

MASTER

**Towards a platform to find and select advisors for housing development projects
an explorative study to enhance the knowledge exchange between project developers**

van der Weide, J.

Award date:
2020

[Link to publication](#)

Disclaimer

This document contains a student thesis (bachelor's or master's), as authored by a student at Eindhoven University of Technology. Student theses are made available in the TU/e repository upon obtaining the required degree. The grade received is not published on the document as presented in the repository. The required complexity or quality of research of student theses may vary by program, and the required minimum study period may vary in duration.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain

Towards a platform to find and select advisors for housing development projects

An explorative study to enhance the knowledge exchange between project developers

Author

J. (Jorn) van der Weide

IDNR: 1028322

Jornvdweide@gmail.com

University

Eindhoven University of Technology

Master Construction Management and Engineering

Graduation committee

Dr. Q. (Qi) Han - Eindhoven University of Technology

Dr. R.J.G. (Raymond) Opdenakker - Eindhoven University of Technology

Prof.dr.ir. B. (Bauke) de Vries - Eindhoven University of Technology

Final presentation date

25-03-2020

Table of contents

Preface.....	V
Management Summary.....	VII
Management Summary (Dutch).....	IX
Abstract	XI
Glossary	XIII
List of figures	XV
List of tables	XV
1 Introduction.....	1
1.1 Problem statement.....	1
1.2 Problem statement.....	4
1.3 Research model	5
1.3.1 Research design.....	5
1.4 Research objectives and limitations.....	6
1.5 Structure of the thesis.....	7
2 Literature review	9
2.1 Managing Knowledge	10
2.1.1 Knowledge.....	10
2.1.2 Generations of knowledge management in AEC-sector	16
2.2 Implications for better value creation through knowledge sharing	22
2.3 Challenges of knowledge management in project development companies.....	25
2.3.1 How is knowledge collected and transferred between individuals?	25
2.3.2 <i>How is knowledge management incorporated within the AEC-industry?</i>	26
2.3.3 Knowledge gap	27
3 Methodology	29
3.1 Design science methodology.....	29
3.2 Interviews	30
3.3 Analyses.....	31
3.4 Conceptual platform design method	32
4 Results	33
4.1 Advisor search and selection.....	33
4.1.1 How do real estate developers of housing projects find and select advisors?	34
4.2 Experience evaluation, documentation, and exchange	34
4.2.1 Evaluation and documentation	34
4.2.2 Knowledge sharing	36

4.2.3	How are experiences documented and exchanged within the decentralized organization?.....	37
5	Project developers platform.....	39
5.1	Continuously expanding data reservoir	39
5.2	References platform.....	40
5.3	Events and meet-ups.....	43
6	Validation and improvements.....	45
6.1	Validation meetings.....	45
6.1.1	Validation meeting 1	45
6.1.2	Validation meeting 2	46
6.2	Platform re-design.....	47
6.2.1	Design adjustments	47
6.2.2	Additional user notes	49
6.3	How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?.....	50
7	Conclusion	53
8	Appendices	59
8.1	Appendix I: Interview Guide	59
8.2	Appendix II: Interview summaries.....	60
8.2.1	Interview 1.....	60
8.2.2	Interview 2.....	64
8.2.3	Interview 3.....	67
8.2.4	Interview 4.....	70
8.3	Appendix III: Wireframe concept	73
8.4	Appendix IV: Validation meeting presentation	75
8.5	Appendix V: Wireframe	77

Preface

Dear Reader,

Finalizing my master thesis by writing this preface will also end my academic journey as a student. In the last six months, I have been given the opportunity and freedom to study the organizational side of project development. A part of the construction industry often underexposed in my point of view. Choosing a subject that has little direct references for the construction industry has not always been easy during the research. Especially the starting phase felt like a never-ending search for information. It gives me pleasure that the results of the thesis can contribute to more efficient use of knowledge with the case organization.

I would also like to thank Peter and Maaïke for allowing me to conduct this study at the case company and giving me the freedom to explore the organization, challenging me to step outside my comfort zone and guiding me during the discussions, and sometimes bringing my feet back to the ground and my ideas and suggestions realistic in an organizational context. And especially in the flexibility needed during the last phase of the process. Also, I want to show my gratitude towards the interviewees and validators for giving me an insight into their working methods and needs. In addition, I would like to thank Annemieke for the pleasant working experience and the social talks during my study hours at the office.

By these means, I would like to thank my graduation supervisors from the University, Qi Han and Raymond Opdenakker, for guiding me through the process of this graduation thesis, starting from a vague idea about a platform for the entire construction industry towards a complete Master thesis focussed on a manageable concept.

At last, I want to thank my family, girlfriend and friends for supporting me during my entire Master.

With these final words, I would like to finish my Master, and I hope you enjoy reading this master thesis.

Jorn van der Weide

February 2020
Baarn/Utrecht

Management Summary

The Dutch real estate market is already for a long time, demanding more, mainly affordable dwellings. Recently even mentioning the term 'woningnood' to highlight the problem of the housing shortage. In addition, the economic downfall led to the efflux of the labor force, leading to a shortage of labor in the construction sector now, the economy is rising once again. The high demand for dwellings with the limited availability of skilled personnel, demands efficient employment. One method for this is to limit the time project developers need for the search and selection for adequate advisors. This study focusses on increasing the efficiency of the use of available knowledge and experiences from project developers with advisors within a decentralized project development organization. Aiming to answer the following research question:

How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?

To answer the research question four sub-questions are studied and answered. The first two sub-questions main question with the help of a literature study focussing on the concept of knowledge and knowledge management within the construction sector, which leads to a solid foundation of the main concepts and current academic insights.

Sub-question 1: *How is knowledge collected and transferred between individuals?*
Sub-question 2: *How is knowledge management incorporated within the AEC-industry?*

The last two sub-questions main question with the help of semi-structured interviews among project developers in a case company. These semi-structured interviews are based on the findings in the literature study. The case company is a decentralized developing construction company focussing on housing construction, operating from 24 office spread among five regions.

Sub-question 3: *How do real estate developers of housing projects find and select advisors?*
Sub-question 4: *How are experiences with advisors documented and exchanged with the decentralized organization?*

For more efficient use of knowledge within an organization, it is essential to understand the concept of knowledge. According to Polanyi (1966), knowledge can be divided into two types, explicit and tacit knowledge. Explicit knowledge can easily be documented and thereby transferred by prints or emails. Explicit knowledge consists of Data, primary objective facts, and Information, processed data with the purpose of making the data useful. Tacit knowledge is hard to document and, therefore, more challenging to share. Tacit knowledge consists of Knowledge, which is what a person remembers because it is useful, and Wisdom, whereby the knowledge is combined to make based on them educated predictions to unknown situations. Ackoff (1989) developed 'the knowledge pyramid' which specified four levels from bottom to top Data, Information, Knowledge and Wisdom, noting that the basis is data from which information can be extracted. Following the creation of knowledge based on the information. This means there is always more data than information and more information than

knowledge. Tuomi (2000) argues the opposite and says you need the knowledge to extract information and information to extract data. Jennex and Bartxak (2013) in their turn, combined these two models and created 'the revised knowledge-KM pyramid', allowing the flow both up and down the pyramid. Nonaka and Konno (1998) studied the processes of knowledge transferring in which the division between tacit and explicit knowledge is also included. It is highlighted by them that the transfer of tacit knowledge, knowledge and wisdom, happens by personal contact and learning by practice. Knowledge management within the construction sector focusses according to Rezgui, Hopfe and Vorakulpipat (2010) mainly on the sharing of information within organizations and projects. To enable with the help of databases, the sharing of project-specific data and information within the organization, and currently focussing on the exchange of information between an organization in a project context, such as BIM. The future is seen as creating value with the help of knowledge. Whereby the focus is on the creation of social networks that motivate each other to share and documents knowledge, an example of this is a Community of Practice.

Within the case, company knowledge exchange between project developers is taking place with the help of project developers' meetings. In those regular meetings, the current status of projects and problems are discussed. Also, educational sessions are in order sometimes. In addition to these formal meetings, the main party of the knowledge exchange happens informally in the offices by constant consultation between the project developers on who is suitable for what advice. Of these consultations and discussions, there is hardly documentation. In addition, the decentralized structure of the company limits the exchange where only a limited number of colleagues are met at the offices on a daily base. Within the regions, the level of familiarity among each other is considered excellent. Between project developers of other regions, the connections are considered less good. This makes there is ignorance about the projects and experiences of project developers in other regions are working on. The implementation of a national database that can be accessed from all regions increases the ability of project developers to search for reference projects. However, to do this, it is needed to dive deep into the data to finds which projects are of interest.

In line with the development of a Community of Practices and the creation of value by knowledge, three improvements are suggested to improve the exchange of knowledge and experiences between project developers. First, the expansion of the database is required to include additional project data on a structured method. Including process-based information on who is working on what projects and a simple rating on how these contributions are experienced by the project developer. So these experiences could be used in future projects. Second, the development of a reference platform is suggested. This platform has a visual focus on projects based on the database. This visual focus allows the project developers to easily slide through the project based on preferences set in the platform App. This allows project developers to find reference projects and get in contact with project developers who possess specific experiences. Where after personal contact can be sought to share knowledge. In addition, the functionality of 'Well of Wisdom' allows for an accessible place for questions on a national level with all project developers and places for discussion. The third action is the organization of events focussing on the improved social interaction between project developers. Whereby a mix in nature of events from educational events to social trips is encouraged. To allow the growth of familiarity between the regions.

Management Summary (Dutch)

De Nederlandse woning markt roept al lange tijd om een sterke toename van het aantal (voornamelijk betaalbare) woningen. Hierbij spreekt het recentelijke gebruik van de term 'woningnood' tot de verbeelding. Daarnaast is in de recente crisis veel personeel uit de bouwsector weggevloeid wat momenteel, bij het aantrekken van de economie, niet volledig is aangevuld. Deze grote vraag naar woningen en beperkte arbeidscapaciteit vraagt om efficiënt inzet van personeel. Eén manier om dit te doen is om de tijd die projectontwikkelaars bezig zijn met het zoeken en selecteren van bekwame adviseurs te verminderen. Deze studie richt zich dan ook op het adequaat inzetten van de beschikbare kennis en ervaringen die project ontwikkelaars hebben omtrent adviseurs. De onderzoeksvraag luidt dan ook:

“Hoe kan de kennis, welke gebruikt wordt bij projectontwikkelaars voor het selecteren van adviseurs bij woningbouwontwikkeling, vastgelegd en uitgewisseld worden binnen een decentrale projectontwikkelaar?”.

Om deze vraag te kunnen beantwoorden wordt er gebruik gemaakt van vier deelvragen. De eerste twee deelvragen worden beantwoord met behulp van een literatuurstudie gericht op kennis en kennismangement binnen de bouwsector. Hiermee wordt een solide literaire basis van de belangrijkste begrippen en de huidige academische bevindingen verkregen.

Deelvraag 1: Hoe wordt kennis vergaard en verdeeld tussen personen?
Deelvraag 2: Hoe is kennismangement binnen de AEC-sector toegepast?

De derde en vierde deelvraag worden door middel van semigestructureerde interviews beantwoord. Hiervoor zal de kennis vanuit de literatuur de basis vormen. Projectontwikkelaars vanuit een casebedrijf zullen hiervoor gebruikt worden. Het casebedrijf is een decentrale ontwikkelende bouwer met de focus op woningbouw. De bouwer kent in totaal 24 vestigingen verdeeld over 5 regio's.

Deelvraag 3: Hoe vinden en selecteren project ontwikkelaars adviseurs?
Deelvraag 4: Hoe worden ervaringen met adviseurs vastgelegd en verspreid in een decentrale organisatie?

Om efficiënter gebruik te kunnen maken van de kennis binnen een bedrijf is het belangrijk om te begrijpen wat kennis is en waar het uit bestaat. Volgens Polanyi (1966) bestaan er twee soorten kennis: tastbare en ontastbare. Tastbare kennis kan makkelijk gedocumenteerd worden en daarom gedeeld, door middel van prints of e-mails. Deze tastbare kennis bestaat uit Data (primaire objectieve feiten) en Informatie (verwerkte data met het doel de data bruikbaar te maken). Ontastbare kennis is moeilijk vast te leggen en daardoor moeilijk te delen. Dit bestaat uit Kennis (hetgeen een person onthoud omdat het nuttig is) en Wijsheid (waarbij kennis wordt gecombineerd om op onbekende situaties te kunnen inspelen). Ackoff (1989) ontwikkelde 'the knowledge pyramid' welke onderscheid maakt tussen (van onder naar boven) Data, Informatie, Kennis en Wijsheid en zegt dat data de basis is van waaruit informatie kan worden verkregen. Informatie kan vervolgens worden omgezet in kennis. Waarbij er meer data dan informatie is en meer kennis dan informatie. Deze kijk is herzien door Tuomi (2000) welke zegt dat het alleen mogelijk is om informatie op te halen wanneer je bepaalde kennis

bezit. Deze twee visies zijn samengevoegd door Jennex en Bartzak (2013) in 'the revised knowledge-KM pyramid' waarin de omzetting beide kanten op kan werken. Nonaka en Konno (1998) hebben onderzoek gedaan naar de manier van kennisdeling waarbij het onderscheid tussen tastbare en ontastbare kennis tevens naar voren komt. Hierbij benadrukken zij dat ontastbare kennis (kennis en wijsheid) gedeeld wordt door het 'leren door doen' en overdragen doormiddel van contact tussen personen. Kennismanagement binnen de AEC-sector richt zich volgens Rezgui, Hopfe and Vorakulpipat (2010) voornamelijk op het delen van informatie binnen organisaties en projecten. Met behulp van databases is het vinden van projectspecifieke data en informatie mogelijk. Hierbij staat nu de uitwisseling van informatie tussen bedrijven in projectmatig verband centraal staat door middel van BIM. De toekomst wordt gezien als het creëren van waarde, door middel van kennis. Dit moet gebeuren door het creëren van menselijke netwerken welke elkaar motiveren om kennis en ervaringen uit te wisselen en kennis vast te leggen. Een voorbeeld hiervan zijn 'Comunities of Practice'.

Binnen het case bedrijf vindt op regionaal niveau geregeld uitwisseling plaats door middel van overleggen tussen projectontwikkelaars, waarbij wordt besproken waarmee eenieder bezig is en wat de problemen zijn die worden ervaren. Daarnaast vindt er in de wandelgangen constant overleg plaats tussen de projectontwikkelaars, het delen van ervaringen gebeurt dan ook in grote mate op een informele wijze en vastlegging van deze ervaringen vindt dan ook nauwelijks plaats. Echter zorgt het decentrale karakter van de organisatie ervoor dat ontwikkelaars elkaar in beperkte maten tegenkomen in de gangen, wat als gevolg heeft dat de uitwisseling van kennis en ervaringen vermindert. Binnen de regio's worden de connecties als goed ervaren, maar tussen de regio's zijn deze connecties vaak minder sterk. Dit zorgt ervoor dat er veel onwetendheid is over wat voor soort ervaringen er zijn binnen andere regio's. De uitrol van een landelijke database waarin projectgegevens kunnen worden opgezocht zorgt ervoor dat het zoeken naar referentieprojecten binnen andere regio's is verbeterd. De presentatiemethode zorgt er echter voor dat de ontwikkelaars diep in de gegevens moeten duiken om de gewenste informatie eruit te kunnen halen.

In lijn met de uitrol van een 'Community of Practice' en het creëren van waarde door middel van kennis is een drie ledig verbeterplan opgesteld om de uitwisseling van kennis en ervaringen tussen projectontwikkelaars te bespoedigen. Allereerst moet de database worden uitgebreid en moeten meer gegevens gestructureerd worden vastgelegd, waarbij deze ook toegankelijk zijn voor projectontwikkelaars van andere regio's. Dit omvat tevens procesmatige informatie zoals wie waar betrokken bij is. Daarnaast moet het mogelijk zijn om op een eenvoudige wijze betrokkenen te beoordelen, zodat dit kan worden bekeken voor nieuwe projecten. Een tweede actie is het ontwikkelen van een referentieplatform, welke met een visuele focus de data uit de database ontsluit waardoor ontwikkelaars op een zeer eenvoudige manier door projecten kunnen zoeken naar potentiële kennisbronnen. Het referentieplatform heeft als doel het in verbinding brengen van ontwikkelaars waarop vervolgens door middel van persoonlijk contact kennis kan worden uitgewisseld. Daarnaast dient de functie van de kennisbank een laagdrempelige manier om met elkaar in contact te komen en een vraag neer te leggen bij projectontwikkelaars. Tot slot dienen er evenementen en bijeenkomsten georganiseerd te worden om de sociale interactie tussen projectontwikkelaars te verbeteren. Deze evenementen kunnen uiteenlopend van aard zijn, van inhoudelijke kennissessies over nieuwe technologieën tot teambuilding weekends.

Abstract

The project development sector is on a high-level dependant on advisors. Within the creative process of creating something on a vacant plot of land, much knowledge must be collected, combined, and created. During a project, the project developers find and select advisors who could best suit their needs. The decentralized character of an organization limits the knowledge sharing capabilities enabling the 're-inventing of the wheel' in every local office. The literature study identifies the tacit and explicit side of knowledge which require different methods of exchange in relation to the cohesion between data, information, knowledge, and wisdom.

A case study performed to identify the knowledge sharing methods at a decentralized project development company. Whereby with the help of interviews, the interaction and exchange between project developers are studied. Showing the high dependency on personal experiences, which were only shared and accessible by direct colleagues. Moreover, the challenge to know who is working on what is a decentralized organization.

It is leading to a three-level strategy that allows for enhanced knowledge sharing on the level of data collecting and accessibility and visual tools to ease the identification of exciting reference projects — focussing firstly on the expansion documentation of data by project developers and the national distribution and accessibility of the data. Secondly, allowing the smooth visual search for reference projects, based on a reference platform, making it easier to see if there are experiences with exciting projects within the overarching organization. Allowing a quick, targeted search for experiences within the entire organization. Thirdly, increasing the interregional familiarity between project developers. Limiting the barriers to connect and allow for face-to-face interaction enabling the flow of tacit knowledge within the organization, fortifying the ease to get in touch with colleagues from other regions after the reference platform wakes interests.

Glossary

- AEC:** Architecture, Engineering, and Construction
- SECI:** Socialization, Externalization, Combination, and Internalization
- DIKW:** Data, Information, Knowledge, and Wisdom
- KM:** Knowledge Management
- ICT:** Information Communication Technology
- IT:** Information Technology
- CoP:** Community of Practice
- BIM:** Building Information Modeling
- ESMP:** Enterprise Social Media Platform
- CF:** Construction firm
- CRM:** Customer Relation Management
- FPD:** Financial Project dossier

List of figures

Figure 1: Research design.....	6
Figure 2: SECI model Spiral Evolution of Knowledge conversion and Self-transcending Process (Nonaka & Konno, 1998, p. 43)	11
Figure 3: DIKW pyramid Ackoff's view, left side, bottom-up (Ackoff, 1989). Tuomi's view, right side, top-bottom (Tuomi, 2000)	13
Figure 4: The revised knowledge-KM pyramid (Jennex & Bartczak, A Revised Knowledge Pyramid, 2013, p. 25).....	14
Figure 5: Deep smarts transfer techniques (Leonard & Swap, 2004)	15
Figure 6: Proposed generations of knowledge management within the AEC-sector by Rezgui et al., (2010, p. 223)	16
Figure 7: Open innovation model (Chesbrough, 2003, p. 37)	22
Figure 8: Conceptual model of tacit knowledge sharing in social media (Panahi, Jason, & Partridge, 2012, p. 1100).....	25
Figure 9: The design science research cycle (van Aken & Romme, 2009, p. 10) with corresponding practical action	30
Figure 10: Wireframe cut-out Login page and Homepage.....	41
Figure 11: Wireframe cut-out Search settings and Saved projects.....	41
Figure 12: Wireframe cut-out Project page and Project developer page	42
Figure 13: Wireframe cut-out Advisor page and Well of Wisdom	42
Figure 14: Wireframe cut-out Project discussion page.....	43
Figure 15: Wireframe cut-out Home page concept versus Home page redesign.....	48

List of tables

Table 1: Historical housing shortage in The Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2018)	2
Table 2: New houses delivered per year between 1945 and 2018 (Centraal Bureau Statistiek, 2019)3	
Table 3: Interviewees functions and regions	31
Table 4: Coding scheme interviews.....	Error! Bookmark not defined.

“The only irreplaceable capital an organization possesses is the knowledge and ability of its people. The productivity of that capital depends on how effectively people share their competence with those who can use it.”

Andrew Carnegie

1 Introduction

As noted by Andrew Carnegie, the knowledge and abilities of people are irreplaceable capital of a company. He not only noted this but also says that the productivity of this knowledge comes from how people share it with others that can make use of it. In many industries, the knowledge needed for a project is not available within one organization. For this reason, external parties deliver the demanded knowledge utilizing consulting or advising. Utilizing knowledge from advisors and consultants also applies to the architecture, engineering, and construction (AEC) industry.

This explorative study investigates the potential of knowledge management within advisor selection during project development. Whereby the main objective is to allow project developers to share experiences with advisors, and by that stimulate the learning potential of the decentralized project development company, ultimately limiting failure costs and exceeding schedules. A case company is selected to identify the working methods used in the industry. The case company is a Dutch construction and project development company operating from five regions with 24 offices across The Netherlands, whereby the aim is to limit knowledge isolation.

