5). For females, the project team's average is slightly lower than the average from the literature (literature 67.5; project team 66.2).

From a historical perspective, the relatively low levels of empathic ability can be explained by the nature of the relationships, for instance between owner, contractor and subcontractors, which were based on pricing and '*the lowest bidder wins*' (Butler and Chinowsky, 2006). In such cases, interpersonal relationships and empathy are not the main drivers of project success. The transition to integrative and collaborative projects and contracts justifies a focus on other competencies such as empathy, as evidenced by the interview data (see Table 6.1).

Table 6.3: Levels of empathic ability derived from studies using the IRI-test and this study.

Name	Year	Country	Sample characteristics
Corte *et al.*	2007	Belgium	Recruitment via advertisements in Magazines (13%), snowball sampling from initial recruitment by research assistants (87%)
Hirvela and Helkema	2011	Finland	Control Group, 61 female (37y), 78 male (36y), recruited via snowball and Facebook advertisement
			Asperger group 23 female (34y), 18 male (31y)
Ewin *et al*	2021	Australia	Project management master students, 18-44 yr, 18% female
			Nursing Students
			Midwifery Students
			Medical Students
Corbera et al	2013	USA	Schizophrenia patients
			Healthy control group, recruited through advertisements (flyers, internet posts) and selected to match the racial, age, and gender composition of the patient sample. 9 females,total av age 40
Hawk *et al*	2012	The Netherlands	Mothers from early (av. age 13,0yr, sample 1) and late (av. age 17,8yr, sample 2) adolescents, randomly recruited from elementary schools and high schools
			Early adolescents
			Late Adolescents
Fernandez *et al*	2011	Chile	Undergraduates from different fields (engineering, psychology, journalism, accounting, and advertising)
Lachman *et al*	2018	China, Germany	University of Electronic Science and Technology, Chengdu, 59.1% Baccalaureate-Diploma, 40.9% a university degree
			Most participants recruited from Ulm University, Germany, remaining participants were adults recruited from the general community in Germany. 70% Baccalaureate, 23% university degree
Guadagni *et al*	2020	Canada	Volunteers recruited through the University of Calgary Research Participation System and COVID-19 research page, social media and word of mouth
Larson *et al.*	2010		Sample of healthy, age 18-30yr, 57% female, recruited from advertisements in the local community and undergraduate psychology courses.
Gould and Gautreau	2014	Canada	University undergraduates introductory psychology classes, av. age 19,5yr., 65% female
			Older adults, av. age 68,75yr., 75% female, recruited through public service announcements
Sinderman *et al*	2019	Germany	Sample from Ulm University, outliers excluded
Kuis *et al.*	2021	The Netherlands	Dutch control group, recruited via social media, local schools, flyers; 71% male, av. 36,1yr.
			Ultra high risk Psychosis group, 44% male, 22,1yr
			Schizophrenia spectrum disorder group, 66% male, 38,9yr
Average			Averages of green marked samples (totals include 58% females)
	2021	The Netherlands	Project team members of the present study

Total						Male							Female						
N	Total	FS	PT	EC	PD	N	Av. Age	Total	FS	PT	EC	PD	N	Av. Age	Total	FS	PT	EC	PD
651	63,7	16,5	17,3	18,1	11,9	299	25	57,7	14,5	16,4	16,6	10,26	352	28	69,1	18,2	18,0	19,6	13,3
139	62,8	16,9	17,0	18,9	10,0														
41	56,4	13,6	14,5	15,6	12,8														
149	65,3	16,5	17,7	17,7	13,4														
-	76,1	19,3	19,8	20,6	16,4														
-	75,9	18,1	19,4	20,9	17,6														
-	-	-	20,3	16,5	14,9														
30	59,8	13,4	16,1	18,5	11,8														
24	62,1	13,8	19,1	20,0	9,2														
													501	Sample 1: 45yr, Sample 2: 48yr	64,4	15,3	18,2	20,0	11,0
269	61,7	15,5	14,5	17,6	14,0	148	13,0	56,7	14,0	13,9	16,1	12,7	121	13,0	65,9	16,8	15,1	18,8	15,2
232	62,5	16,7	16,6	17,8	11,5	107	17,8	55,1	14,5	15,4	16,0	9,3	125	17,8	68,9	18,7	17,6	19,3	13,3
435	63,0	15,4	16,9	18,4	12,2	201	18-36, av. 20	59,0	14,1	16,6	17,2	11,10	234	18-36, av. 20	66,4	16,5	17,3	19,4	13,2
612	61,0	15,8	15,8	17,7	11,7	450	18-32	60,5	15,6	16,0	17,5	11,42	162	18-32	62,5	16,3	15,3	18,3	12,5
304	69,5	18,8	17,8	19,6	13,3	97	18-63	62,4	16,7	17,3	17,3	11,04	207	18-63	72,8	19,8	18,0	20,7	14,4
573	63,8	15,3	15,8	20,2	11,0	112	26	54,7	13,0	14,6	17,3	8,80	459	26	65,9	15,9	16,1	20,8	11,5
30	62,8	17,7	14,6	20,8	9,8														
144	66,8	17,3	18,1	19,4	12,0														
120	63,5	13,1	18,7	21,3	10,4														
1098	68,5	18,7	17,3	19,1	13,5	304	18-30yr, av. 21,9	60,6	16,4	16,6	16,4	11,24	794	18-30yr, av. 21,9	71,6	19,6	17,6	20,1	14,4
49	56,4	13,1	17,1	17,0	9,2														
43	60,9	17,0	13,7	16,1	14,1														
92	61,9	13,8	16,5	18,0	13,7														
4184	**63,6**	**15,9**	**17,2**	**19,1**	**11,3**	**1463**		**59,1**	**15,0**	**16,2**	**17,1**	**10,64**	**2709**		**67,5**	**17,7**	**17,0**	**19,8**	**13,2**
219	**57,2**	**12,8**	**18,2**	**16,7**	**9,5**	**185**		**55,5**	**12,1**	**18,1**	**16,2**	**9,17**	**34**		**66,2**	**16,8**	**19,0**	**19,0**	**11,4**

Diving into the four IRI dimensions, it is noted that the lower levels of empathy of the project team are driven by lower scores for FS, EC and PD. The PT scores are higher than the averages from the literature. This suggests that relatively low affective empathic abilities drive the project team's lower overall empathy scores. Where women of the project team score 20% higher than men on affective abilities (EC+PD), they score only 5% higher on the cognitive abilities (PT), indicating that higher women's empathic abilities are driven by higher affection. These results may reflect the construction industry's culture of 'getting things done', 'results first' and focusing on progress. Such a culture might also be conditional for success and could even be hindered by affection (Bloom, 2018). So, the significance of the relatively low affective empathic ability in a changing civil engineering industry needs more study.

The data were also analysed for group characteristics. The owner's team scores significantly higher on empathy than the contractor (owner 65.2; contractor 56.2). The owner's team consisted of 32% females, and the contractor's team consisted of 13% females, which partly explains the difference. The owner's team scored higher than the literature's average (63.3), whereas the contractor's team scored significantly lower.

6.6.3 Merging the results of parts I and II

The analysis of the interview data showed that empathy positively supports the most critical success factors for project performance during the integrated design phase. However, the measurement shows that the project team's level of empathy is relatively low compared to the averages found in the literature (Project team 57.2; the literature 63.3). Although more research is needed to investigate the significance of such a gap, the difference is considered remarkable. Given the relatively high level of empathy of women, the data suggest that project performance can be improved by increasing the gender diversity of project teams. The positive correlation of gender balance with performance of project-based organisations is demonstrated in the literature and is driven by factors such as team cohesiveness, collaboration, adaptability and customer service (Baker *et al.*, 2019). Empathy is an ability that supports these success factors.

Furthermore, the interviews revealed the project roles and disciplines for which empathy is especially important, see Section 6.6.1. By combining these findings with the empathy measurement for these disciplines, it can be verified whether the empathy levels are in line with expectations, see Table 6.4.

Table 6.4: Combination of the interview data and the empathy measurement data per role and discipline. Figures in red deviate from the expectations.

Average level of empathic ability of the project team: 57,2			
Empathic ability is important		**Empathic ability is less important**	
Role	**Empathy**	**Role**	**Empathy**
Project Managers and Team Leaders of the disciplines	53,1	Project Control - Finance	48,3
Contract Managers	65,6	Participants low in the organisational structure	58,4
Stakeholder Managers	61,1		

The figures indicate that the empathy levels of Contract Managers and Stakeholder Managers are relatively high, which corresponds with the statements of the interviewees. According to the interviewees, Project Managers and discipline Team Leaders should score high on empathy. They were held responsible for interacting with other organisations and stakeholders, supervising their teams and getting their teams to collaborate effectively. All participants supervising more than ten people were checked to verify this group. This part of the sample scored 53.1 (N=22) on average, which is relatively low.

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Participants of the Project Control – Finance group scored low, which corresponds to the importance of empathy that the interviewees ascribed to this group. This confirms that for some project roles empathy will not be an essential competence or may even be counterproductive. For the participants lower in the organisational structure, the group of participants that had no supervision was verified. This group scored 58.4 (N=149), which is higher than the team average. Although empathy was considered less important for this group, the relatively high level of empathy can be valued positively since empathy was considered to some extent relevant for the whole team. Nevertheless, it is noteworthy that this group scored higher than the Project Managers, who were expected to score highest.

The importance of empathy for project management and performance that emerged from the interview data is supported by the literature, which emphasises in particular the relationship between empathy and transformational leadership. A transformational leader is defined as a leader who increases the trust of individuals or groups and focuses on exchanging subordinates' needs and interests (Butler and Chinowsky, 2006; Toor and Ofori, 2008). The integration challenges of today's projects and, in particular, the integrated design phase require transformational leadership. Given the relatively low levels of empathic ability of the Project Managers and discipline Team leaders, there is scope to improve performance by increasing the empathic abilities of this group.

6.6.4 Limitations of the study

As this is the first study to examine the interaction of empathy in the field of civil engineering, there are a few limitations to the research. Firstly, only one project was used to collect the data. Therefore, more multiple case studies are recommended to strengthen generalisation. In addition, the data were collected through interviews with people who may have lacked a clear understanding of what empathy is. During the interviews, it became evident that empathy is a complex concept for people to fully understand. Furthermore, the method used to measure empathy has some limitations. A self-assessment requires a certain degree of self-knowledge of the respondents and some commented that they found the questions used in the IRI-test rather difficult to understand. Since this study used relative levels of empathy, this limitation is considered minimal. Finally, there was a low response rate for some specific disciplines.

6.7 CONCLUSION

In recent decades, civil engineering projects have had to contend with the increasing integration of stakeholder interests and disciplines. Given the current challenges of climate adaptation, circularity, biodiversity and increasing urbanisation, this trend is expected to continue. Changing project characteristics will affect the key competencies of project teams, since the crucial role of project team participants' competencies for project success is broadly accepted in the literature. Although research has demonstrated the positive contribution of empathy to team performance and design processes in general, the impact of the empathic abilities of project teams in civil engineering projects has not yet been studied.

This study investigated the role of empathy in a large infrastructure projects involving a high level of complexity in terms of integrating stakeholder interests and disciplines. Although empathy was identified as an important competence for project performance, the results indicate a relatively low level of empathy in the team, caused by low scores on affective abilities. Moreover, the team's project management, which was expected to score high on empathy, scored lower than the team's average.

The implications for practice are that there is potential for improvement of project performance by increasing the team's level of empathy, particularly that of the project management. Given the relatively high level of empathic abilities among women, mainly driven by higher affective abilities, this study suggests that performance can be improved by increasing the proportion of women in project teams, particularly in management roles of the project. The insights into the substantial difference in the level of empathic ability between women and men also contribute to the body of knowledge on the effects of gender diversity in the civil engineering sector and substantiate its interaction with project performance.

Although this study provides initial and important insights into the levels of empathic abilities, more research on project teams is needed to further generalise the levels of empathic ability in the civil engineering industry and its interaction with project performance. The significance of the gap between the expected and measured levels of empathy needs to be further understood, as balancing the need for more empathy resulting from integration challenges and maintaining a culture of 'getting things done' is a point of attention.

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7

Reflection II: The role of empathy in civil engineering projects

7.1 INTRODUCTION

Chapter 6 comprised a first step in Dewey's experimental phase of the process of design inquiry (see Table 1.7), i.e. exploring and testing a potential relationship between the team's empathic abilities, the integrated design process, and project performance. This chapter concisely reflects on the study results presented in Chapter 6 in the context of the research question and the previous study results regarding the role of integration in design processes and project performance. These reflections are only based on the researcher's analysis of the data and deepen the analysis made in Chapter 6.

7.2 A REFLECTION ON THE RELATIONSHIP BETWEEN INTEGRATION, COLLABORATION AND EMPATHY

The results presented in Chapter 6 once more confirm the critical role of integration in civil engineering projects and design processes. Comparable to the study results presented in Chapter 3, a distinction between integration of stakeholders' and disciplines' interests could be made. Collaboration emerged as a dominant factor for performance, where collaboration between disciplines, organisations, and within the team are distinguished. As such, integration and collaboration seem connected concepts and share similar dimensions (internal (within teams, disciplines) and external (owner-contractor, stakeholders, disciplines)).

The apparent relationship between integration and collaboration could be explained from their interpretations and definitions. Collaboration is appropriate when more than one party or organisational unit is necessary for a project to achieve a goal. The presence and involvement of different parties imply the existence of contrary or conflicting interests to some extent. Although collaboration is a broad concept, it at least comprises the development of a collaborative way of working to align the goals and interests of the parties involved in the project and joint problem-solving (Suprapto, 2015). As such, collaboration overlaps with integration in the design process, which was interpreted as the process of understanding, adopting, and aligning the parties' interests to be able to integrate them into a shared problem definition and an integrated and supported design solution. Integration and collaboration can be considered different perspectives for a comparable process and purpose. The connection between collaboration, integration and aligning interests was demonstrated by the quotes of the interviewees:

- '*When you encounter a dilemma, you need to be able to find each other and collaborate.*' (Stakeholder Manager, contractor).
- '*It is essential that you are open to different interests and disciplines and that you deliver the project together.*' (Technical Manager, owner).
- '*It is about collaboration and the attitude of both parties when unforeseen circumstances take place.*' (Stakeholder Manager, owner).

In the previous chapters, integration was introduced as a crucial factor for performance and interpreted as adopting the project context and aligning project participants' interests in the process and the design solution. The critical role of understanding interests and needs was confirmed in the study of Chapter 6. Moreover, the need for (partly) aligning processes and cultures as part of the process of integration (see Figure 4.1) also emerged in this part of the study. Interviewees indicated the importance of '*adapting ways of communication*', '*understanding the others' process and challenges*', '*understanding what language to use*', and '*you need to see that you cannot change the other, but you can adapt to someone. Then you can connect further and talk about the content*'. The quotes refer to the need to first resonate with the other's language, process or ways of working to be able to connect and arrive at mutual understanding and integration of interests.

The goal of the study in Chapter 6 was to test and explore the role of empathy in the projects and to get an initial understanding of how empathy interacts with performance. Chapter 5 interpreted empathy as the ability to have an emotional response to another's emotional state and to reflect on that by perspective-taking; wandering around in the others' world, connecting to resonate and detaching to take appropriate action. In projects, particularly the integrated design process, empathic behaviour manifests itself by connecting, listening, openness, and willingness to feel and understand the other. The Chapter 6 case study reveals that '*understanding interests*', '*communication*' and '*openness*' support the critical success factors and performance. The interviewees indicated the importance of mutually '*understanding*' and '*envisioning*' the '*interests*', '*wishes*' and '*needs*'. Additionally, several expressions of communication were raised as supportive of critical factors for success, such as '*being able to talk to each other*', '*asking questions*', '*staying on speaking terms*', and '*starting a conversation.*' They are all connected to empathy, where '*good communication*' in itself obviously also relates to empathic abilities. The quotes represent the empathic behaviour of wandering around, connecting and resonating with the other, and overlap with the expressions presented in Table 3.3, which initiated the research into empathy. It could be concluded that integration and collaboration were interacting success factors for the project and that they were both nourished and strengthened by factors related to empathic abilities. Consequently, the study established indications for a relationship between the team's empathic abilities and project performance.

The results present an initial insight into how empathy interacts with performance. The model distinguishes empathy within the team and between teams or organisations. Team empathy concerns aligning interests and feelings on a personal level, assuming the team's participants pursue the same project goals and interests. It enables an open, safe, and pleasant atmosphere, contributing to motivated participants willing and driven to share ideas and achieve the team's goals. Interdisciplinary and inter-organisational empathy focus on aligning and integrating the interests of disciplines and organisations, although personal interests and feelings could play a role as well (for instance, regarding a safe environment). The study suggests the inter-organisational empathy between the owner and the contractor to be critical.

The gap between the empathy scores of the project team and the scores found in the literature is remarkable. However, the project team's apparently relatively low scores on empathic abilities were not unexpected based on experiences from practice. The Dutch civil engineering industry has a long history of rather monodisciplinary projects, limited interaction with the environment, and construct-only contracts driven by pricing and the lowest bidder, lacking the need to integrate parties' interests. Partly, this is still the driving mechanism, particularly in smaller infrastructure projects. These projects initiated a culture based on power, where collaboration, sharing interests nor empathic abilities were supportive or considered necessary for project success. Only with the development of increasing integrality and complexity of the design process did the need for new and other competencies arise in the sector. Section 2.10 delineated a gradual development of change towards more integrative projects and collaborative contracts during the past two decades. Such a timespan seems too short to complete a cultural and organisational transition. However, more data is needed to generalise the conclusions on the levels of empathic abilities and their effects on integration and performance.

7.3 GENERALISABILITY OF THE STUDY RESULTS

The study presented in Chapter 6 aimed to answer subquestion 2, redefined as how empathy influences performance through the integrated design process and how it can contribute to an improvement of the performance of civil engineering projects. The results suggest a positive correlation between empathic abilities and performance and a relatively low level of empathic abilities in the civil engineering sector. The context of the study was a large Dutch infrastructure project. Although the project scope is considered representative of civil engineering projects, more data is needed to generalise the study results. Particularly, the data on the team's empathic abilities needs to be extended to gain more insights into the average empathic levels of the industry and a potential improvement. Additionally, the relationship between the empathic ability and performance needs a more fundamental base.

Therefore, the investigation was expanded with additional projects and empathy measurements to be better able to generalise the conclusions. Chapter 8 presents the next step in the experiment and testing the hypothesis, i.e., the relationship between the team's empathic abilities, the integrated design process, and project performance, and investigating how empathy interacts with integration and performance. Subsequently, improvements for the industry can be determined based on the results.

7.4 REFERENCES

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8

An expanded investigation on the relationship between empathy and performance

This chapter reflects a manuscript published in the *Journal of International Project Management* titled "Empathic Ability as a Driver for Project Management" by Guus Keusters, Marcel Hertogh, Erik-Jan Houwing and Hans Bakker, (2024) Vol. 42, Issue 4, https://doi.org/10.1016/j.ijproman.2024.102591.

It comprises an expanded experiment to test the hypothesis, i.e. the relationship between empathy, the integrated design process and project performance of civil engineering projects. Additionally, the study aims to understand more deeply how empathy interacts with performance. The content of sections 8.2 and 8.3 describe the study's problem statement and a description of the concept of empathy, which were more broadly discussed earlier in Chapters 1 and 5 respectively. Consequently these sections contain repetitions. For the sake of completeness these sections are included in this chapter anyway. The questionnaires used in this study's survey are presented in Appendix A.

8.1 ABSTRACT

Empathy is receiving increasing attention as it can contribute to the collaboration and connectedness required for today's global challenges. A similar trend reveals itself at the scale of project management, given the change from technological to integration-driven challenges in projects. The necessary integrated approach affects the key competencies sought in project team participants. Since empathy enhances one's feeling for and understanding of the project participants' interests, it could support the integration assignment. Therefore, focusing on the Dutch civil engineering industry, this study investigated whether the project team's empathic ability drives project performance. The results suggest a positive correlation between the team's empathic abilities and performance. Additionally, the study provides insights into the industry's current level of empathic ability, prompting the conclusion that there is room to improve performance by increasing the project teams' empathic abilities.

8.2 INTRODUCTION

The existence of empathic skills in humans can be explained from an evolutionary perspective and the need to collaborate and understand other's interests to survive. The growing interconnectedness of societies and systems calls for collaboration and connection to tackle today's global challenges. This development drives increased attention to empathy to counter the focus on self-interest and individualism (De Waal, 2019). The same challenge of connection and integration reveals itself within today's project management as growing interdependencies and contrary interests characterise projects. Civil engineering projects in particular are increasingly driven by the need to collaborate and integrate a growing number of interests and parties (Demirkesen and Ozorhon, 2017; Leclère, 2020). Therefore, it is generally valuable to explore the interaction between empathy and project performance and particularly focus on civil engineering projects.

An important driver for increasing integration is the need to merge urban mitigation and adaptation strategies to address climate change and realise the sustainable development goals (IPCC, 2022). These transitions introduce new spatial claims and types of land use, especially in urbanised deltas. Where civil engineering is defined as the design and construction works serving the public domain, such as transportation infrastructure and water management, civil engineering projects are concerned with the built environment and play a crucial role in these transitions. Integrating project goals related to the transitions introduces new project functions, e.g. adapting to drought, flooding, heat stress or biodiversity, which need to be integrated with enduring and more traditional ones, such as mobility (Visser, 2020; Hertogh, 2013). As a result, the civil engineering project's problem definitions are becoming increasingly complex, reflected in the growing number of contradicting stakeholder interests that need to be adopted and integrated (Maddaloni and Davis, 2017; De Schepper *et al.*, 2014). Meanwhile, more and new disciplines are introduced in the projects and need to be integrated at a lower level of abstraction of the project processes. Additionally, civil engineering projects suffer from a history of poor performance and have found it hard to achieve predefined goals in terms of costs, time and quality (Flyvbjerg *et al.*, 2013; Locatelli *et al.*, 2017), further emphasising the need to improve. In short, due to integration challenges, managing civil engineering projects is becoming increasingly complex, while performance is already a struggle.

While many variables influence project performance, the competencies of the team's participants have been broadly identified as a crucial factor for project performance in the literature (Bakker and de Kleijn, 2014). Research focuses on the critical role of project management and leadership competencies (Nicholas and Steyn, 2017; Toor and Ofori, 2008). In addition, the team's competencies have also been identified as an important factor for performance (Scott Young *et al.*, 2019). While the characteristics of civil engineering projects are subjected to the integration of a growing, dynamic context, competencies to adopt the context of the project problem and integrate it into the problem definition and the solution have become essential to project success. Recognition of the impact of this development on the team's competencies is crucial (Moradi *et al.*, 2020).

Empathy is defined as a person's ability to feel, understand and share another person's world with self-other differentiation (Hakkanson Eklund and Summer Meranius, 2021). It is often described as stepping imaginatively into the other's shoes to gain an understanding of feelings and perspectives. Although it is often confused with sympathy, it differs where it does not allow the observer to develop personal emotions. The empathic ability has an affective (experiencing, feeling) and a cognitive (understanding) dimension, which are intertwined (Gerdes *et al.*, 2010). Empathy is related to the project manager's tasks and competencies essential for project success, such as communication, collaboration, and trust (Solares Menegazzo *et al.*, 2015). Moreover, empathy is acknowledged as an important ability to adopt the needs and emotions of the user in the design process and to foster performance (Heylighen and Dong, 2019), especially in product design and architecture. These disciplines are characterised by high human interaction and context integration by nature. On the other hand, since empathy occurs mainly between individuals and is affected by in-group bias, it involves the risk of prioritising individual interests over best-for-project. Moreover, it could hinder an attitude of decisiveness and determination, which is also critical in project management (Bloom, 2018).

Empathy will be most effective during project stages that place high demands on interpersonal interactions and when understanding mutual interests is crucial. This is especially the case in the integrated design process, which we define in this study as the course of human activities whereby an existing situation is transformed into a plan for a new one in order to satisfy needs, including and balancing the interests of all parties and disciplines involved (Keusters *et al.*, 2022). The positive correlation between this process and project performance has been demonstrated (Chan *et al.,* 2004*;* Doloi, 2013; Love *et al.*, 2015), and the importance of the design process is growing, given its increasingly collaborative and interdisciplinary character (Koutsikouri *et al.*, 2008).

The increasing need for adopting and integrating project context, stakeholder interests, functions and disciplines also links the empathic ability to today's engineering project performance. After all, and more generally, experiencing and understanding the feelings, needs and interests of stakeholders, the participants of the adjacent disciplines and colleagues in the project team could facilitate adopting the project context, defining the design problem and finding the best possible solution, consequently improving performance.

Although correlations between empathy, design processes and performance have generally been discussed, the interaction between the team's empathic abilities and the performance of engineering projects has not yet been investigated in detail. Furthermore, no quantitative data are available on the empathic abilities of project teams or their relationship with performance. Therefore, the research question guiding this study is whether the empathic ability of the participants of the integrated design team is a relevant variable affecting the project performance, where the study's context concerns civil engineering projects.

This mixed-method study comprised eight representative projects in the Dutch civil engineering industry. It is the first study that used quantitative data on the team's empathic abilities to investigate its relationship with project performance and delivers initial insights into the empathic abilities in the industry today. Additionally, it proposes guidelines for improving the performance of projects by focusing on empathy, given its increasingly integrative character.

8.3 THE INTERACTION BETWEEN EMPATHY, THE INTEGRATED DESIGN PROCESS AND PERFORMANCE

Empathy is subject to different views and interpretations, and reassessments of claims on human social interactions are ongoing (Mezzenzana and Peluso, 2023). Scholars agree that empathy is the ability to have an emotional response to another's emotional state and reflect on that by perspective-taking. De Waal (2012) considers cognitive perspective-taking a secondary development built around more elementary mechanisms, such as state-matching and emotional contagion. As such, empathy can be interpreted as an emerging element in human-related factors crucial for project management, given the increasing number of participants and their conflicting interests in projects.

Common ground in the concept of empathy can be found when focusing on empathy related to managing design processes and performance. Empathising in a design process comprises entering, discovering and immersing in the user's world and interest, connecting to resonate with the user and finally detaching to take appropriate action. Kouprie and Sleeswijk-Visser (2009) described a process of "*wandering around*" in the user's world, stepping in to gain a deep understanding and stepping back to take competent action. In this process, empathic behaviour manifests itself by connecting, listening, openness and willingness to feel and understand the other or even non-human stakeholders (Talgorn and Ullerup, 2023).

The self–other distinction is an important aspect of empathy. Although the process of empathising induces similarity between the feelings one experiences oneself and those expressed by others, Decety and Lamm (2006) stress the importance of avoiding self-other confusion. Empathy is predominantly other-oriented, which is where it differs from sympathy. Sympathy concerns the other's well-being, whereas the goal of empathy is to understand and feel the other person's experiences (Wispe, 1986). Sympathy refers to 'relating' and allows the observer to have his own emotion as a response to the other's emotion, while empathy relates to 'knowing' and does not allow the observer to develop his personal emotion. The self-other differentiation promotes empathy to an applicable concept in a professional and competitive setting.

Empathy cannot be considered an all-or-nothing phenomenon. First, someone's empathic abilities depend on one's empathic horizon, which can be defined as the individual's range of understanding of and empathy for user experiences in different contexts, such as background, culture, age and gender. McDonagh-Philp and Denton (2000) argue that expanding one's horizon is a never-ending process if actively considered, implying an expanding ability to empathise with increasing age. Next, the literature has demonstrated that empathy is affected by in-group bias, which means that it is easier to empathise with group members or familiar individuals (De Waal, 2012; Decety and Lamm, 2006). Although this implies a lack of empathy for out-group individuals, it can be activated by outsiders. Finally, someone's emotional state, engagement in or commitment to the project can also affect someone's level of empathy (Kouprie and Sleeswijk-Visser, 2009). Although the positive effects of empathy have been widely endorsed, some limitations have also been raised. Bloom (2018) attributes rational competencies to humanity above all. Therefore, he considers empathy-based and individual-oriented decision-making in the here and now inferior to human rational decision-making.

The empathic abilities of the project team participants can contribute to performance via the integrated design process in two ways (Keusters *et al*., 2023). Firstly, a sound design problem definition is essential (Cross, 2001). This requires a deep understanding of the project's context. It is suggested that the designer's ability to feel and understand the other's interests and concerns about the project will enhance adopting the project context, accurately defining a design problem definition, and finding solutions. The understanding of context applies at different levels of abstraction of the design process. At the higher levels of abstraction, the project context is mainly dominated by the stakeholders affected by the project. At this system level, feeling and understanding their concerns and interests is crucial and has become a key managerial challenge (Unterhitzenberger *et al*., 2021; Witmer, 2019). At the lower levels of abstraction, the integration of disciplines governs the design process. The empathic ability of the project participants to feel and understand the concerns and interests of the participants of the adjacent disciplines or parties could help define the design problem at the component level and consequently find the best solutions (Baiden and Price, 2011). So, empathy could support mutual understanding and the adoption of interests and perspectives at any level of the integrated design process.

Secondly, empathy supports the performance of a group or team with the same characteristics and interests by fostering collaboration and creating an emotionally safe working atmosphere where people feel free to share their ideas and concerns (Miyashiro, 2011; Roberge, 2013). By viewing integrated design teams as groups that perform through social processes (Bucciarelli, 1988), empathy could also enhance the performance of civil engineering project teams. The relationship between high-performing teams and transformative leadership and the mediating role of empathy is demonstrated in the literature (Toor and Ofori, 2008; Socas, 2018; Solares Menagazzo *et al*., 2015). Moreover, the literature relates empathy to other factors essential for project management and success, such as communication, collaboration, trust and human interaction (Valente, 2016; Köppen and Meinel, 2015; Moradi *et al*., 2020). Thus, empathy could be part of a tangle of mutually dependent, human-related factors affecting team performance, project management, leadership, and project performance.

The hypothesised positive correlation between empathy, the integrated design process and project performance is visualised in the research model in Figure 8.1. Being a comprehensive process and closely interacting with several other critical processes in project management, the positive correlation between the design process and performance is evident and demonstrated in the literature (see Section 1). Where the literature tends to the positive effects of empathy on design processes and (team) performance, downside effects or possible overrepresentation of empathy also need consideration, since they might introduce a lack of a best-for-project attitude, decisiveness and determination.

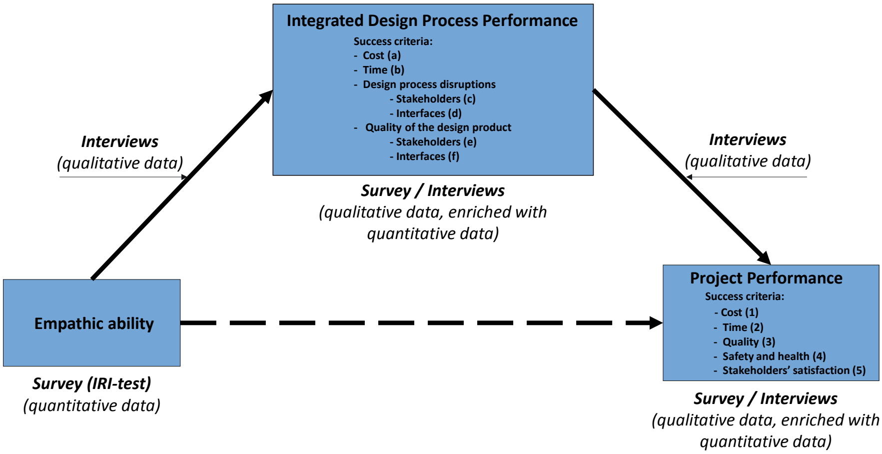

Figure 8.1: Research model and research methods.

Project performance can be defined in many ways and depends on the participant's perspectives (Kylindri *et al.*, 2012; Koops, 2017). Besides the well-known iron triangle success criteria (cost, time, quality; Nicholas and Steyn, 2017), stakeholder satisfaction has become a critical success criterion. The public character of civil engineering projects implies large numbers of heterogeneous and increasingly assertive stakeholders, such as politicians, residents, or interest groups, affecting or affected by the project and contributing to the project's social complexity (Westerveld, 2003; Davis, 2014). Finally, the importance of health and safety during construction and the total project life cycle has grown over the past decades (Silva *et al.*, 2019). Therefore, in this study, we defined project performance as the extent to which predefined goals related to cost (1), time (2), quality (3), safety and health (4) and stakeholder satisfaction (5) are achieved. These criteria rule the civil engineering projects and Economically Most Advantages Tender (EMAT) criteria of today's tenders in the Netherlands.

The performance of the integrated design process is determined by the extent to which the predefined budget (cost (a) and time (b)) related to the design process are met. Additionally, the extent to which the process is disrupted (by integrating stakeholder interests (c) and interface issues (d)) and the quality of the design product (related to the stakeholders (e) and interface issues (f)) are used as success criteria. Criteria c) to f) refer to the aforementioned integration challenges of the design process at the stakeholders' and discipline levels.

8.4 RESEARCH METHODS

This study investigated eight projects where the level of empathic ability, the performance of the integrated design process and project performance were measured. While empathic abilities and (to some extent) performance can be measured quantitatively, the interactions between the variables can only be verified qualitatively, given the complex and human character of the subject under study. As such, the research is characterised as a mixed method multiple case study, where the quantitative data enriches the qualitative data. Figure 8.1 shows the research methods used.

The cases were selected in the Netherlands based on a broad variety of project sizes (contract value €25-800 million), owners (12 different authorities, with some projects having several owners), contractors (10 different companies, with some projects being awarded to joint ventures consisting of several contractors), types of integrated contract (Design & construct (#4), Design Build Finance & Maintain (#1), 2-phase contracts (#2), Design & Construct Alliance contract (#1)) and project scope (comprising flood defences, railway works, road works, viaducts, bridges, tunnels or combinations). As such, the projects and the project teams were considered representative of the Dutch civil engineering industry.

Although several methods are available to measure empathic abilities, such as observational methods and neurological scans, self-report tools are most used as they provide valuable and easily accessible data. This study applied the most commonly used Interpersonal Reactivity Index (IRI) of Davis (1980). The IRI-test has the advantage of the availability of a Dutch version, the validity and reliability of which have been demonstrated for measuring empathic tendencies. (De Corte *et al.*, 2007). In addition, the index provides insights into the affective and cognitive abilities of the participants by measuring a total empathy score that consists of four sub-scale scores: Fantasy (FS), Perspective-taking (PT), Empathic-concern (EC) and Personal-distress (PD). PD and EC assess the affective dimension of empathy, while PT represents the cognitive dimension. FS is assigned to the cognitive (Ewin *et al.*, 2021) and the affective dimension (De Corte *et al.*, 2007).

For each subscale, participants were asked to answer seven questions on a five-point scale, from 0 (does not describe me well) to 4 (describes me very well). Additionally, characteristics of the respondents were collected, such as age, gender, discipline and the number of team participants they supervised. Finally, the respondents were asked to score their perception of the project's complexity related to integrating stakeholder interests and disciplines. These variables were supposed to drive complexity and possibly moderate performance.

All participants interacting with the integrated design process received an invitation to participate in the survey, which was conducted based on anonymity following the guidelines of the Delft University of Technology ethics committee. The analysed sub-groups were chosen such that individuals could not be identified. In total, 462 participants responded to the survey, representing an average response of 50% across the eight projects. 86% of all respondents were men, representing the Dutch civil engineering sector (CBS, 2021). 82% of the respondents represented a contractor, which can be explained by the fact that the responsibility for the design scope of the integrated contracts mainly rested with the contractor in the cases.

Subsequently, the integrated design process and project performance were measured through semi-structured interviews. In total, 33 interviews were conducted, three to six interviews per project, with the owners' (#17) and contractors' (#16) key actors of the projects and the integrated design process, such as project managers, contract managers, technical managers and design managers. Three of them were women. The interviews lasted approximately one hour and consisted of two parts. In the first part, the interviewees were asked to score the project performance with performance criteria (see Figure 8.1) on a scale from 0 (very poor performance) to 4 (very high performance). Each score was defined as objectively as possible to make the scores of the interviewees comparable across the projects. The interviewees had the opportunity to explain their scores. Finally, considering all performance criteria, the interviewees were asked to score the overall project performance on a scale from 0 to 4. This score was considered a assessment in which all criteria were subjectively weighted.

Likewise, the interviewees assessed the performance of the integrated design process. They were asked to score criteria a) to f) (see Figure 8.1) on a scale from 0 to 4. Finally, they had to score the overall performance of the integrated design process on a scale from 0 to 4, subjectively weighting all criteria.

The second part of the interviews focused on the interaction between project performance, the integrated design process and the empathic ability of the team, aiming to determine whether empathy was among the dominant variables affecting performance. The interviews unfolded based on two open-ended questions:

1. What were the dominant factors affecting the project performance criteria?
2. What were the dominant factors affecting the performance criteria of the integrated design process?

The data analysis was based on interview reports validated by the interviewees. First, each interview was mined to find the dominant factors, after which they were aggregated per case. Parallel to this analysis, the interview reports were coded. Quotations referring to the same phenomena were coded as concepts potentially relevant for theory-building. The concepts were ranked based on the highest groundedness. A theory regarding the interaction between empathy and performance could be derived from the main concepts and their interconnectedness (Corbin and Strauss, 2014). Atlas TI software was used to structure and analyse the data. The dominant factors influencing performance were tested against the main concepts and found to correspond in all cases.

Finally, for each case, the interview data analysis was merged with the quantitative empathy and performance data analysis to arrive at conclusions regarding the interaction between empathy and performance. A cross-case analysis was then conducted to draw general conclusions on the relationship between empathy and performance and to build a theory on how empathy influences performance.

8.5 RESULTS

8.5.1 Levels of the empathic ability of the sample

Since the sample is considered large and representative, it can provide insights into the current empathic abilities of the civil engineering construction sector. Therefore, it is valuable to analyse the sample in addition to the interaction between empathy and the performance of the cases. Figure 8.2 shows the levels of the teams' empathic abilities and the average level of empathic ability across all eight cases. In addition, the figure shows a level of empathic ability derived from a literature study by Keusters *et al.* (2023), comprising 4184 respondents without specific characteristics, such as control groups. Therefore, this level, which is based on a 50/50 split between men and women, is considered a reference to facilitate comparison.

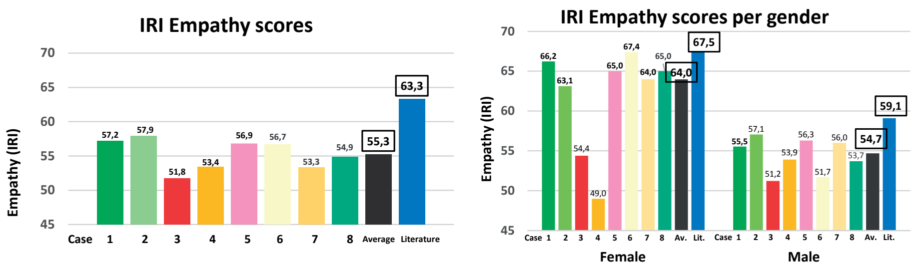

Figure 8.2: Levels of the empathic ability of the eight cases and a reference level of empathic ability from a literature review (Keusters et al., (2023)).

The figure indicates that the levels of empathy vary across the 8 cases (between IRI=51.8 and IRI=57.9). Furthermore, the average level of empathy across the cases (IRI=55.3, marked black) was relatively low compared to the reference level from the literature (IRI=63.3). Zooming in on the data, we notice the striking differences between the empathy levels of men and women, both from the sample of this study (women IRI=64.0, men IRI=54.7) and from the literature review (women IRI=67.5, men IRI=59.1). Although the sample's relatively poor levels of empathic ability can be partly explained by the overrepresentation of men (84%), both women and men in the sample scored lower than the averages from the literature.

The cognitive empathic dimension (PT) of the sample scored higher than the literature reference (sample IRI=17.7, literature IRI=16.6), whereas the affective dimension (EC + PD) scored lower (sample IRI=26.1, literature IRI=30.3). So, the relatively low affective abilities of the project teams' participants are a key driver of the low overall scores. The sample also scored lower on the fantasy (FS) dimension (sample IRI=12.2; literature IRI=16.4).

The distribution of the empathic abilities across age and supervising roles of the project teams is worth mentioning, see Figure 8.3. The empathic abilities show a declining trend with age, contrary to expectations based on literature insights, suggesting that more life experiences could extend someone's empathic horizon (McDonagh-Philp and Denton, 2000). Since the characteristics of the age categories are comparable, the conclusion could be that a generation with higher empathic abilities is entering the sector, or the sector is unable to retain people with more empathic skills. Additionally, the figure indicates that the empathic abilities decrease as respondents supervise more employees. This is considered remarkable since the literature demonstrates the importance of empathy-related skills for people with management roles. Correspondingly, respondents of the project management discipline scored below the sample's average (IRI=53.8, N=41, N_{female}=3 (7%)).

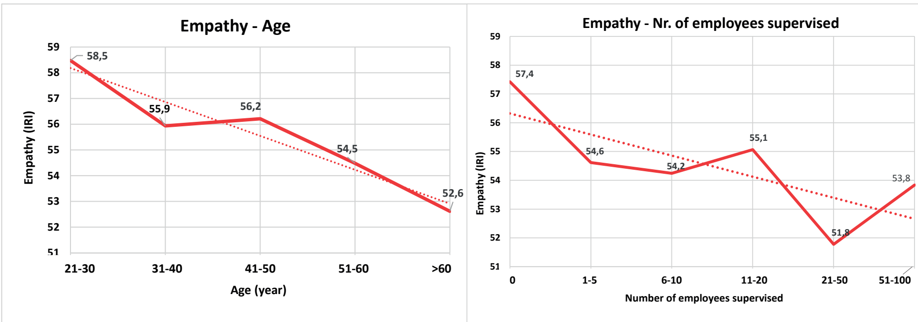

Figure 8.3: Levels of empathic ability with age and number of participants supervised.

8.5.2 Quantitative data analysis

The quantitative data analysis assessed relationships between the empathic ability scores, the integrated design performance scores and the project performance scores. Initially, relationships from the quantitative data were verified by plotting the levels of empathic ability and performance scores. The interviews revealed different perspectives on the performance between the owner and the contractor. Given their separate budgets for the projects, this was considered natural for the cost criterion. However, other criteria were also considered from different viewpoints, with owners being more demanding concerning stakeholder satisfaction and quality and contractors focusing on costs, safety and time. For this reason, the data analysis was split between the owner's and the contractor's perspectives.

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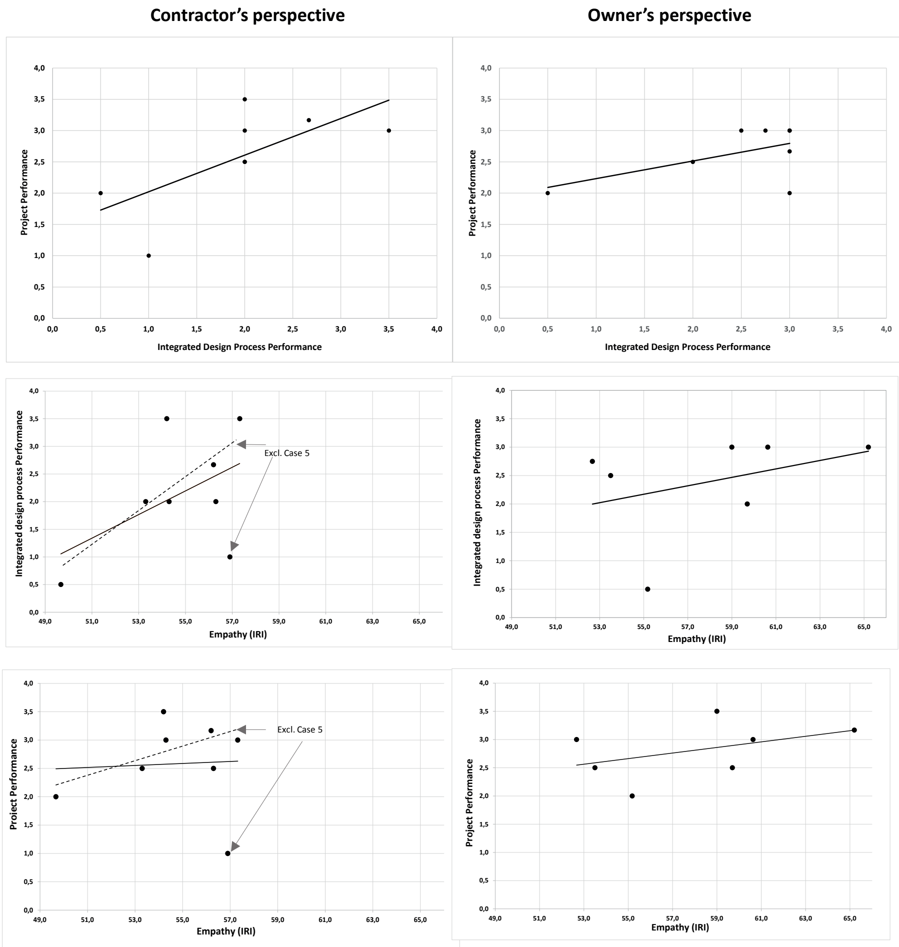


Figure 8.4: Linear trendlines of relationships between levels of empathic ability and performance based on quantitative data.

First, Figure 8.4 suggests a relationship between the overall performance of the integrated design process and project performance, which aligns with the theory (Koutsikouri *et al.*, 2008; Love *et al.*, 2015). Next, the figure shows the scores and linear trend lines of the empathic abilities and the overall performance scores of the contractors' and owners' teams. Both from the perspective of the contractor and the owner, weak relationships appeared between the level of empathic ability and the overall performance of the integrated design process and the overall project performance. However, given the number of cases and the spread of the data, the correlations are not significant. The cost and time performance criteria indicated similar weak, non-significant relationships with performance. For the other project performance criteria (quality, safety, stakeholders' satisfaction), no clear relationships could be determined from the quantitative data. The integrated design performance criteria (cost, time, disruptions and quality) suggested positive correlations with empathy, but none could be classified as significant. Since the owner of Case 5 had no participants involved in the integrated design team, no owner empathy measurement was available for this case.