This introduction chapter will start with the relevance and motivation of the study. The research objectives and research questions follow. After which the methodology, and finally, the scope and limitations will be discussed.

1.1 Problem statement

The Netherlands is experiencing an incredible housing shortage. The shortage mainly concerns the housing of economically less fortunate people in the larger cities of The Netherlands. Many politicians, NGOs, and companies from within the construction industry often highlight the importance of developing and constructing more dwellings for this target group. Many of the stakeholders in the Dutch housing market argue about the best methods to reduce the housing shortage.

The current housing shortage in the Netherlands is not something unknown for the Netherlands. In the early 20th century, there was a problematic shortage in the country. After the second world war the period of reconstruction kicked-off, in which many dwellings were constructed at a high rate. At this same period, the 'baby boom' generation was conceived. This generation demanded houses of their own by the end of the 1960s. In combination with the high number of immigrants and the up-swing of more individualism and emancipation, demanded new houses, resulting in the housing shortage, called the 'Woningnood' in Dutch (Meusen and van Kempen, 1995). In this period, the housing shortage in the Netherlands was characterized as public enemy number 1, where the housing shortage in 1945 was 14% of the housing stock and 8% in 1960. Since then, the housing shortage has shrunk, as can be seen in table 1, to 1,8% in 2015 and 2016 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2018).

Table 1: Historical housing shortage in The Netherlands (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2018)

jaar	Woningtekort	Woningtekort in % van de woningvoorraad
1945*	300.000	14,0%
1960**	217.000	8,0%
1970**	77.100	2,0%
1978*	110.000	2,4%
1986	127.000	2,4%
1990	127.000	2,2%
1994	134.000	2,1%
1998	90.000	1,4%
2002	173.000	2,5%
2005	179.000	2,5%
2006	167.000	2,4%
2010	139.000	1,9%
2012	162.000	2,2%
2015	134.000	1,8%
2016	138.500	1,8%

*) van der Schaar, J. Groei en bloei van het Nederlandsche volkshuisvestingsbeleid, 1987.

***) Nota Volkshuisvesting 1972 TK 1971-1972 11 784 nr. 1

De meetmethode en definitie van het tekort is in de loop der jaren bijgesteld.

Bron 1986 ev: Primos en WoON.

With the already present housing shortage in mind, the Raad van State judged on the 29th of May 2019 that the method used to calculate the amount of nitrogen and ammonia emissions, which would come from new planned activities, could no longer be used to determine if a new activity would be allowed. Many housing projects were put on hold (Programma Aanpak Stikstof, 2019), resulting in even fewer constructed houses.

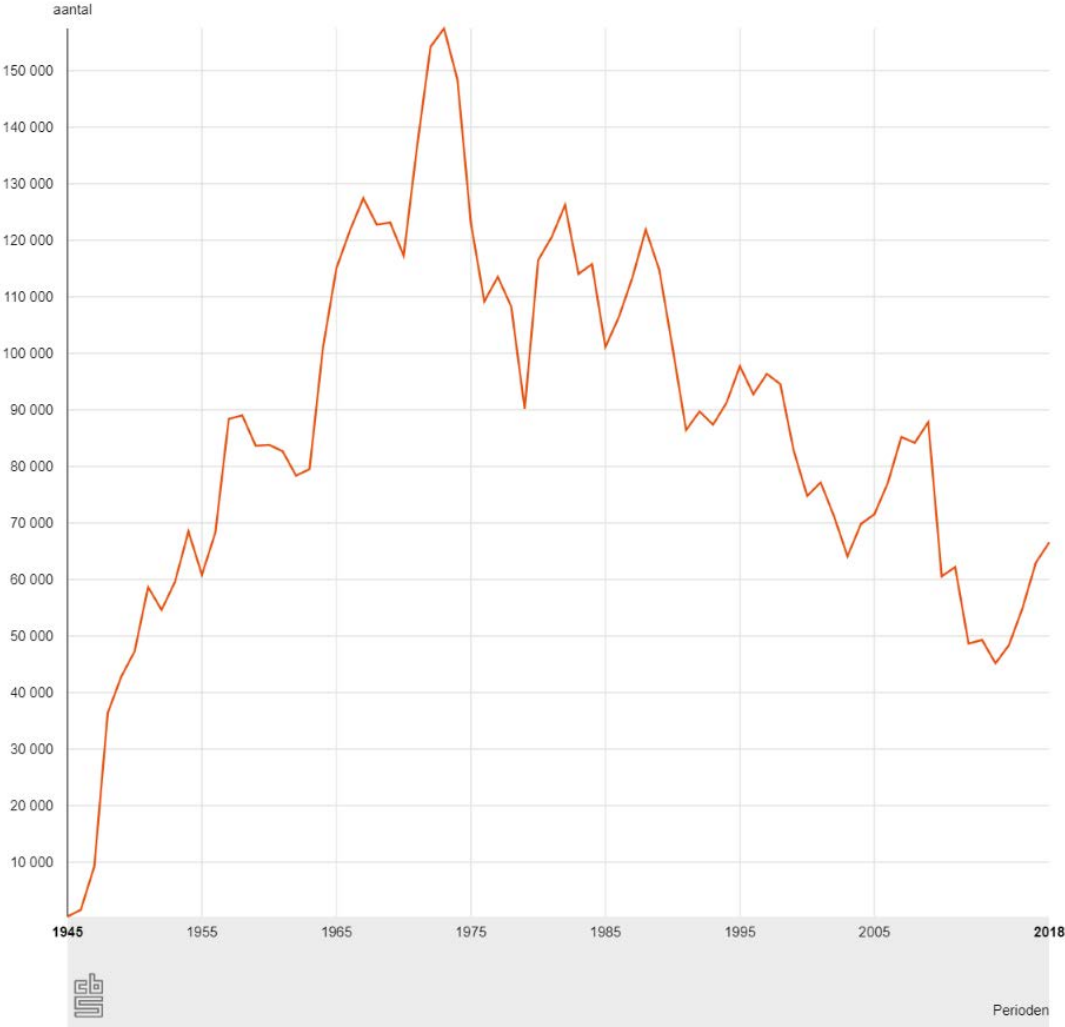
Two possible solutions are possible to counter a shortage. The first possible solution would be to limit demand. In the case of the housing shortage, this would be almost impossible. It could be possible to demotivate people to move out of their parents' house or ease the possibilities for people to share a house with friends. However, it would not be possible to forbid people to divorce or to live in a house without making use of the entire capacity of it. The second possible solution to reduce the housing shortage is to amplify the stock. Meaning the housing production must be above the housing demand. Unfortunately, the most recent prognosis of Primos 2019 predicts that the housing shortage is growing from 3,6%, 279.000 houses, in 2018 to 3,8%, 296.000 houses, in 2020. The forecast shows that housing production outnumbers the demand for houses in 2025. It is resulting in a decrease in the housing shortage (ABF Research, 2019, pp. 17-20).

As noted in the situation of a housing shortage, it is hardly possible to limit the demand. Therefore the foci must be on methods to increase the housing production. The financial crisis, starting in 2007, struck the construction industry. The production of the sector decreased from €68 billion in 2008, by approximately €15 billion, to €53 billion in 2013. After which the construction production recovered towards €70 billion in 2018 (Stichting Economisch Instituut voor de Bouw, 2018). Table 2 shows the house production over the period 1945-2018, with the years on the horizontal axes and the number of houses delivered on the vertical axes. It shows that after 2009 there was a steep downfall in the production numbers, which only after 2014 started to show persistent recovery (Centraal Bureau Statistiek, 2019).

This downfall in production had its impact on the scaled labor within the industry. Where in 2008, there were 481 thousand jobs associated with the construction industry. In 2018 only 443 thousand jobs were present. The downsizing of the industry during the depression made that employees left the industry. Resulting in a shortage of skilled personnel once the construction sector was growing again. The need for personal is also noticeable at the number

of job vacancies in the construction industry. The number of vacancies per thousand employees is in 2018, back on the pre-crisis level of 2008, with 53 vacancies per thousand employees (Stichting Economisch Instituut voor de Bouw, 2018). An often-heard term in the construction industry is there for personal scarcity. This scarcity also limits the production potential of the construction market. They are demanding more productivity from the available workforce. Resulting in a high burden for the workforce to perform and meet the growing demand for housing. Enabling the available workforce to be more productive would limit the effects on the housing shortage. Therefore the current method of working must be reviewed to enable higher productivity.

Table 2: New houses delivered per year between 1945 and 2018 (Centraal Bureau Statistieken, 2019)



Since it is not possible for everyone involved in the construction sector to work harder or more hours, improving the productivity of the workforce demands a different way of working. Two types of innovation are distinguished. The first method is by making use of product innovation, which speeds up the construction. Examples of this are machines that can lay bricks and drones, which can picture the progress made on the construction site (Bock, 2015; Rakha & Gorodetsky, 2018). The second is process innovation; this type of innovation looks at how the used processes could be changed and enhances to achieve better results. Both innovation types can again be distinguished into two types — incremental innovation, which are minor adjustments or updates to the known process or product — furthermore, radical innovation,

whereby a whole new product or process, is introduced. Pries and Dorée (2005) note that the construction industry mostly innovates at the process level, and the product innovations come from suppliers. The product innovations often focus on new construction methods, more efficient installations, and production with less waste. The process innovation focuses on better teamwork within the construction chain.

This construction chain starts with the project developer. At the start of a project, the details are still vague, and adjusting the plan is more accessible and less expensive compared to later stages of the process. Therefore the choices made in this phase must be correct, and limited changes to the plan must be made later on. Project developers, at this moment, use their experiences from the previous project. Among others, Forcada et al. (2010) and Dave and Kosela (2009) note that knowledge is an essential asset within the construction industry. The way this is managed plays a vital role in the competitive advantage of a project developer. Bad knowledge management limits the potential of employees, forcing them to spend time retrieving or reproducing information and data, eventually resulting in negative impacts on the productivity and level of innovation.

1.2 Problem statement

Project-based working is the norm within the construction industry. Making the business process downright different than most industries. Often a project is even seen as prototype development, whereby the difference to prototype development for the manufacturing industry is that the prototype is the end product. Moreover, for that reason must gratify all requirements. Another aspect specific to the construction industry is the high level of fragmentation. Project developers function as a central player. Uniting the demand of the market and client with the knowledge of and information from the external advisors and their knowledge. Ultimately delivering a coherent project plan for the development of houses on a unique plot.

Many scholars highlight the importance of knowledge management. One of the research subjects within knowledge management is the ability for project members to share and utilize project knowledge and information within a project (Khalfan, Kashyap, Li, & Abbott, 2010) (Yang, Chen, & Wang, 2012). Egbu (2004) studied how knowledge management supported the organizational innovativeness within the construction industry. Thereby he notes that Information Communication Technology (ICT) are tools that enable the storing and sharing of knowledge. As a result of this, he mentions the importance of educating people in using these tools to capture the added value of knowledge sharing capabilities. Egbu (2004, p. 313) concludes

“If the construction industry is to build core competencies, maintain capability and benefit from innovation, it has to change from an adversarial and blame cultures to a sharing culture. Innovation and KM should be seen as long-term strategic concerns. They are complex social processes, which require an integrative approach and supportive organizational contexts which involve due consideration of the people, culture, finance, technology, environmental issues, effective organizational learning and process improvement dimensions.”

Egbu (2004), with these words highlight, both the importance of KM (knowledge management) and knowledge sharing for the competitive advantage of construction

companies. As the underexposed research area of the social processes involved with knowledge management within the construction industry. The latter aspect will, therefore, be the subject of this study.

As noted above, knowledge management and sharing within a project team have been the subject of research from various academics. However, the utilization of project information on other projects is not studied. Once the project is finished, the information created is stored in the project documents and within the mind of the project members. Each member takes his or her specific experiences with them to future projects. However, the rest of the company is not able to utilize the gained experiences. To enable others within the company to utilize the experiences, the organization must be able to learn. Moreover, to align the learning capabilities with future projects to optimize organizational learning through knowledge management.

1.3 Research model

This study focuses on the project development phase of housing development projects. This study aims to create a framework to support project developers to share knowledge and experiences. Allowing to answer the following research question:

How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?

A decent knowledge of organizational learning and knowledge management is necessary. Therefor four sub-questions are answered to broaden the knowledge to answer the research question.

Sub-question 1: *How is knowledge collected and transferred between individuals?*

Sub-question 2: *How is knowledge management incorporated within the AEC-industry?*

Sub-question 3: *How do real estate developers of housing projects find and select advisors?*

Sub-question 4: *How are experiences with advisors documented and exchanged with the decentralized organization?*

1.3.1 Research design

To answer the research question, the research design, as shown in figure 1, is followed. The study starts by underpinning the academic and professional need for this research with the help of a literature study on current academic knowledge. This literature study will focus on understanding the concepts of knowledge and knowledge management concerning the AEC-sector. Understanding these two concepts will result in thorough theoretical knowledge bases to answer sub-question 1 and 2. Moreover, it is the fundament for the remaining sub-questions and research question.

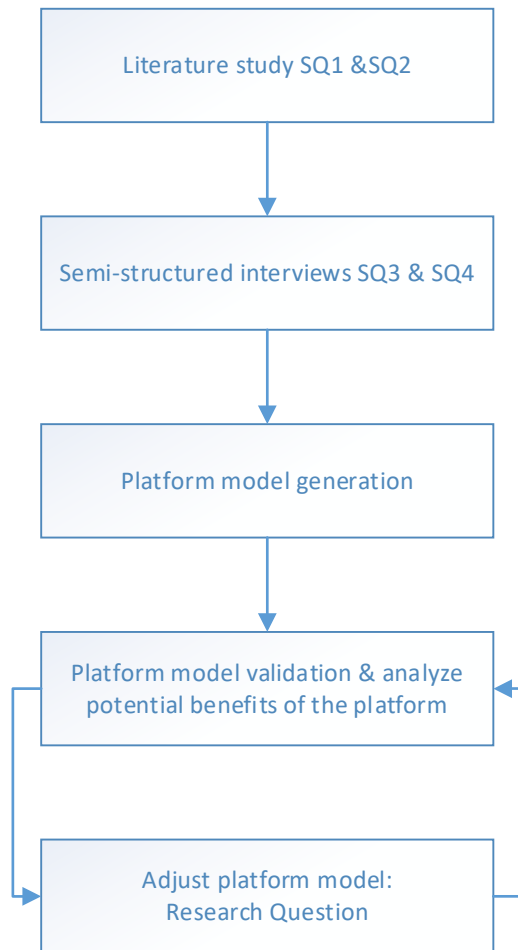


Figure 1: Research design

As noted, a literature gap exists considering knowledge and knowledge management within project development companies, resulting in limited productivity and learning capacity of these organizations. Therefore with insights from the literature study, semi-structured interviews will be conducted with project developers. To expose how information is stored and exchanged on a daily bases and answer sub-questions 3 and 4.

These new insights allow for the development of a conceptual framework for storing and exchanging knowledge, aiming to increase the productivity of the project developers by enhancing the organizational learning capacities through knowledge management. This conceptual framework will then be reviewed with the help of an expert panel, followed by refinements of the framework.

1.4 Research objectives and limitations

The expected results of this study will be two-sided. On the one hand, it will give a more profound knowledge of the concepts of knowledge management and organizational learning based on the literature study. On the other hand, it will produce a framework that shows how project developers can enhance their productivity by improved organizational learning due to better knowledge management.

The study is only limited to the project development phase of construction projects. Whereby the focus is on the knowledge gathered from cooperation within a project with advisors and the exchange of knowledge within a decentralized project development company, the focus will be on the internal organization, and exchange with external parties is not within the scope.

1.5 Structure of the thesis

The following chapter will entail the literature study, which focuses first on knowledge management and subsequently on organizational learning. The third chapter will address the methodology used in this research. This chapter includes the exact method used in this study for data collection and analysis. The results which can be drawn based on these interviews are in chapter four. Chapter five continues with the presentation of the proposed enhancements based on the literature and insights from the case company. These proposed enhancements are validated in chapter six, refinements on the enhancements are presented, and the research question is answered. The final chapter covers the conclusion, which included the lessons learned during this study, and what is yet to be studied. Also, addressing the limitations of the study and future research fields.

2 Literature review

The construction industry is a sector that is known to be traditional and slow in adopting new technologies and processes. In addition to this, the sector works project-oriented, whereby every project can be seen as the development of a prototype. These not repetitive characteristics of the sector make it even more important to diffuse the knowledge from individuals among colleagues. Since it is difficult to change and adjust the known procedures when errors are unknowingly made. Learning from each other's experiences and thereby potentially limiting the number of times flaws occur within multiple projects could give a company in the Architecture, Engineering, and Construction (AEC) industry an advantage over its competitors in the sector.

Randolph (2009) sets out guidelines to structure a dissertation literature review. He before all mentions the importance of a suitable and complete literature review for the success of the rest of the study. The focus of this review will be on the research outcomes establishing the lack of information, and justifying this research. Providing an academic base for this study and identifying the to be filled knowledge gap. What can then be validated by the practitioners within the AEC-sector.

As mentioned before, the goal is to establish a solid foundation within the field of knowledge management, which allows creating a connection to the current work methods within the AEC industry. This foundation will be gained from a neutral perspective whereby the assumption is there is limited existing knowledge on the concepts of knowledge, knowledge sharing, and knowledge management, by an audience consisting firstly of the reviewers and secondly of the corporate supervisors.

The literature used in this review is collected mainly from the Eindhoven University of Technology databases. The search in the databases occurred with the help of keywords considering the research topics such as knowledge, knowledge management, or organizational learning. Also, searches were explicitly conducted in selected journals focussed on the construction sector, such as 'Automation in construction', 'Construction Research and Innovation' and 'Engineering, Construction and Architectural Management. Also, searches were conducted in social and or behavioral journals, for example, 'Social and Behavioral Sciences'. They were followed by more specific keywords gained from the found literature. Examples of these are 'knowledge management in projects oriented organization' or 'explicit knowledge'. To filter the vast amount of articles from these searches, more recent articles were given priority. Hereby the underlying articles were also screened to identify the source of ideas and concepts. In addition, articles and books used in prior education and Master courses were taken into account.

To compose a thorough understanding of what has been studied in the field of productivity enhancement and reduction of failure costs by knowledge management within the AEC sector. The first sub-chapter will focus on the concept of knowledge and how knowledge management is studied in the sector. The importance of academic research within this research gap will then be pointed out in sub-chapter 2. Subsequently, this research gap will be further explored, and experiences with the topic will be sought outside the AEC branch. This will also help to identified solutions suggested by scholars to help improve knowledge sharing and knowledge management. Within this also relevant concepts and points of view

related to knowledge and learning are set out. The last sub-chapter will focus on the interaction between the current concepts and points of view for knowledge management and sharing within the AEC industry, resulting in shortcomings of information and knowledge management within decentralized project-based companies in the AEC sector.

2.1 Managing Knowledge

The construction industry is one that is known to be a slow adaptor of new technologies. Whereby the lead time of projects is long, which makes that it is challenging to include the newest technologies. Making changes to the project at a later stadium is considered costly and time consuming compared to changes in the early phases of the project. This makes that it is hard for ongoing projects to include the newest innovations. The AEC sector also has a reputation for being a world of routine and customs that are held on to. Why change something that is already working for years? In contrast to the drawn image of the AEC-sector, there are innovations that enable the sector to work more efficiently and reducing the failure costs and lead time of projects.

To understand how knowledge can be managed it is important to understand what knowledge is and what factors affect the value creation by knowledge management as highlighted by Rezgui et al. (2010). Therefore this sub-chapter will first introduce the concept of knowledge. After that, the most relevant developments in knowledge management within the AEC sector are discussed.

2.1.1 Knowledge

Knowledge can be divided into two types. The first type of knowledge is objective making it easy to be documented and shared. Explicit knowledge is the same for everybody and can be put down into words or numbers. No context is needed to understand the meaning of the documented knowledge. This type of knowledge is called 'explicit knowledge'.

In 1966 Polanyi said, "We can know more than we can tell" (p. 4), with this in mind, Polanyi introduces the concept of 'tacit knowledge', which is the second type of knowledge. Tacit knowledge he says is knowledge based on experiences and captured within the mind of a person. This makes that tacit knowledge is highly personal and thereby hard to share. Polanyi explains how tacit knowledge can be shared with the example of a chess player. He notes: "Chess players enter into a master's spirit by rehearsing the games he played, to discover what he had in mind." (1966, p. 30). Polanyi hereby illustrates that in order to learn why the master made a particular move, the student must understand the context in which the knowledge is used, which cannot be done by merely documenting the steps taken. But the student must recreate the situation and thereby gain the same experiences as the master has by practice.