The interviews were experienced as open and transparent and revealed the complexity of objectively assessing performance. Apart from the owners and the contractors having different perspectives, the criteria were also assessed differently within the owner and contractor teams. One of the reasons was that factors outside the team's sphere of influence were identified as impacting performance, such as unrealistic budgets or time schedules allocated to the project before the project team under study was involved. These exogenous factors seemed to be differently accounted for in the scores by the interviewees. Additionally, the construction phase had just started for some projects, meaning the respondents could only share performance forecasts rather than make objective assessments.

Table 8.1: Categorisation of levels of empathic ability and performance (based on performance scores enriched with interview data) and hypothesis verification per case.

Contractor						
Case	**Empathy**		**Performance**			**Hypothesis?**
	IRI	**Category**	**Design**	**Project**	**Overall category**	
1	56,2	High	2,7	3,2	High	Confirmed
2	57,3	High	3,5	3,0	High	Confirmed
3	49,7	Low	0,5	2,0	Low	Confirmed
4	54,3	Average	2,0	3,0	Average	Confirmed
5	56,9	High	1,0	1,0	Low	Rejected
6	56,3	High	2,0	2,5	Average	To some extent
7	53,3	Average	2,0	2,5	Average	Confirmed
8	54,2	Average	3,5	3,5	High	To some extent

Owner						
Case	**Empathy**		**Performance**			**Hypothesis?**
	IRI	**Category**	**Design**	**Project**	**Overall category**	
1	65,2	High	3,0	2,7	High	Confirmed
2	60,6	High	3,0	3,0	High	Confirmed
3	55,2	Low	0,5	2,0	Low	Confirmed
4	52,7	Low	2,8	3,0	Average	To some extent
5	-	-	-	2,0	Low	-
6	59,7	Average	2,0	2,5	Average	Confirmed
7	53,5	Low	2,5	3,0	Average	To some extent
8	59,0	Average	3,0	3,0	High	To some extent

As a result, it was concluded that the hypothesis could not be tested purely quantitatively. For this reason, an additional analysis was performed in which the quantitative performance scores were enriched with the qualitative data from the interviews by considering the interviewees' explanations of the scores, the outlined project context and the measured project complexity. By doing so, the project performance and the performance of the integrated design process were categorised into high, average or low performance levels, see Table 8.1. Based on these classifications, an overall performance category was aggregated per case. Seeing as project performance matched integrated design process performance in most cases, the resulting aggregated score was evident for most cases. Performance categories differed from the contractor's perspective in case 4 and the owner's perspective in cases 1, 4 and 7. For these cases, the overall performance category was based on the additional interview data.

The same categorisation was applied to the levels of empathic ability, classifying the cases into categories of high, average or low levels of empathic ability. Subsequently, the empathic ability and performance levels could be compared for each case. Table 8.1 shows the results regarding the relationship between empathy and performance.

If the performance and empathy categories matched (High-High, Medium-Medium, Low-Low), the case was considered to confirm the hypothesis. Case 5 shows high levels of empathic ability and low performance, indicating that the hypothesis should be rejected. If the case presented a combination of high and average or low and average categories, the hypothesis was confirmed to some extent and subject to a full qualitative analysis to draw final conclusions.

From the contractor's perspective, five cases confirmed the hypothesis, two confirmed the hypothesis to some extent, and one (case 5) refuted the hypothesis. From the owner's perspective, the hypothesis was confirmed for four cases, while the hypothesis was confirmed to some extent for three cases, pending qualitative analysis.

8.5.3 Qualitative data analysis

The qualitative data from the second part of the interviews were used to investigate the dominant factors that affected the performance of the integrated design process and project performance and whether these factors interacted with the teams' empathic abilities. First, in all cases, the interviewees confirmed the positive correlation between the integrated design process performance and project performance. Then, the dominant factors for project performance overlapped with those determining the integrated design process performance. The factors indicated by the interviewees were aggregated to form the three dominant factors per case, see Table 8.2.

Table 8.2: Dominant factors affecting the integrated design process performance and project performance.

		Case							
	Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Dominating factors for project performance and performance of the integrated design process	**A: Integrated approach of the design process**	**Integrated approach of the design process and the Verification process**	**Integrated approach of the design process**	**Integrated approach of the design process**	**Integrated approach of the design process**		**Integrated approach of the design process**	**Integrated approach of the design process**	**Openess (open communication)**
	B: A proper problem definition and verification process			Proper **problem definitio**n and specifications	Proper **problem definitio**n and specifications			Proper **problem definitio**n and specifications	Proper **verification process**
	C: Competencies for collaboration and shared understanding of interests **Team composition** balanced related to empathy , "getting things done" mentality , knowledge	Competencies related to **Team Collaboration**	Competencies related to **Team Collaboration**	Competencies related to **Collaboration** in a alliance type of contract and contractual conditions	Competencies related to **Team Collaboration** and **Mutual Understanding**	Competencies related to T**eam collaboration** and **Integrated approach**	**Shared understanding** of problem definition and assignment	**Shared expectations and understanding** of the assignment and collaboration	**Team composition** (balanced related to openess / empathic and "getting things done" mentality)
	D: Other		**Contract**, providing E**arly Contractor involvement** and an integrated approach			**Risk Management / Cost awareness**	**Processes** fit for the assignment / technology and experience above processes		
					Ownership				
	Hypothesis: The dominant factors for performance relate with empathic abilities.	**Confirmed**	**Confirmed**	**Confirmed**	**Confirmed**	**Rejected**	**Confirmed**	**Confirmed**	**Confirmed**

The table generally shows three dominant categories (A, B and C), all related to empathic behaviour, as described hereafter. One category (D) includes items not related to empathy. The categories are substantiated by a selection of quotations from the interviewees referring to their experiences in the project, which are shown in '*italics*' and were translated from Dutch into English.

A. An integrated design process approach

The interviewees indicated the importance of '*integral considerations and integral motivating the decisions, to arrive at the best-for-project solution*.' '*This requires a team that wants to merge and not only thinks from its own world. So, it has to do with people; it is the people who do it in this process.*' '*People need to listen to each other, talk to each other, understand each other.*' '*An integrated nature of the team promotes collaboration and requires empathy. So, for the overall result of the project, it helps to be more empathic*.' As inhibitors for integrality, '*Different cultures, lack of connection, inability to think beyond the parties' own interests*' were indicated.

Empathy is considered a competence that supports understanding other disciplines' problems or interests and consequently supports integration and performance. Listening, understanding and talking to each other are considered expressions of empathic behaviour.

B. A proper problem definition and verification process

A recurring issue was the lack of a sound design problem definition (the specifications), causing scope and contractual discussions delaying the entire planning. To determine the problem definition, '*one needs to understand the context very well, be able to build a relationship. … That requires much effort from people. It tends towards empathy. Do you understand the other person's behaviour, do you ask the right questions?*' '*The team constantly has to ask itself the question: "Does this provide a good product for the user… beyond the interests of each party?"*' Defining and interpreting the problem definition is a wicked challenge, introducing the inevitable iterative design process. However, '*the designers determining the requirements are far from flawless. If they could not properly capture what the stakeholders really want, meeting the requirements will not necessarily imply the quality of the design is good.*' '*Do you understand what the other person is doing? Do you understand that, and do you ask the right questions about it? Ask questions: "What is bothering you?"*'

Adopting the project context and being able to feel and understand the emotions and interests of the stakeholders is important for a good design process and project performance. Empathy contributes to defining an accurate design problem. As such, this category appeared in four cases and is therefore considered relevant. Asking questions, thinking beyond the parties' interests, understanding, and capturing what the stakeholders really want are expressions of empathy.

C. Competencies for team collaboration, shared understanding of interests

Collaboration and team composition related to collaboration were among the three dominant factors in all cases. Behaviour or abilities related to empathy and supporting collaboration were frequently reported during the interviews. '*Within the management team, we needed to be sensitive to each other, be open and empathise with each other's world.' 'Shifting into the role, interests and points of view of the other.' 'Good collaboration requires being open in what is bothering you and putting yourself in the other person's shoes.' 'Paying attention to each other… being and staying connected.'*

Mutual understanding was mentioned as an important condition for collaboration. Moreover, it was stressed that it was not self-evident and required additional effort. '*Organisations have to truly understand each other to come together.' 'It requires empathy to understand why [-] reacts in a certain way.' 'We had the patience to reflect on those interests by asking questions.' 'When one says that the collaboration is good, the question arises: "How is the empathy? Do we really understand each other?" That is often not the case. We settle for good relationships, but empathy is something else. Empathy is not the same as interacting and communicating pleasantly.*' Empathy-related behaviour, such as understanding, shifting into the other's role, connecting, and giving attention, were identified as playing a role in collaboration.

Table 8.2 shows that, for seven cases, two or three dominant factors affecting performance were related to expressions and behaviour referring to empathic abilities. The interviewees of these cases confirmed the positive correlation between empathy and the integrated design process performance and project performance. In case 5, the interviewees proposed other dominant factors such as ownership, cost awareness and risk management.

8.5.4 Merging quantitative and qualitative analyses

The combined results of the quantitative (Table 8.1) and the qualitative analyses (Table 8.2) are presented in Table 8.3. The qualitative and the quantitative analysis confirmed the hypothesis for cases 1, 2 and 3. Therefore, for these cases, the hypothesis could definitively be confirmed. For case 5, the quantitative analysis ran counter to the hypothesis. The qualitative analysis confirmed that empathic abilities were not linked to the dominant performance factors in this case, although empathy-related factors did affect performance.

Table 8.3: Combination of the results of the quantitative and the qualitative analysis and the verification of the hypothesis per case.

	Contractor			Owner			Hypothesis confirmed or rejected
	Quantitative	Qualitative	Hypothesis confirmed or rejected	Quantitative	Qualitative	Hypothesis confirmed or rejected	
Case	Are empathy and performance scores aligned	Are dominant factors related to empathic abilities?		Are empathy and performance scores aligned	Are dominant facrors related to empathy?		
1	Yes	Yes	Confirmed	Yes	Yes	Confirmed	Confirmed
2	Yes	Yes	Confirmed	Yes	Yes	Confirmed	Confirmed
3	Yes	Yes	Confirmed	Yes	Yes	Confirmed	Confirmed
4	Yes	Yes	Confirmed	To some extent	Yes	Confirmed	Confirmed
5	No	To some extent	Rejected	-	To some extent	-	Rejected
6	To some extent	Yes	Confirmed	Yes	Yes	Confirmed	Confirmed
7	Yes	Yes	Confirmed	To some extent	Yes	Confirmed	Confirmed
8	To some extent	Yes	Confirmed	To some extent	Yes	Confirmed	Confirmed

For cases 4, 6, 7 and 8, the qualitative analysis confirmed the hypothesis, but the quantitative analysis confirmed the hypothesis only to some extent, either on the side of the contractor or the owner. The analysis hereafter combines the quantitative and qualitative interview data to arrive at final conclusions per case.

Case 4

In case 4, the owner's level of empathy was relatively low, while performance was average. The interviews revealed that design process disruptions were caused by a poor problem definition and deficient stakeholder management, resulting in delays and scope changes. Since the owner was responsible for stakeholder management and the resulting design specifications, the issues could have been caused by the owner's poor empathic ability, limiting the attention paid to the stakeholders. As several of the factors influencing performance identified by the interviewees were linked to empathy, both in a positive and a negative sense, it was concluded that levels of empathy had a positive correlation with performance.

Case 6

In case 6, all performance and empathy scores were average, apart from the contractor's level of empathy, which was just slightly above average. For this case, a 2-phase contract was applied with a joint owner-contractor team during the first phase. The interviewees indicated that this team had to grapple with an unrealistic budget from the beginning of phase one, negatively affecting performance (especially the cost and time criteria). The team did not manage to overcome the budget issue, which was attributed to a lack of integrality and shared understanding of the project goals. The interviews confirmed that the lack of empathic abilities could have played a role here. While the contractor's level of empathic ability scored only slightly above average, higher empathic abilities could have helped to solve the difficult budget problem. Since the qualitative analysis revealed the role of empathy in the process and the quantitative analysis did not contradict the interaction, a correlation between empathy and performance was confirmed for case 6.

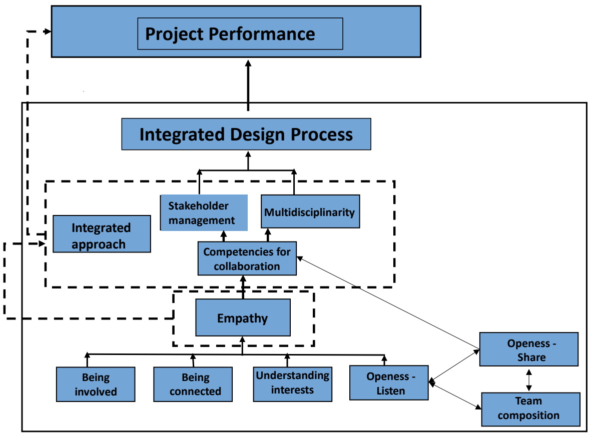
Case 7

By the time the interviews and the survey of case 7 were conducted, construction had started, but the design phase had not yet been finalised. At that time, the performance scores were forecasted as average. However, the contractor and the owner mentioned project risks caused by a lack of mutual understanding of the consequences of scope changes and contractual issues that had not yet been settled. The owner scored relatively low on empathy, and although the contractor's empathic ability was average, it was the second lowest of the eight cases. The lack of mutual understanding of contractual positions and interests was linked to the relatively low empathic abilities of the teams. Both parties acknowledged the risks this implied for the project. Therefore, it was concluded that case 7 demonstrated a correlation between the empathic abilities of the team and performance.

Case 8

In case 8, the empathic abilities of the owner and the contractor were average, while performance scores were higher than in any other case. Diving deeper into the data, the difference between the relatively poor empathic ability of the construction management team (IRI=47.3; N=6) and the relatively high empathic ability of the project management and the design management team (IRI=60.1; N=7) is remarkable. The positive effects of this difference on performance were confirmed by the interviews, where the project success was explained by the project management and design management team's willingness to share problems and to work closely together, resulting in mutual understanding. At the same time, the project also benefited from the "getting things done" attitude of the construction management team, which could have benefited from relatively poor empathic abilities. In several cases, it was revealed that an optimal team composition consists of members with higher levels of empathy for project management, stakeholder management and design management roles, while participants with lower empathic abilities would do better in construction roles. In summary, it was concluded that an optimal distribution of empathic abilities across the team fostered performance, confirming a correlation between empathy and performance.

Figure 8.5 reflects the results of the process of coding and theory-building on how empathy interacts with performance. The figure includes the concepts with the highest groundedness across the eight cases. The relationships were built up based on relatively high code co-occurrences of the concepts. The figure shows that the integrated approach of the design process is crucial for project performance and is determined by the extent to which stakeholder interests and disciplines are integrated into the process and the solution. The team's competencies, specifically empathic abilities, are important for the extent to which the team collaboratively arrives at an integrated approach. Expressions of empathic behaviour are listening, willingness to understand the other's interests, connection (talking to each other, being in contact) and involvement with team participants and other parties' participants. Sharing, interpreted as being open to proactively sharing one's interests and issues, was often mentioned as important for success (third highest groundedness). This concept is not considered part of empathic behaviour and was introduced as a crucial counterpart to being open to listening. The importance of balancing between empathic listening and proactively sharing one's problems and feelings was emphasised, reflected in the balanced team composition concept, which also scored relatively high.



1	Integrated approach	81
2	Collaboration	79
3	Openess - share	69
4	People's competencies for interaction/collaboration	55
5	Openess - listening	53
6	Being connected	52
7	Understanding interests	51
8	Design problem definition	48
9	Team composition	46
10	Interests	38
11	Talk to each other	38
12	Contract	37
13	Being in contact with	33
14	Trust	33
15	Sharing problems, knowledge	25
16	Having shared expectations / goals	23
17	Stakeholders' interests management	23
18	Knowledgeable	22
19	Verification and Validation	22
20	Being involved	19

Figure 8.5: Overview of relationships between performance, the integrated design process and empathy, and the top twenty concepts with the highest groundedness.

The concepts seem to point towards cognitive empathy (understanding, listening, connecting), rather than affective empathy (feeling), which aligns with the results of the IRI-test. It also underpins that the interviewees referred to (cognitive) empathy rather than sympathy, which is more superficially concerned with others and focuses on one's own emotions.

A more extensive explanation of the data analysis, in addition to the published paper: As described in Section 8.4 and in addition to the interview data analysis described in Section 8.5, a process of coding and analysing the interview data following elements of grounded theory was conducted to gain a deeper understanding of the interaction between empathy, the integrated design process and performance. The quotes of the interview reports were coded based on concepts relevant to performance. Open coding was used to facilitate optimally gaining insights into success factors. Integrated approach, competencies, and collaboration were the initial provisional concepts based on the theory described in Chapters 3 and 6. While the analyses progressed, concepts were added, and concept definitions were adjusted, demonstrating the iterative nature of the analysis process.

The analysis converged to the twenty highest grounded concepts and insights into their interrelatedness, see Appendix B. A network of thematically grouped concepts could be constructed. The results are consistent with the initial analysis based on the determination of the dominant variables from the interviews (Section 8.5.3), which identified A: "An integrated approach of the design process", B: "A proper problem definition and verification process", and C: "Team competencies for collaboration and shared understanding of interests" as the dominant factors for performance. The network of interrelated concepts of Appendix B was combined with the previous results and insights of the study presented in Chapters 3 and 6 (see Figure 3.7), and, finally, evolved into the model presented in Figure 8.5, representing a theory on the relationship between empathy, the integrated design process and project performance.

8.6 DISCUSSION

The cross-case analysis based on the results presented in Table 8.3 reveals that the hypothesis could be confirmed for seven out of eight cases. Therefore, referring to the research question, this study suggests a relevant correlation between the team's empathic abilities, the integrated design process performance and project performance. Consequently, empathy emerges as a vital human-related factor in today's project management. The growing relevance and the currently relatively low levels of empathic abilities of project teams can be explained by the increasingly integrative character of civil engineering projects which is new for the sector and requires competencies that were less called upon until now. Empathic abilities contribute to the integration challenges of contemporary and future projects by enhancing the mutual deep understanding of interests. Furthermore, the interview data confirm the interaction between empathy, leadership and team collaboration as argued in the literature (Moradi *et al.*, 2020). This study indicates in particular potential regarding the project managers' empathic abilities, given their relatively low scores, and their crucial role in leadership and performance.

Generally, the study indicates relatively low levels of empathic ability in the sector. In addition, women outscore men on empathic abilities. Consequently, performance could be improved by increasing the levels of empathic ability of the project teams, particularly by increasing the currently low gender diversity. The positive role of gender diversity in project teams is demonstrated in the literature and is based on women's focus on cohesiveness and collaboration (Baker *et al.*, 2019). This study substantiates the positive role of gender diversity from an empathy perspective.

The interview data also revealed that the distribution of empathic abilities across the team needs to be taken into account because empathic abilities are considered beneficial for collaboration between parties and the integration challenges but might be counterproductive for less integrative tasks or during the construction phase when a "getting things done" attitude is more effective. The concepts of "Openness–Share" and "Team Composition" seem to refer to the downside effects or overrepresentation of empathy in project teams and point to the need for a balanced and targeted use of empathy to contribute to performance. Furthermore, it is noted that the type and intensity of peoples' emotions can affect project decision-making (Svensson and Pesämaa, 2018). It can be argued that high empathic abilities could recognise true emotions and that the perspective-taking dimension provides additional assurance to an appropriate response. However, more research is needed to investigate how empathy moderates the type and intensity of emotions for decision-making in project management.

The generalisation of the study's conclusions depends on the context of the cases. Some considerations need to be discussed in this respect. In case 5, the empathic abilities of the team were not a dominant factor for performance, as the interviewees considered poor risk management, low cost-awareness and lack of ownership more decisive for the poor performance. The project's complexity related to integrating stakeholders' interests and multidisciplinarity scored the lowest of all cases. Where the research model assumed integration as a main driver of current project complexity, it seems the project could not benefit from the team's relatively high empathic abilities since the integration challenges were limited, making other factors more dominant for performance. As such, the study suggests a certain level of integration, i.e. integrating stakeholder interests and disciplines, necessary for empathy to support performance.

The data were collected in the Dutch culture, which can be classified as feminine and long-term oriented. In a project-based setting, this culture prioritises collaboration and builds relationships and trust (Hofstede *et al.*, 2010). In such a culture, reflected in the qualitative data (see Figure 8.5), empathic abilities can find a breeding ground and enhance performance relatively easily, which might not be the case in cultures or types of contracts focusing less on collaboration and relationships.

Finally, the interviewees indicated human-related behaviour such as involving, connecting, listening, collaborating, understanding, and trusting as supportive of integration and performance (see Figure 8.5). The process of empathising described in Section 2 (entering, discovering and immersing the user's world; Kouprie and Sleeswijk-Visser, 2009) refers to this behaviour. Therefore, the study's results introduce empathy as a factor in the field of mutually interacting human-related variables affecting performance. As such, a positive correlation between empathy and performance could have been found through mediating variables other than the integrated design process, such as collaboration, which the interviewees confirmed. This interplay between empathy and other human-related factors (e.g. collaboration, trust) needs further study.

8.7 CONCLUSION

This study confirms the importance of integration in today's projects and suggests that the project team's empathic abilities could contribute to an integrative approach and the performance of projects. This is a relevant conclusion in the realm of project management. Specifically in civil engineering, the transitions related to climate change and biodiversity and their interaction with the built environment will increase the need for integration. The current empathic abilities of the civil engineering sector are relatively low compared to the reference values from the literature, mainly caused by below-average affective abilities. Consequently, in practice, there is room to potentially improve project performance by increasing the empathic abilities of the teams. Given their relatively low empathic abilities and their crucial role in leadership, the focus should be on the project managers. Since women tend to have higher levels of empathic ability than men, this study also contributes to substantiating the effectiveness of gender diversity in projects, especially when women occupy more management positions. In addition, the integration challenge in projects can be supported by enhancing in-group empathy of disciplinary teams through the use of processes and tools focusing on mutual understanding and exchanging one's interests and concerns.

The study is the first to combine quantitative data on empathic abilities with qualitative data to establish a relationship with performance. This has led to initial insights into the relationship between empathy levels and performance in projects and the distribution of empathic abilities across teams. The generalisation of the results is determined by the study's context, of which, in particular, the integrative nature of the projects and the Dutch culture of civil engineering projects, focusing on collaboration and relationships, enabled the positive effects of empathy. More study is needed to gain insights into the role of empathy beyond this study's context, the desired levels of empathic abilities to support performance, and the interplay with other human-related factors.

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Reflection III:
The relationship between empathy and performance

9.1 INTRODUCTION

In the previous chapters, the study results broadly underpinned the essential role of integration in the design process and its relationship with performance. The first steps of integration, i.e. bridging to unfamiliar cultures, parties, and disciplines and understanding others' interests, emerged as an essential success factor for the integrated design process. The interviewees' quotes referred to the need to resonate with the other's language, process and ways of working to be able to connect and arrive at mutual understanding and integration of interests. In this context, collaboration was also introduced as a critical factor, which overlapped with the interpretation of the integrated design process used in this study, i.e., the understanding and adoption of the interests of parties involved in the project to arrive at shared and supported resolutions.

People's competencies to understand and adopt others' culture, interests, problems, and emotions were raised as the critical factor to arrive at an integrated approach (see Figure 8.5), where the role of empathy was broadly tested in Chapter 8. In 7 out of 8 cases investigated, a relevant positive correlation emerged between the teams' empathic abilities, the performance of the integrated design process and project performance. The interviewees firmly indicated empathy-related behaviour or explicitly empathy itself as an important factor in enhancing performance. As a result, it was generally argued that the project team's empathic abilities positively correlate with the performance of the integrated design process, which in turn supports project performance.

This chapter further reflects on the context of the relationship between empathy and performance and the interpretation of the Chapter's 8 study results. The reflections are based on the researcher's analysis of the data and the literature and deepen the analysis made in Chapter 8.

9.2 CONTEXT DESCRIPTION

The claim that empathy is an important factor for performance needs a well-defined context description. The cases in this study covered a wide range of civil engineering projects. However, they were all located in the Netherlands and, therefore, subject to Dutch construction culture. In Section 2.10.3, this culture was characterised as feminine, focusing on collaboration, prioritising relationships, and building trust. Possibly, in such an environment, empathy could more easily be identified as a critical success factor. Consequently, the study's conclusions should be used with restraint for projects in more masculine environments, focusing on power and short-term relations. In addition, following the problem definition, the study focused on projects with relatively high integration challenges, i.e. integration of the stakeholders' and disciplines' interests. In other words, the projects were located in complex environments and highly interdisciplinary. Although it is argued that this applies to most contemporary civil engineering projects, it should be noted that the assertion can be applied to integration driven projects only.

Chapter 8 discussed the downside effects of overrepresentation of empathy, i.e. a lack of a best-for-project attitude, decisiveness and determination. The study results demonstrate the importance of a balanced team (represented by the concept of *'team composition')* by identifying two interpretations of the concept of '*openness*' (see Figure 8.5). Where openness was interpreted as '*listening*,' it can be related to empathic abilities, i.e. being open to listening and understanding the other's interests and emotions. Where it was interpreted as '*sharing*', it was related to quite the opposite behaviour, i.e. an attitude of primarily pro-actively sharing one's emotions, interests or problems instead of listening. Both concepts were considered equally relevant:

- '*Empathy is a dominant factor. You really have to work together. But you also need people that put it on the table when something goes wrong.*' (Project Manager, contractor).
- *'We had the right people on board. We had a joint venture of two contractors. One of them was about "not talking but doing", while the other was about "thinking first". That mix, also in the management-roles, resulted in a good team, risk-driven and thinking, but also able to accelerate.'* Design Manager, contractor)

In line with this, it is concluded that empathic abilities are particularly supportive of the integrative project phases. Empathy is explicitly considered important during the front-end development phases, including the integrated design phase, which is dominated by integration, interaction and acceptance, and will be less supportive during the construction phase, which is considered less integrative and, instead, dominated by concrete and operational doing. In this study, the construction phase is assumed to comprise production only, since the previous integrated design phase has brought about a supported design and plan for realisation.

The same pattern is reflected in the project roles, where empathy is expected to be more supportive of integrative roles. Figure 9.1 presents the levels of empathic ability of the sample discussed in Chapter 8 distributed per discipline.

As was expected from their role, stakeholder managers scored highest, as they are assumed to be able to empathise with the project's stakeholders and integrate their wishes into the process. It is noted that the share of women is highest for the highest scoring disciplines. The designers scored slightly above the sample's average, whereas the project managers, the participants of the preparation, and the process management discipline scored slightly below the sample's average. Finally, the participants of the finance and construction disciplines scored the lowest. The share of women in these groups is low. The participants of the construction and finance teams are considered to conduct tasks with the lower levels of integration, and the interviewees actually appreciated their getting-things-done attitude as the counterpart of empathy. Generally, it is argued that the participants' levels of empathic ability follow the extent to which their disicplines conduct integrative tasks.

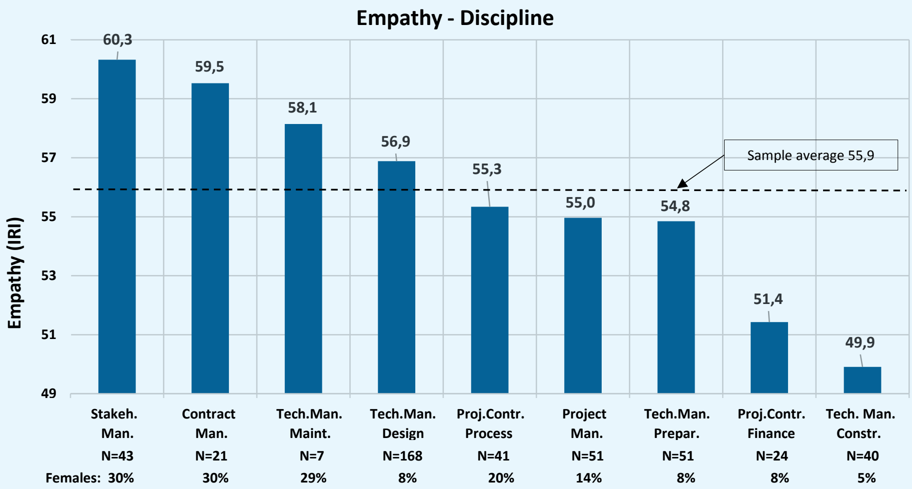


Figure 9.1: The levels of empathic ability per discipline (16 (out of 462) respondents were not attributed to a specific discipline).

This was not the case for the project managers. Their relatively low level of empathic ability is remarkable. Only 7% of the project managers supervising more than five people were female, which generally explains lower levels of empathic ability. The potentially positive effects of increased gender diversity in project management needs more study. The previous chapters concluded that empathic abilities are particularly important for project managers, given the positive correlation with leadership, the positive effects of empathic management regarding team collaboration and performance, and the critical role of empathy related to collaboration between parties and the stakeholders in which the project managers play an important role. The positive effects of empathic leadership were particularly attributed to the integrated design phase of the project, which is more transformative, aiming for inclusion, togetherness and integration.

Consequently, Chapter 8 particularly focused on the potential of increasing the empathic abilities of project managers to improve performance given their low scores and their crucial role in the project. However, it is argued that all actors participating in the integrated design phase contribute to the integration assignment to some extent. The literature generally demonstrates the crucial role of the team's competencies for performance (Scott Young *et al.*, 2019) and the mediating role of empathy as a driver for social cohesion and improving collaboration and performance (Roberge, 2013). Given the relatively low scores of empathic abilities of the project participants in general, it is believed that increasing the empathic abilities of the entire team could positively contribute to the performance of the integrated design process and project performance, taking into account the context and limitations delineated in this section.

As discussed in Chapter 8, the data from Case 5 refuted the hypothesis. Where the level of empathy was above average, the average project performance score of the interviewees was the lowest of all cases. It was discussed that the overall complexity of this case and the complexity related to the integration of disciplines scored lowest of all cases, prompting the suggestion that the integration challenge of the case was too low for empathy to be supportive. Although integration-driven projects define the context of the study, it is difficult to distinguish between integrative and non-integrative-driven projects related to the positive role of empathy. Diving into the interview data, it was noticed that the interviewees generally acknowledged the positive role of empathy for performance but that they considered other factors ((lack of) leadership, ownership) more dominant for the project performance:

- *'The team has experienced unpleasant situations. What didn't happen then was the conversation:"… let's all see how that will be resolved." I see that as empathy. Being able to empathise how annoying that is for the team. I doubt if empathy was really there. ... Empathy played a role, but ownership was more dominant.'* (Project Leader, Contractor).
- *'Everyone has done their best. But there was insufficient experience, understanding or feeling of the importance of the person you worked with.'* (Project Manager, Contractor)

The (lack of) integration in the design phase was also indicated as an important factor for performance: '*There were only a few connectors in the design phase - people who brought the team together. … We have not been sufficiently aware of its impact on the contract, costs, on other disciplines. That ultimately causes that you do not have an integral design.'* In conclusion, integration and the positive effects of empathy were acknowledged in this case, however, these factors emerged as less dominant than in the other seven cases, where the dominant factors clearly related to empathic behaviour. Therefore, it is argued that this case does not undermine the claim that empathy is a relevant factor in the spectrum of performance determinants.

9.3 PERCEPTIVE PERFORMANCE

Performance is the dependent variable of this study. As discussed in Section 2.11, performance is subject to the subjective interpretation and perception of the project participants. In this study, performance assessments were made during the interviews with the key managers of the project (i.e. the project managers, technical managers, and contract managers). The interview data used in Chapter 8 revealed the dependence on project roles, organisational background and culture in assessing performance. This was most obvious in the assessments between the owner and the contractor. Therefore, the analysis of the relationship between the empathic abilities and performance was separated for the owner and the contractor. Figure 9.2 shows the average performance scores per success criterion of the owners (blue) and the contractors (red). The figure demonstrates that, although the perception of performance differed per case and interviewee, the performance perceptions followed the same pattern on average. In addition, the performance perception of the cost and time criteria are assessed as low compared to the quality and stakeholders' satisfaction criteria. It is once more emphasised that the quality and stakeholders' satisfaction assessments were made by the project's key participants, not the stakeholders themselves. Nevertheless, the results seem to reflect the important role of the stakeholders' support for the project performance, which is regulated and imposed through permit procedures in the Netherlands. Furthermore, the relatively high perception of the overall performance compared to the individual criteria is striking. Apparently, the perception of the overall project performance is high, despite the sometimes low performance on costs and time.

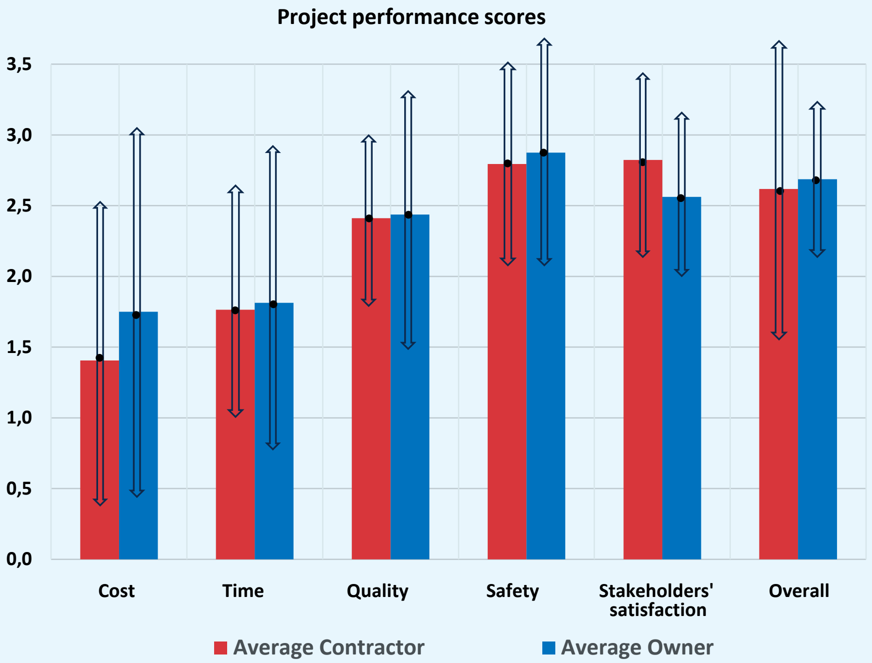


Figure 9.2: Average performance scores of the owners (blue) and the contractors (red) on a scale from 0 through 4.

Despite the overall identical assessment of the performance per success criterion, the differences between the owners and the contractors, and even between the participants of the same organisations, are remarkable and are reflected in the relatively high standard deviation of the scores, in particular the standard deviation of the cost criterion (presented through error bars). In one of the cases, the performance scores for the cost criterion varied between 1 and 3 for the owner's interviewees and 0 and 2 for the contractor's interviewees (where 0 = very poor performance, 1 = poor performance, 2 = not poor/not good performance, 3 = good performance, and 4 = very good performance). Although the success criteria were made as objectively assessable as possible (see Appendix A1), the interviewees assessed performance subjectively for several reasons. They regularly included factors outside their sphere of influence differently, such as the budgets and time schedules determined before they were involved in the project or permit procedures. Additionally, in most cases, the assessments were forecasts because the projects were still in the construction phase by the time of the interviews. Therefore, the interviewees had to make their own estimates and projected their own views on future results, for instance on the outcomes of ongoing contractual disputes. Finally, their organisational background and culture will have influenced their assessments. It caused them to weigh the importance and performance of the criteria differently (e.g. the owners being more demanding on stakeholders' satisfaction and quality and the contractors' more demanding on costs and safety).

It is evident that, given the number of cases and interviews, the analyses of the performance data required proper inclusion of the project context and the interviewees' interpretations. As such, the data demonstrated the perceptive character of the performance assessments (see section 2.11) and the basically qualitative nature of the research. Nevertheless, the wide spread of the assessments was remarkable, indicating the lack of a shared view on the project performance perception by the key participants. Where satisfactory project performance is the primary goal of all participants, the suggestion arises that more attention should be paid to determining and assessing shared goals and performance. The observation is that contemporary projects pay limited attention to making performance and success explicit within and between parties. Paying more attention to making mutual project goals explicit could make mutual interests more transparent, which could help the project. Tools for making success criteria explicit and measurable will support this process. Moreover, competencies, such as empathy, will reinforce the willingness to understand the other party's interests and performance perception.

9.4 THE APPLICABILITY OF THE IRI-TEST FOR CIVIL ENGINEERING PROJECT TEAMS

The quantitative measurement of the levels of empathic abilities of the project teams provided additional insights into the relationship between empathy and performance and into the levels of empathic abilities of the teams and the sector. However, given the multitude of definitions of empathy and the multidimensional conceptualisation of empathy, measuring empathy is complicated. Matching the definition and the measurement of empathy is essential. In Chapter 5, the definition of empathy comprised different components, i.e. emotional state matching, reflecting on that by perspective taking, retaining self-other differentiation and providing appropriate action (Gerdes *et al.*, 2010). Ideally, these dimensions are reflected in the measurement.

The best applicable method of measuring empathy for this study was the self-assessment, given the high number of participants involved and the possibility of efficiently collecting valuable data. Chapter 5 discussed two dimensions of the empathic ability, i.e. empathy as a trait and situational empathic tendencies. While the self-assessment questionnaires are considered to have difficulties in simulating situational empathic behaviour, they are assumed to measure trait mainly. The empathic trait was proposed as consisting of layers cumulatively determining empathic behaviour (Rijnders *et al.*, 2021). Where people's layers developed differently, different levels of empathy are measured.

Several self-assessments are available for this purpose, and this study used Davis' IRI-test because of the availability of a validated Dutch version and the differentiated measurement of the affective and cognitive dimension, which provides valuable and crucial information on empathic abilities. Moreover, although the measurement has been around for more than thirty years, it is still the most widely used self-assessment (Chrysikou and Thompson, 2016), offering optimal opportunities for comparison with the results of other studies.

As discussed in Chapters 6 and 8, the IRI-test comprises four dimensions, which are separately identifiable and together define a total level of empathic ability. EC (Emotional Concern) and PT (Perspective Taking) are obviously attributed to the affective and cognitive dimensions respectively, and follow the corresponding components of the empathy definition (see Figure 9.3). PD (Personal Distress) represents the individual's own feelings of fear, apprehension and discomfort at witnessing the negative experiences of others (Davis, 1980). The literature attributes this scale to the affective dimension of empathy and demonstrates positive correlations with the EC scale and significant negative correlations between PD and cognitive PT scale scores. The elements of the PD dimension seem indeed highly affective-driven (e.g. "*When I see someone who badly needs help in an emergency, I go to pieces.*", or "*In emergency situations, I feel apprehensive and ill-at-ease.*"). Referring to Davis' definition of PD and the elements attributed to it, and considering the self-other dimension of the empathy definition, one could argue that high PD scores are associated with a low empathic ability to differentiate the other's emotions from one's own emotions. The PD score may represent the affective component but seems to contradict the self-other component of empathy. Hawk *et al.* (2012) consider PD to load less strongly on the global construct of empathy.

The FS (Fantasy) dimension appears to tap the tendency to imaginatively transpose oneself into fictional situations (Davis, 1980). The literature is ambiguous about the extent to which FS really measures dimensions of empathy (e.g., Baron-Cohen and Wheelwright (2004) and De Corte *et al.* (2007)) state that FS correlates with empathy but does not represent empathy itself). The correlations with the other dimensions are the weakest, and FS can not be positioned easily along the affective-cognitive axis. Generally, studies indicate positive correlations between the affective dimensions (EC and PD), between PT and FS and between PT and EC. There are negative correlations or no associations attributed between PD on the one hand and PT and FS on the other (Hawk *et al.,* 2012; De Corte *et al.*, 2012).

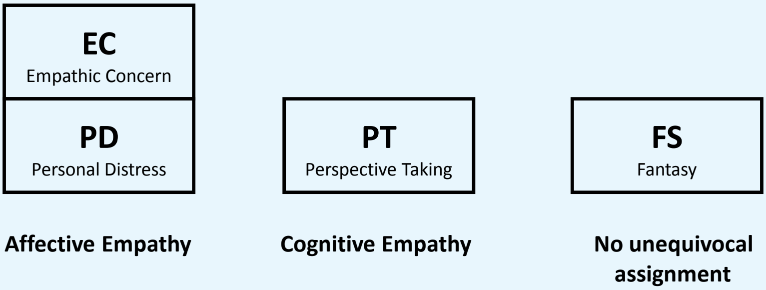


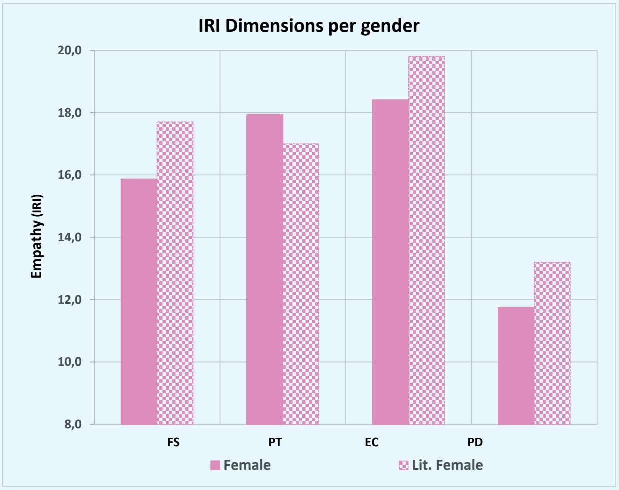
Figure 9.3: Affective and cognitive dimensions of the IRI-test.

With the EC and PD dimensions representing the affective empathic abilities, PT representing the cognitive abilities, and FS not attributed to either the affective or the cognitive ability, the IRI-test tends to be more affective-oriented. The ability to differentiate between self and other seems to be missing, unless considered part of the PT dimension. So, the IRI-test struggles to fully cover the interpretation of the concept of empathy used in this study. This is generally the problem when using self-assessments (Gerdes *et al.,* 2010). Nevertheless, this is surmountable if the limitations of the measurement are acknowledged. The IRI-test, at least, differentiates between the affective and cognitive empathy dimensions, which is not the case with several other tests.

Additionally, the measurement results were mainly used for comparison purposes. In this study, project teams with empathic abilities above the sector's average (i.e. IRI=approx. 57) but lower than the literature references showed high performance. However, more data is needed to conclude on absolute levels of empathic abilities given an integration assignment in projects. The study revealed the importance of balancing empathic tendencies and a "getting things done" attitude in projects. Too high empathy scores might include risks for a "best-for-project" attitude, decisiveness and determination. Taking these considerations into account, the IRI-test used in this study proved to be a valuable method to provide insights into the team's empathic abilities and, as such, can form a basis for insights into team dynamics and team composition related to performance.

9.5 THE EMPATHIC DIMENSIONS IN THE CIVIL ENGINEERING INDUSTRY

Bearing in mind the deviations between the IRI dimensions and the empathy definition, diving into the data of Chapter's 8 sample provides valuable insights into the empathic characteristics of the Dutch civil engineering industry and its effects on performance. Figure 9.4 visualises the average scores of females and males per dimension. The blue columns represent the males, where the pink columns represent the females. The solid columns are derived from the sample, where the patterned columns represent the literature study scores (see Chapter 6).



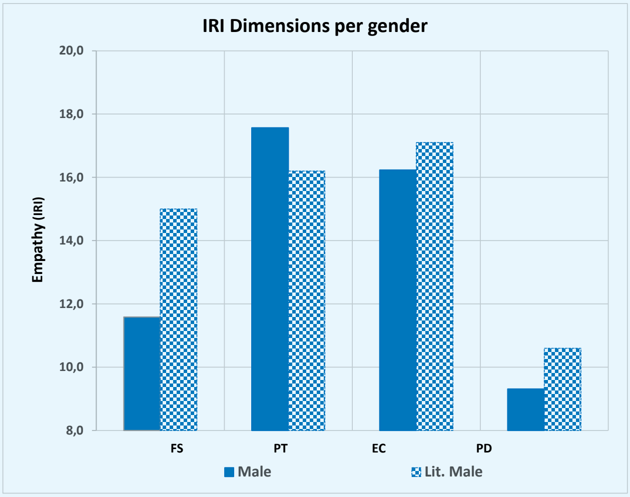


Figure 9.4: Average IRI dimension scores of females (pink) and males (blue) of the sample and the literature study.

The figure indicates that the average scores of EC, PD and FS of the males in the sample are lower than those in the literature (this accounts for all separate cases). Meanwhile, the males' PT scores in the sample are slightly higher than those in the literature for all cases. The females' average scores show the same pattern (although a few cases show higher FS, EC and PD scores than the literature and lower PT scores). The average female FS, EC and PD scores are also lower, and the average PT scores are higher than the literature scores. As already concluded in Chapter 6, although the total empathy scores of the sector's sample are considerably lower than the literature's scores, the cognitive empathic abilities in the sector are higher than the average cognitive abilities derived from the literature study, where the affective abilities (EC and PD dimension) of males and females are lower than those shown in the literature study. The sample's FS dimension also scores lower than the literature's values.

Figure 9.4 shows females outscoring males in all IRI dimensions, both in the sample and the literature study. For the cognitive dimension, the gap between females and males is small compared to the other dimensions in the sample, implying that women in the civil engineering sector particularly distinguish themselves by contributing to affective empathic abilities. The figure shows the cognitive empathic abilities of the sector's participants outscoring the affective abilities, exposing the cognitive over affective empathic preference of the civil engineering sector's participants. Furthermore, referring to the aforementioned discussion on the PD dimension, the relatively low PD scores seem to indicate lower affective abilities but also higher abilities for self-other distinction. Generally, the figure demonstrates that the low overall empathy scores are driven by relatively low scores on the affective empathic ability and low FS scores.

Focusing on the EC and PT dimensions in particular as the primary and undisputed empathy dimensions, the summarised EC+PT sample scores for females are 36.3 in the sample and 36.6 in the literature, and 33.8 for males in the sample versus 33.3 in the literature. So, the higher cognitive abilities seem to compensate for the lower affective abilities. However, whether the same summed values of EC+PT that are composed differently lead to comparable empathic behaviour is questionable. Assuming that the affective state matching is the primary mechanism of empathy, supported and followed by cognitive perspective taking (De Waal, 2019; Kouprie-Sleeswijk-Visser, 2009), it can be argued that higher cognitive abilities could not completely compensate for lower affective abilities. More generally, the recently developed "zip-theory" on the affective and cognitive empathic components underlines their bi-directional interdependency (Rijnders *et al.*, 2021). However, more study is needed to investigate the effects of lower affective and higher cognitive abilities, and the effects of the IRI dimensions on empathic behaviour and performance more generally.