Understanding that there are two types of knowledge is of importance to understand how knowledge can be transferred and spread within organizations. Nonaka and Takeuchi (1995) worked further on the concept, introduced by Polanyi to understand how knowledge can be created within organizations. They specified four basic patterns for the creation of knowledge within organizations, socialization, externalization, combination, and internalization. In 1998, Nonaka and Konno updated their model with the interaction between these four basic patterns. Hereby they argue that the tacit dimension in itself has two dimensions. Firstly it compasses the technical dimension, which is the "know-how" of an individual, where informal

skills or crafts are situated. The second is the cognitive dimension. This dimension is described by Nonaka and Konno as: “It consists of beliefs, ideals, values, schemata, and mental models which are deeply integrated into us and which we often take for granted. While difficult to articulate, this cognitive dimension of tacit knowledge shapes the way we perceive the world.” (Nonaka & Konno, 1998, p. 42). With these two dimensions of tacit knowledge and the explicit knowledge dimension in mind, they created the SECI model, figure 2, which stands for the four basic patterns Socialization, Externalization, Combination, and Internalization.

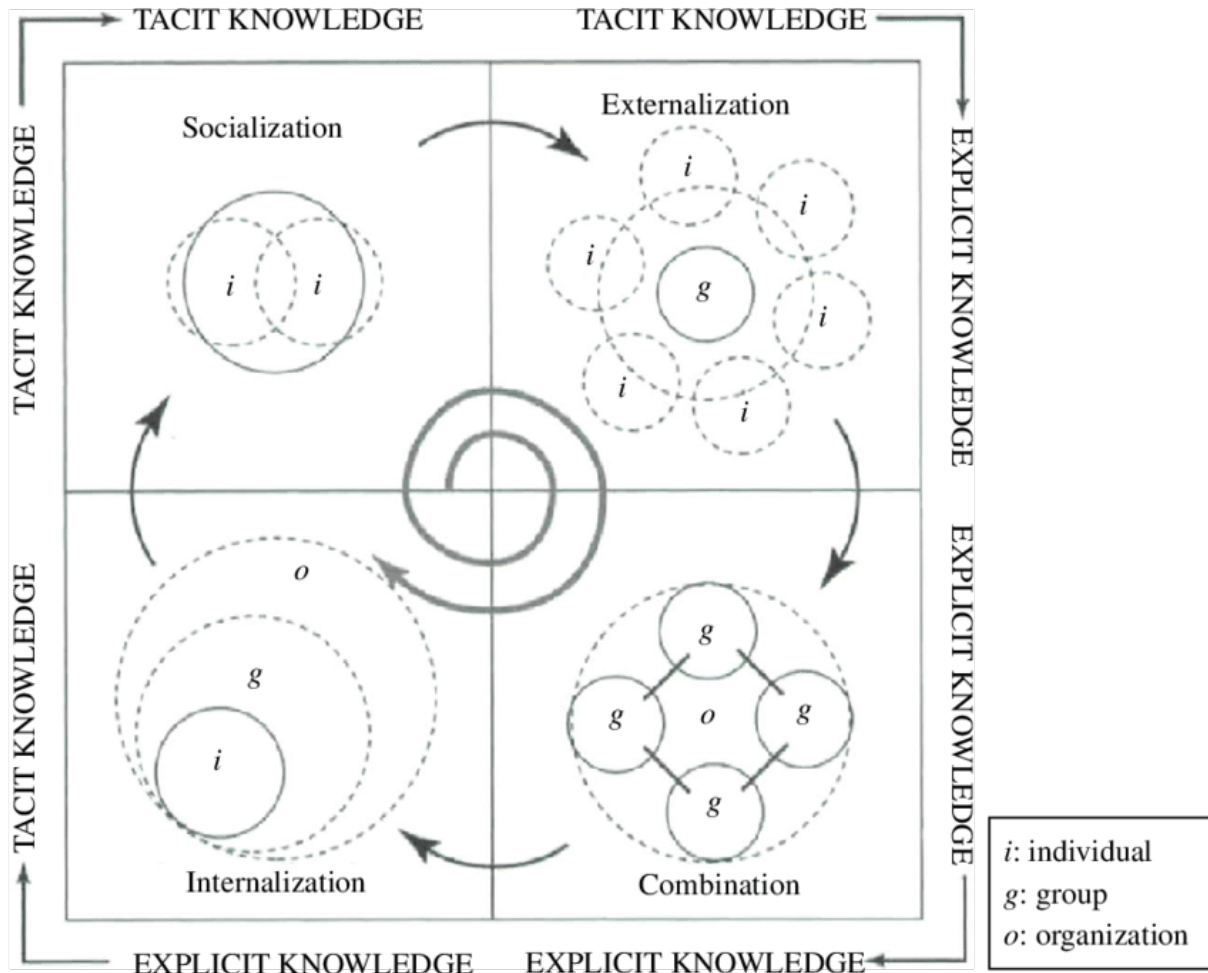


Figure 2: SECI model Spiral Evolution of Knowledge conversion and Self-transcending Process (Nonaka & Konno, 1998, p. 43)

The creating of knowledge is, according to Nonaka and Konno, a spiral process whereby knowledge is created through the interaction between tacit and explicit knowledge. The SECI model consists of four quarters. The first quarter 'Socialization' transfers tacit knowledge directly from one person to another by practicing and training. Hereby the knowledge remains tacit during the transfer. This happens when a master craftsman learns his trade directly to his apprentice by hours of practice. The exact motion, feeling, or understanding that is required cannot be explained but must be learned by hours of training and understanding the situation and factors that are of importance in a particular situation.

The second quarter 'Externalization' encompasses the tacit knowledge becoming explicit knowledge and thereby easily transferable to others. To do this, Nonaka and Konno (1998) speak of two key factors. Articulation of tacit knowledge and translating tacit knowledge into readily understandable forms. In the former, it is good to apply technics to express someone's

tacit knowledge, such as visuals or figurative language. Metaphors or analogies could help. The later consists of making precise knowledge accessible for a more broad public by translating it so that it understandable by a person with fewer experience in that specific field.

The third quarter, wherefrom explicit knowledge new explicit knowledge is created by combining documents and or data is called 'Combination'. Thereby multiple explicit documents are put together, and with the help of a person's tacit knowledge, new explicit knowledge is extracted. This new explicit knowledge can then be diffused so it can be used by others as they can easily understand the new explicit knowledge.

The final quarter encompasses 'Internalization'. This happens when explicit knowledge is used within the organization and becomes part of the knowledge someone possesses without that person realizing it. This knowledge is then part of the tacit knowledge of that person.

According to the SECI model of Nonaka and Konno (1998), knowledge creation within an organization start at the socialization quarter and then spirals through the other quarters. At this point, the spiral starts all over again, and the newly created tacit knowledge will be translated into explicit knowledge once again to be able to share it throughout an organization.

Another point of view of knowledge is that of Ackoff (1989). He developed the knowledge pyramid, which consists of Data, Information, Knowledge, and Wisdom (DIKW), as shown in figure 3.

The first level is data (D), which consists of primary, discrete, objective facts such as who, what, when, where, about something. The second level is information (I) is processed data, which has the goal to make the data more useful. Information can give answers to questions starting with who, what, when, where, and how many. Level three is knowledge (K), which the memorized information by a person due to its usefulness. Knowledge enables us to answer how-to questions and to give instructions. The final and fourth level is wisdom (W). At this level, the knowledge is combined to make based on them educated predictions to unknown situations. With this, the why question can be answered (Ackoff, 1989). Between these four levels, a hierarchy can be identified. Which is put into the following formula by Houston and Harmon (2002):

$$I = \sum(D), K = \sum(I) = \sum\sum(D), \text{ and } W = \sum(K) = \sum\sum(I) = \sum\sum\sum(D)$$

Where Ackoff (1989) and Houston and Harmon (2002) argue that data is the basis of the pyramid, and wisdom is on the top, whereby a higher level of the pyramid also means a higher level of abstraction. Tuomi (2000) argues that the pyramid should not be seen from a bottom-up point of view but from a top-down point of view. Tuomi (2000) says that without knowledge, it is not possible to create information, and without information, no data can be extracted.



Figure 3: DIKW pyramid Ackoff's view, left side, bottom-up (Ackoff, 1989). Tuomi's view, right side, top-bottom (Tuomi, 2000)

A more sophisticated and inclusive model is created by Jennex and Bartczak (2013). This model is called 'The revised knowledge-KM pyramid', figure 3. Herein it is tried to put the knowledge pyramid in a real-world context. The revised knowledge-KM pyramid is a combination of two other pyramids.

The first of these two is 'The revised knowledge pyramid', which argues that there is more information than data and more knowledge than information and so on. What makes that data is no longer the largest segment of the pyramid, but Wisdom is. Between the four elements of the pyramid, a dotted two-sided learning arrow can be seen. This learning arrow is a combination of the insights from Ackoff (1989) and Tuomi (2000). It describes that it is possible to, for example, give meaning to data and evolve it to information but also to create data with the use of information. In addition to this, the reality is shown, with arrows pointing from the reality towards the bottom line of the data segment at which sensors are placed. These sensors translate the reality to data. This can be both human sensors and technological sensors. In the model, also 'Social Networks' are included. They are revering towards the formal and informal interaction between persons to transfer Data, Information, Knowledge, or Wisdom.

The second is 'The knowledge-KM pyramid'. This pyramid focusses on knowledge management. This pyramid has the classic build-up of the DIKW pyramid but does not include the peak of the pyramid, as this implies that there is an ultimate point of knowledge management, which is questionable. Between the segments of the pyramid, a two-sided arrow is seen representing the application of knowledge management processes such as knowledge capture, and application. Also, 'Wisdom' is converted into 'Intelligence' due to the organizational knowledge management perspective. Jennex and Bartczak (2013, p. 23) note that:

“KM targets specific knowledge and wisdom needed by an organization to perform specific tasks. Specific, actionable knowledge and wisdom are defined as intelligence, and it is the goal of KM to provide intelligence to the organization for use in decision making.”

This notion of specific knowledge and wisdom makes that the knowledge-KM pyramid captures not all Data, Information, Knowledge, and Wisdom, but only the section which is of the importance of the organization. Ultimately contribute to organizational learning. This can also be identified in figure 4, in which Jennex (2017), has further expanded the revised knowledge-KM pyramid with the segments of ‘Big Data’ and ‘Internet of Things – and Other Sensors’ which shows the increasing capabilities of automatic and machine moderate capturing of the reality into data. It is also possible to apply the automated analysis of these massive amounts of data.

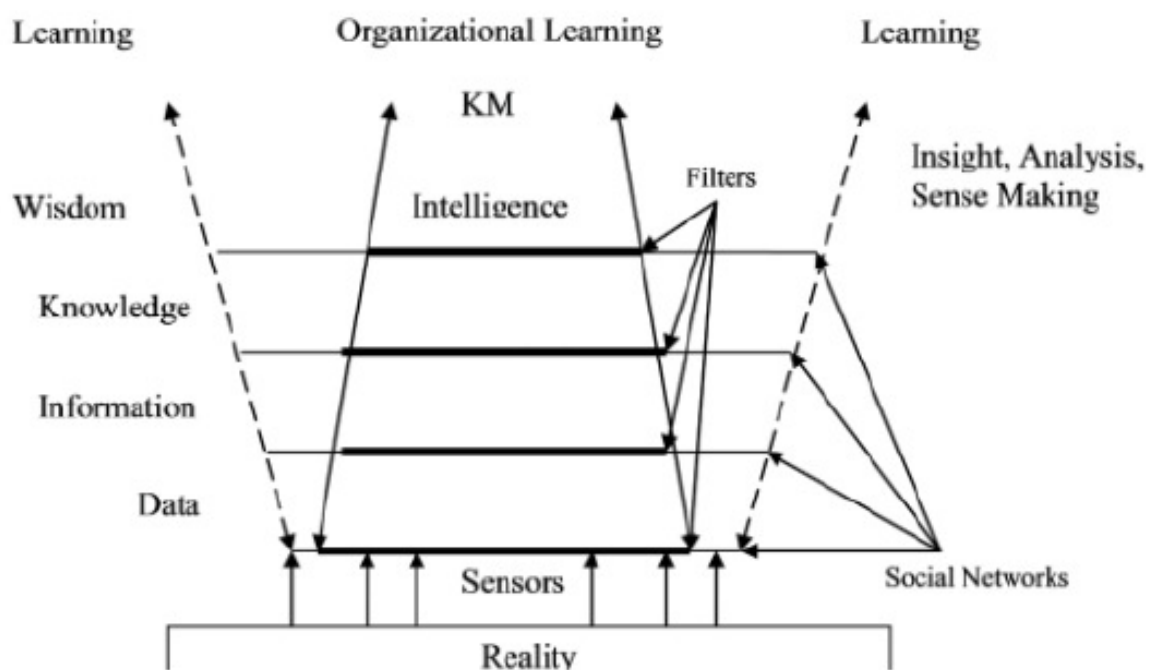


Figure 4: The revised knowledge-KM pyramid (Jennex & Bartczak, A Revised Knowledge Pyramid, 2013, p. 25)

Leonard and Swap (2004) introduce the term deep smarts. In which they include both parts of the wisdom pyramid as of tacit knowledge. They highlight the importance of the context in which an action is made. And mention the difficulties of transferring this to others, since it is hard to make it explicit. This they note is due to it is often not known by the one that has in-depth knowledge of how it precisely makes use of different parts of knowledge gained by experiences. Deep smarts are seen as vital knowledge possessed by employees, which are gained numerous situations where experience is gained. That can be used in a new situation. Once an employee with deep smarts leaves an organization, this is also lost. Therefore the transfer of this knowledge is of importance to the organizational consistency.

“The central paradox in transferring deep smarts is that constantly reinventing the wheel is inefficient, but people learn only by doing.” (Leonard & Swap, 2004)

This quote highlights the problem of deep smarts transfer but also that of tacit knowledge transfer, as noted earlier by Nonaka and Konno (1998). The transfer of knowledge that is hard to describe, write down, or verbalize is time-consuming and transferred by gaining experience by doing. Leonard and Swap (2004) distinguish a number of knowledge transfer techniques, as shown in figure 5. For effective transfer of deep smart, they note that both the receiver and the sender of the knowledge must be actively involved.

Moving Toward Deep Smarts



Figure 5: Deep smarts transfer techniques (Leonard & Swap, 2004)

Where the nature of knowledge that is transferred differs also, the technique used must be adjusted. On the left figure, 5 shows the passive transfer of explicit knowledge transfer by documents, followed by rules of thumb, which helps the receiver to apply knowledge in practice. This is followed by the transfer with the help of storytelling, whereby the nuances can be explained, and the situation can be explained. The fourth technique is that of Socratic questioning in which the receiver asks questions challenging the sender to reflect and formulate the reasoning.

The four transfer techniques on the right side involve the guidance of an expert that possessed the deep smarts. But the receiver is actively involved in creating their own experiences. The case of SAIC is noted, which makes use of the “see one, lead one, teach one” principle. A new consultant learns the job by first watching how a senior consultant is conducting a consulting session. Then the new consultant is taking the lead in the session and received feedback from the senior. When the new consultant is found experienced enough, he teaches other newer consultants the newly gained experiences with the help of the same principle. Guided observation is also described as a powerful technique by Leonard and Swap (2004) in this, the receiver observes the expert by attending meetings and listening and experiences the situation, where after in a debriefing with the expert, the meeting is discussed. Another method of guided observation described is field trips, whereby the vision is broadened, and what is taken for granted is reassessed by stepping out of the familiar.

The guided problem solving technique allows the novice to tackle the problem with the counsel of the expert. The novice will learn by doing, observing, copying the expert, and feedback, whereby the novice creates deep smarts of itself. The latest technique discussed is guided experimentation. Experiments are often considered costly and time-consuming; however, starting-up full-scale production without knowing the market or the full functionalities of the product could be even far costlier. Hereby experiments help to learn how a product functions or how the market reacts, and the experiments can help to answer if a hypothesis is correct. An expert could give advice on the type and the number of experiments.

2.1.2 Generations of knowledge management in AEC-sector

Rezgui et al. (2010) studied, based on academic and corporate literature, if there is an evolution of knowledge management within the AEC-sector. They found three generations of knowledge management that can be distinguished in the industry:

- 1st generation** **Knowledge Sharing;**
- 2nd generation** **Knowledge Conceptualisation & Nurturing;**
- 3rd generation** **Knowledge Value Creation.**

These three generations are highly dependent on the capabilities of Information Technologies (IT) systems. Figure 6 shows the distinguishing between the three-generation made by Rezgou et al. (2010). The first generation of knowledge management exists before the introduction of IT systems. The focus of knowledge management was project information management. In which it was necessary to archive all the documents created in a project so that it could be retrieved when needed. All these documents were stored hardcopy in the companies archive, whereby the importance was on finding the right document as easy as possible when needed. This kind of knowledge sharing still exists. However, the document is often no longer archived hard-copy but digital, making it easier to search, adjust, and share the project documentation.

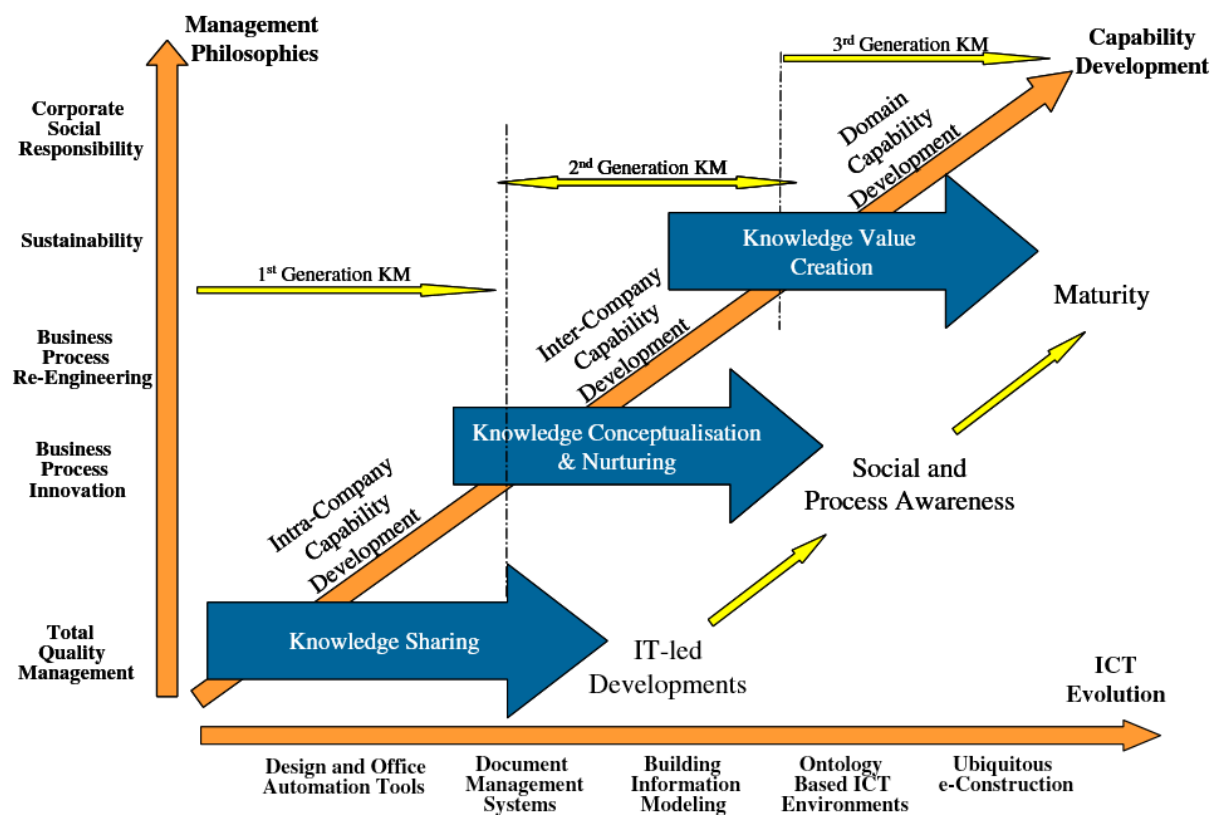


Figure 6: Proposed generations of knowledge management within the AEC-sector by Rezgui et al., (2010, p. 223)

Where the foci of the first generation were on the sharing of knowledge, in the form of information, the second and current generation focuses on the interaction between documents and giving meaning to them. The evolution of the IT systems allowed for the designs to interact and the changes being made to be documented. The different designers have to interact to create a design that suits all the workforces interacting in the total design. It is crucial that all the specialist look at the complete design from their own point of view but make concessions to be able to create the best-finished product. The importance of this generation is highly mentioned in the academic literature, whereby one of the best-known examples of innovative knowledge sharing within the AEC-sector is Building Information Modeling (BIM). This enables the project partners to share and incorporate the various designs to ensure the coherence of the different specialized construction drawings. Among others, Georgiadou (2019) and Olawumi and Chan (2019), studied the benefits BIM could have on the AEC projects and clearly point towards the potential improvement of efficiency. This improved efficiency is gained from better sharing of the project information and developed knowledge within the project. This type of knowledge sharing within companies can be seen as a combination where explicit knowledge from several departments or companies is combined to create new knowledge. Where BIM is beneficial for the exchange of explicit knowledge, the users identify the lack of capabilities to share tacit knowledge within BIM. The use of BIM and other technical solutions to combine explicit knowledge are widespread and a lively topic of study in the world of academics. These studies most often focus on how to exploit the technical solutions that are present or how these solutions could be improved.