Projecting these results on the integrated design process of civil engineering projects, one could state that participants have a less-than-average ability to experience the feelings of others involved in the project and feel less-than-average discomfort from the others' negative experiences. Based on their affective response, they have (slightly) above-average abilities to take the perspective of another and understand their feelings. This profile of the current "typical" civil engineering participant could fit well in a technological and process-oriented setting. However, when aspects outside the technological or procedural context become dominant, such as dynamic or non-rational opposition to the project or conflicts of interests between disciplines, more affective abilities could be beneficial as a basis for perspective-taking and appropriate action. This view aligns with the conclusions of Zwart and Kroes (2015; see Chapter 2), arguing that designers tend not to own influences outside the technical core of the design brief, being the procedural context of the process and the substantive context of the design product. Given the relationship between empathy and project performance and the increasingly dynamic and non-rational context of projects, particularly the affective state matching abilities, being the elementary foundation of empathy, should increase to improve performance.

The next chapter will dive deeper into the mechanisms of integration in the design process and how empathic abilities can affect these mechanisms and improve performance.

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10

Improving performance by focusing on empathy

10.1 INTRODUCTION

In this chapter, the study results presented in the previous chapters accumulate into a convergent analysis and an answer to the research question, i.e. how the performance of civil engineering projects can be improved through the integrated design process. First, this chapter will analyse how empathy interacts with integration based on the data and findings of the study. Then, it will consider how performance can be improved by focusing on empathic abilities, based on the functioning of empathy as determined in the previous chapters. Finally, the validity, reliability and reflexivity of the study will be discussed and a broader perspective on empathy and the future of civil engineering projects will be contemplated. In this chapter, quotes from this study are translated from Dutch to English and marked in *italics*.

10.2 HOW DOES EMPATHY AFFECT INTEGRATION?

Now that a relationship between the team's empathic abilities, the integrated design process, and project performance is established, a deeper understanding of the interaction is needed to arrive at adjustments to the design process and subsequently performance improvement. The analysis in the study discriminated two mechanisms for empathy to affect performance: 1) through the adoption and integration of the problem context in the integrated design process and 2) through a tangle of interacting human-related factors in project teams. Both mechanisms will be elaborated hereafter.

10.2.1 Adoption and integration of the problem context

The essence of designing is the adoption and integration of the design problem context in the design process and the solution to arrive at shared and supported resolutions. For this reason, civil engineering design was defined as an integration process by definition. The study results revealed that the adoption and integration of context are particularly difficult in two areas: the mutual integration of the disciplines' interests and the integration of the stakeholders' interests.

Let's first delve into the mutual integration of the disciplines' interests. Chapter 2 presented the issues that emerged when the technical tunnel installations became a critical discipline in Dutch tunnel designs and needed integration into the existing and dominant civil design culture. Only after a decade could the differences between the design cultures be overcome. This development exemplified the challenging integration between disciplines caused by cultural differences and its impact on performance.

Culture can be considered from different perspectives. Section 2.10.3 discussed the effects of the Dutch culture on collaboration, contracts and the interaction between owners and contractors in the Dutch civil engineering industry. This can be seen as a high-level cultural perspective driven by shared values. In the case of the Dutch construction sector, a feminine culture focusing on long-term relationships was distinguished, resulting in valuing collaboration. Disciplinary cultures are considered lower cultural levels and are characterised by the behavioural patterns and practices of the group (Kotter and Hesket, 1992). They develop based on the discipline's essential success criteria, resulting in specific practices and behaviour for problem-solving and learning. For civil designers, designing economical, well-constructable, and structurally safe elements is crucial. Hence, their immediate tendency towards objects and detailed technical specifications when starting a design. The essence of technical installation designers is the integration of many (off-the shelf) objects into a working system that meets the user's specific requirements. This causes a design culture focusing on functional requirements and integration (own observation, being involved in several tunnel projects where civil and technical installation cultures collided). While these cultures evolved as success factors related to the discipline's siloed success criteria, clashes emerge when the disciplines meet in integrated processes. A focus on objects and technical requirements versus a system and functional requirements focus exposes the culture clash between the civil and installation disciplines.

Expressions of the discipline's culture are expected to be more visible, for instance, in language, practical working processes, and procedures, as is reflected in the interviewees' quotes ('different language', 'different words'). As such, they are also expected to be less resistant to change (which was apparently the case for the differences between the civil and technical installation cultures since these were overcome after a number of years). Nevertheless, focusing on the disciplinary cultures in the integrated design process, cultural characteristics in this study also include behaviour and even values: 'different worlds', 'different lines of thoughts', 'different perspectives', 'different characters', 'it's two worlds, values, a different way of viewing the world.' Apparently, disciplinary cultural differences can transcend practical differences. Then, differences become persistent and hard to overcome. This was particularly evident between the design and construction disciplines. The vast majority of integration failures between disciplines in this study refer to issues related to integrating the construction context into the design, which is reflected in many quotes:

- *'Design can be seen as a cyclical process, while realisation is a linear process. There is little mutual understanding.'* (Project Director, contractor).
- *'The abstract thinking capacity in the construction organisation was lacking to consider the costs from coarse to fine. Therefore, we missed that things were not right at the beginning.'* (Technical Manager, contractor).
- *'We started with the conceptual design, …, to involve everyone in what we were going to do. But the construction people could not play their role at that stage. It was not possible to follow along with the design.'* (Project Manager, contractor).
- *'Nevertheless, there is a strong separation between design and construction in certain areas. The team was not sufficiently aware that we faced a joint task. It was not intrinsic to the organisation. Ultimately this was on a human level.'* (Project Manager, contractor).
- *'Introducing construction knowledge into the design is also difficult with D&C contracts. The cause lies in the fact that they are different cultures, different lines of thought, different perspectives, they speak a different language, different characters too: the designer is calm, strives for thoroughness, while the construction manager strives for speed and cheap solutions. This is where tension and miscommunication arise.'* (Tender Manager, contractor).
- *'It is the interaction between design and construction. As a designer you should not want to create a design without construction input.'* (Project Manager, contractor).
- *'…, design and implementation must come closer together. And switch roles. A construction review is not enough, it must be deeper.'* (Project Manager, contractor).
- *'The work preparation people became interested in the design and got involved with it and I liked it too. It meant that we could switch quickly; If there was a question regarding the construction, it was quickly addressed and answered. Furthermore, sketches and conversations could be translated into construction. Not everyone can do that.'* (Design Manager, contractor).
- *'I was very surprised that a good experienced design manager and a good construction manager could not work well together. Unable to tackle the task together, even though we put them together and they were on board early. It is culture, not used to working together, no openness, no solidarity… focused on improvisation.'* (Project Manager, contractor).
- *'It's two worlds. The designer is quite strict, thinks in terms of requirements, standards and guidelines; is ready when the verification report is completed. The people from the construction come from a somewhat different culture, they have to get things arranged. They are more interested in building and phasing and the drawing is something that has to be done in order to jump through hoops.'* (Design Manager, contractor).

In the integrated design process, the construction participant is considered an (active) actor. Similar to the stakeholders, he represents a group of intermediate users with their own needs, limitations and boundaries (Smulders and Dunne, 2016). In the analysis step, the designer takes the best notice of the construction participant's partly implicit interests, problems and emotions. After generating and synthesising solutions and elaborating the preferred solution in the simulation phase, the solution is presented to and evaluated by the construction participant. The communication between the construction and design discipline in this process is accurately described by Kolb (1976), focusing on new product design and production cultures and distinguishing operational (construction) and cognitive (design) learning styles, see Figure 10.1. While finding solutions at the component level (referring to Figure 2.6), the designer reflects on abstract concepts in a cognitive process with undefined and unpredictable outcomes. He strives for growth and innovation through an iterative process. On the other hand, the construction participant tends to rely on active and concrete experiences. He prefers adapting to a steady state. If issues occur, he anticipates immediately by using known solutions. It is about doing versus thinking, linear versus iterative and routine versus non-routine. Meanwhile, their ways of working and processes remain unknown and partly inscrutable to each other.

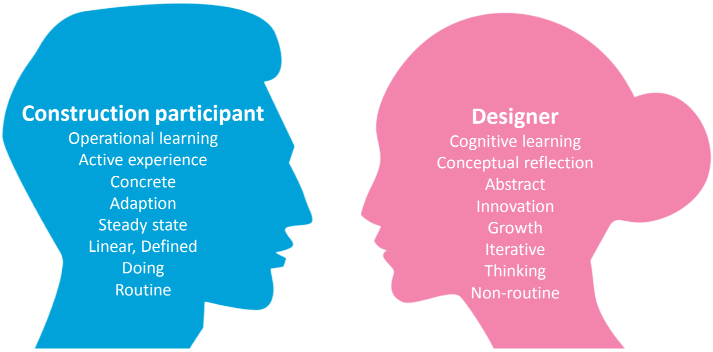

Figure 10.1: Interaction between the construction participant and the designer when adopting and integrating context, based on Kolb (1976).

The figure indicates two opposing and colliding cultures, comprising different attitudes and even values, which, however, are forced to find a common level of communication, at least to a certain extent, to efficiently exchange information about the context and the solution. The quotes demonstrate the struggle that emerges. The designer considers the construction participants incompetent to play their role in her abstract thinking and development process, while the construction participant deems the designer unable to provide concrete and adequate solutions that solve his immediate problems and instead lingers to slow and vague processes (own observation, based on practicing in the design assignments and being employed at contracting companies).

Adopting and integrating the stakeholders' interests shows similar patterns of opposing cultures. The stakeholders in the public domain of civil engineering projects include large numbers of heterogeneous and increasingly assertive groups and organisations affecting or affected by the project. These stakeholders represent various, sometimes conflicting, interests and emotions related to the project. The owners represent the stakeholders in the integrated contracts investigated in this study. They are in the lead to collect the stakeholders' requirements and wishes, to decide which ones to honour and which not, how to deal with conflicting requirements, and to compile a clear set of requirements on the basis of which the contractor could integrate them into a design. In this course of integrating the stakeholders' interests, the cultural differences between the contractors' and the owners' participants became apparent, as shown in the quotes:

- '[The owner] *said they understood us, but did they really understand it? Likewise,* [the owner] *indicated that a satisfied environment was most important to them. The question is whether we really understood that. The interests are different.'* (Design Manager, contractor).
- [The owner was] '*contemplative, process-oriented, striving for acceptance, …*.', [the contractor was] '*striving for practical solutions, doing instead of thinking, working in a straight line, …*'. (Design Manager, contractor).
- '*There is a big cultural difference between people who strive for support and people who want to build on time. It is a challenge to bring this together, you can't solve that just like that… For visualisation purposes, I compared it to a gap the size of the Grand Canyon.'* (Contract Manager, owner).
- *'You have to consider the different dynamics of ... a governmental organisation and a private company: how do you bring these together?'.* (Project Manager, owner).
- '*… the people in the spatial planning phase wanted something that was correct and permit-proof, while we* (the contractor) *wanted something that could be built as cheaply as possible. You use the same words, but the noses point in different directions. We often encountered that.'* (Design Manager, contractor).
- *'An example is that when we presented our design …, they indicated that they had 14 "points of concern". However, they meant that in their view there were 14 "non-conformities", … failures to meet their main interests. However, they were presented to as points of interest, so the seriousness of their concerns was not clear to us. We literally did not speak the same language. Only when our plan was not accepted, the seriousness of the situation became clear to us.'* (Design Manager, contractor).
- *'Do we really understand each other? That is often not the case.'* (Project Manager, owner).
- *'This was clearly the most logical connection for the* [the project]. *However, there was a lot of resistance to this solution from* [interest groups], *making the solution politically unfeasible. In retrospect, we probably didn't explain this well at that time, too much from a technical perspective.'* (Project Manager, owner).

Referring to the cultural differences between the designers and the construction participants, similar cultural differences appear between the owners and the contractors regarding solution-finding and learning style cultures at the system's level, see Figure 10.2. Where the owners strive for acceptance and consensus with the stakeholders in an iterative process of thinking and contemplation, the contractor strives for doing and practical, technical solutions focusing on costs and time. The cultures and the resulting behaviour seem to result from the party's critical success criteria, i.e. stakeholders' satisfaction for the owners (related to acceptance, contemplation) and cost and time for the contractors (related to concrete doing), see Section 8.5.2.

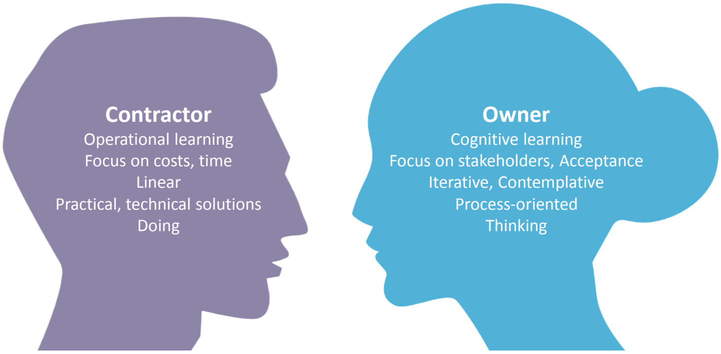

Figure 10.2: Interaction between the contractor and the owner when adopting and integrating context.

The examples have in common that cultural differences prevent parties from properly exchanging knowledge about the context, the problem and the solution, resulting in designs lacking constructability, cost overruns and delays (designer-construction participant), or unsatisfactorily meeting the stakeholders' wishes and introducing contractual scope disputes (owner-contractor). The examples show that several group arrangements comprising cultural disciplinary differences can be identified within a project team, causing issues in exchanging knowledge in the design process (e.g. between different policy agencies, civil and architectural designers, and the main contractor and subcontractors).

Where the mental worlds of the project participants differ so substantially, exchanging knowledge between the designer, the stakeholder and the disciplines' representatives becomes a wicked challenge. Unravelling cultural gaps can only occur through connections between people. This is where the empathic abilities emerge. Empathy can enable bridging these cultural gaps by being open to entering, experiencing and consciously synchronising the other actors' mental worlds and discovering the origins of the drivers of the other's behaviour. This is an attitude of connecting, talking, being in contact and being open to listening to the other (see Figure 8.5). Only then will project participants be able to feel and understand each other's emotions, problems, or interests and they will be able to synchronise their communication styles.

Ultimately, settling cultural gaps needs to result in effectively exchanging knowledge in the integrated design process. This is the knowledge of the design problem and its context that needs to be transferred from the (intermediate) stakeholder to the designer (Smulders *et al.*, 2008). The essence here is the implicit or tacit knowledge of the context, which will be more easily captured if the designer is able to empathise with the drivers and the preferential behaviour of the stakeholder. Likewise, the knowledge of the provisional solution needs to be transferred from the designer to the (intermediate) stakeholder. Empathy supports the designer in conveying his solution understandably, adapting to the recipient's capabilities to adopt abstract yet undefined proposals. However, considering the stakeholders and construction participants as active actors in a collaborative, integrated design process, they also need to empathically anticipate and adapt to the designers mental world and capabilities to adopt their interests and emotions, and respond to his provisional design solutions. In short, an integrated civil design process, requires an empathic exchange of explicit, implicit and tacit knowledge between all actors involved in the integrated design process.

10.2.2 The tangle of interacting human-related factors in project teams

The results of this study demonstrate the crucial role of factors related to human interaction for performance. Collaboration, trust, openness, and communication emerged as important factors affecting performance, besides focusing on empathic abilities. At least to some extent, most of them relate to empathy; see Figure 8.5 and Appendix B presenting the data analysis of the Chapter 8's study. The question arises as of how these factors interact and which role empathy plays in this tangle of factors affecting performance.

From the extended experiment in Chapter 8, collaboration is the second highest grounded concept after an integrated approach (see Figure 8.5). These two concepts showed a relatively high interrelatedness. In Chapter 7, this relationship was explained from their interpretations and definitions. Both concepts refer to the mutual dependency of parties to achieve goals, and to understand and adopt mutual interests to arrive at shared and supported goals and solutions. Integration and collaboration can be considered comparable processes with similar purposes from different perspectives (see "1" in Figure 10.3). The interviewees' quotes also revealed the overlapping interpretations and the interchangeability between the integrated design process and collaboration, as well as the relationship of both concepts with empathic behaviour.

- '*Good collaboration, i.e. taking each other along in what is bothering you and put yourself in the position of the other.*' (Project Manager, owner).
- '[A success factor] *for creating collaboration is; joining the weekly talks, ask questions, take each other along, what does everyone encounter, do you need help, ...? So sharing knowledge, and sharing problems and challenges.*' (Technical Manager, contractor).
- '[A success factor is] *collaboration, sitting close to each other, trusting each other and expressing what gut feelings are; that helps us to avoid problems.*' (Project Manager, owner).
- '*Working in the spatial planning phase forces you to work in an integrated manner even more, because this phase only involves integral considerations and motivating the considerations, demonstrate that you have made the best solution integrally. This has resulted in integral collaboration….*' (Project Manager, contractor).
- '*We had periodic evaluations on the collaboration; "How do we respond to each other, how do we keep to agreements?" Really on the relationship. … We could easily find each other. We understood each other.*' (Technical Manager, owner).
- '*When one says that the collaboration is good, the question arises: How's the empathy? Do we really understand each other? That is often not the case. We settle for good relationships, but empathy is something else.*' (Project Manager, contractor).

The relationship between empathic abilities and the integrated design was already discussed in this chapter. The theoretical foundation for the positive correlation between empathy and collaboration was discussed in section 5.4.1 as well (see "2" in Figure 10.3). The study's theoretical analysis described the general positive role of empathy in team performance. Empathic behaviour enhances people's well-being in teams and encourages people to feel free to come up with new ideas or issues (Roberge, 2013). This interpretation refers to the concepts of openness which is firmly grounded in the results of the extended study. The interpretation of openness as being open to listening to others was considered an important element of empathic behaviour (see "3" Figure 10.3). Openness, interpreted as being open to expressing one's problems or emotions, was considered equally important, however, not representing empathic behaviour. Nevertheless, an attitude of being open to listening to others seems essential for others to feel open to expressing their feelings and ideas (see "4" Figure 10.3). Therefore, openness, as being open to expressing oneself, interacts with openness interpreted as listening and, thus, empathy.

Finally, trust is an relevant concept emerging in this study. It is considered important for collaboration and performance and interacts mainly with openness and empathy, as demonstrated by the interviewees' quotes and Appendix B.

- *'If you don't have the opportunity to empathise with the other person, then openness and honesty are also difficult. Perhaps it is a condition.'* (Project Manager, owner).
- *'The contractor went through an intensive requirements analysis with us, expectations management, and questions to find out whether the contractor had understood what is in the contract and what we wanted to achieve with it. We had never experienced that before. As a result, trust grew and collaboration became more pleasant.'* (Project Manager, owner).
- *'It's all about the same denominator: Name it openness, trust, ... that's what it's about.'* (Technical Manager, owner).
- *'While in an alliance-contract you should throw this* [traditional] *behaviour overboard, because there is no more owner and contractor. You are colleagues, with one pot of money. But if that openness isn't present, you don't create trust and you don't get along, you don't work well together.'* (Technical Manager, owner).
- *'The collaboration, sitting close to each other, trusting each other and expressing what gut feelings are; that helps us to avoid problems.'* (Project Manager, owner).
- *"Trust has already been set in motion during the tender. That required collaboration, trust, openness, honesty and transparency.'* (Project Manager, owner).
- *'I think there is a relationship between openness, trust on the one hand and empathy on the other. It is absolutely important to empathise with the other. We also did project-start-ups, project-follow-ups for that: a look behind the scenes, how are things going at the owner, how are things going at the contractor? What are the interests of the other? Embrace the other side. That certainly has something to do with it.'* (Project Manager, owner).

- *'If you ask each other questions based on an outspoken trust, you will have a different conversation. State in advance that you have trust in each other. And that you don't break that trust. Full transparency is also part of it.'* (Contract Manager, owner).
- *'You have to be able to put certain interests aside in order to come to a solution. You have to be able to trust the other in this. That's pretty exciting. Can look at the greater good. It's hard to get that done. You have to want to listen and talk to each other and have understanding, that is also empathy.'* (Project Manager, contractor).
- *'Yes it is definitely a factor of importance. Openness, trust, trust in each other's expertise and good intentions, drive, involvement, it is absolutely important.'* (Design Manager, contractor).

The interviewees link trust to openness and transparency, i.e. proactively putting one's interests and problems on the table (see "5" Figure 10.3). Being open and transparent about one's interests supports the trust that there are no hidden agendas and stimulates others to share their interests as well. When there is trust, people will have the feeling that their openness will not be misused. Trust will lead to and depends on the open sharing of interests and problems. Mutually sharing interests was considered crucial for collaboration, the integrated design process and performance (see "6" Figure 10.3). On the other hand, trust and openness can be linked to empathic abilities, such as the willingness to listen and embrace other perspectives; trust will enhance when people feel their interests are sincerely heard and adopted. And the other way around, when there is trust, people will listen to each other and be open to mutual understanding and adopting interests (see "7" Figure 10.3).

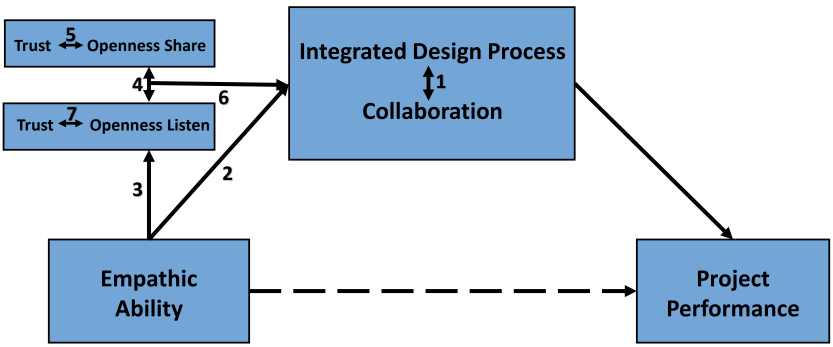

Figure 10.3: The network of human-related factors affecting project performance and the role of empathy.

A network appears where empathy supports the integrated design process and collaboration, which in turn support project performance. Collaboration and the integrated design process can be considered equivalent mediating variables for empathy to support performance. Generally, the interviewees interpreted the positive correlation between empathy and performance as broader than just through the integrated design process (*'The role of empathy is broader; it's not just the design* *process, it plays throughout the project')*. In addition, openness and trust are important moderating factors for expressing and mutual understanding of interests, emotions and problems, which in turn are essential for the integrated design process and collaboration. In summary, empathy broadly supports human interaction and human-related factors affecting project performance. As such, it can be considered a basic factor for human-dominated processes and, thus, for the integrated design process.

10.2.3 A transformative design process for civil engineering projects

Chapter 2 described the integrated design process as a partly non-rational, dynamic and limitedly structured process, aiming at achieving the best possible compromise between an ill-defined design problem and the solution space. It is a highly social process conducted by individuals and parties with different cultures, backgrounds and interests.