The concept of Communities of Practice (CoP) was then introduced to the AEC-sector to enable users to share the tacit dimension of their knowledge. Wenger, McDermott, and Snyder (2002) describe how CoP functions and the benefits of sharing knowledge about a particular topic with peers without them being involved in the project. Wenger et al. state the following:

“Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.” (2002, p. 4)

From this, it can be drawn that a CoP is continuously developing. It can also be noted that knowledge and expertise are gained by the interaction of persons who are interested in the same subjects. The interplay of the participants makes the CoP transferring and creating knowledge. In the light of Polanyi (1966), the distinction is made between tacit and explicit knowledge, and the importance of tacit knowledge for organizations is highlighted by Wenger et al., (2002). And the need for interaction and informal learning processes is named as a means to transfer this kind of knowledge. The strength of a CoP, according to them, lies in the combination of social knowledge and personal knowledge. Nowadays, it is perceived as impossible for a person to know and understand everything. Wenger et al. (2002, p. 10) say:

“We need others to complement and develop our own expertise.”

This underpins that for improvement and learning, it is essential to interact with others to expand one's own knowledge. All the attendees of a CoP contribute to the collective knowledge that is captured in it. The individuals might then be able to extract knowledge

based on their own perceptions and expertise of the subject. By this, an individual can make use of the expertise of others without having their exact experiences, which has the ability to strengthen organizations' knowledge diffusion. Looking at the current AEC-sector, it is almost impossible for a project developer to have the most up-to-date knowledge about the upcoming rules and regulations, for example, nitrogen measures, CO² neutral construction, and the 'Omgevingswet'.

A CoP can have many forms, it can be a group of friends with a shared interest, but it could also be a global internet forum on a specific topic. Within an organization, a CoP is often structured as a focus group with a specialist of specific expertise. Wenger, McDermott, and Snyder (2002) have, from their experiences, named seven principles to design a CoP with the intention of it to be alive and active. These seven principles will be further discussed.

1. Design for evolution.

A community is organic and evolving during its existence. The start of a CoP often comes forth out of personal networks. Individuals already personally connected and agitated by the overlap in interests. These personal networks must be able to connect and disconnect within the community continually. This demands that the focus when developing a CoP must be on the ability of the community to develop and grow. A CoP must be able to flow with the input from new participants allowing for new points of interest whereby the design of the CoP enhances this organic evolution.

2. Open a dialogue between inside and outside perspectives.

The CoP must be designed with an inside perspective, as this insider view makes it possible to identify the nature of the community. This insider knows how the personal networks flow and who must be connected to the community — being able to identify the issues that are faced. This demands for a senior employee, with an extensive network, to be involved in the creation of a CoP. This employee knows what knowledge is of value to share within the community and what is not. However, an outsiders' view is seen to be important in highlighting and render the opportunities a CoP could bring to the community members and an organization. The interaction between outsiders' experiences with the potential benefits of a CoP and the insiders' view of the core issues present in the community, allows the insider to see the potential of the CoP. And could, with the help of the outsider, steer towards new capabilities within the CoP.

3. Invite different levels of participation.

When designing a CoP, it is crucial to understand that there are different levels of involvement of the participants. Usually, three levels can be distinguished.

The first and smallest group consists of the core. These persons were actively participating in the discussions, knowledge sharing, and activities organized by the community. This group also steers the communities to relevant topics and support the community coordinator. This community coordinator organizes activities and connects the participants.

The second group is the active group. This group is less actively involved then the core group; however, they are present on a regular basis and once in a while share knowledge and join a conversation or discussion.

The third and largest group of the CoP are the members on the sideline and are seldom heard. However, they can follow the input of other community members. Wenger et al. (2002) note that this would, in a general meeting, be discouraged, but in the CoP, it is an essential dimension. Since these members are able to follow what is happening in the CoP, they can pick from it what is attractive to them. This could be used and spread outside the view of the CoP. From the sideline, these members are able to learn and develop their own personal knowledge.

In addition to these three levels of participation, there is also a group that surrounds the CoP and is interested in the topics. From this surrounding group, an expert on a specific subject could be invited for debates, gatherings, or learning sessions.

A participant can evolve within the CoP and is not bound to one of the groups. Once the CoP is evolving, topics can be more or less interesting for participants. It is potentially making them shift from the active group to the core group or from the active group to the sidelined group. Hereby it is of importance that not only the core group feels like a member but also the participants from the sideline to be welcome to watch and pick what is interesting for them. This often implies a CoP to incorporate a public section for debates but also more private places for discussion.

4. Develop both public and private community spaces.

“The heart of a community is the web of relationships among community members, and much of the day-to-day occurs in one-on-one exchanges. Thus, a common mistake in community design is to focus too much on public events.” (Wenger, McDermott, & Snyder, 2002, p. 58)

As the citation above, Wenger et al. (2002) highlights not only the public events where the participants are invited to come together and interact are essential. Since most of the interaction between participants will occur outside the view of the CoP and the CoP thereby plays a linking role between participants. For the community coordinator, it is of importance to notice these informal private connections and to be able to make use of them and pinpoint what is on the mind of the community members. And thereby be able to address relevant topics during the events. The informal interaction between members could strengthen their willingness to take part in the public events, at which new connections could be made. This makes it essential for events to allow the participants to interact between sessions informally.

5. Focus on value.

For members to participate in a CoP, it is crucial that it creates value in some sort. Especially at the start of a CoP, it can be challenging to target how value is created and if it is created. However, keeping in mind that members must be able to extract value from the CoP and to discuss how this value is created and realized raises awareness. This could be used by other members in order to extract the value of their own from the community. This value can be knowing whom to call, extending your private network, but also applying new techniques or insights in projects.

6. Combine familiarity and excitement.

For a community to be alive, it is necessary, according to Wenger et al. (2002), to have a mix of familiar and exciting events. This allows the community members, on the one hand, to have

a stable, comfortable feeling and become acquainted with other members. This makes that the participants have the freedom to express themselves without barriers or getting dragged along in practical execution. The natural part of the CoP could be the forum on which questions can be asked or the monthly drinks.

On the other hand, exciting events could stimulate participants to think outside the box. And shatter light on new innovations, techniques, and emerging changes. These exciting events have the ability to draw the participants to the core of the community and spark more active participation. These events can consist of field excursions abroad or days focussing on be twisted topics in the field.

7. Create a rhythm for the community.

Wenger et al. (2002) compare a community with a heart and the blood flow. If there are too many events, so the heart is beating too fast, the participants will feel as if too much energy is demanded to participate. If there are too few events, the connectivity with the community is weak, resulting in little activity on the CoP. The community coordinator must, for each phase of the CoP, find what works. At the start, when building the community, more activities to enhance personal interaction can be needed. When the CoP is established, and most of the participants know each other, the demand for face-to-face or more significant events could become less frequent. And shifts towards online discussions or events focussed on sub-topics.

However, Wenger et al. (2002) give handles that must be given thought when developing and cultivate a CoP. It is clear that every CoP is unique; this makes it essential to have a person who is in the middle of the community. Who knows how to engage members to the community, is able to understand what is on top of the mind of its participants, and is able to sense what events are needed to draw people into the community and participate.

Knowledge value creation, the third generation mentioned by Rezgui et al. (2010), is their vision of the future of knowledge management. In this future, the focus is on creating value with the application of knowledge management. To support this claim, Rezgui et al. (2010) point towards many developments in the knowledge management literature which discuss the relationship between value creation and knowledge management. The argument of Davenport and Prusak (1998) is followed, which says that value creation is realized and facilitated by four actions:

- 1. Creating knowledge repositories;**
- 2. Improving knowledge access;**
- 3. Enhancing cultural support for knowledge use;**
- 4. Managing knowledge as an asset.**

Davenport and Prusak (1998) mention that the size of a company and its organization, clustered or shattered, is of importance to the ability to know who possesses what knowledge. A decentralized organization shattered over multiple offices complicates the sharing ability of employees. And is a barrier for knowing who works on what. Davenport and Prusak state:

“The mere existence of knowledge somewhere in the organization is of little benefit; it becomes a valuable corporate asset only if it is accessible, and its value increases with the level of accessibility.” (1998, p. 14).

This highlights the importance of knowledge management within an organization. Especially knowledge management of tacit knowledge, which is difficult to store in an archive or library and therefore challenging to search for.

This third-generation build forth on the concept of CoP, whereby the focus in the second generation was on the sharing of tacit knowledge, now it is on creating human networks. These human networks and sense of community motivates the participants to share and maintain the knowledge within the CoP. Rezgui et al. (2010) name this generation ‘knowledge value creation’. Whereby value is created from the help of the knowledge repositories, the innovation literature describes a likewise concept ‘Open Innovation’. Whereby ideas and product innovations from participants outside the company are used, these participants are, most often, not financially compensated for their contribution. But participate for their own benefits, well-known examples of this are social media networks, such as Facebook and LinkedIn, but also the Linux computer software (Chesbrough & Appleyard, 2007; Chesbrough, 2003). Without participants, these networks have no value, and the more input is given by the participants, the more value is created and can be extracted by the organizations and participants. Figure 7 shows ‘The Open Innovation Model’ whereby the red striped funnel shows the boundary of the firm. During the start of the research period of innovation, the funnel is narrowed down as more information is created about the direction of the projects. At this open funnel, not only ideas for research projects from employees within the company are studied, but also ideas from outsiders are taken into account. When a ‘Research Project’ is considered viable, and for the company, it will be put forward into development. However, in the Open Innovation model, it is also possible that innovation is considered viable but not suitable within the company. In this case, the idea can be brought on to the market. This can mean it will be sold to others who are active in the field in which the innovation is contributing. But it could also mean that it is made public for everybody who is interested. Another option is that the company sees the potential for the innovation and becomes active in a new market with a new company. Within this model, innovations developed outside the organization could also be picked up by the company. This could be done in several ways, such as buying the rights or make use of it when it is freely available on the market. Allowing the corporation to incorporate innovations from outside the organization could benefit the company since it has not to develop the wheel over and over again.

It is important to create a culture of trust, to make these ecosystems function. Rezgui et al. (2010) highlight the importance of social capital to create this trust making the shift from individualism towards collectivism and co-operation. Being able to incorporate new ideas and innovations from outside the company could increase the innovativeness of the organization and make the products better connected to the target group.

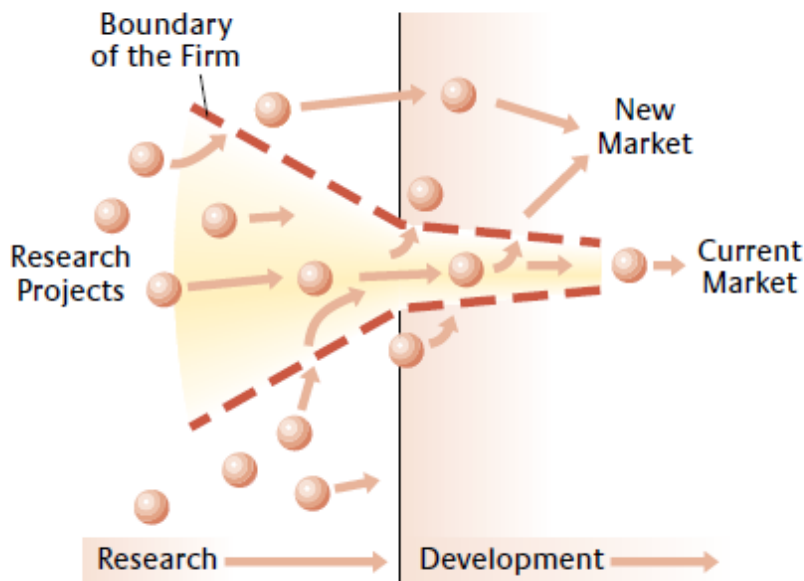


Figure 7: Open innovation model (Chesbrough, 2003, p. 37)

2.2 Implications for better value creation through knowledge sharing

Where Rezgou et al. (2010) highlight knowledge value creation as the third generation, which has not fully kick-off yet. Other authors highlight more or less the same principle as CoP but use words to describe the phenomena to exchange explicit and tacit knowledge often with the help of IT. Examples of this are 'Portals', 'Knowledge Repositories', 'Internal knowledge bank', 'Dynamic Knowledge Map' and 'Knowledge Hub' (Dave & Koskela, 2009; Fernandes, Raja, & Austin, 2005; Lee, Kim, & Koh, 2009; Woo, Clayton, Johnson, Flores, & Ellis, 2004; Maqsood, 2006). All of these authors emphasize the tacit side of knowledge and the importance of sharing the expertise of experts along with explicit knowledge. Some such as the Dynamic Knowledge Map focus on offering a guide to who could possess specific tacit knowledge. Others, such as portals and knowledge hubs, emphasize collaboration through chat abilities directly in the tool. All of these IT tools require the tacit knowledge to be translated into words in order to be transferred. Von Krogh et al. (2000) note that, however, IT is helpful. It is limited in enabling groups to share the emotions and experiences related to tacit knowledge. Whereas it is hard to translate tacit knowledge into words.

Khuzaimah and Hassan (2012) note the importance of uncovering the tacit knowledge within the construction project. And highlight the risk of losing knowledge at the end of a project or project phase and when a team member abandons the team. They follow the notions of Nonaka and Takeuchi (1995) that social interaction is needed to extract this knowledge. They see CoP as the most efficient method for this and underline the abilities for discussion, openness, trust, and different points of view that are able to grow with the help of CoPs. This shows once again that the use of IT in knowledge management is ever-growing. Yang et al. (2012) studied the causal relations of the impact IT has on project success through knowledge management with the help of structural equation modeling. They found that especially for project teams that have bad relationships or are of considerable size, the implication of IT in the use of knowledge management has a positive effect on the project benefits. Hereby they underpin the importance of managers to share knowledge. It emphasizes the need to make

use of the potential of IT; however, the research does not clearly point to what IT systems should be incorporated.

Oliva (2014) studied the barriers that are perceived for knowledge management within large Brazilian companies. By surveys spread among a sample of the 1,100 largest Brazilian companies. He found that the three of the five most significant barriers, which are: lack of interest from employees, inefficient communication, lack of a culture of sharing, lack of competence of staff, and lack of incentive, could be assigned to knowledge dissemination. Knowledge dissemination is also highlighted as the most significant barrier to organizational knowledge management before the evaluation of knowledge. Leal et al. (2017) studied based on the literature the inhibitors and facilitators for knowledge sharing within the construction sector. Herein they state:

“Given that CFs [construction firms] work on projects with different characteristics and normally many at the same time, it is important to realize that such project are managed differently. These management characteristics must be shared so that other teams can use this shared knowledge in particular conditions of similar projects, in this way it is possible to use resources (time, people and materials) more efficiently.” (2017, p. 1000).

This comes right to the basis of the importance of knowledge management within the AEC-sector and the potential benefits that could be created by building forth on the experiences of others from within an organization. They highlight the importance of creating a culture wherein sharing knowledge and experience is the standard and supported by role models, such as senior managers. However, sharing knowledge takes time, and this makes that a lack of time obstructs employees from sharing knowledge. Making them reserved on whom to share their knowledge with, taking in mind that they want, now or later, favor back. These findings are also supported by Saini et al. (2018), and elaborated by the mentioning that sharing tacit knowledge must be trained, by both the receiver as the sender, in order to enable a smooth transfer of knowledge.

Rode (2016) studied the extrinsic and intrinsic motivations to share knowledge through an Enterprise Social Media Platform (ESMP). This study was conducted with the help of a web-based questionnaire spread among the employees of a German high-tech firm. In which, as confirmed by preliminary interviews, work is highly knowledge-intensive, and knowledge sharing and collaboration is frequent. Within this company, an ESMP was introduced, to ease knowledge sharing through the globally distributed company locations. Rode (2016) hypothesizes two extrinsic motivational factors, expected professional reputation, and expected mutual benefits from sharing knowledge on the ESMP. Both of these hypotheses were found to be drivers for the sharing of knowledge. In addition, it is found that it is more likely for an employee to share knowledge on the ESMP when he or she thinks to be self-efficacy in doing so. Cavaliere, Lobardi and Giustiniano (2015) studied the enablers of knowledge sharing at 23 highly knowledge incentive manufacturing located in the Tuscany region in Italy. This study was conducted with the help of a web-based survey. In contrary to Cavaliere et al. (2015), who found no statistical evidence that the enjoyment of sharing knowledge is a driver to do so, Rode (2016) found that this is a positive influence on the donation and collecting knowledge. Rode (2016) and Calvaliere et al. (2015) both found that perceived self-efficacy in sharing knowledge and highlight the importance hereby of

employees to enjoy their work. And to be confident of their knowledge and skills, making them more likely to share knowledge. Therefore empowerment programs are suggested to help establish this confidence with employees. Also, the role of managers in promoting sharing and collecting knowledge is mentioned. This could be done by actively participating in it, by both asking colleagues for advice as giving advice directly to them when asked. In this light, the importance of personal contact is mentioned for sharing knowledge, and in contrast to that, ICT tools are not necessarily seen as enablers of sharing. This is endorsed by Israilidis, Siachou, Cooke, and Lock (2015) noting:

“Specifically, despite being time-constrained, employees highlighted the role of face-to-face interaction (as opposed to technology) in reducing ignorance, emphasizing that informal ad hoc face-to-face communication can produce effective organizational outcomes.” (2015, p. 1115)

Israilidis et al. (2015) focus on the ignorance of employees considering knowledge. Semi-structured interviews were conducted with employees of a large aerospace and defense industry to identify how ignorance impacts knowledge sharing. From these interviews, three types of ignorance in relation to knowledge sharing were classified:

1. Ignorance of subject matter experts;
2. Ignorance of Knowledge Management Systems;
3. Ignorance of the corporate knowledge, the combined knowledge of all employees, itself.

These findings highlight the importance of understanding the need to incorporate the presence of ignorance about knowledge sharing within the organization when implementing knowledge management strategies and tools.

Razmerita, Kirchner and Nielsen (2016) identify the same drivers towards knowledge sharing. In addition, they identify and specifically mention a lack of time and trust as barriers to sharing knowledge. The importance of management support in the sharing of knowledge is highlighted, and the management is also addressed as the layer that should take the initiative to build mutual trust within the organization and allow employees to take time for knowledge sharing. Panahi et al. (2012) studied how tacit knowledge is transferred through social media networks and developed a conceptual framework to understand the concept of tacit knowledge sharing better. Figure 8 shows that there are five essential requirements to enable to flow of tacit knowledge within a social, digital network, including the before mentioned social interactions and trust. It also creates the opportunity to locate and search for knowledge by networking and finding experts.

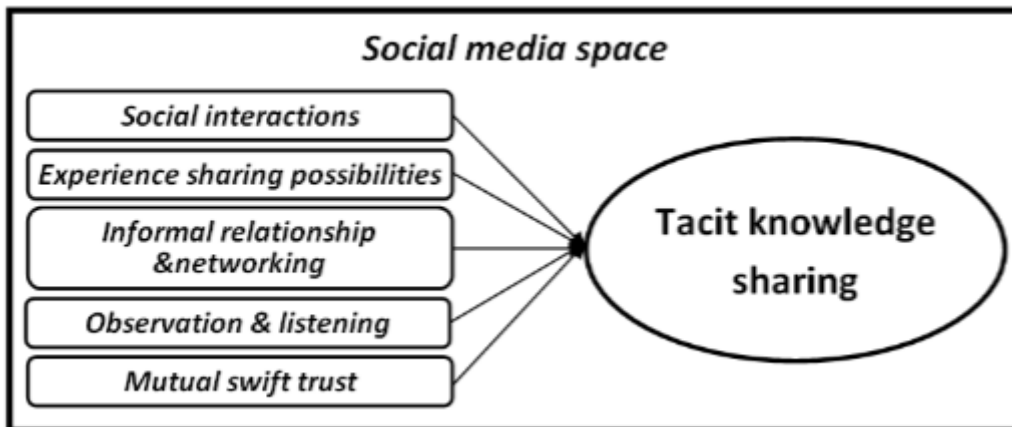


Figure 8: Conceptual model of tacit knowledge sharing in social media (Panahi, Jason, & Partridge, 2012, p. 1100)

Like Panahi et al. (2012), Schmidt et al. (2016) studied the transfer of knowledge with the help of an online platform. For this, they used the 'Carbon Connected' platform, which enables organizations within a cluster to cooperate and share knowledge. In the first concept, tacit knowledge was included. However, the final model is excluded due to the insights that are hard to transfer tacit knowledge without the ability for face-to-face communication. The final conceptual model, however, included required steps to enable the sharing of knowledge through a network, such as registration, connection, and building up trust. Explicitly mentioning the difficulty of creating trust-based on digital interaction.

2.3 Challenges of knowledge management in project development companies

The aim of the literature study was to answer both sub-question one, 'How is knowledge collected and transferred between individuals?' and two, 'How is knowledge management incorporated within construction companies?'. To be able to answer both questions first, the context and meaning of knowledge are discussed. Follow by more in-depth theoretical methods on transferring knowledge to answer sub-question one. And literature study into the use of knowledge management within the AEC-sector to answer sub-question two.

2.3.1 How is knowledge collected and transferred between individuals?

As noted by Polanyi (1966), knowledge consists of two dimensions. The explicit dimension consists of knowledge that can be put on paper and is easy to document. And the tacit dimension, which consists of hard to document knowledge and is in contrast to explicit knowledge challenging to transfer. Nonaka and Konno (1998) and Leonard and Swap (2004) note that for the transfer of deep smarts or tacit knowledge, active learning or practicing is required. This means the one collecting knowledge is guided by the sender in practice to experience the actions within the context. This is time demanding for both parties, and the transfer consists of one-on-one, or in small groups depending on the situation. This type of knowledge transfer can be taken into consideration when a novice in the field of project development is introduced within the organization. None the less this can only be executed by interpersonal contact. Hereby it is important to understand the different levels of the knowledge pyramid as proposed by Ackoff (1989) and later revised by Tuomi (2000). It is thereby essential to incorporate the factors which influence the adoption of knowledge, as is proposed by Jennex and Bartczak (2013) in the revised knowledge-KM pyramid.

When considering the collection and transfer of knowledge first, it is essential to distinguish the tacit and explicit dimension of knowledge. In addition to this, it is crucial to realize where on the knowledge pyramid this knowledge can be placed. When it is easy to put on paper or articulate, the transfer can be done with the help of documents. This can take shape in the form of an online database, e-mail conversations, or digital designs and integration of these graphic designs with the help of BIM. If this is not the case, more time consuming personal interaction is required to transfer the tacit knowledge with the help of guidance from the sender of the knowledge.

In addition to the interpersonal transfer of tacit knowledge, with the rise of IT tools, the transfer of tacit knowledge through digital networks is studied. It is seen that persons with the same interest try to interact through these platforms to share experiences. In a corporate context, there are multiple names for these kinds of platforms, such as Community of Practices and Enterprise Social Media Platforms. Both of these platforms focus on informal interaction between employees, encouraging the sharing of thoughts and experiences. The main barrier hereby identified by multiple scholars is the factor of trust between the users. And the difficulty in establishing this on purely digital platforms. Both Wenger et al. (2002), focussed on CoP, and Panahi et al. (2012) and Schmidt et al. (2016), focused on social media platforms, point towards the personal interaction between persons to establish trust and increase the willingness to share knowledge.

2.3.2 How is knowledge management incorporated within the AEC-industry?

It is crucial to have a strategy on how to enable a constant flow of knowledge within an organization. This encompasses not only tacit knowledge but also explicit knowledge. To create value from the experiences gained by the different project developers it is essential to execute the four actions mentioned by Davenport and Prusak (1998). It is starting with the establishment of a knowledge repository, which encompasses the data from past, current, and potential future development projects. These repositories could consist of raw project data. From the repository, it can be extracted who should have what kind of experiences. Continual improvements towards the accessibility of the knowledge repository should be implemented. To increase the ease and ability of employees to extract and insert knowledge from and into the repositories. And enable them to use this in practice; this should also be supported by senior management. It is needed to act towards it as an asset to make the most out of the available knowledge. Whereby the aim is to extract knowledge from employees and enable others within the organization to use it, it is of importance to allow both knowledge from within the organization as knowledge from outside the organization to be adopted and be a source of inspiration.

As described in the previous sub-chapters, Rezgui et al. (2010) sketch a clear development of knowledge management in the field of AEC. From the static transfer of documents, first in hard-copy and later digital, through simultaneously working on documents and designs as an iterative product. Where the effects of changes from one, can immediately be seen and processed by others. Towards, ultimately capturing the thoughts and context that were present when creating the explicit documents enabling the externalization of tacit knowledge. And enabling value creation through the exchange of knowledge. It can be noted that these first two generations of knowledge management are mainly focused on the creation and accessibility of explicit knowledge within project teams. The third and future generation is

envisioned to incorporate the tacit side of knowledge. It is improving the access for users to find the needed knowledge and experiences within the organization.

Housing development demands a broad level of skills for the realization of a project. The project developer functions hereby as the middleman connecting the expertise from numerous companies and individuals into a complete project plan and design. To do this efficiently, the project developer builds on experiences and prior accumulated trusted collaborations. The experiences and connections a project developer possesses are of great value to the company and are arguably even the most valuable asset from a development company. It is essential to share them within the organization to utilize these assets to their maximum. However, these experiences are captured within the mind of the project developer and linked to the context of the situation at which they were gained. This makes them tacit and, as described earlier, very hard to communicate and share. As in other industries, in the construction industry, it is essential to possess a competitive advantage to be able to win tenders and execute projects according to the project plan. Therefore it is essential to have the right advisors to guide the project and deliver the needed specialized input. Being able to not only make use of the project developers' own experience with advisors could help in the decision making and ultimately exclude incapable advisors reducing the failure costs and timeline of a development project. This is in line with the vision of Rezgui et al. (2010) of the third generation of knowledge management within the AEC-sector named Knowledge Value Creation. This again highlights the importance of focusing on both sides of the knowledge spectrum. And enable the archiving of explicit knowledge and the interpersonal interaction between employees for the transfer of tacit knowledge. A database with previous projects and project data could help guide in the search for potential linking pins within a network. However, extracting the data from these projects could be a time-consuming task, especially when knowledge seekers are inexperienced with the use of the database. Or the knowledge that is sought is hard to express, or even not clear for the seeker. Working in project development demands a set of practical skills that can be learned by doing. In addition to this, the developer needs to know where to find the right information and input for the project. Experienced developers have a sophisticated network of advisors and colleagues to fall back on when specialist knowledge is needed. However, a new project developer has not been able to establish this network and, therefore, must rely on the presence of direct colleagues to guide him and develop a network of advisors. It is unexpected, even after years, that a network will ever become complete, and all the knowledge needed for projects can be extracted from it or re-used. In addition to this, employees tend to leave move from employers once in a while, whereby the tacit knowledge from the employee is lost for the organization.

2.3.3 Knowledge gap

Where the needs and advantages of advanced knowledge management within the AEC-sector are well studied and emphasized. These studies focus on the integration of new building methods and information within the project team or within and between organizations. The emphasis of knowledge management studies in AEC has until the last few years clearly been on the exchange of explicit knowledge and the interaction of these documents and designs. As shown with examples of BIM, the AEC-sector possesses a robust system to exchange documents and designs. In which the state of the art visualization possibilities enable the transfer of, and interaction between, this knowledge. However, these IT tools seem to be limited in the incorporation of the tacit knowledge gained by the developers of the designs

and documentation. Limiting the diffusion of knowledge within project teams. Only the last few years, the tacit side of knowledge was integrated, and the first case studies whereby the social effects of knowledge sharing and capturing experiences from others became present in the AEC-sector. None the less these studies were all focussed on the design or construction process and enabled the participants of project teams to link specific communication through IT tools to topics of the project. The distinctive natural differences between tacit and explicit knowledge highlight the importance of research in how these two types of knowledge can be exchanged. Incorporating the difficulties of exchanging tacit knowledge through IT. In other sectors, such as innovation sciences, there are innumerable examples of how the sharing of tacit knowledge has a positive influence on the innovativeness of an organization.

To the best of my knowledge, there is no literature where the experience sharing of project developers through a project-oriented organization was studied. This makes that the 'how - to' question of sharing knowledge gained by the experiences of working with consultants and advisors remains unanswered, and the wheel is invented over and over again. This exposes the void which this study tries to fill. The goal of this study is to identify and validate how the experiences of project developers can be spread throughout the organization. And what tools are able to facilitate project development companies in this. Whereby the main focus is not on the explicit side of knowledge, raw project data, but on the tacit side of the experiences gained by the project developer. This makes it in addition to creating knowledge repositories and improving access to these, essential to create a sharing community whereby there is room to exchange thoughts, experiences, and to think out of the box.

3 Methodology

To be able to answer the main question, it is vital to have a suitable methodology to gain the needed information. As with the help of the literature study, the first two sub-questions are answered. This gained knowledge is incorporated in the next section of the study, in which sub-questions 3 and 4 will be answered. A case company is selected to do this. At the case company, the current methods for finding and selecting advisors and the sharing of experiences between project developers are studied.

The case company is a more than 100-year-old construction firm with a focus on developing and realizing houses. The company is responsible for a significant part of the yearly housing production within The Netherlands. To be able to do this, the company works with a decentralized organizational structure. Resulting in 5 regions, all of which consist of three to five local offices, resulting in a total of 24 offices in The Netherlands. The regions function as separate business units in which every local office has its own construction department, and the project development department is organized at regional levels. The project developers work on several local offices within their region. Making them easily accessible to customers and familiar with the market they operate in. This also enables them to work in close contact with the construction department at the local offices. When developing a project, many knowledge and experience from previous projects are re-used. Due to the unique nature of a development project, a developer is not able to re-use all the knowledge captured and gained from previous experiences. Therefore additional, often very project-specific, knowledge must be hired for studies and designs. Some of the most well-known advisors that are hired for this are the architect and urban planner.

The following sub-chapter entails the steps that are undertaken to construct a conceptual platform. Thereafter the individual steps are elaborated. Starting with the information that is required to establish the current work methods within a decentralized development company, to share knowledge, experience, and know-how about advisors is collected — followed by how this information is processed.

3.1 Design science methodology

With the insights from the literature study on knowledge and the collection and transfer of it and the literature of knowledge management within the AEC-industry, it is as suggested there is a research gap and lack of adaption of experience sharing, about advisors, within the project development field. Since there is a field problem identified, this study makes use of the design science research cycle, figure 9, as is suggested by van Aken and Romme (2009), to enhance the collecting and sharing of experiences. Aken and Romme (2009) note that the choice of field problem to be addressed as the starting point from the design science research cycle.

Once the field problem is identified, the literature related to the problem is reviewed in step two. To establish a sufficient foundation on the subject and pinpoint the research gap. Then interviews are conducted with project developers from the case company to determine the current methods used for the finding and selection of advisors. And the methods used for documentation and exchange of the experiences gained with advisors among project developers, how these interviews are conducted is further explained in chapter 3.2 Interview.

The third step of research synthesis consists of the analysis of the insights from the interviews and the literature study, how the analysis is conducted discussed in detail in chapter 3.3. With the insights from the interviews, the current situation within the field can be established, and from the literature, insights to improve this situation are drawn. The combination of these two will highlight the potential room for improvement within the field.

These potential improvements are the start of the design propositions, which is the fourth step of the cycle. In this step, potential solutions for the identified problem will be created. And the potential pros and cons are discussed, leading to a conceptual framework that could solve the field problem.

In the last step, the proposed conceptual framework will be validated to expose the potential, flaws, and limitations. This will be done with the use of expert panels, in which project developers from the case company will take a seat. The new insights obtained from these panel meetings will be taken into consideration, and improvements will be implemented in the framework.

Denyer, Tranfield and van Aken (2008) describe the concept of CIMO-logic which could partly be applied in this approach. From the literature study and the interviews the context, field problem and desired outcome are extracted. To achieve this desired outcome an intervention is designed based on the specific context. Whereby the intervention triggers a mechanism that results in the desired outcome. In this study, the mechanisms that are triggered can only be presumed but not be tested, as the proposed interventions are not implemented.

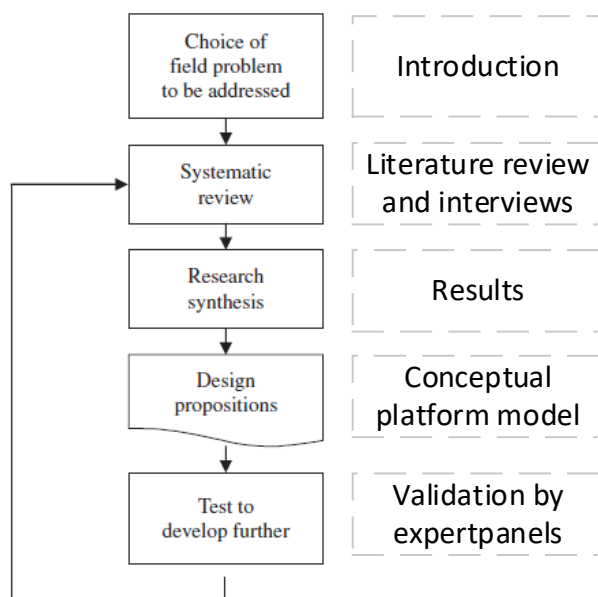


Figure 9: The design science research cycle (van Aken & Romme, 2009, p. 10) with corresponding practical action

3.2 Interviews

The experiences project developers have with advisors is the center of attention in this study. These experiences are often tacit knowledge, as is mentioned before. It is often hard to describe why cooperation was pleasant or unpleasant and how the cooperation precisely functioned. With this in mind, the choice has been made to conduct a semi-structured

interview. This kind of interview makes it possible to move along with the conversation and elaborate on exciting experiences and the expertise of the interviewee. This makes it compared to structured interviews better suitable to extract knowledge and personal experiences from the interviewees (Lune & Berg, 2017; Taylor, Bogdan, & DeVault, 2016). The goal of the interviews is to understand how project developers work and how they exchange experiences with each other. The interviewees were selected in cooperation with the management of the case company. Whereby the aim was to have a representative overview of the company. This includes an even spread among the regions and both beginning project developers as seasoned experts in the field. An overview of the functions, regions, and interview dates is given in Table 3. The interviews were conducted in Dutch. The duration varied between one and one and a half hours. The location was chosen by the interviewees to make it as convenient as possible for them.

Table 3: Interviewees functions and regions

Function	Region	Interview date
Head of real estate and ground transactions	Head office	30-10-2019
Director Project development	East/North	13-11-2019
Senior Project developer	Middle	20-11-2019
Junior Project developer	West	18-12-2019

For the semi-structured interviews, an interview guide is drafted. The interview guide is to help structure the interview. The interview guide is drafted based on the 'Interview Guide Template' of Peter Ibarra (Taylor, Bogdan, & DeVault, 2016). The interview guide that is used during the interviews is shown in Appendix I.

First, the context of the interview is sketched, and the interviewee is asked to introduce his- or herself. This is followed by the core of the interview in which a number of topics are addressed. The goal of the interviews is to gain insights into finding and selecting advisors and the sharing of knowledge about this from the perspective of the individual project developers. Therefore it is crucial to let them talk and explain about experiences they have and specify the actions they undertook during these specific situations and how they handled the situation to achieve the knowledge that was needed. The topics focus on the information and knowledge sharing within the regional offices and the umbrella organization. It is focussed on establishing what methods the project developers use for the collecting and sharing of information and knowledge. And if they experience any barriers, limitations, or drivers towards sharing information, knowledge, and experiences. Within this core of the interview, there is no pre-set order of questions. This allows the interview to flow with the knowledge and topics of interest from the interviewee. Thereby it is not necessary to address all questions that are posted on the interview guide. In the end, the interviewees are challenged to envision the future of knowledge sharing between project developers both within the regions as organization-wide.

3.3 Analyses

In order to analyze the results, the interviews were recorded. These records are transcribed to allow the identification of themes. For this purpose, a coding scheme is developed. After the initial thematic ordering of the transcript, the ordering is evaluated and linked to the

literature. It was chosen to merge the initially identified themes Evaluation, Documentation, and Information/database, due to the high overlap and connection with the explicit side of knowledge. All of these themes consisted, for at least a part, of the externalization of knowledge and the ability to document it. The other mere consists of the themes Knowledge, Sharing, Cooperation, and Barriere into Knowledge sharing. This is also due to the overlap and the difficulty to speak of them without involving the other. The barriers identified in the interviews were all related to the sharing of knowledge, and in that same context, the sharing consists of experiences and thereby the tacit side of knowledge and not data or information on a documented method. Resulting in a reduction of from eight unique themes to three unique themes, advisor search and selection, evaluation and documentation, and knowledge sharing. Summaries of the interviews can be found in Appendix II.

With the help of these themes and typologies, the current methods for advisor search and selection and the corresponding knowledge sharing and collecting between project developers can be established (Taylor, Bogdan, & DeVault, 2016). In addition to this, the tools currently used by project developers to store and exchange knowledge and experiences are analyzed based on the insights from the literature study. This allows for the answering of the third and fourth sub-question:

Sub-question 3: How do real estate developers of housing projects find and select advisors?

Sub-question 4: How are experiences documented and exchanged within the decentralized organization?

3.4 Conceptual platform design method

With the knowledge of the methods used by the project developers to find and select advisors, and of the documentation and exchange of experiences between project developers in relation to the literature study and answers of the first two sub-questions:

Sub-question 1: How is knowledge collected and transferred between individuals?

Sub-question 2: How is knowledge management incorporated within the AEC-industry?

Three improvements for knowledge documentation and sharing are suggested to incorporate in decentralized project development organizations. These improvements will be validated by expert meetings, whereby the experts are future users. During these meetings with future users, the goal is to discuss the proposed improvements in order to get insights into limitations and flaws that are expected. The suggestions from these experts will be taken into account, and a revised version of the framework will be developed. For the expert, it is chosen to visit the two regions that are not covered during the interviews to establish the current situation. Therefore project developers from the northern and southern regions are picked based on availability. This improved framework will be the basis of the conclusion of this study and the answer to the question:

How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?

4 Results

Interviews were conducted, transcribed, and analyzed with the help of coding to understand the current situation in relation to knowledge sharing among the project developers. Summaries of the interviews based on the coding can be found in Appendix II. The results of these interviews are discussed in this chapter. Firstly focussing on the methods used in the search and selection of advisors, which was identified as one of the codes. Answering sub-question 3: *How do real estate developers of housing projects find and select advisors?* Followed by the current methods for documentation and evaluation used in the organization. And finishing with the knowledge sharing within the organization. Allow answering sub-question 4: *How are experiences documented and exchanged within the decentralized organization?*

4.1 Advisor search and selection

Two of the four interviewees were active on the search and selection of advisors on a more or less daily basis. The other two interviewees had a more passive role in this and operated more as advisors and linking pins in the process. However, they were no longer actively involved with the selection of advisors they were up-to-date on the methods of searching and selecting.

The search and selection of advisors within the case company is, according to all interviewees, mainly based on previous relationships with the advisors. All being like-minded on the importance of a personal and organizational network of trusted advisors. The desire to have a partner who is known by someone in the organization is highly appreciated. And as mentioned by interviewee 3, this is unfortunate for new parties, since this forms a barrier to start working with them. New network parties are often introduced by project developers who have previous experiences at other companies and are passed on from senior to junior developers.

When project developers work on a project, they discuss with whom they are going to work with their direct colleagues at the office. When there is no suitable advisor, the question is usually transferred to the regional director or close colleagues at one of the other regional offices, according to interviewee 2, 3, and 4. This mainly happens by phone, mail, or face-to-face since project developers often work at multiple regional offices during the week. Interviewee 4 notes that it could happen that a search for an advisor is conducted on Google when no suitable advisor can be found in the personal or organizational network, which will lead to a number of quotations, of which one will be chosen in regards to price, time, and gut-feeling.

The gut-feeling of the project developers is something that is very important and highlighted by all. Especially when the advisor is sought for more creative advice, according to interviewee 3. There must be a 'click' with the advisor, which creates for a proper working and cooperation climate. Interviewee 1 states:

"It's no rocket science. There are no heavy models behind it. It's just with whom have you worked before in a good way."

Interviewee 1 highlights that there are no set requirements for advisors on a national level. And that the decentralized organizations are all free to choose their own advisors. And that

there are two topics on which the advice goes through a central point, namely tax and legal advice. Interviewee 2 highlights that it could happen that an advisor is chosen based on local or regional business interests. In these terms, the advisor gains benefit from one side of the organization and, on the other side, help in the creation and utilization of new business opportunities.

It is found by interviewees 1, 2, and 3 that the architect should be judged differently than other advisors where the aesthetics play an essential role. The references of the architect could also be of importance in the winning of the tender.

4.1.1 How do real estate developers of housing projects find and select advisors?

The results on the search and selection procedures used in the case company allow to answer sub-question 3:

“How do real estate developers of housing projects find and select advisors?”

The interviewees are quite homogenous about the methods for searching and selecting advisors. The process of searching and selecting advisors goes reasonably informal and is highly dependent on previous experiences from the project developers themselves or colleagues. In order to find the right advisor, there is a high level of consultation between project developers on a regional scale. The consultation for more complicated or specialistic advisors with whom little experience is present within the region could be forwarded by the directors to gain the advantage of the national organization, getting together the right persons. The selection goes on a high level on gut-feeling, and the ‘click’ between project developer and advisor is essential.

Tax advice goes through a central person in the organization who, with his experiences, can give advice and, in more advanced or specific cases, can include the tax advisors of the organization. Legal advice is covered by a legal team in which all regions have a representative. Who gives advice and could advise on the involvement of external parties when necessary.

In exclusion of the legal and tax advisors, the search for advisors is performed in a simple and via-via method based on experiences. And the selection is mainly based on the gut-feelings of the project developers, as noted ‘it’s no rocket science’. Especially when time is a factor, and the advice is required fast.

4.2 Experience evaluation, documentation, and exchange

4.2.1 Evaluation and documentation

The documentation of development projects is until recently not managed on a national scale. The developers were responsible for their own project documentation. Recently the Financial Project Dossier (FPD) has been introduced. The goal of the FPD is to get better insights into what is happening in the organization and function as a database, out of which later on, information can be extracted. This system was introduced due to the lack of information on the national level and the inability to quickly extract information, as interviewee 1 notes:

“At this moment we do not know with which architect we have worked on what project in The Netherlands.” (Slot, 2019, p. 6)

The FPD tooling allows the project developers to work from an on national level managed Excel sheet. Documenting all data inserted by the project developers. The FPD is mainly focussed on the financial side of the development project. And gradually expanded to incorporate organizational data from the project such as architect and constructor. Recently the FPD is up-dated with the addition of GPS coordinates to allow linking to GoogleMaps. The system behind the FPD also allows project developers to see each other's FPD. The FPD functions as the central source of data that is used in the organization. As interviewee 1 reference to the data in the FPD as:

“For me, there is only one truth.”