Section 10.2.1 and 10.2.2 delineated a design process where designers, stakeholders and participants from all disciplines immerse in the mental worlds of the other actors in the design process, actively empathise with different cultures and enable the transfer of knowledge of interests, emotions and concerns related to the design problem and of provisional design solutions, see Figure 10.4. In this way, integrated and broadly supported design solutions develop. The actors play different roles in the process: they can be designers for their discipline and, meanwhile, stakeholders for adjacent disciplines. Such a process can be characterised as transformative, meaning the context does not just provide the boundaries but becomes an inseparable, fluid, and natural part of the iterative process at all levels of the design process (Kroes and Van de Poel, 2009). The context affects the solution and the solution positively affects the context.

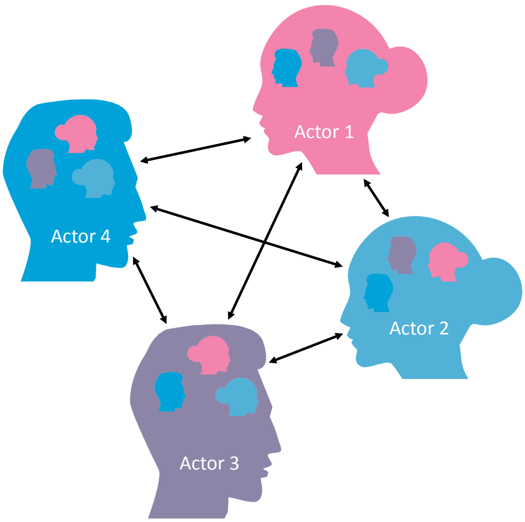

Figure 10.4: A transformative design process for civil engineering projects where all actors actively participate and empathise with each other's cultures, mutually adopt interests, and share knowledge about the problem and the solution.

The actors' empathic abilities enhance such a transformative process. Empathy stimulates the willingness to understand others' cultures, ways of working and language, to adopt the other actors' interests, and to fathom emotions, concerns, and provisional solutions. Moreover, empathic behaviour in a collaborative team of designers, stakeholders and disciplines' participants enhances openness and trust, stimulating the sharing of interests and emotions, as well as new ideas or creative solutions.

10.3 HOW COULD PERFORMANCE BE IMPROVED BY FOCUSING ON EMPATHY?

This study revealed a positive correlation between empathy and performance and the relatively low empathic abilities of the Dutch civil engineering sector, implying room for performance improvement by focusing on empathy. Chapter 5 discussed the definition of empathy, where a person's empathic abilities were defined as the multidimensional catch-all concept, consisting of a person's empathic trait and situational empathic skills and behaviour, see Figure 10.5. Where the empathic trait can be influenced to a limited extent, situational empathic skills and behaviour can be influenced on a project level. The in-group empathy can be stimulated by actively creating group feelings in a project and empathy can be activated through motivation related to the project goals. The following sections discuss how an increasing focus on empathy can improve the performance of civil engineering projects through these dimensions.

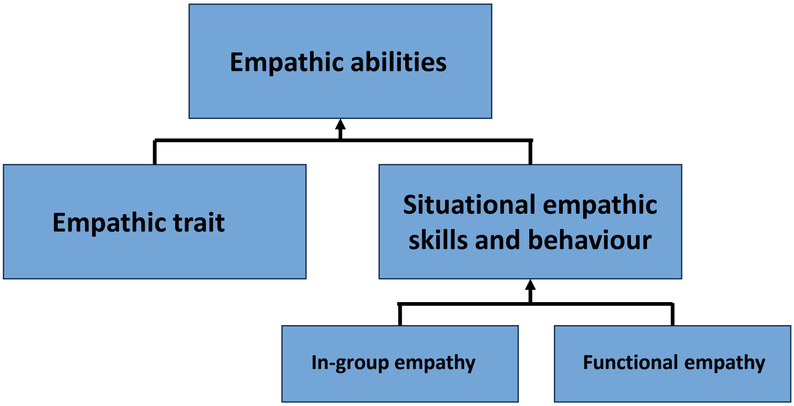

Figure 10.5: The multidimensional concept of empathic abilities related to improving performance through empathy.

10.3.1 Focusing on empathy as a trait

Chapter 5 discussed the trait dimension of empathy. This is considered an essential dimension related to the empathic behaviour people expose. Empathy as a trait is mainly evolutionary and genetically determined, meaning it is hard to influence and not trainable. The trait dimension of empathy can be affected during a person's early childhood and can slowly develop through experiences in life by stepping in the other's shoes if actively stimulated. When using self-assessment for measuring a person's empathy, the trait dimension will be mainly measured since situational empathic tendencies can not easily be captured through a questionnaire (see Section 9.4).

The male-female empathy distinction exemplifies evolutionary trait development. The female's higher empathic abilities are explained from an evolutionary perspective, i.e. the need to empathise with newborn children unable to express themselves verbally. Chapter 8 showed the relatively high levels of empathic abilities of the sample's females (IRI=64.0) compared to males (IRI=54.7). The share of women in the sample was 14%, which is representative of the Dutch construction industry. Where the empathy trait dimension is hard to develop, the levels of empathy in project teams and the sector can be increased by increasing gender diversity. The most effective use of increased gender diversity is during the integrative project phases, such as the integrated design phase, and in integrative project roles.

The importance of transformational leadership in the integrative-oriented design process and its relationship with empathy has been demonstrated, considering its focus on relationships, common ground, and creating shared values and ideas. In addition, Chapter 5 described the functioning of mirror neurons, experiencing and copying the other's behaviour, thus explaining the important exemplary role of the project managers. Therefore, projects will take particularly advantage of increased empathic abilities of project managers and technical managers given their substantial influence on performance. The share of women in the project management sample supervising more than five people is 7%. Women scored particularly higher on the affective dimension, which was considered the empathy's core and the dimension with the highest potential for improvement in the civil engineering sector. Although diversity, and particularly gender diversity, is getting increasing attention in the Dutch civil engineering construction sector (Stichting van de Arbeid, 2018), accelerated growth could bring about a rapid step forward in performance.

The development of empathy as a trait by an extending empathic horizon suggests increasing empathy with age. However, the sample of this study showed the opposite. The entrance of a more empathic generation was suggested, with the older generation associated with a culture of less collaborative and integrative projects, lacking the need for empathy. In addition, the observation is that the sector still experiences challenges embracing diverging competencies and preventing a gradual exit of collaborative- or affective-driven people.

Finally, job rotation can be considered a measure contributing to actively extending one's empathic horizon and more easily understanding the interests of other disciplines. Job rotation can be applied between disciplines and organisations, for instance, between owners and contractors, and will be most effective between parties with the most significant cultural differences.

10.3.2 Focusing on empathic skills and behaviour

The empathic trait basically determines a person's empathic abilities. In addition, empathy is considered an ability that can be situationally activated. People make choices when exposing empathic behaviour depending on the situation. This section considers the increased empathic abilities towards in-group participants and the increased empathic behaviour resulting from willingness and motivation.

10.3.2.1 Increasing in-group empathy

In Chapter 5, the phenomenon of in-group empathy was introduced, i.e. empathising more easily with people within an identifiable group than people outside this group. Consequently, people exhibit different levels of empathic behaviour depending on the group the other person belongs to. This phenomenon provides opportunities to create groups in projects with which participants identify and with which they have integration challenges. In such a group, participants will more easily empathise with each other and adopt and understand each other's interests and emotions. Since projects are temporary organisations consisting of people unfamiliar with each other at the start of the project, in-group feelings are far from self-evident. On the contrary, when in-group feelings are lacking, project participants may treat each other as competitors, resulting in counter-empathic behaviour and lack of collaboration (see Chapter 5). Therefore, already today, projects undertake numerous initiatives to promote in-group feelings, such as team-building sessions, project start-ups, and project follow-ups. While many participants enter the organisation during the project, an appropriate onboarding process is another measure to make new project participants feel comfortable and quickly included in a group, contributing to in-group empathy.

Groups can be identified on several levels in the project: a project team including all actors, the owner's team, the contractor's joint venture, or a discipline. In-group feelings promoting empathy should be stimulated at the levels where the integration assignment is the most challenging. Chapter 5 indicated identification as the main portal to in-group empathy. Identification can be encouraged by creating and emphasising shared values and goals. The recent and rapid rise of bouwteams in the Dutch civil engineering industry is a striking example of creating in-group feelings between the owner and the contractor, facilitating empathising with each other's interests and stimulating collaboration. Within the bouwteam (usually during the first phase of a 2-phased contract), shared goals are determined and an integrated design is made with the owner's and the contractor's involvement. The increasing project complexity and the growing inability to define design solutions without involving contractors (and other parties) in the project forced parties to adopt more collaborative ways of working and types of contracts.

In Chapter 2, it was stated that the top-down introduction of integrated contracts underestimated the significant impact it had on the organisations and the people's competencies it required. Likewise, today's rapid introduction of bouwteams and 2-phased contracts in the Netherlands still requires the project participants to develop the abilities to think integrally, delve into each other's world and understand each other's interests. If this fails, participants will remain in their traditional, non-integral roles. In that case, the project risks have shifted between the owner and the contractor, but nothing has changed at the highest project level. One of the cases discussed in Chapter 8 showed this phenomenon. So, although de bouwteams facilitate empathic tendencies and mutual understanding of interests, these projects should still focus on empathic abilities, and the creation of shared goals and values.

Figure 10.4 delineated a transformative, collaborative design team, including all actors, such as the stakeholders, actively sharing interests and problems and developing shared solutions. This would be the highest project level where in-group feelings and empathic tendencies should exist. However, the larger the group, the more divergent cultures and interests will be and the more challenging it will be to achieve in-group empathy. Nevertheless, generally, striving for shared goals and in-group feelings on the highest levels deserves more attention and will become necessary when complexity and the need for integration increase.

10.3.2.2 Motivation to expose functional empathic behaviour

Chapter 5 discussed the neurological studies demonstrating that neural activity related to empathic feelings is (partly) under people's control. People can deliberately choose how deeply they allow their emotions to resonate with those of others, indicating that empathy is not a fixed concept and can be influenced. People make choices about the extent to which they empathise with others. They simply can not empathise with everyone all day. The preference for empathising with in-group members over out-group members is an example of such a choice.

The possibility of influencing the people one empathises with provides opportunities for projects. If project team members understand and realise that empathising with others helps achieving project goals, their willingness, commitment and engagement to empathise will grow. Although they will not increase their empathic trait, they can be learned to exhibit functional empathic behaviour to be successful, like listening, connecting, trying to understand the other's interest, and postponing one's judgement. This behaviour can be trained and is considered an effective and relatively quick measure promoting empathic behaviour and enhancing mutual understanding of interests, collaboration, the performance of the integrated design process and project performance.

The awareness of the positive effects of empathy related to performance should run parallel with growing awareness and recognition of the existence of unknowns and undefined knowledge by definition when being involved in integrated design processes. Project participants should realise they are unaware of all relevant knowledge about the other discipline or the stakeholder when developing new artefacts. This requires curiosity and asking questions rather than diving into solution-finding.

The question as to whether empathy can be developed through training has been subject to debate. Although several studies suggest that empathy is trainable, Chiu *et al.* (2011) question these study results because of the lack of congruence between the definition of empathy, training and measurement content, and construct validity. They suggest that these studies show that it is possible to enhance one's skills to act empathically but that evidence that training can effectively change people's natural propensity to behave empathically in their natural environment is lacking. This analysis demonstrates the double-sided dimension of empathy and the assertion that empathy as a trait is not trainable, but that empathic skills and behaviour can be acquired and situationally activated.

10.3.3 Focusing on integration competencies in education

This study underlines the critical role of participants' competencies for project success, which is broadly discussed in the literature. Where competencies and human-related factors are identified as critical success factors for projects and designs have become social processes, socio-technical aspects and transformative approaches deserve more attention in today's civil engineering education and research, besides developing technological skills (Ninan *et al.*, 2022).

Students should learn the importance of competencies and human-related factors for project success, how competencies affect project performance and how they can effectively use competencies for project success. They should be aware that competencies can be developed and learned and that they, being young professionals at the start of their careers in the civil engineering sector, are at the beginning of developing their own abilities for the crucial integration challenges.

This will create a new type of young and empathic civil engineer who, apart from having acquired technological knowledge, is curious about other disicplines, able to adopt the feelings and interests of all actors involved in the problem, and translate these into supported solutions. Moreover, this engineer is able to connect and play a guiding role in transformative processes, is capable of transcending different transitions' disciplines and willing to develop competencies supporting the integration challenges.

10.3.4 Empathy as a driver for performance

From the previous analysis and considerations, a final view of the relationships between empathy, the integrated design process and performance can be constructed. This view gradually evolved from the explorative study in Chapter 3 (see Figures 3.5 and 3.7), the extended investigation of the relationship between empathy and performance in Chapter 8 (see Figure 8.5) and the analysis in the previous sections on the functioning of empathy in the integrated design process (Figure 10.5). Eventually, Figure 10.6 reflects the conclusive understanding of the relationships.

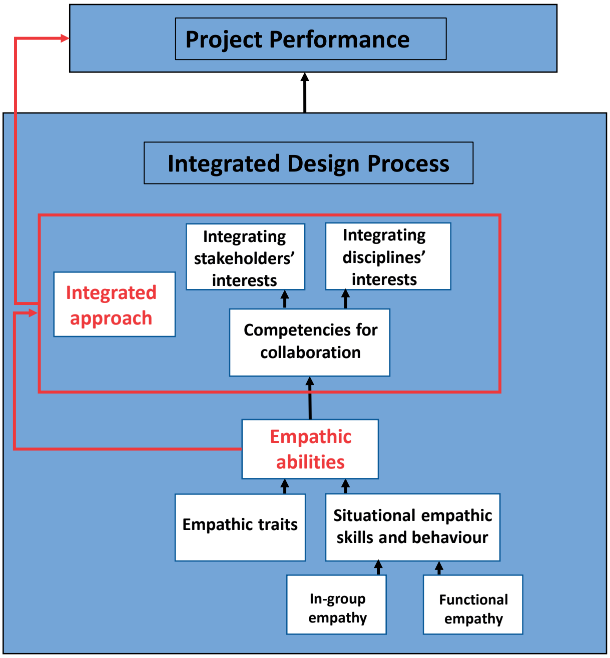

Figure 10.6: The mechanism of the relationship between project performance, the integrated design process, an integrated approach and empathic abilities.

By focusing on empathy as a trait and situational empathic skills and behaviour, the empathic abilities of civil engineering project teams can be increased. The increased abilities to bridge cultural gaps within the project team's parties and disciplines enable effective communication about the problem and the solution and support collaboration. Eventually, this will support the proper integration of the party's interests, the development of a shared and supported integrated solution, and project performance.

10.4 VALIDITY, RELIABILITY AND REFLEXIVITY

This study followed a constructivist approach aiming to develop a theory based on interpretations of human interactions (see Chapter 1). Consequently, qualitative research methods governed the research, although, in Chapters 6 and 8, quantitative methods were introduced. As such, mixed-method research was unrolled in which the quantitative data enriched the qualitative data, making more valuable analyses possible. Case studies based on interviews were the main qualitative methods used, while a survey was chosen as the quantitative method.

This section addresses the research's validity and reliability. The validity of qualitative and case study research concerns construct validity (identifying operational measures), internal validity (establishing causal relationships) and external validity (generalising the study's findings). Reliability is about demonstrating the finding's repeatability (Yin, 2014; Creswell and Creswell, 2018). In Chapter 1, the importance of a reflexive attitude of the researcher was indicated in the case of interpretative, constructivist research. Since the researcher of this study was a practitioner in the field of the research topic, the importance of reflectivity and transparency was particularly emphasised. Therefore, Section 10.4.3. discusses the researcher's experiences with the risks of biased reasoning and shaping interpretations based on his views.

10.4.1 Validity

Construct validity
Using multiple sources of evidence is an important measure to assure construct validity. Although interviews were the main source of data for this study, documents of the cases, online information, and the researcher's observations of the projects were also used. In addition, multiple cases were included (12 in total). Each case comprised interviewees from the owner and the contractor and at least two participants from both the owner and the contractor were interviewed (except for Case 5, as described in Chapter 8). All interviews (73 in total) were recorded and reported. The interviewees could review and comment on the reports, validating the correctness of the data.

All cases and interviews were anonymised, stimulating the interviewees' openness and transparency and supporting the quality of the data. Open questioning was mainly used to ensure gathering different views. Additionally, interviewees had the opportunity to comment in general on the topic at the end of the interviews. All case analyses were included in comprehensive reports. The supervisors and peer reviewers reviewed the research results and reports.

Internal validity
Internal validity concerns the explanatory parts of the study (Yin, 2014). Chapters 3, 6 and 8 described the building of a chain of evidence by the determination and comparison of concepts, the aggregation to categories and theory and the verification of theory by the quotes of the interviewees. Discrepant results, such as Case 5 in Chapter 8, were reported and included in the theory and the conclusions. In addition, rival explanations were accounted for, such as theories

advocating the adverse effects of empathy in human interactions. Finally, conclusions on the levels of empathic ability of the sector and the associated room for improvement were formulated with care, and the need for further research was emphasised.

External validity

The study's context defines the external validity. Chapter 9 broadly discussed the context of this study also implying the limitations. The Dutch culture focusing on collaboration and relationships, and the integrative character of the projects were indicated, as well as the possible downside effects of overrepresentation of empathy in project teams. The study's context also suggests topics for further research, such as the role of empathy in projects dominated by other cultures and the insights into levels of empathy related to the project's integrative character.

10.4.2 Reliability

Reliability is concerned with demonstrating that the study operations can be repeated with the same results (Yin, 2014). In this study, the repeatability of the data collection was ensured by the use of case study and interview protocols. For the qualitative parts of the research, databases were built, mainly consisting of interview reports based on recorded and transcribed. The interviewees' quotes were the raw data and are presented in this dissertation. The data were analysed with the help of software providing a structured and repeatable method of determining concepts and their interrelatedness and the development of the theory (see Chapter 3). The empathy measure was based on the validated and widely used IRI-test.

10.4.3 Reflexivity and transparancy

I started this study as a practitioner in civil engineering with more than 30 years of experience and as a relatively inexperienced scientist. The motivation for starting a PhD research was my involvement in several poor-performing infrastructure projects, the willingness to understand better the causes of poor performance and contribute to an improvement in the sector. In addition, I have been fascinated by the ever-increasing complexity of the integrated design process. From this background, my presumption was that improvements should be found in contracts between the owners and the contractors and in adjusting the design processes. Ultimately, I arrived at a completely different dominant factor.

My involvement in civil engineering projects made me aware of the risk of bias and ethics, especially given the interpretative character of the research. Therefore, reflection and transparency were important points of attention during the research; see Section 1.7.3. On the other hand, being an insider in the sector was considered valuable for the study and should not be left unused. This section reflects on this contradiction.

First, scientific reasoning and thinking were encouraged and monitored by my supervisors and supported by courses. It made me embrace science, driven by a conviction of the importance of truth in today's society but also of evidence-based improvements in the civil engineering practice. My supervisors encouraged me to find something unexpected in the research. I believe I managed to do so, ending up with empathy as a dominant factor for performance. And indeed, discovering the unexpected is the thrill of doing scientific research.

During the research, discussions on the study's topic were often accompanied by examples from practice, which were inevitably shaped by my own interpretations and views. I tried to be transparent about my observations during the research by explicit indications, as I did in Chapters 2, 4, 7 and 10 of this dissertation. Furthermore, this study was interpretative by definition, but I forced myself to make interpretations substantiated and traceable.

The interviews as the main source of data collection required special attention. I was aware of the restraint I had to exercise. Asking open questions, avoiding mentioning the hypothesised factors for performance, and cherishing silences during the interviews were helpful in gaining new insights. Attention was paid to an atmosphere of confidentiality, trust and avoidance of being impressed by an experienced, in-group interviewer. The interviews were open, transparent and pleasant. Interviewees were willing to contribute to the research. They represented the strong willingness of the sector's participants to improve, which was very helpful for the research.

Being embedded in the sector provided the opportunity to broadly discuss the study's results in practice during the research. On many occasions, I could present preliminary study results. Empathy turned out to be a topic recognised as new and important and sparked a lot of discussions, questions and theories. New questions were raised, and rival theories arose. It made me realise that I was on the right track. Moreover, the discussions shaped and enriched my interpretations. Several times, they threw me back, but they always contributed to valuable reflections on the research. Therefore, I experienced working as a pracademic as a stimulus for reflection.

More generally, I was in a position to connect science and practice. Real issues the sector is struggling with were addressed in this study. On the other hand, scientific knowledge was inserted into the projects. Reflections from practice contributed to the validation of the research, while scientific reflectivity supported insights for practice. The contradiction of being kindred spirits from mirrored universes has been articulated by Alkemade (2021), delineating that scientists should doubt what they are sure of, whereas designers (and artists) should be sure of what they doubt. As such, they are perfectly complementary. Moreover, they share imagination and a desire for an unknown reality as a common ground. They are specialists in change.

It goes without a doubt that risks of bias need to be managed but I experienced the combination of the scientific and the practical perspectives as valuable and beneficial rather than a risk to the study's validity. I tried to doubt what I was sure of, and to confirm what doubted. The results of this study could not have been achieved without one of the two. Generally, the interaction between science and practice in the civil engineering sector is limited compared to other disciplines. I tried to contribute to bridging this gap and be an example for new initiatives in this respect.

10.5 A BROADER PERSPECTIVE ON EMPATHY AND THE FUTURE OF CIVIL ENGINEERING PROJECTS

10.5.1 A broader perspective on empathy

In recent decades, there has been growing global attention to empathy in local, national and global politics and economics (Mezzenzana and Peluso, 2023). Illustrative is former US President Barack Obama's speech to the 2006 graduating class at Northwestern University in which he suggested an empathy deficit:

> *'There's a lot of talk in this country about the federal deficit. But I think we should talk more about our empathy deficit – the ability to put ourselves in someone else's shoes; to see the world through those who are different from us – the child who's hungry, the laid-off steelworker, the immigrant woman cleaning your dorm room.'*

The growing focus on empathy can be judged as a response to a development that started in the Enlightenment and continued through the Industrial Revolution, neoliberalism and individualism. This period of material progress and welfare for humanity was founded on Social Darwinism (a misinterpretation of Darwin's theory of evolution) and masculine, i.e. initiating and growing, power. Climate change, the depletion of the Earth's resources and the loss of biodiversity contributed to the insight that we have reached the end of this too narrow perspective on life. Meanwhile, societies and economies became more interconnected on a global scale. Several global crises have demonstrated the interdependencies and entangled network of institutions, countries, and societies. Detachment is not an option in a world of inextricable interdependencies. The paradigm of the individual as a part of the integrated whole was described in a frequently quoted text attributed to Albert Einstein dated 1950 (Haymond, 2018):

> *'A human being is a part of the whole, called by us "Universe", a part limited in time and space. He experiences himself, his thoughts and feelings as something separate from the rest—a kind of optical delusion of his consciousness. The striving to free oneself from this delusion is the one issue of true religion. Not to nourish it but to try to overcome it is the way to reach the attainable measure of peace of mind.'*

The climate crisis is a current example of a global and system crisis that can only be solved by connecting the affluent with the less affluent and most vulnerable (IPCC, 2023). This, at least, requires delving into the other and taking note of the other's feelings and emotions. It calls for broad perception, attention to the coherence of things and an integral experience of reality (Wijffels and De Rek, 2019). These traits are more associated with feminine qualities. Empathic abilities contribute to these qualities, i.e. the ability to feel and understand the others that are part of the system. Therefore, the growing attention to empathy could be explained by today's global and societal challenges and the necessity to arrive at shared visions, interests and solutions on a local, national and global scale.