And in line with this, only wanting to ask data from the developers once. Whereby the data is collected as close to the source as possible and also making them accountable for the quality of the data, this interviewee 1 calls the ‘ask only once’ principle.

It is noted by interviewee 4 that the search in other FPDs is used for reference purposes, whereby it is essential that all project developers are well-known with the functionalities of the system.

In addition to the FPD system, the Customer Relation Management (CRM) system is mentioned in which contact details of advisors are stored. The CRM system does not incorporate a link between the advisors and the projects they were involved with. These links are mainly unwritten and known by the involved developers. Apart from this, the financial system offers the ability to search on invoices, allowing developers to search for advisors and link them to projects based on where the invoices are linked to.

During the search and selection of advisors, there is no documentation on why an advisor is selected or is not selected. Also, it is not documented which parties were involved in the pre-selection.

When projects are in the acquisition phase and very uncertain, it is often not documented and available for others. These projects are mainly documented by the individual project developer, and only a sketch calculation is made. This has, in previous occasions, lead to an unfortunate situation in which multiple locations contacted the same party, as noted by interviewee 2:

“... it’s clumsy, and it happens more often, you are not informed of actions from others. So maybe this is a field we can improve on.” (Dousma, 2019, p. 8)

Both interviewees 2 and 3 note that there is a formal evaluation form, which should be conducted when the building permits are requested. Noting that these forms are rarely used due to the lack of follow-up on them and when used not documented and able to quickly retrieve. Evaluation of performance is more often based on direct communication between project developers, according to interviewee 4. Whereby it is common to discuss the outstanding or poorly performing advisors, these evaluations are highly informal and not documented and communicated only in the direct working environment of the project developer. And in new selection procedures, these advisors are not recommended.

Aiming at visuals allowing the users to screen if a project suits their demands quickly. By which the user can find who can be contacted for more information about the project, interviewee 3 notes:

“It would be handy if there would be a kind of reference pages of projects. Which could easily be browsed” (Reeze, 2019, p. 14)

4.2.2 Knowledge sharing

As noted above, all interviewees underline that a lot of knowledge and experiences with advisors are shared between the project developers. Mostly this is done by phone, e-mail or face-to-face at the offices. And a lot of consultation, both vertically as horizontally, takes place during the selection process in which knowledge is shared.

Within the organization, the experiences with advisors are transferred from the senior developers towards the junior developers. During this process, the junior developer is introduced to the regularly used advisors of the project development office. Making the offices' relations with the advisors part of the junior's own experiences. In addition to this, experiences with advisors are transferred by recommendation. When project developers work on a new project, they discuss this with their direct colleagues at the office. When they do not know a suitable advisor, the question is usually transferred to the regional director or close colleagues at one of the other regional offices. This mainly happens by phone, mail, or face-to-face since project developers often work at multiple regional offices during the week.

The project developers from all interviewed region stated they have annual project developers meetings. With a frequency ranging from once a month to once in six weeks. Which was, according to them, sufficient to know who was working on what project within the region. The set-up of these meetings differs from the region. In at least one region, the set-up of the meetings differs each time. They are switching between learning sessions, location visits, and discussion. Another interviewee highlighted that all the developers gave a short update of their current projects allowing all the project developers to share their struggles and achievements. The group-size at these meetings from around 20 developers made that the pitches were short and very shallow. However, it made it possible to link developers, whereby they had the opportunity to discuss details outside the meeting. Also, the regional directors of the project development meet-up every two months and have, recently, made a what's app group in order to share insights and news informally. Also, a national project developer event is organized in order to meet and share experiences with project developers from other regions. Next to the corporate meetings, it is mentioned that there are also other organizations organizing events for project developers to meet, which often are informal and useful ways to get familiar with each other.

However, the collaboration and sharing of information on a regional scale are perceived as sound. On a national scale, there is a lot of ignorance within the organization on what has been developed and what experiences are present in the other regions. It is mentioned that every region has some 'specials' by which they win tenders. And that the sharing of experiences with these specials and tenders could be improved. It is suggested that for better knowledge sharing the link of 'the winning strategy' with visual could be helpful.

To allow for a better knowledge sharing within the organization, the expansion of the FPD is mentioned by the interviewee. If the FPD is extended and encompasses more data, the addition of filter could allow the searcher to find information that is relevant more easy according to interviewee 1. Interviewee 1 has a distinct vision of how the data collection and sharing should be conducted and thereby follows his 'only ask once' principle. Actively discourage the addition of a new platform or form in the organization. And when scoring of advisors is required to keep it simple like thumb up, neutral or down. Interviewee 4 underlines this and notes that the future of the FPD could allow for a pre-search, after which a more target request for information could be made.

At this point, the FPD is not used much for the search of reference projects according to interviewees 3 and 4. This is mainly happening via-via. Reference projects of other regions are found helpful for inspiration and also already helped to get to the pre-selection process in some projects. The decentralized structure of the organization makes it harder to know who is working on what project. And even within the region, not working at the same office is disadvantageous, and both were highlighting the benefits of knowing colleagues in person. Thereby interviewee 3 noted that:

"The most important is to know who possesses what knowledge on a national scale."

4.2.3 How are experiences documented and exchanged within the decentralized organization?

With the results on evaluation, documentation, and knowledge sharing from the interviews, sub-question 4 could be answered:

"How are experiences documented and exchanged within the decentralized organization?"

As noted in the interviews, there is a strong dependence on previous relations with advisors in the case company. These experiences are not documented. However, the project developers build up a network of trusted advisors. This network is informal and is mainly based on personal preferences. There is a financial administration in which it is possible to search which advisors are used for what projects. In that, however, there is no documentation of why this advisor was selected and how the quality of the advice was.

Formally from the quality management system, the project developers are required to evaluate the involved parties. This must be one at the end of the build team when the permits are requested. With this evaluation, all parties involved are discussed in the final build team meeting. The outcome of these evaluations is mainly documented in the minutes and then stored with the project documents, whereby it is not possible to share these within the organization. Also, this evaluation is rarely conducted. The primary method for evaluation goes by recommendation and informal discussions between project developers. Whereby 'good' or 'oke' advisors are not so often discussed. However, the 'outstanding' or 'disappointing' advisors are generally discussed in the office.

Next to the discussion and consultation, which happens at the offices, the region has regular project developer meetings, in which the project is discussed, and additional courses and information are given. These meetings could also involve location visits or other activities.

These meetings allow the project developers on a regional level to get familiar with each other. On a national level, there is an annual project developers meeting allowing all project developers to meet-up, gain new insights, and learn from each other in an informal setting.

Recently the FPD was introduced. This system automatically documents the project data on a server that can be accessed by all project developers — allowing them to see data from other developers on a national scale. The data required to insert in the FPD is gradually extended from a central point in the organization. This is done in deliberation with the regional project development directors. The starting point was a financial document in which the required calculation for a project could be conducted. Most recently, the addition of GPS coordinates is required to link the project to the project site on a map, thereby enabling searchers to see in what context and environment the project is developed.

The possibility for project developers to look into another project has already been used for the search for reference projects. From which the interests are attracted after which contact by phone was made. Most of the reference projects are found by recommendation via colleagues. Whereby it is highlighted that these are often based on casual relations. And a more structured approach could lead to more use of knowledge and references that are present within the organization. As the inability to see who is working on what in the organization now limits the ease of contacting the right person.

5 Project developers platform

To be able to improve the knowledge sharing capabilities within decentralized project development organizations it is vital to understand the different dimensions of 'The revised knowledge-KM pyramid' by Jennex et al., (2013) in relation to the methods of knowledge transfer by Nonaka and Konno (1998) and Leonard and Swap (2004). These methods for data, information, and knowledge sharing must be linked to the needs and current methods used within the project development organizations. The previous chapter studied the current methods used to select and search for advisors. Also, the methods used to collect, store, and exchange knowledge in a decentralized project development organization were identified. This with the previously suggested three generations of knowledge management in the AEC-sector by Rezgui et al., (2010), the results support that there is room for improvement in the capturing and exchange of knowledge between project developers. Relating back to the main question:

“How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?”

The knowledge sharing between project developers is highly informal and happens by socialization. In addition to this data is transferred with the help of a database, which allows project developers to access data from each other. It is vital to extend the amount of data that is documented and to externalize knowledge, transferring it from tacit to explicit. To improve and increase the amount of data exchange within the project development organization. The next sub-chapters discuss three actions which enable decentralized project development organization to improve the knowledge sharing capabilities and minimize the ignorance of corporate knowledge, whereby the main goal is to allow project developers to find each other and know organization-wide who is working on what. In this it is important to realize that to perform their jobs the project developers use wisdom which is based on their experiences.

5.1 Continuously expanding data reservoir

The current database of developments project arises from the Financial Project Dossier. Which originally is a calculation tool for development projects in which the entire project can be calculated and financially documented. The case company is actively working on the collection and accessibility of data with this tool. Where the FPD focusses on the financial side of the development projects, the future challenge lies with the incorporation of the know-how of the project developers and the accessibility to the data. When experiences, co-workers, and collaborations are not documented, it is impossible to share them other than by direct contact between persons. Therefore to be able to improve the ability to exchange the experiences must be put on paper. Where it is challenging to express in an objective manner how cooperation was, the focus must be on allowing others to find who has been working with what parties during projects. This makes that partners, advisors, and co-operators must be named and documented in the databases. In order for other developers to see who was involved with the projects. At this point, the FPD is being expanded, and more fields, such as project picture and architect name, are mandatory to note when filling the FPD document.

The case company manages this expansion of the data reservoir from the head-office in cooperation with the regional directors. Allowing a step-by-step approach, whereby it is noted

to slowly progress and not obligate the project developers to insert a large amount of data in one moment. This is a well-chosen method for the roll-out of the expansion and an essential step for the increasing knowledge sharing between the developers. A worth mentioning addition to the FPD is the link to a mapping tool in which the projects are located on the map giving an overview of the location and the surroundings of the project, something that is of great importance in the project development branch.

The data reservoir should be extended, and more non-financial data should be added. Having a pool that contains all the information on development projects allows developers and other personnel from the organization can extract the data they demand. This will then transform into information for the user. It is impossible to determine all the information that is possible to extract or demanded by the developers in advance. Therefore the database should be designed to be able to not only consists of the predetermined data but also allows the project developers to insert specific or currently ignorant data. This allows the database to grow with future needs and developments within the project development industry. Making both the insertion of data as the extraction as easy as possible it could drive project developers to store more data. And also easily search for data from other developers or collect data from previous projects, which is now embedded in staples of papers and hard to extract other than remember from the experiences.

It is essential to document all the advisors involved in the project by name and expertise to improve the finding and selecting of advisors. This allows others to know who was involved in what projects and generates a reservoir of advisors with whom experiences are gained and available within the organization.

5.2 References platform

The reference platform is suggested to improve the accessibility of the collected project data and allow project developers to find projects that are of their interest based on visuals and factsheets. This reference platform should be paired to the FPD, utilizing the '*only ask one-time*' principle, which is operational in the case company and enables the translation from data to information. The aim of this platform is to inspire project developers with past and current projects from within the organization. The usability of the platform should be smooth and pleasurable. The platform functions as a tool to translate the data into information for the project developers. The platform will take advantage of a swiping mechanism in which, in one view, a project developer can determine if the project is of interest or not. The application of filters allows the searcher to focus on topics of interest, such as outstanding energy performance, construction method, or urban typology. With the help of an annotated wireframe cut out in figures 10, 11, 13, and 14, the main characteristics of each page are highlighted. For an overview of the linking pages, Appendix III contains a file in which the links are activated, and the user can see what options are available.

Once a project developer chooses to make use of the reference platform, it is needed to identify himself based on corporate credentials. Within these preferences can be selected based on the searching criteria. These criteria can be adjusted at any moment since the project developers are free to search as often and varied as they like.

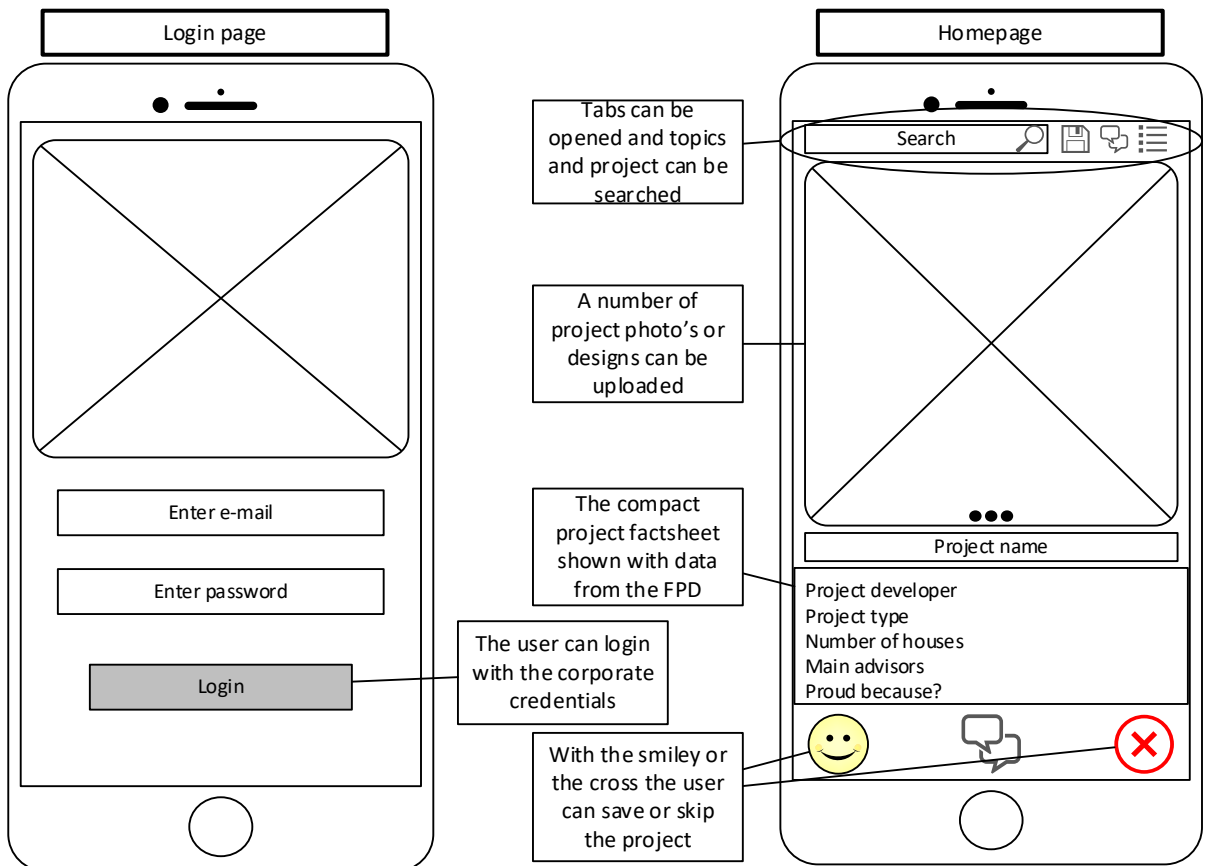


Figure 10: Wireframe cut-out Login page and Homepage

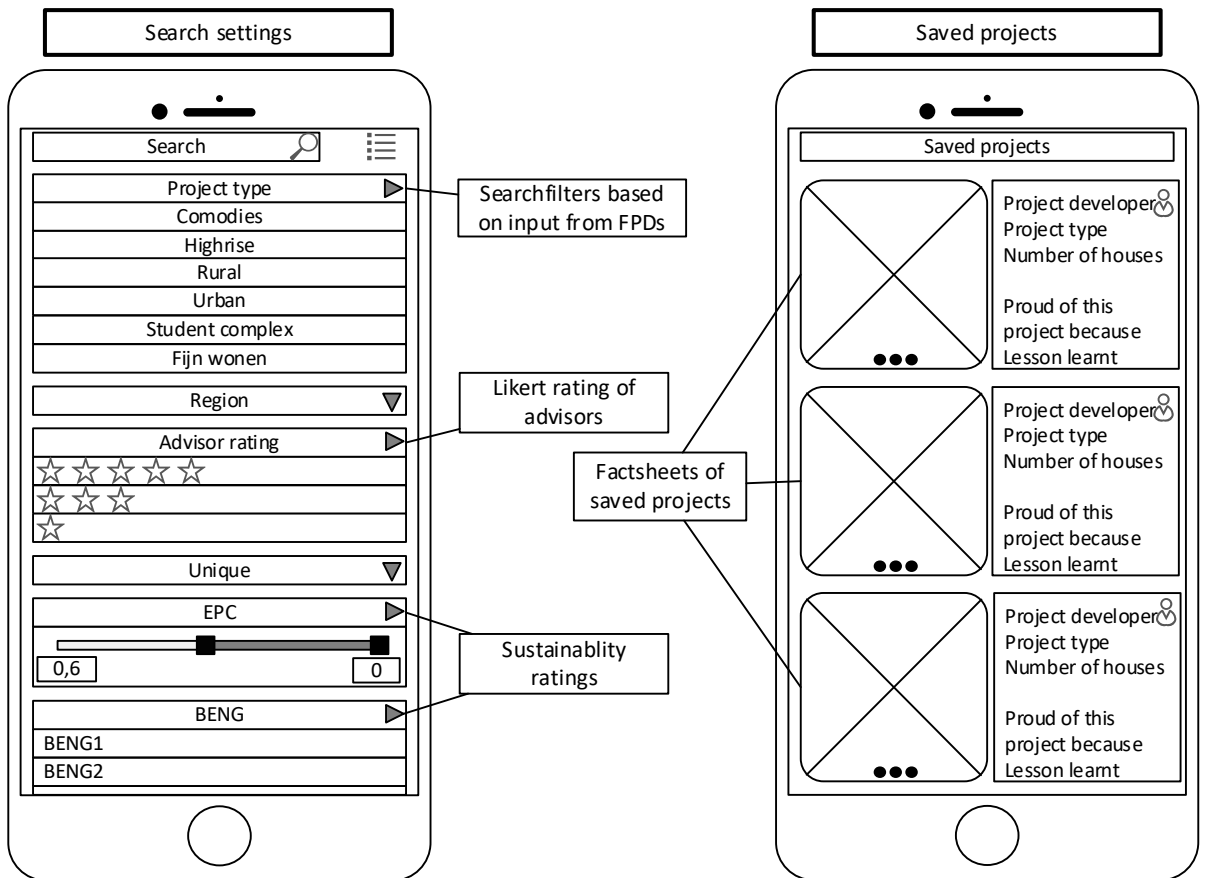


Figure 11: Wireframe cut-out Search settings and Saved projects

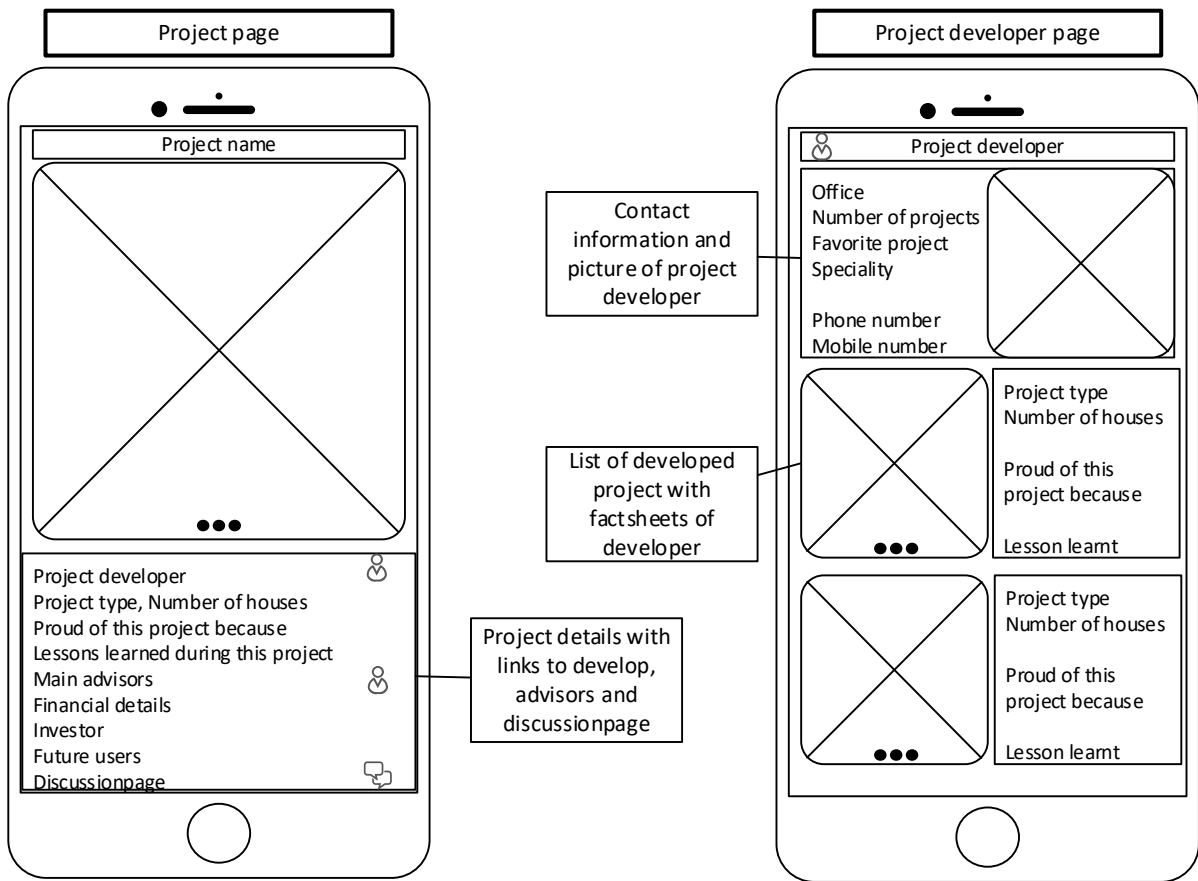


Figure 12: Wireframe cut-out Project page and Project developer page

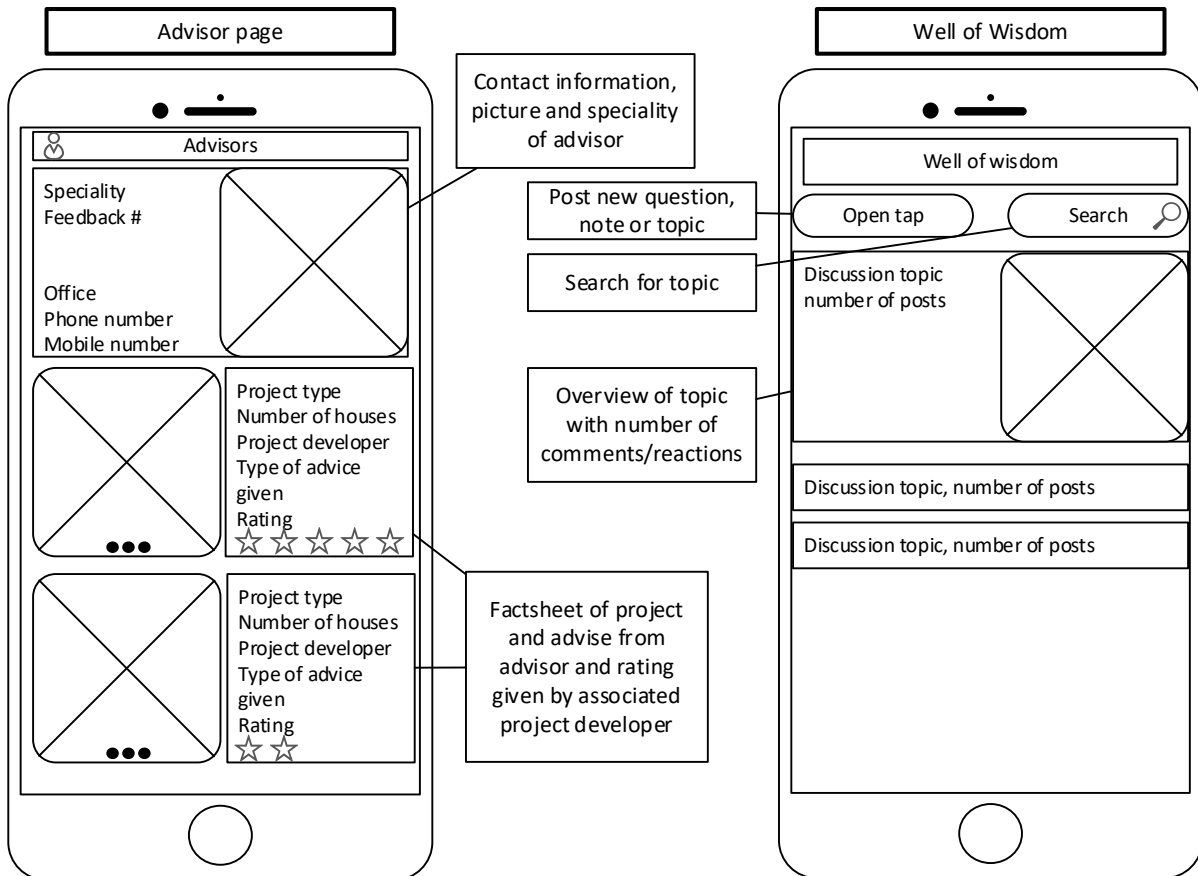


Figure 13: Wireframe cut-out Advisor page and Well of Wisdom

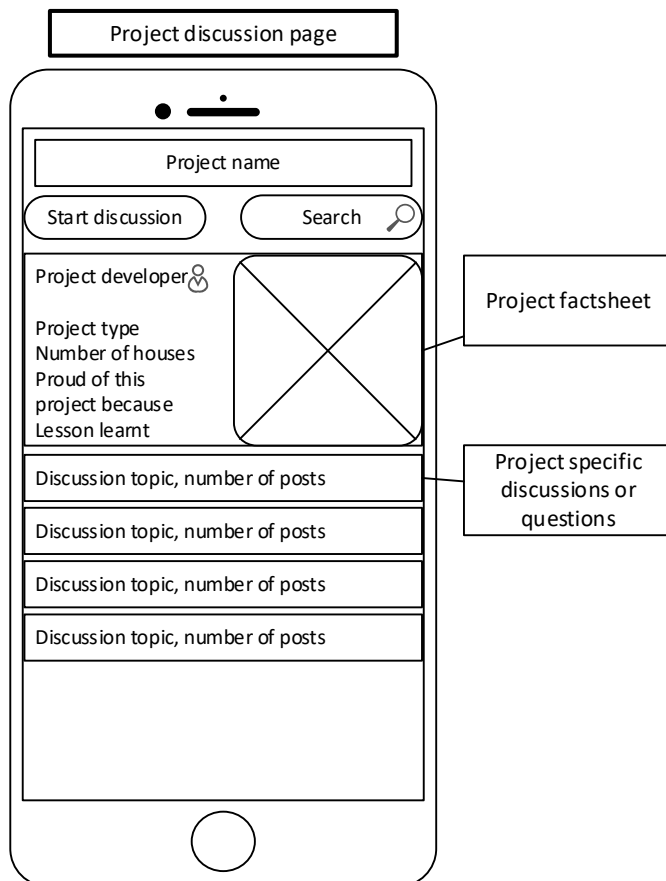


Figure 14: Wireframe cut-out Project discussion page

An essential and meaningful filter within the reference platform will be ‘the experimental filter’. Projects with the experimental label will have, in one way or another, a progressive idea incorporated. This could help spread the knowledge of new innovations through the organization. Whereby lessons could be learned from other completed projects, but also progressive ideas that have not been realized for some reason. Hereby the focus is on display the idea and not on expressing all the details. If a user is interested in the details and how it works or why it has not been realized, the contact button will guide him/her towards the project owner. This highlights the main feature of the platform, allowing project developers to easily contact each other and by that exchange knowledge in person. The platform allows for the sharing of knowledge of both the data and information level. As plain data is inserted and can be filtered as demanded by the user. In addition to this it allows the sharing of knowledge outside the platform. By connecting project developers in search of experienced co-workers with project developers who have demonstrable experiences.

5.3 Events and meet-ups

In order to manage knowledge as an asset and benefit from the knowledge in possession of the project developers within the company, it is essential for others to be able to utilize this knowledge and not just know that the project developer knows it, as noted earlier by Davenport and Prusak (1998). This implies that the specific knowledge of the project developer should be externalized, enabling others to be shared in the organization and internalized by others. It is often very difficult to make tacit knowledge explicit. In the case of good or bad experiences with cooperation, it is difficult or even impossible to generate an objective review. Trying to capture this tacit knowledge from the project developers will most

probably result in a meaningless pile of data from which, due to the highly personal characteristic, hardly anything could be extracted and learned. However, being acquainted with one another could limit the barrier to ask for help or guidance or comment on others from a different point of view. A safe and open-minded environment is desirable, in which different ideas are free to be discussed, and a person is not judged on his or her ideas.

To stimulate the personal interaction between the project developers beyond the regional level. Where on a regional level, the project developers interact with one another on a more daily basis and have regional organized events. On a national level, these events are minimal. These national events, meet-ups, and activities could be organized to improve the community feeling within the national organization. These inter-personal events could vary in nature; the focus of some events could be educational; others could focus on social interaction and fun activities or be on a specific expertise or construction method or new technology. With this also, the size of the events could vary from an expert panel with 10 people to a company-wide event or a ski trip with everybody who is willing to participate.

The importance of these events is to get to know project developers from other offices and regions, ultimately allowing for a more effortless flow of knowledge through the company. This flow is created with the help of the inter-personal connections and band created between persons. This creates trust and limits the barriers of reaching out to each other. In addition to this, on a personal level, it could also improve the willingness among each other to help one another out and so to say put them on top of the pile. Being familiar with colleagues from other regions could, in combination with the reference platform and the database, allow for a smoother exchange of knowledge. Whereby the database allows for the storage and accessibility of the data, this data can, with the knowledge of the project developers, be filtered in order to provide useful information for the circumstances. On the other hand, the reference platform could assist in the search for the correct data from the database and give the seeker of information a more visual perspective of the project.

The project developers should be stimulated to visit these events by senior management and realize that, even though no production work will be done during the events or activities, the gained contacts and improved familiarity with their colleagues could in the future pave the way for problems during development projects. Also, it is always possible to inspire someone during these events or to be inspired and become less ignorant about the knowledge available within the organization. It is essential to follow the interests of the participants and not be afraid to differ from the standard topics and events. To stimulate the feeling of the community in which personal contact is crucial for engagement. The participants should be free to initiate topics for new events and activities, and also a shift among the persons organizing the events is encouraged.

6 Validation and improvements

The process of design science demands for the validation of the new design. This is done with the help of project developers who have not been involved in the process of the development and evaluation of the current procedures at the case company. The experts selected for the validation are from the northern and southern regional offices of the case company; this also includes the insights from these two regions of the organization.

6.1 Validation meetings

The validation of the wireframe design was conducted with the help of a presentation of the literature findings, interview findings, and the three suggested improvements, Appendix IV. This was followed by a test run of the wireframe by the project developer. In which the steps made by the project developer were followed, and a discussion took place about what was missed and what has been found attractive by the user, of the steps taken on the suggestions, and identified benefits notes were taken.

6.1.1 Validation meeting 1

Interested to note is that the expert noted that in the earlier that same week project developers meeting. A point of discussion was how the reference project could be better shared within the organization and how the time invested in finding references could be limited. Whereby it is highlighted that when looking for a reference project, visuals and factsheets are most useful. (V. Welberts 2020, personal communication, 22 January)

During the wireframe test-run, it became clear early on that there was no return-button available; this made that it is not possible to go back to the homepage. The high-level cooperation between the project development organization and the construction organization was mentioned, and it was pointed out that in this relationship, the construction organization also acts as an advisor for the project developer. In which the Project leader is named as a foremost advisor at the construction organization from a project developer's point of view. Therefore the link towards a project leader in project pages could be added to allow project developers to see which project leader was involved. Or the addition of a project leader page, which shows an overview of the project a project leader was involved with. (V. Welberts 2020, personal communication, 22 January)

The 'Well of Wisdom' was mentioned as an excellent addition to the app. In which items, documents, and or exciting developments could be shared with others. Whereby an annotation was made on the success rate of the page. This is highly dependent on the users and the willingness to actively take part in this. And if this will be done by project developers. (V. Welberts 2020, personal communication, 22 January)

The set-up of the factsheets of the projects was discussed, mentioning in addition to the already stated project information, the product types, the current phase of the project, and the classification of the project based on the chance of success. And that the project should be uploaded to the platform once they were labeled as 'real projects', meaning they were in the sketch-design phase. (V. Welberts 2020, personal communication, 22 January)

Another suggested addition was the ability to link project publications on the project page. Newspapers, journals, or websites often take note of the development and write about it. It

was mentioned that many project developers collect these articles. The ability to link these articles to the project page enables both the sharing of the information from these data sources as a platform to store the links for the project developers themselves. (V. Welberts 2020, personal communication, 22 January)

6.1.2 Validation meeting 2

A second validation meeting was held with a project developer from the northern region of the case company. This meeting had the same structure as the first meeting. Whereby also, the time-consuming activity of searching for a reference project within the organization was mentioned. Once the wireframe was shown, the focus immediately was on the 'smiley' and the 'red cross' buttons, which, according to validator 1, indicate a good or bad. And actively questioning the desirability of this suggested consideration between good and bad. Suggesting to change this in icons representing 'saving for later' and 'move to next project'. (A. Tuil 2020, personal communication, 23 January)

During the wireframe test-run, the discussion focussed on the discussion section and the reason to open and use the app. Three reasons were identified:

1. To look at new developments after a 'notification'.
Whereby the 'basic' settings and notification was identified as vital for success, this comprises of the order the projects are shown to the user; the suggested setting was the newest project shown first. Whereby a notification could be sent to the app or email when a certain number of new projects are uploaded or updated. The main goal is to see where other project developers are working on in the organization.
2. For a targeted search for a topic according to a pending development project.
Once a developer encounters an obstacle in development, it can be useful to search if others have encountered a likewise problem before. Therefore the developer could search on a particular topic to find projects which did or did not overcome the obstacle, and advice could be collected at the involved project developers.
3. To send information to the app, inform others about a topic or development.
The project developers could come across an interesting document or gain insights about a new technology that could benefit others in the organization. In this case, the platform could allow the project developer to share it directly to whom it may concern — also enabling others to find it in a search when needed later on. (A. Tuil 2020, personal communication, 23 January)

Also, the 'what to insert when' question was discussed, around 80% of acquisitions are not developed, but these acquisitions could possess interesting subjects or items learning purposes. It is meant that these first sketches and calculations could also be shared among project developers with the help of the platform. Thereby the importance is noted of not mandatory filling all 'cells' in the FPD simply because of the uncertainty and use it merely as a sketch calculation tool. Having certain cells mandatory in this stage makes that the calculation sheet of the FPD is copied to a not managed Excel sheet in which the project developer has the freedom to try and experiment as much as wanted or needed. By doing this, the experiences and lessons learned are not documented in the FPD systems and thereby also not

available for the application, missing out of the chance to share the lessons learned. Additionally, this applies to the underlying advice gained for the purpose of a development project. The platform has a strong focus on the visual aspects of the projects. Whereby it is not per se clear that for a project a very detailed advise concerning traffic or ground was needed. The project developer highlighted the importance of clear labeling of the 'extensive' advice of a project. Whereby the 'basic' advice is less interesting to share. (A. Tuil 2020, personal communication, 23 January)

In line with validation meeting 1, the discussion page was criticized, and the need and usefulness of it were questioned. Whereby it was mentioned that probably the platform would be used to find reference projects and associated project developers. After which the communication would be continued by phone, e-mail, or face-to-face. (A. Tuil 2020, personal communication, 23 January)

6.2 Platform re-design

The validation meetings, on the one hand, exposed some important flaws of the wireframe, which should be eliminated and will be discussed in the following paragraphs. On the other hand, it confirmed the need for better knowledge sharing between project developers focussing on reference projects within the organization. Underlining the struggle within decentralized organizations to know what others are working on and the spread of knowledge. And the need for a way to help employees to find each other and connect with others with experiences and know-how on specific topics. The Re-designed wireframe can be found in Appendix V

6.2.1 Design adjustments

- Save and next buttons

The first adjustment of the design, which was highlighted by validator 2, is the 'good versus bad' buttons. The point made about this and the implication it has on the project should be eliminated. The goal is to improve the knowledge sharing capabilities and the ease to find one another. Not labeling projects as good or bad. Therefore the buttons are changed, allowing the user to store a project of his interests for later or go to the next project when the project is not contributing to the needs of the user. This implies that the 'red cross' button is changed into an arrow pointing right to indicate going to the next project. In addition to this, the user is still able to swipe the page to the right, also going to the next project. Also, a new button with arrows to the left is added to allow the user to go back to the last project when a project is pushed away by accident.

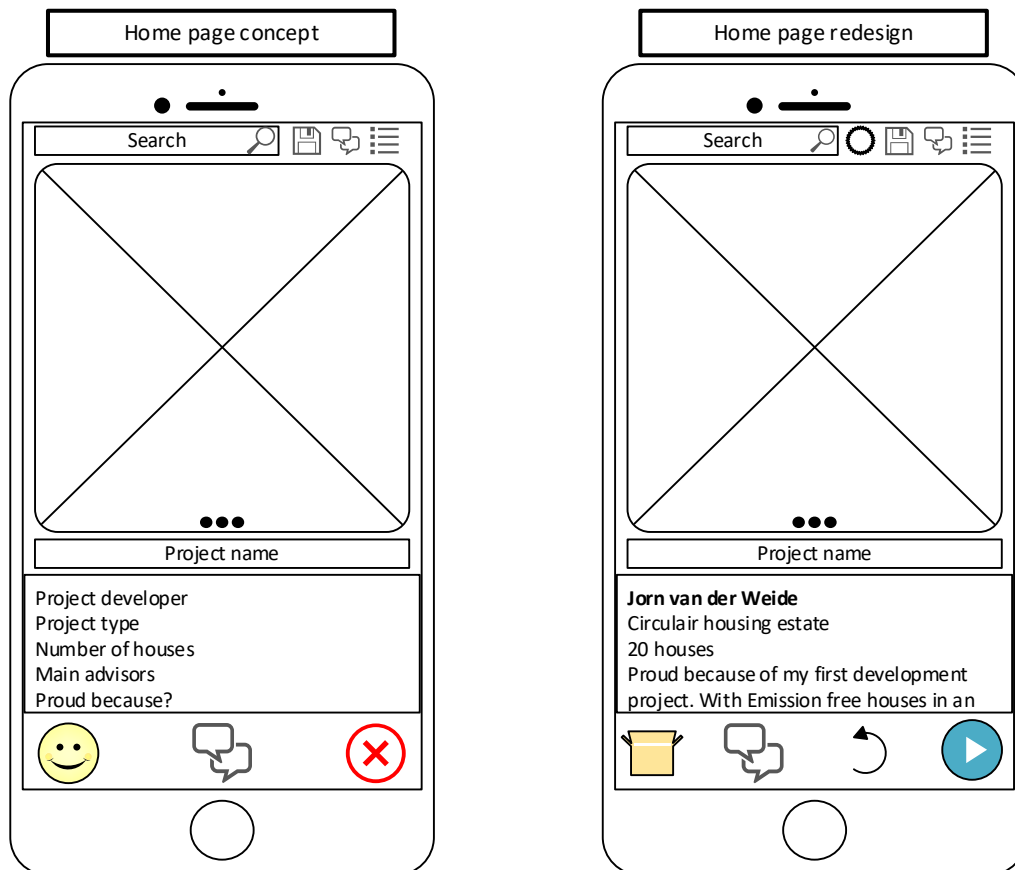


Figure 15: Wireframe cut-out Home page concept versus Home page redesign

- Project details

Both validator 1 and 2 noted the type of information that is required to insert during what phase of the project. And in which project phase a project should be posted on the platform. Where validator 1 notes that projects should be added starting at the sketch design phase validator 2 suggests also incorporating earlier acquisition phase projects. In which the acquisition phase purely focusses as an inspiration for others. As a way to share brainwaves and changes which have been studied. It is chosen to incorporate the acquisition phase of the project in the application. This allows project developers who want to share acquisitions they have worked to do so. Whereby it is advised to incorporate a 'sketch' model in the FPD, which allows the project developer to play around and try out some ideas. Before being mandatory to enter all the details of the projects. This will likely prevent project developers from using another calculation sheet and thereby missing the ability to collect the data in the database. Hereby the project developer has the authority to 'share' or 'hide' the sketch, making themselves responsible and able to decide if it is of interest for others. Project details that could be stated are:

- Project developer
- Project type
- Phase
- Number of houses
- Project phase
- Project leader
- Project environment/location
- Proud of this project because

- Lessons earned during this project
- Main advisors and the accompanied job description
- Financial details
- Investor
- Future users
- Discussion page

- Discussion page

However, the usefulness of the discussion page was questioned. The page was preserved for the ability to document the informal knowledge search of users. This could help others from the sideline to adopt the knowledge and find others with likewise or previous questions about a specific project. Also, the discussion page could be used by inspirational projects or from outside the corporation.

- Notifications

On the home page, a button for platform settings is added. From which the user is able to select which notification is on and off. This allows the users to choose if they want to be informed about new projects, new publications linked to saved projects, new discussion topics, or additional comments on a followed topic. In this, the user is free to set if they want to be notified with an alert on their phone, a bullet at the app button on their phone screen, or email notification. Also, it could be selected if they want a notification when there is one new selected interest or a minimal number of them. In order to not overload the amount of notification.

- Additional chances

In addition to the before-mentioned adjustments, more general adjustments are made. One of these is the button at the top of the pages to return to the homepage, to allow the users to go back whenever that is needed.

6.2.2 Additional user notes

In the design of the platform, it is essential to realize that there is no comprehensive design in which all project developers can be fully satisfied. Realizing this, as is noted by the development of a CoP, the platform should go with the flow. Allowing the users to suggest changes and also have the freedom to insert data, which at this moment is not found vital, by having open cells in the FPD.