10.5.2 The future of civil engineering projects

Similarly, a trend of increasing interconnectedness can be observed on the scale of civil engineering projects. Several related developments and transitions affect the built environment, being the civil engineering's concern. This study elaborated on global trends affecting today's and future projects, such as urbanisation, mitigation and adaptation strategies to address climate change, the need for increasing biodiversity, the energy transition, the agriculture transition and the inevitable unfolding of circularity of building materials and the transformation from designing new towards rehabilitating and adapting existing assets. Additionally, the social and economic effects of civil engineering projects need to be accounted for, given the significant impact projects can have on societies and inclusiveness.

Considering these trends are interdependent and resulting in spatial claims, a huge challenge looms for civil engineering projects. Next-level integrated approaches and policies are needed, resulting in highly integrated design processes in the projects. The interrelated transitions do not allow for incremental or siloed approaches but require a process of actively connecting all parties across the transitions to arrive at new transdisciplinary solutions. Section 10.2 delineated transformative design processes where all actors, including the stakeholders, actively participate and collaborate, are able to empathise with each other's cultures and exchange knowledge about the problem and provisional solutions. In this way, they develop integrated solutions transcending singular policies, developments, and transitions. Transformative design approaches reveal themself at any level of the design process, i.e. from the system and policy level to the component and disciplinary level. Given the extensive nature of civil engineering design team, comprising many stakeholders, it is illusory to arrive at complete transformation in large projects (Visser, 2020). However, projects should adopt transformative approaches to achieve higher degrees of integration than today.

Fortunately, transformative initiatives are already visible in the Netherlands today. Chapter 1 discussed the 'Room for the River' programme. These projects were initiated for safety against flooding purposes but also integrated urban and nature development on national, regional and local levels. Apparently, the actors in the programme managed to overcome cultural differences and mutually adopt context to arrive at integrated solutions.

A small example of such a transformative solution was found in one of the cases of this study concerning a flood protection and dyke reinforcement project. At one spot a restaurant was located. A traditional elevation of the dyke would imply that the terrace visitors would no longer have a view of the river. As a result, the restaurant owner was a project opponent. Subsequently, the owner was actively involved in the design process. Together with the team, they designed a movable glass wall that could function as a flood barrier but also preserved the view of the river. It was agreed that the restaurant owner would manage the flood barrier. The example demonstrates a process in which the stakeholder changed from a condition setter to an active actor in the process. Without his active input and the exchange of the problem and the solution, the supported design would not have been achieved.

Figure 10.7: A flood protection solution resulting from a transformative design approach.

Although the 'Room for the River' solutions suited the Dutch situation, they can not be considered a one-size-fits-all flood protection solution. For instance, the densely populated deltas in South-East Asia require different solutions aligned with the local context. Characteristic of transformational processes are precisely integrated solutions adapted to the specific project context.

The 'Room for the River' projects could be a harbinger for a new land consolidation programme. In the early 20th century, the need to increase food production initiated a legally based land consolidation programme in the Netherlands, aiming for reducing the land fragmentation and making agricultural mechanisation possible. Participation was on a voluntary basis, and the idea was that all participants (farmers, land owners, waterboards) would benefit. The land consolidation programme in the Netherlands has contributed to the highly effective agriculture sector it is to date. Given today's spatial claims resulting from several transitions, a new local land consolidation programme could contribute to the climate, agricultural, biodiversity, and energy transitions. When the land owners and representatives involved in the transitions are brought together, they can design new land arrangements and integrated, customised solutions (Stańczuk-Gałwiaczek *et al.*, 2018). Civil engineers can play a decisive role in such a process. Obviously, they need to be able to bridge cultures and mutually adopt interests, meaning they must have empathic abilities to succeed.

The adoption of nature-based technology in civil engineering projects is a promising development that fits well in a transformative approach and contributes to higher-degree integrated solutions. Nature-based solutions are defined as actions that '*aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions which are inspired by, supported by or copied from nature*' (European Commission, 2015). However, such integration requires a connection between nature-oriented policies, organisations, and disciplines and traditional ones, requiring a new shared understanding of project goals and success. Furthermore, nature-based solutions introduce uncertainty since responses to the solution are partly as yet unknown. Consequently, adaptivity and monitoring approaches are required. In the Netherlands, some nature-based solutions have already been accomplished, such as flood protection of the Houtribdijk, see Figure 10.8. This project includes an innovative dyke reinforcement, using natural material from the project's vicinity (sand) and widened banks. Additionally, nature development was enabled using surplus sludge from the dredging of the dykes and new ecosystems could develop (Rijkswaterstaat, 2019). The project was developed by a public-private consortium in which all parties involved participated.

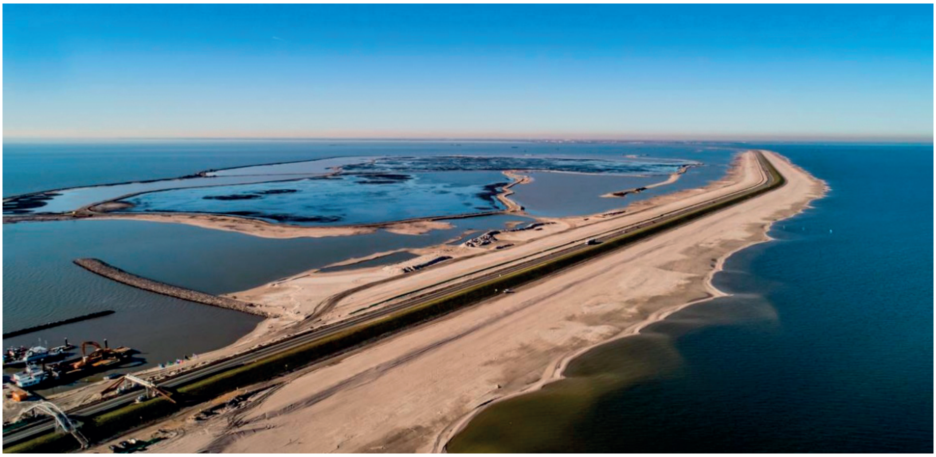

Figure 10.8: The nature-based solution of the Houtribdijk, the Netherlands, developed by a public-private consortium in which all parties involved participated (Source: Rijkswaterstaat, 2019).

Like many deltas worldwide, the Netherlands is on the verge of redesigning the built environment. Integrating spatial claims resulting from the climate, energy, agriculture and biodiversity transitions will eventually entail substantial changes in spatial planning. The examples in this dissertation demonstrate that most examples of transformative processes and solutions are found in water management projects. Infrastructure projects seem to have more difficulty integrating with other functions and applying nature-based solutions. Therefore, infrastructure projects, in particular, require an acceleration in integration and transformative approaches.

Research by design and imagination play an important role in unrolling a positive narrative of a possible future and, eventually, the development of solutions. This positive narrative is necessary to stimulate the search for more integrated, sustainable design solutions. As the traditional initiator for technological water management and transportation solutions, civil engineering has an important role in telling this story. More than ever before, expertise, disciplines, organisations, policymakers and stakeholders must be brought together to develop future solutions. This means bringing people together. Civil engineers must become able to bridge the differences, listen and understand others' interests.

Chapter 1 referred to the biblical story of the Tower of Babel. This challenging project failed because people spoke different languages. As a result, they did not understand each other, and general confusion ensued. Today, civil engineers have the task of understanding and speaking the language of others so that the challenging assignment they have to fulfil for future generations will succeed. Those challenges may extend beyond the prestigious Tower of Babel project. Obviously, empathic abilities will contribute to this assignment.

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11

Conclusions and recommendations

11.1 CONCLUSIONS

Among many interrelated factors affecting project performance identified in the literature, the early project stage has been widely acknowledged as an essential phase of the project life cycle. The integrated design process of civil engineering projects is a crucial part of the early project stage, defined in this study as the course of all human activities transforming an existing situation into a plan for a new one to satisfy a need, including and balancing the interests of all parties and disciplines involved. As such, it is a broad overarching concept, providing a valuable perspective to evaluate and improve civil engineering projects. The essence of designing in today's civil engineering is integrating the project context into the design process and the solution to arrive at supported solutions at all levels of abstraction. Therefore, the civil engineering design process is integrated by definition.

The interconnected global trends and transitions, such as climate change, biodiversity, energy, agriculture, and urbanisation, affect spatial claims and introduce new types of land use, especially in the urbanised deltas. As a result, civil engineering projects and their design problem definitions are becoming increasingly integrative and complex. Due to the increasing and necessary integration of project context, functions, stakeholders' interests, and disciplines into the process, projects developed from technologically driven to integration-driven challenges. Today's integrated design process can be defined as a partly rational, dynamic, limited structured process aiming to achieve the best possible compromise between an ill-defined design problem and the solution space. As such, it is a highly human and social process, meaning it has limited predictability and rationality.

Despite its crucial role in the design process, proper integration in today's civil engineering design process is far from self-evident. Therefore, this research was guided by the main research question of how project performance can be improved by focusing on integration in the design process. The study's main warranted assertions will be discussed based on the research (sub)questions defined in Section 1.6 and the refined subquestion 2 in Section 5.4.3. Finally, recommendations for practice and science are summarised.

11.1.1 Subquestion 1: 'What are the dominant variables affecting the integration of the design process and the performance of civil engineering projects?'

This study confirms a positive correlation between the performance of the integrated design process and project performance, where performance is defined as the extent to which predefined goals related to costs, time, quality, safety, and stakeholders' satisfaction are met. The performance assessments were perceptive and varied among the project participants, indicating a limited shared view on performance related to the success criteria within the project teams.

The extent to which the project team achieves an integrated approach in the design process is crucial for performance, where two main dimensions of integration are identified: the integration of stakeholders' interests at the project system's level and the integration of the disciplines' interests at the component level into the design process and the solutions. Integration is most challenging when cultural differences between groups are most significant. This study particularly identified cultural differences and related integration issues between the design and construction disciplines and between the contractors and the owners representing its stakeholders.

The project team participants' abilities to adopt and integrate the project and the design problem's context determine the extent to which teams arrive at an integrated approach at any level of abstraction of the design process. These competencies are considered more critical than other factors, such as the type of contract, processes or technology. Competencies focusing on integration are not self-evident in civil engineering projects, negatively affecting project performance. Empathy is identified as an important project participant's ability that supports an integrated approach and team collaboration.

11.1.2 Subquestion 2: 'How does empathy influence the performance of the integrated design process, and how can empathy contribute to an improvement of the performance of civil engineering projects?'

Empathy is defined as the ability to feel and understand another person's world, with self-other differentiation. Empathic abilities enable bridging cultural gaps in project teams by being open to entering and experiencing the other actors' mental worlds and discovering the origins of the drivers of the other's behaviour. Subsequently, communication and ways of working can be synchronised, and implicit and tacit knowledge about the context of the problem and the provisional solution can be exchanged between the actors in the integrated design process. Since all actors involved in the project need to participate actively in this process, they should all be supported by empathic abilities in adopting and integrating mutual feelings and interests about the design problem and the solution. Furthermore, empathy generally supports human-related factors which are positively correlated with team performance, such as collaboration, trust, and openness.

The study demonstrates a positive correlation between the project participants' empathic abilities, the performance of the integrated design process, and the performance of civil engineering projects. The assertion applies to projects dominated by integration, i.e. integration of stakeholders' interests and disciplines. Given the global challenges of integrating an increasing number of functions, stakeholders' and disciplines' interests resulting from the current transitions into the design process, this condition applies to many civil engineering projects today and in the future. Consequently, focusing on empathy can contribute to an improvement of civil engineering projects.

11.1.3 Main research question: 'How can the performance of civil engineering projects be improved through the integrated design process?'

A literature study on empathic abilities demonstrates that the Dutch civil engineering industry scores relatively low compared to the average levels of a reference sample composed of participants from control groups. This particularly applies to the affective empathic abilities. Consequently, there is room for performance improvement by focusing on the project teams' empathic abilities.

Considering the concept of empathic abilities, three options are identified to increase empathic abilities in civil engineering project teams and improve performance. First, recognising that the empathic trait is difficult to develop in humans, a team's empathic ability can be enhanced by appointing project participants with a higher empathic trait. This is particularly effective by increasing gender diversity in integrative project roles, given the currently low share of women in the sector and the relatively high affective empathic abilities of women compared to men. Second, in-group empathy can be increased by creating group feelings in (part of) the project team, stimulating the empathic tendencies between project participants and exchanging feelings, interests and ideas. Third, functional empathic behaviour can be situationally activated by motivation and training if related to achieving project goals.

The interdependent transitions related to climate change result in increasing integrative challenges for civil engineering. Therefore, the design process requires transformative approaches, meaning the project context not just provides the boundaries but becomes an inseparable, fluid, and natural part of the iterative process. In such a process, all actors, including the stakeholders, actively participate and collaborate, are able to bridge to others' cultures, and exchange knowledge about the problem and provisional solutions, resulting in shared and higher-degree integrated solutions. Empathy will support this transformative approach of the civil engineering design process.

11.2 RECOMMENDATIONS

11.2.1 Recommendations for practice

Generally, many interacting factors affect performance. This study concludes that integration is crucial for performance and that an integrated approach is far from self-evident in today's civil engineering projects. While the integration challenges of stakeholders' and disciplines' interests will increase in the future, the sector should generally focus on improving integration. The pluralistic and interdependent causation of factors affecting integration and performance also comprises several variables, such as types of contract, processes and complexity from project context and interdisciplinarity.

In this study, the project participants' competencies appear to be an essential factor for integration. Within this tangle of human-related factors, focusing on empathy emerged as a means to improve performance. Following the theoretical functioning of empathy discussed in Section 10.3 (and summarised in Figure 10.5), an enhanced focus on empathy can be practically implemented in three ways.

1. Increasing project participants' empathic trait (increasing gender diversity)

People's empathic abilities are mainly determined by their empathic traits, which are evolutionary and genetically determined, meaning they are hard to develop within a project's timespan. Consequently, increasing a project team's empathic ability by focusing on the team members' empathic trait development will not be effective. However, appointing participants with higher empathic traits can increase the project teams' empathic abilities. While women outscore men on empathy, in particular on affective abilities, increasing gender diversity is an effective measure to increase the project team's empathic abilities. This is particularly effective in the integrative project phases and for integrative project roles, specifically project and technical management roles, given their influential role in the integrated design process and the project.

Although the civil engineering sector already stimulates increasing diversity, developing gender diversity and competencies contributing to integration is slow. Apparently, adjusting team compositions to be more integration-capable is not a quick-fix. Therefore, the sector should focus even more on the implementation of diversity policies and really embracing new competencies in their organisations. In addition, where empathy seems to broadly support human-related processes and, thus, the integrated design process, other interdependent factors related to empathy, such as collaboration, trust, and openness, are also essential and deserve attention when focusing on competencies and improving integration and performance.

The project teams' empathic trait can be measured by using the IRI-test. Although more data are required to conclude on absolute levels of empathic ability, the present study provides data for reference purposes and insights into team composition.

2. Enhancing in-group empathy

Since it is easier to empathise with someone with whom one easily identifies, creating group feelings and identification is an effective measure to increase the empathic abilities of a project team. It enhances the mutual understanding of interests and collaboration, positively contributing to performance. Current activities creating in-group feelings and empathy are team-building sessions, project start-ups, project follow-ups, and onboarding procedures. Setting shared goals for a team more explicitly will also contribute to group feelings and in-group empathy.

Groups can be identified on different aggregation levels in a project. In-group empathy should be stimulated where cultural differences are most significant. On the owner-contractor level, the application of bouwteams and alliances in contracts stimulates in-group empathy; joint teams are created to establish and identify shared goals, budgets, and risks. Consequently, the team members are stimulated to empathise with the other party's interests and feelings to arrive at shared and integrated resolutions. On the other hand, a lack of identification of shared values and goals threatens in-group empathy and the success of bouwteams. Where this study also identified cultural differences between disciplines as critical, here too increased attention to shared values and goals can introduce more in-group empathy and better performance.

Given the major challenges resulting from several transitions, an even higher level of integrated design solutions will ultimately have to be strived for in the civil engineering sector. To this end, in-group empathy is necessary at the highest level, namely, within all those involved in the project. The sector will ultimately have to grow towards these transformative processes and focus on identifying the shared interests of all involved and developing in-group empathy. Obviously, the sector needs time to expand to this level.

3. Activating functional empathic behaviour by motivation

Finally, empathic abilities can be activated by situational motivation. Team members can be made aware of implicit and unknown knowledge about the problem and the solution and the positive role of empathy in gaining unknown knowledge, i.e. understanding others' interests, behaviour and emotions. If project participants acknowledge the positive role of empathy in achieving their project goals, they can and will deliberately activate empathic behaviour. Situational empathic behaviour, e.g., connecting, listening, asking questions, and postponing opinions, appears to be trainable. However, little is known about the effectiveness of training methods, which dimensions of empathy can be trained, and how these can be sustainably converted into different behaviour. Therefore, although functional empathic behaviour may be rapidly activated, more study is needed to determine effective training methods (see Section 11.2.2.). Meanwhile, stimulating interaction, listening and asking questions will contribute to performance anyway.

Finally, the study revealed the difficulty of defining a shared and objective view on performance related to the success criteria. Satisfactory performance is the main goal of all project participants. Therefore, more effort needs to be put into the party's expectations regarding success criteria and performance and into monitoring performance as objectively as possible. This will provide more guidance to the project and could also support project evaluation and learning in the sector.

11.2.2 Recommendations for research and education

This study provides initial insights into the levels of empathic abilities of project teams in the civil engineering industry. Furthermore, it is the first to quantitatively relate the levels of empathic ability to project performance. However, more data is needed to generalise the levels of empathic ability and their interaction with performance. Data from other countries, cultures, contracts or disciplines will add valuable insights into reference levels of empathic abilities across the civil engineering industry and their effects on performance. This can also provide better insights into the gap observed between the civil engineering sector's levels of empathic abilities and those of the reference derived from the literature.

Generally, the concept of empathy leaves unexplored areas. Consequently, an important field of further research is how empathic behaviour can be effectively enhanced in project teams having a relatively short lead time. First, this study recommends increasing gender diversity to raise the empathic traits of the project team participants. Although the literature (Baker *et al.*, 2019) and this study suggest the positive effects of gender balance on performance, its effective implementation in organisations and the effects on the civil engineering sector specifically need more study to accelerate. Additionally, while the Dutch culture is characterised as focused on collaboration and relationships, the effectiveness of increasing empathy in more masculine cultures requires further study.

Next, studies suggest that empathic behaviour is trainable, however, little is known about training methods and the best trainable dimensions of empathy, and the effectiveness of training is hard to demonstrate (Chiu *et al.*, 2011). Where training seems to focus on the cognitive dimension of empathy, a question is whether the empathy's fundamental affective dimension also can be activated to become more effective (Rijnders *et al.*, 2021). Additionally, as discussed in Section 9.4, interpreting the IRI dimensions and their contribution to empathic behaviour remains subject to discussion. A better understanding of the relationships between the IRI dimensions and performance can be supportive of team composition.

Another debate in the literature is to what extent empathy can be incited towards groups, where empathy basically happens between individuals. Referring to the civil engineering sector, empathy would be most effective when it can be developed between culturally determined groups, such as owners, contractors, stakeholders, and disciplines. Although studies indicate the positive effects of perspective-taking for intergroup and collective empathy (Vanman, 2016; Akgun *et al.*, 2015), more study could provide valuable insights into methods to stimulate empathy between groups in civil engineering projects.

Finally, given the essential role of project participants' competencies in projects, this study recommends more attention to competencies related to integration in education. Students should learn the importance of competencies and human-related factors for project success, how competencies affect project performance and how they can effectively use competencies for project success. These insights should also initiate the development of one's competencies in a professional career. This will contribute to creating a new civil engineer who guides the necessary transformative approach of the civil engineering processes and the interdependent global transitions.

11.3 REFERENCES

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Appendices

APPENDIX A: SURVEY QUESTIONNAIRE

A1: Performance Survey

1 Project performance

Hoe waardeer je de project prestatie t.a.v.:

Kosten

0: Zeer slecht	Budget is meer dan 10% overschreden
1: Slecht	Budget is 0 – 10% overschreden
2: Niet goed, niet slecht	Kosten zijn gelijk aan budget
3: Goed	Kosten zijn 0-10% lager dan budget
4: Zeer goed	Kosten meer dan 10% lager dan budget

Tijd

0: Zeer slecht	Vertraging is meer dan 10%
1: Slecht	Vertraging is 0 – 10%
2: Niet goed, niet slecht	Project loopt op planning
3: Goed	Project loopt 0 – 10% voor op planning
4: Zeer goed	Project loopt meer dan 10% voor op planning

Kwaliteit

0: Zeer slecht	Aan diverse belangrijke eisen is niet naar tevredenheid voldaan
1: Slecht	Aan een aantal eisen is niet naar tevredenheid voldaan
2: Niet goed, niet slecht	Aan enkele eisen is niet voldaan of moesten worden aangepast
3: Goed	Aan alle eisen is voldaan
4: Zeer goed	Aan alle eisen is voldaan, sommigen boven verwachting

Veiligheid

0: Zeer slecht	IF > 2,0
1: Slecht	IF = 2,0
2: Niet goed, niet slecht	IF = 1,0
3: Goed	IF = 0,5
4: Zeer goed	IF = 0

Tevreden Stakeholders

0: Zeer slecht	Stakeholders zijn zeer ontevreden
1: Slecht	Stakeholders zijn ontevreden
2: Niet goed, niet slecht	Stakeholders zijn niet ontevreden, noch tevreden
3: Goed	Stakeholders zijn tevreden
4: Zeer goed	Stakeholders zijn zeer tevreden

Overall

0: Zeer slecht
1: Slecht
2: Niet goed, niet slecht
3: Goed
4: Zeer goed

2 Performance of the integrated design process

Hoe waardeer je het integrale ontwerpproces t.a.v.:

Kosten van het integrale ontwerpproces

0: Zeer slecht	Budget is meer dan 10% overschreden
1: Slecht	Budget is 0 – 10% overschreden
2: Niet goed, niet slecht	Kosten zijn gelijk aan budget
3: Goed	Kosten zijn 0-10% lager dan budget
4: Zeer goed	Kosten meer dan 10% lager dan budget

Tijd t.b.v. het integrale ontwerpproces

0: Zeer slecht	Vertraging op oorspronkelijke planning is meer dan 10%
1: Slecht	Vertraging op oorspronkelijke planning is 0 – 10%
2: Niet goed, niet slecht	Proces is volgens planning verlopen
3: Goed	Project loopt 0 – 10% voor op planning
4: Zeer goed	Project loopt meer dan 10% voor op planning

Procesverstoringen a.g.v. het integreren van stakeholder belangen

0: Zeer slecht	Zeer hoog
1: Slecht	Hoog
2: Niet goed, niet slecht	Niet hoog, noch laag
3: Goed	Laag
4: Zeer goed	Zeer laag

Procesverstoringen a.g.v. raakvlak issues tussen disciplines

0: Zeer slecht	Zeer hoog
1: Slecht	Hoog
2: Niet goed, niet slecht	Niet hoog, noch laag
3: Goed	Laag
4: Zeer goed	Zeer laag

De kwaliteit van het ontwerpproduct voor de stakeholders
0: Zeer slecht
1: Slecht
2: Niet goed, niet slecht
3: Goed
4: Zeer goed

De kwaliteit van het ontwerpproduct t.a.v. raakvlakissues (uitvoerbaarheid, veiligheid, etc.)
0: Zeer slecht
1: Slecht
2: Niet goed, niet slecht
3: Goed
4: Zeer goed

Overall
0: Zeer slecht
1: Slecht
2: Niet goed, niet slecht
3: Goed
4: Zeer goed

A2: Empathy Survey

Enkele persoonlijke gegevens:

Wat is je leeftijd? *

- o < 21 jaar
- o 21 - 30 jaar
- o 31 - 40 jaar
- o 41 - 50 jaar
- o 51 - 60 jaar
- o > 60 jaar

Wat is je geslacht *

- o Man
- o Vrouw
- o Anders

Vanuit welke organisatie ben (was) je bij het project betrokken? *

- o Opdrachtgever
- o Opdrachtnemer

In welk vakgebied bent je werkzaam? *

- o Project Management
- o Project Beheersing - Financieel Management
- o Project Beheersing – Proces Management
- o Contract Management
- o Omgevingsmanagement
- o Technisch Management - Ontwerp
- o Technisch Management - Werkvoorbereiding
- o Technisch Management - Uitvoering
- o Technisch Management Onderhoud
- o Anders

Aan hoeveel mensen geef (of gaf) je direct of indirect leiding op het project? *

- o 0
- o 1-5
- o 6-10
- o 11-20
- o 21-50
- o 51-100
- o 101-150
- o 151-200
- o 201-250
- o >250

Het project

Hoe beoordeel je de complexiteit van het project m.b.t. raakvlakken? Denk aan: diversiteit technische disciplines, raakvlakken tussen de verschillende disciplines, afhankelijkheid van deelprojecten, afhankelijkheid van andere projecten, aard van de omgeving, bereikbaarheid en bouwlogistiek.
1 = 'Ik ervaar het project helemaal niet als complex' .. 5 = 'Ik ervaar het project als zeer complex'. *

1	2	3	4	5

Hoe beoordeel je de complexiteit van het project m.b.t. raakvlakken? Denk aan: diversiteit technische disciplines, raakvlakken tussen de verschillende disciplines, afhankelijkheid van deelprojecten, afhankelijkheid van andere projecten, aard van de omgeving, bereikbaarheid en bouwlogistiek.
1 = 'Ik ervaar het project helemaal niet als complex' .. 5 = 'Ik ervaar het project als zeer complex'. *

1	2	3	4	5

Hoe beoordeel je de complexiteit van het project m.b.t. raakvlakken? Denk aan: diversiteit technische disciplines, raakvlakken tussen de verschillende disciplines, afhankelijkheid van deelprojecten, afhankelijkheid van andere projecten, aard van de omgeving, bereikbaarheid en bouwlogistiek.
1 = 'Ik ervaar het project helemaal niet als complex' .. 5 = 'Ik ervaar het project als zeer complex'. *

1	2	3	4	5

Vragenlijst (IRI-Test)

1 = 'Omschrijft mij heel goed' ……….... 5 = 'Omschrijft mij totaal niet'. *

1	2	3	4	5

o Ik dagdroom en fantaseer, met enige regelmaat, over dingen die zouden kunnen gebeuren met mij
o Ik heb vaak tedere, bezorgde gevoelens voor mensen die minder gelukkig zijn dan ik
o Ik vind het soms moeilijk om dingen te zien vanuit andermans gezichtspunt
o Soms heb ik niet veel medelijden met andere mensen wanneer ze problemen hebben
o Ik raak echt betrokken met de personages uit een roman
o In noodsituaties voel ik me ongerust en niet op mijn gemak
o Ik ben meestal objectief wanneer ik naar een film of toneelstuk kijk, en ga er niet vaak volledig in op
o Ik probeer naar ieders kant van een meningsverschil te kijken alvorens ik een beslissing neem
o Wanneer ik iemand zie waarvan wordt geprofiteerd, voel ik me nogal beschermend tegenover hen
o Ik voel me soms hulpeloos wanneer ik in het midden van een zeer emotionele situatie zit
o Ik probeer mijn vrienden soms beter te begrijpen door me in te beelden hoe de dingen eruit zien vanuit hun perspectief
o Uitermate betrokken raken in een goed boek of film is eerder zeldzaam voor mij
o Wanneer ik zie dat iemand zich bezeert, ben ik geneigd kalm te blijven
o Andermans ongelukken verstoren me meestal niet veel
o Als ik zeker ben dat ik over iets gelijk heb, verspil ik niet veel tijd aan het luisteren naar andermans argumenten
o Na het zien van een toneelstuk of film, voel ik mij alsof ik een van de karakters ben
o In een gespannen emotionele situatie zijn, schrikt me af
o Wanneer ik zie dat iemand unfair wordt behandeld, voel ik soms weinig medelijden met hen
o Ik ben meestal behoorlijk effectief in het omgaan met noodsituaties
o Ik ben vaak nogal geraakt door dingen die ik zie gebeuren
o Ik geloof dat er twee zijden zijn aan elke vraag en probeer te kijken naar beide
o Ik zou mezelf beschrijven als een vrij teder persoon
o Wanneer ik naar een goede film kijk, kan ik mezelf zeer gemakkelijk in de plaats stellen van het hoofdpersonage
o Ik neig ertoe controle te verliezen tijdens noodsituaties
o Wanneer ik overstuur ben door iemand, probeer ik mijzelf meestal voor een tijdje 'in zijn schoenen' te verplaatsen
o Wanneer ik een interessant verhaal of roman aan het lezen ben, beeld ik me in hoe ik me zou voelen indien de gebeurtenissen in het verhaal mij zouden overkomen
o Wanneer ik iemand zie die zeer hard hulp nodig heeft in een noodsituatie, ga ik kapot
o Alvorens iemand te bekritiseren, probeer ik mij voor te stellen hoe ik mij zou voelen mocht ik in hun plaats staan

Tot slot

Zijn er verder nog zaken die je zou willen delen met betrekking tot het onderzoek / deze vragenlijst?

APPENDIX B: DATA ANALYSIS

This appendix presents the results of the process of coding and analyses of the study presented in Chapter 8. The data were analysed using Atlas TI. First, the 20 highest grounded concepts are presented, including their cooccurrence, indicating the extent to which they are interrelated. The code-cooccurrence is defined as $c = n12 / (n1 + n2 - n12)$, where:

n1 = groundedness of concept 1
n2 = groundedness of concept 2
n12 = number of co-occurrences for n1 and n2 in the quotes

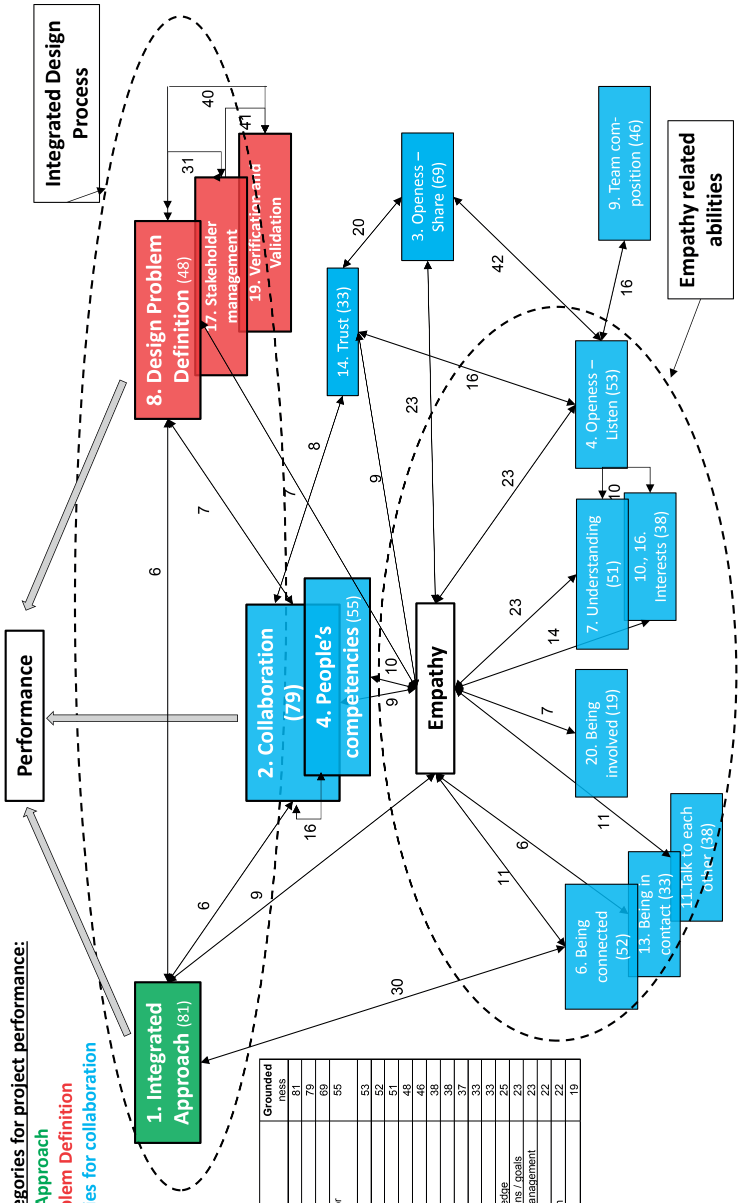
Then, the results are presented in a network of thematically grouped concepts and relevant interrelatedness. The numbers attributed to the concepts correspond to their groundedness ranking. The colours of the concepts relate to the three dominant concept groups affecting performance derived from the analysis presented in Section 8.5.3, i.e. A: An integrated approach of the design process, B: The Design problem definition and verification process, and C: Competencies for collaboration and understanding interests. This overview was combined with the results of the previous studies (see Figure 3.7) and finally evolved into theory building on the relationship between empathy and performance and the model presented in Figure 8.5.

Top 20 concepts and code-cooccurrence

	○ Being connected Gr=52		○ Being in contact with Gr=33		○ Being involved Gr=19		○ Collaboration Gr=79		○ Design problem definition Gr=48		○ Empathy Gr=142		○ Having shared expectations / goals Gr=23		○ Integrated approach Gr=81		○ Interests Gr=38	
	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff
○ Being connected Gr=52	0	0.00	4	0.05	2	0.03	8	0.07	3	0.03	20	0.11	3	0.04	31	0.30	5	0.06
○ Being in contact with Gr=33	4	0.05	0	0.00	0	0.00	4	0.04	0	0.00	10	0.06	2	0.04	8	0.08	1	0.01
○ Being involved Gr=19	2	0.03	0	0.00	0	0.00	3	0.03	1	0.02	13	0.09	0	0.00	2	0.02	1	0.02
○ Collaboration Gr=79	8	0.07	4	0.04	3	0.03	0	0.00	8	0.07	18	0.09	5	0.05	9	0.06	6	0.05
○ Design problem definition Gr=48	3	0.03	0	0.00	1	0.02	8	0.07	0	0.00	12	0.07	5	0.08	7	0.06	2	0.02
○ Empathy Gr=142	20	0.11	10	0.06	13	0.09	18	0.09	12	0.07	0	0.00	11	0.07	18	0.09	22	0.14
○ Having shared expectations / goals Gr=23	3	0.04	2	0.04	0	0.00	5	0.05	5	0.08	11	0.07	0	0.00	7	0.07	3	0.05
○ Integrated approach Gr=81	31	0.30	8	0.08	2	0.02	9	0.06	7	0.06	18	0.09	7	0.07	0	0.00	10	0.09
○ Interests Gr=38	5	0.06	1	0.01	1	0.02	6	0.05	2	0.02	22	0.14	3	0.05	10	0.09	0	0.00
○ Knowledgeable Gr=22	3	0.04	2	0.04	1	0.03	5	0.05	0	0.00	1	0.01	0	0.00	5	0.05	0	0.00
○ Openess - listening Gr=53	2	0.02	3	0.04	1	0.01	11	0.09	3	0.03	37	0.23	1	0.01	3	0.02	5	0.06
○ Openess - share Gr=69	4	0.03	6	0.06	3	0.04	16	0.12	2	0.02	40	0.23	4	0.05	1	0.01	3	0.03
○ People's competencies for interaction Gr=55	3	0.03	3	0.04	0	0.00	18	0.16	2	0.02	18	0.10	0	0.00	4	0.03	4	0.04
○ Planning Gr=21	2	0.03	1	0.02	0	0.00	3	0.03	7	0.11	3	0.02	0	0.00	3	0.03	0	0.00
○ Sharing problems, knowledge Gr=25	4	0.05	2	0.04	2	0.05	8	0.08	0	0.00	17	0.11	2	0.04	1	0.01	2	0.03
○ Stakeholder management Gr=23	2	0.03	0	0.00	0	0.00	1	0.01	17	0.31	3	0.02	1	0.02	7	0.07	0	0.00
○ Talk to each other Gr=38	2	0.02	4	0.06	1	0.02	2	0.02	1	0.01	18	0.11	2	0.03	4	0.03	6	0.09
○ Team composition Gr=46	5	0.05	3	0.04	0	0.00	10	0.09	1	0.01	9	0.05	2	0.03	5	0.04	2	0.02
○ Trust Gr=33	2	0.02	1	0.02	2	0.04	8	0.08	2	0.03	14	0.09	1	0.02	2	0.02	2	0.03
○ Understanding Gr=51	3	0.03	3	0.04	2	0.03	10	0.08	7	0.08	36	0.23	6	0.09	4	0.03	8	0.10
○ Verification and Validation Gr=22	1	0.01	0	0.00	0	0.00	3	0.03	20	0.40	5	0.03	2	0.05	4	0.04	0	0.00

	○ Knowledgeable Gr=22		○ Openess - listening Gr=53		○ Openess - share Gr=69		○ People's competencies for interaction Gr=55		○ Planning Gr=21		○ Sharing problems, knowledge Gr=25		○ Stakeholder management Gr=23		○ Talk to each other Gr=38		○ Team composition Gr=46		○ Trust Gr=33		○ Understanding Gr=51		○ Verification and Validation Gr=22	
	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff	count	coeff
○ Being connected Gr=52	3	0.04	2	0.02	4	0.03	3	0.03	2	0.03	4	0.05	2	0.03	2	0.02	5	0.05	2	0.02	3	0.03	1	0.01
○ Being in contact with Gr=33	2	0.04	3	0.04	6	0.06	3	0.04	1	0.02	2	0.04	0	0.00	4	0.06	3	0.04	1	0.02	3	0.04	0	0.00
○ Being involved Gr=19	1	0.03	1	0.01	3	0.04	0	0.00	0	0.00	2	0.05	0	0.00	1	0.02	0	0.00	2	0.04	2	0.03	0	0.00
○ Collaboration Gr=79	5	0.05	11	0.09	16	0.12	18	0.16	3	0.03	8	0.08	1	0.01	2	0.02	10	0.09	8	0.08	10	0.08	3	0.03
○ Design problem definition Gr=48	0	0.00	3	0.03	2	0.02	2	0.02	7	0.11	0	0.00	17	0.31	1	0.01	1	0.01	2	0.03	7	0.08	20	0.40
○ Empathy Gr=142	1	0.01	37	0.23	40	0.23	18	0.10	3	0.02	17	0.11	3	0.02	18	0.11	9	0.05	14	0.09	36	0.23	5	0.03
○ Having shared expectations / goals Gr=23	0	0.00	1	0.01	4	0.05	0	0.00	0	0.00	2	0.04	1	0.02	2	0.03	2	0.03	1	0.02	6	0.09	2	0.05
○ Integrated approach Gr=81	5	0.05	3	0.02	1	0.01	4	0.03	3	0.03	1	0.01	7	0.07	4	0.03	5	0.04	2	0.02	4	0.03	4	0.04
○ Interests Gr=38	0	0.00	5	0.06	3	0.03	4	0.04	0	0.00	2	0.03	0	0.00	6	0.09	2	0.02	2	0.03	8	0.10	0	0.00
○ Knowledgeable Gr=22	0	0.00	0	0.00	1	0.01	3	0.04	0	0.00	0	0.00	1	0.02	2	0.03	6	0.10	0	0.00	1	0.01	0	0.00
○ Openess - listening Gr=53	0	0.00	0	0.00	36	0.42	5	0.05	0	0.00	6	0.08	1	0.01	5	0.06	1	0.01	12	0.16	9	0.09	1	0.01
○ Openess - share Gr=69	1	0.01	36	0.42	0	0.00	6	0.05	0	0.00	16	0.21	0	0.00	3	0.03	3	0.03	17	0.20	10	0.09	0	0.00
○ People's competencies for interaction Gr=55	3	0.04	5	0.05	6	0.05	0	0.00	0	0.00	5	0.07	0	0.00	5	0.06	14	0.16	4	0.05	3	0.03	1	0.01
○ Planning Gr=21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.05	1	0.02	0	0.00	0	0.00	1	0.01	2	0.05
○ Sharing problems, knowledge Gr=25	0	0.00	6	0.08	16	0.21	5	0.07	0	0.00	0	0.00	0	0.00	3	0.05	2	0.03	4	0.07	3	0.04	0	0.00
○ Stakeholder management Gr=23	1	0.02	1	0.01	0	0.00	0	0.00	2	0.05	0	0.00	0	0.00	0	0.00	2	0.03	0	0.00	0	0.00	13	0.41
○ Talk to each other Gr=38	2	0.03	5	0.06	3	0.03	5	0.06	1	0.02	3	0.05	0	0.00	0	0.00	2	0.02	2	0.03	7	0.09	0	0.00
○ Team composition Gr=46	6	0.10	1	0.01	3	0.03	14	0.16	0	0.00	2	0.03	2	0.03	2	0.02	0	0.00	2	0.03	0	0.00	1	0.01
○ Trust Gr=33	0	0.00	12	0.16	17	0.20	4	0.05	0	0.00	4	0.07	0	0.00	2	0.03	2	0.03	0	0.00	3	0.04	2	0.04
○ Understanding Gr=51	1	0.01	9	0.09	10	0.09	3	0.03	1	0.01	3	0.04	0	0.00	7	0.09	0	0.00	3	0.04	0	0.00	5	0.07
○ Verification and Validation Gr=22	0	0.00	1	0.01	0	0.00	1	0.01	2	0.05	0	0.00	13	0.41	0	0.00	1	0.01	2	0.04	5	0.07	0	0.00

The network of interrelated concepts affecting performance



Nr.	Concept	Groundedness
1	Integrated approach	81
2	Collaboration	79
3	Openess - share	69
4	People's competencies for interaction/collaboration	55
5	Openess - listening	53
6	Being connected	52
7	Understanding interests	51
8	Design problem definition	48
9	Team composition	46
10	Interests	38
11	Talk to each other	38
12	Contract	37
13	Being in contact with	33
14	Trust	33
15	Sharing problems, knowledge	25
16	Having shared expectations / goals	23
17	Stakeholders' interests management	23
18	Knowledgeable	22
19	Verification and Validation	22
20	Being involved	19

DANKWOORD

Promoveren is een eenzame aangelegenheid. Heel wat uren bracht ik in mijn eentje door op de zolderkamer. Tegelijkertijd is de hulp van veel mensen noodzakelijk om het traject tot een goed einde te brengen. Daarom is dit proefschrift bovenal het resultaat van de samenwerking met en de hulp van heel veel mensen die ik daarvoor dank ben verschuldigd.

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Tijdens dit onderzoek heb ik een brede vertegenwoordiging vanuit de sector gesproken over waarom projecten wel of niet succesvol zijn. 73 interviews maken onderdeel uit van dit onderzoek. De openheid en kwetsbaarheid van de deelnemers aan deze gesprekken is me bijgebleven en heeft een belangrijke positieve invloed gehad op het resultaat van het onderzoek. Ik dank alle betrokkenen daarvoor. Ik heb de positieve insteek in de gesprekken geïnterpreteerd als een grote drijfveer om als sector te willen verbeteren en dat geeft hoop voor de toekomst.

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ABOUT THE AUTHOR

Guus Keusters was born on 19 January 1965 in Gilze and Rijen, the Netherlands. In 1989, he received his master's degree from the Faculty of Civil Engineering at Delft University of Technology. After his studies, he started his career at Ingenieursbureau Grabowsky and Poort as a structural engineer in architecture and civil engineering projects. The desire to consider design from a different perspective led to a move to the contracting industry. At Bam Infra and Bam International he worked mainly on international projects from a design perspective. Back in the Netherlands, he made the switch to Heijmans in 1996, where he worked as an integral design manager on large integrated contracts, including projects of the Betuweroute, HSL-Zuid and the PPP wastewater treatment plant Harnaschpolder. From 2006 to 2017, he became responsible for Heijmans Infra's design department. During this period, he was also, among other activities, a member of the Supervisory Board of the Constructeursregister, chairman of the Vakgroep Ingnieursbureaus Bouwbedrijven of Bouwend Nederland and member of OCIB.
In 2018, he moved to Dura Vermeer Infra, where he shaped the design organisation of the infrastructure division. Currently, he is appointed as a director for the Landelijke Projecten business unit of Dura Vermeer, which is involved in designing and building large civil engineering projects in the Netherlands. In addition to this role, he started a PhD research at TU Delft, with the working title "The effects of the integrated design process on the performance of civil engineering projects". The research strongly interacted with his daily working practice, providing the possibility to bridge science and practice. This dissertation reflects the final results of this research.

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About this dissertation

Transitions related to climate change, energy and biodiversity affect spatial claims and require an integrated approach. These developments herald a redesign of the built environment. Consequently, civil engineering projects are changing from technological to integration-driven assignments and their complexity is increasing. These challenges manifest themselves particularly in the integrated design process.

Therefore, this dissertation focuses on the question of how performance can be improved by focusing on integration in the civil engineering design process. An optimal, integrated approach emerges as a critical factor. Additionally, the increasingly integrative, social and dynamic character of the civil engineering design process necessitates project team members to collaborate, connect and delve into the others' interests. Therefore, empathy turns out to be a relevant factor for project success. Moreover, the empathic abilities of the Dutch civil engineering sector appear to be relatively low, implying room for improvement.

Over dit proefschrift

Transities gerelateerd aan klimaatverandering, energie en biodiversiteit beïnvloeden ruimtelijke claims en vragen om een integrale aanpak. Deze ontwikkelingen luiden een herinrichting in van de bebouwde omgeving.
Hierdoor veranderen civieltechnische projecten van technologische naar integratie-gedreven opgaven en neemt hun complexiteit verder toe. Deze uitdagingen manifesteren zich met name in het geïntegreerde ontwerpproces.

Om die reden is dit proefschrift gericht op de vraag hoe de performance van civieltechnische projecten kan worden verbeterd door te focussen op integratie in het ontwerpproces. Een optimale, geïntegreerde aanpak komt daarbij naar voor als een kritische factor.
Het in toenemende mate integrale, sociale en dynamische karakter van het ontwerpproces maakt het noodzakelijk dat projectteamleden samenwerken, verbinden en zich verdiepen in de belangen van anderen.
Daarom blijkt empathie een belangrijke factor voor project succes te zijn. Bovendien blijkt het empathisch vermogen van de Nederlandse civieltechnische sector relatief laag te zijn, hetgeen ruimte biedt voor verbetering.