The usability of the user highly depends on their own input. The saying of 'Reap what you sow' is strongly related to this. The more data is inserted in the FPD, and more information can be extracted. This could be a barrier at the start of the launch. However, the link to the FPD, in which the project developers are already working, could limit the barrier to insert data. The use and search for information at the platform should be more comfortable than calling a developer on the guess that they have experience with it. Thereby noting that the platform should not enlarge the barrier to on the guess call other developers, but make a guess better aimed.

For the usability of the 'Well of wisdom,' it must be understood that there is no right or wrong in the information posted or requested by the users. Looking at the level of professionalism

that may be expected from the project developers, it is up to them to decide if a new topic or question is needed.

The addition of external projects could be considered to show developers what is happening outside the organization, to trigger the project developer's attention. And when new products are developed within the organization, sharing them through the platform in addition to the events and existing intranet could benefit the spread and ability to make use of the knowledge.

It should be noted that in the platform, just as with a CoP, not everybody will be active in the participating of discussions. This must, as noted by Wenger et al. (2002), there are different levels of involvement. Meaning that it is no problem when users are only reading or sliding through the projects, as they will adopt the information and could share or use it outside the platform. This knowledge sharing outside of the platform is highly encouraged, and project developers should be supported to be involved in events outside the organization as well. The benefits of the platform can only be

6.3 How could the knowledge, which is used by real estate developers in the selection of advisors during a housing development project, be captured and exchanged within a decentralized development company?

For the selection of advisors, project developers are highly dependent on experiences of their own and their direct colleagues. The organization structure creates a barrier to the exchange of experiences between regions. The exchange of knowledge, which for the selection of advisors consists of a high level of tacit experiences from the developers, is done informally and based on direct via-via contact. The first steps are made to enhance the exchange of documents, explicit knowledge. To capture and exchange knowledge within decentralized organizations, the distinction between these two types of knowledge and the method for exchange must be made.

Firstly, the focus should be on the documentation of explicit knowledge, consisting of data. Which, with the experiences of developers and the right filters, could be transferred to information for project developers. This documentation should be elaborated on a national level, allowing developers to access the project data from each other. The focus hereby must be on the structured documentation and ability to insert data easily. From the overarching point of view, the data reservoir should be set-up and managed to allow the project developers to insert and extract as much data as needed. In which a constructive method with the continuous development of the database and the insert option based on the needs of the developers is encouraged.

Secondly, the importance of tacit knowledge in the organization must be underlined. The value of the experiences within the organization should be realized and the positive impact to be able to find each other more easily to share experiences. Where explicit knowledge can be easily documented and shared with the help of email or databases. The focus of the tacit knowledge must be on bringing the right persons together. Therefore firstly the data reservoir plays a central role. The data reservoir allows project developers to search for projects and apply filters allowing them to extract information. In addition, it allows the project developers

to find each other and know what projects have been developed and are being developed — leading to direct contact with colleagues outside the region whereby experiences could be shared. The developers should be able to access projects without barriers and see if a project is of interest, whereby the visuals are essential. In which filters could be applied for a more focussed search and more profound analyses of the data could be conducted when the interest is aroused.

Thirdly, project developers should be encouraged to regularly meet-up in person with each other outside the regional offices. Allowing to a more direct exchange of knowledge and the limitation of ignorance of who is doing what and of who works within the organization. These meet-ups could, for example, focus on highlighting the regional challenges, the recently learned lessons, or the working winning strategies for tenders.

7 Conclusion

The knowledge demand for project developers is something that has been given little attention in academic society. Making it difficult to confirm the outcome of this research with others. However, there are studies conducted in the field of knowledge management focussed on decentralized organizations. This highlights the difficulties to know what knowledge is available in the organization as this study has done. Where this study was initiated to focus on the sharing of knowledge considering advisors, the subjective nature of experiences showed the difficulty to document and share this. This is very much in line with the studies conducted on knowledge and knowledge management (Nonaka & Takeuchi, 1995; Jennex & Bartczak, A Revised Knowledge Pyramid, 2013; Leonard & Swap, 2004). This highlighted the importance not merely to focus on extracting the knowledge based on experience from employees to data. But on the ability of employees of the organization to find who possesses what experiences and allowing and easing the contact between, sometimes distanced, colleagues.

In this research, it is tried to give decentralized organizations operating in project development the understanding of knowledge and the means of transferring it. This lead to the creation of a three-level approach for knowledge management, focussing on the characteristics of project developers' knowledge demand. Whereby the interviews confirmed that the knowledge management within project development operates on the first generation as identified by Rezgui et al. (2010), and highlighted the need to evolve towards the 2nd or even 3rd generation.

The knowledge management science in the AEC-sector has until now focussed on the project level and sought for new systems for the documentation and integration of project data, allowing users to extract information. And recognize problems before the construction phase of a project started in order to limit the failure costs and lead times.

Due to the highly subjective nature of experiences and the differences within the context in which an experience is gained. It makes that it is partially challenging to review cooperation with an advisor for a project developer. For the project developer, certain aspects of cooperation are easy to document with the help of an evaluation form, which can then be exchanged within a decentralized organization. However, these aspects do not give a clear overview of how the cooperation is perceived by the project developer but mainly consists of objective fields such as schedules, costs, budgets, or according to agreements. The aspects that make cooperation pleasant and exceeding expectations are harder to express. And therefore difficult to document and exchange within the decentralized organization with the help of evaluation forms. For these aspects, it is important to enabling the project developers to have interpersonal interaction. During these interactions, the sharing of experiences with an advisor in specific situations can take place, enabling the knowledge transfer between the decentralized organization.

This makes that the initials plan to develop a platform that could help to find and select the best advisor for a specific task is challenging to realize in the primal version as an exclusively digital platform. To maximize the capabilities of knowledge documenting, sharing, and extracting a combination of digital documentation, which easy accessibility and organic development must be creating. Next to personal interaction stimulation between different regions, whereby the focus must be on a judgment-free environment in which users are free

to discuss, ask, and suggest all that is important for them, not limiting them by topics and or communication structures. This implies that the platform could allow users to communicate through it and enable both private as open communication. But not limit users to communicate outside the platform. Scoring advisors based on the experiences should be kept necessary, and no extensive surveys should be implemented as the subjective nature of cooperation could hardly be documented. Therefore the focus is on the finding of colleagues with previous experiences with an advisor.

The field of knowledge sharing between project developers is hardly studied. Making that future scholar could continue this elementary study. Where this study was conducted based on a case company, in which interviews and validation are conducted, others could broaden the scope of conducting surveys and additional interviewees on a broader range allowing for the sharing of knowledge between project development organizations. This study has focussed on the creation of the platform and the prerequisites to enable the implementation of this. Further research could focus on the practical use of the platform and the benefits perceived by the users.

References

- ABF Research. (2019). *Primos 2019 Prognose van bevolking, huishoudens en woningbehoefte 2018-2050*. Delft: Primos.
- Ackoff, R. (1989). From Data to Wisdom. *Journal of Applied Systems Analysis*, 3-9.
- Bock, T. (2015). The future of construction automation: Technological disruption and the upcoming ubiquity of robotics. *Automation in Construction*, 113-121.
- Cavaliere, V., Lombardi, S., & Giustiniano, L. (2015). Knowledge sharing in knowledge-intensive manufacturing firms. An empirical study of its enablers. *Journal of Knowledge Management*, 1124-1145.
- Centraal Bureau Statistieken. (2019, 09 23). *Voorraad woningen; standen en mutaties vanaf 1921*. Opgehaald van CBS Statline: <https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82235NED/line?ts=1569243197261>
- Chesbrough, H. W. (2003). The Era of Open Innovation. *MIT Sloan Management Review*, 35-41.
- Chesbrough, H. W., & Appleyard, M. M. (2007). Open Innovation and Strategy. *California Management review*, 57-76.
- Dave, B., & Koskela, L. (2009). Collaborative knowledge management-A construction case study. *Automation in Construction*, 894-902.
- Davenport, T. H., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Boston, Massachusetts: Harvard Business School Press.
- Denyer, D., Tranfield, D., & van Aken, J. E. (2008). Developing Design Propositions through Research Synthesis. *Organization Studies*, 393-413. doi:10.1177/0170840607088020
- Dousma, G. (2019, November 13). Interview 2, advisor selection, evaluation and experience sharing. (J. van der Weide, Interviewer)
- Egbu, C. O. (2004). Managing knowledge and intellectual capital for improved organizational innovations in the construction industry an examination of critical success factors. *Engineering, Construction and Architectural Management*, 301-315.
- Fernandes, K., Raja, V., & Austin, S. (2005). Portals as a knowledge repository and transfer tool - VIZCon case study. *Technovation*, 1281-1289.
- Forcada, N., Casals, M., Fuertes, A., Gangoells, M., & Roca, X. (2010). A web-based system for sharing and disseminating research results: The underground construction case study. *Automation in Construction*, 458-474.
- Georgiadou, M. C. (2019). An overview of benefits and challenges of building information modelling (BIM) adoption in UK residential projects. *Construction Innovation*, 298-320.
- Houston, R., & Harmon, E. (2002). Re-envisioning the information concept: Systematic definitions. In H. Bruce, R. Fidel, P. Ingwersen, & P. Vakkeri, *Emerging frameworks and methods in Proceeding of the fourth International Conference on Conceptions of Library and Information Science* (pp. 305-308). Greenwood Village, CO, USA: Libraries Unlimited.

- Israilidis, J., Siachou, E., Cooke, L., & Lock, R. (2015). Individual variables with an impact on knowledge sharing: the critical role of employees' ignorance. *Journal of Knowledge management*, 1109-1123. doi:10.1108/JKM-04-2015-0153
- Jennex, M. E. (2017). Big Data, the Internet of Things, and the Revised Knowledge Pyramid. *The DATA BASE for Advances in Information Systems*, 69-79.
- Jennex, M. E., & Bartczak, S. E. (2013). A Revised Knowledge Pyramid. *International Journal of Knowledge Management*, 19-30.
- Khalfan, M., Kashyap, M., Li, X., & Abbott, C. (2010). Knowledge management in construction supply chain integration. *International Journal Networking and Virtual Organisations*, 207-221.
- Khuzaimah, K. H., & Hassan, F. (2012). Uncovering Tacit Knowledge in Construction Industry: Communities of Practice Approach. *Social and Behavioral Sciences*, 343-349.
- Leal, C., Cunha, S., & Couto, I. (2017). Knowledge sharing at the construction sector - facilitators and inhibitors. *Computer Science*, 998-1005.
- Lee, H., Kim, J., & Koh, J. (2009). A contingent approach on knowledge portal design for R&D teams: Relative importance of knowledge portal functionalities. *Expert Systems with applications*, 3662-3670.
- Leonard, D., & Swap, W. (2004, September). *Deep Smarts*. Opgehaald van Harvard Business Review: <https://hbr.org/2004/09/deep-smarts>
- Lune, H., & Berg, B. L. (2017). *Qualitative Research Methods for the Social Sciences*. Essex: Pearson Education Limited.
- Maqsood, T. (2006). *The Role of Knowledge Management in Supporting Innovation and Learning in Construction*. Melbourne: School of Business Information Technology RMIT University.
- Meusen, H., & van Kempen, R. (1995). Towards residual housing? A comparison of Britain and The Netherlands. *Netherlands Journal of Housing and the Built Environment*, 239 - 258.
- Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2018). *Staat van de Woningmarkt Jaarrapportage 2018*. Den Haag: Ministerie van Binnenlandse Zaken en Koninkrijksrelaties.
- Nonaka, I., & Konno, N. (1998). The Concept of "Ba": Building a Foundation for Knowledge Creation. *California Management Review*, 40-54.
- Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company*. New York: Oxford University Press.
- Olawumi, T. O., & Chan, D. W. (2019). An empirical survey of the perceived benefits of executing BIM and sustainability practices in the built environment. *Construction Innovation*, 321-342.
- Oliva, F. L. (2014). Knowledge management barriers, practices and maturity model. *Journal of Knowledge Management*, 1053-1074.
- Panahi, S., Jason, W., & Partridge, H. (2012). Social Media and Tacit Knowledge Sharing: Developing a Conceptual Model. *World Academy of Science, Engineering and Technology* (pp. 1095-1102). Paris, France: World Academy of Science, Engineering and Technology.
- Polanyi, M. (1966). *The Tacit Dimension*. Garden City, New York: Doubleday & Company, INC.

- Pries, F., & Dorée, A. (2005). A century of innovation in the Dutch construction industry. *Construction Management and Economics*, 561-564.
- Programma Aanpak Stikstof, Uitspraak 201600614/3/R2, 201600617/3/R2, 201600618/3/R2, 201600620/3/R2, 201600622/4/R2, 201600630/3/R2 (Raad van State mei 29, 2019).
- Rakha, T., & Gorodetsky, A. (2018). Review of Unmanned Aerial System (UAS) applications in the built environment: Towards automated building inspection procedures using drones. *Automation in Construction*, 252-264.
- Randolph, J. J. (2009). A guide to writing the dissertation literature review. *Practical Assessment, Research & Evaluation* (14), 1-13.
- Razmerita, L., Kirchner, K., & Nielsen, P. (2016). What factors influence knowledge sharing in organizations? A social dilemma perspective of social media communication. *Journal of Knowledge Management*, 1225-1246.
- Reeze, M. (2019, November 20). Interview 3, advisor selection, evaluation and experience sharing. (J. van der Weide, Interviewer)
- Rezgui, Y., Hopfe, C. J., & Vorakulpipat, C. (2010). Generations of knowledge management in the architecture, engineering and construction industry: An evolutionary perspective. *Advanced engineering, Informatics*, 219-228.
- Rode, H. (2016). To share or not to share: The effects of extrinsic and intrinsic motivations on knowledge-sharing in enterprise social media platforms. *Journal of Information Technology*, 152-165.
- Ruuska, I., & Vartiainen, M. (2005). Characteristics of knowledge sharing communities in project organizations. *International Journal of Project Management*, 374-379.
- Saini, M., Arif, M., & Dennis, K. J. (2018). Critical factors for transferring and sharing tacit knowledge within lean and agile construction processes. *Construction Innovation*, 64-89.
- Schmidt, D. M., Böttcher, L., Wilberg, J., Kammerl, D., & Lindemann, U. (2016). Modeling Transfer of Knowledge in an Online Platform of a Cluster. *26th CIRP Design Conference* (pp. 348-353). Stockholm, Sweden: CIRP The International Academy for Production Engineering.
- Slot, J. (2019, Oktober 30). Interview 1, advisor selection, evaluation and experience sharing. (J. van der Weide, Interviewer)
- Sporrong, J. (2011). Criteria in Consultant Selection: Public Procurement of Architectural and Engineering Services. *Australasian Journal of Construction Economics and Building*, (4) 59-76.
- Stichting Economisch Instituut voor de Bouw. (2018). *Trends op de bouwmarkt 2018-2023*. Amsterdam: Stichting Economisch Instituut voor de Bouw.
- Taylor, S. J., Bogdan, R., & DeVault, M. L. (2016). *Introduction to Qualitative Research Methods: A Guidebook and Resource*. Hoboken: John Wiley & Sons, Inc.
- Tuil, A. (2020, 01 23). Validation meeting 2. Zwolle, Overijssel.
- Tuomi, I. (2000). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems*, 103-177.

- van Aken, J. E., & Romme, G. (2009). Reinventing the future: adding design science to the repertoire of organization and management studies. *Organization Management Journal*, 5-12.
- van der Vlugt, C. (2019, December 18). Interview 4, advisor selection, evaluation and experience sharing. (J. van der Weide, Interviewer)
- Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling Knowledge Creation*. New York, New York: Oxford University Press, Inc.
- Walker, D. (2016). Reflecting on 10 years of focus on innovation, organisational learning and knowledge management literature in a construction project management context. *Construction Innovation*, Vol. 16 No.2 pp. 114-126.
- Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Boston, Massachusetts: Harvard Business School Press.
- Woo, J.-H., Clayton, M. J., Johnson, R. E., Flores, B. E., & Ellis, C. (2004). Dynamic Knowledge Map: reusing experts' tacit knowledge in the AEC industry. *Automation in Construction*, 203-207.
- Yang, L.-R., Chen, J.-H., & Wang, H.-W. (2012). Assessing impacts of information technology on project success through knowledge management practices. *Automation in Construction*, 182-191.
- Yeong, A. (2010). Integrating knowledge management with project management for project success. *Journal of Project, Program & Portfolio Management*, 8-19.

8 Appendices

8.1 Appendix I: Interview Guide

Introduction

Personal introduction

What is your work experience?
How came to be in project development?
What drives you for your job?

Core

Information need

What do you know of an advisor before making a choice?
What do you ask colleagues about advisors?
What information do you miss about advisors while selecting?
What do you want to know about an advisor previous to the selection?

Advisor search

How are advisors found? (experiences, via-via?)
Is there a knowledge base/ database for advisors?
How is the knowledge/information/data for the knowledge base/database used?
By project developers, business analytics?
(How) Are these tools contributing value toward the projects?
Is the feedback between the users (project developers, analysts) of the tooling?

Justification of chooses/evaluation

Is it documented why certain advisors are chooses and why other advisors are not selected?
Are the chooses justified?
How is the knowledge of selecting advisors shared between project developers?
Digital, face-to-face, conferences, meetings, social activities
Do you evaluate cooperation?
How do you evaluate cooperation?
How do you measure/judge the results of the cooperation?

Barriers and driver

Do you experience barriers to share knowledge with others in the organization?
Do you experience drivers to share knowledge with others in the organization?
What limits you in the sharing of knowledge?
Is the sharing of knowledge stimulated from within the organization (managers, senior managers, directors)?
Do you consider the decentralized nature of the organization as a barrier to knowledge sharing?

Future prospect

How do you see the future of knowledge sharing between project developers?
CoP, Digital interactive forum, social activities, digital database?

8.2 Appendix II: Interview summaries

8.2.1 Interview 1

The first interview has been conducted with the Head of real estate and ground transactions. He is not linked to one of the regional offices but operates under the national organization. He identified himself as a 'Jack of all trades', by his advising role towards the regional offices on a wide range of subjects. In this role, he tries to connect the regions and share knowledge and experiences from a central point in the organization. In addition to this, he fulfills a controlling function for the Board of Directors. In this role, he first takes a seat in the credit commission, in which projects are judged in order to process and granted budget for further development. The second part of his controlling function focusses on the cooperation and process steps that are agreed to be taken in order to control the projects. From this point of view, he possesses vital knowledge about the selection-, documentation- and evaluation process within the project development branch of the organization.

Advisor search and selection

According to interviewee 1, all regions are free to choose their own advisors. With the exception of legal and financial advisors, those must go through the Head office. Where the legal department is seated. There are five legal representatives, more or less one for each region. Which are involved with legal issues and can advise and are involved in the discussion of contracting third party lawyers (Slot, 2019, p. 5). Hereby Interviewee 1 notes that:

"With a specific specialism, it is better, instead of muddling up at the beginning, to have a specialist. This will require some additional investments, but you are, often, able to give proper advice straight away." (Slot, 2019, p. 6)

The organization has chosen to centralize the tax advising through interviewee 1, considering project development. Most of the questions can be answered by him since these or likewise, questions are asked before. When the answer is not present within the organization, interviewee 1 could consider making a call to inform about the issue to the tax adviser or request formal advice from the home tax advisor. Whereby Interviewee 1 can formulate the question in such a way, it could be used on multiple projects and/or regions. (Slot, 2019, p. 4)

On the national level, there are no guidelines for the selection of advisors, according to interviewee 1. The search and selection of advisors are, according to the decentralized organization model, a concern of the regional offices. Senior project developers have often developed a network of advisors with whom they have good working relations. From where they can select an advisor for a new advice application, stating:

"It's no rocket science. There are no heavy models behind it. It's just with whom have you worked before in a good way." (Slot, 2019, p. 14)

Interviewee 1 is convinced that the organizational side of project development is working well at this moment. The project developers make well-considered decisions about what advisors to involve and have a proper consultation with each other about this.

In addition to gut feeling and good previous experiences, availability and reasonable price are essential. There is consultation, both vertical as horizontal, in the project developers' offices.

Also, there are specific topics of which the directors share knowledge and information of it, concerning who was involved for what kind of advice and when the output was satisfactory these advisors are adopted to other projects. (Slot, 2019, pp. 6, 14)

Evaluation and documentation

Interviewee 1 is involved in the development of the 'financieel project dossier' (FPD). This is a managed Excel sheet which is used for the financial documentation and calculation of development projects. Where the sharing of knowledge is now many done in an informal way by consultation. The FPD is designed to give insights into projects on a national level. (Slot, 2019, p. 6)

"At this moment we do not know with which architect we have worked on what project in The Netherlands." (Slot, 2019, p. 6)

What advisors were involved in what projects were not formally documented. The vision of interviewee 1 is that it all starts with documentation, apart from the question 'why did you choose or how did you choose?' those questions are not relevant at this moment. (Slot, 2019, pp. 6-7)

In line with the documentation, the evaluation of involved parties is also based on informal methods. When a reference is needed, it is simply asked by others 'hey, how did you come to that party?' or 'how was the quality and was everything delivered on time?'. But this is not documented, let alone documented on a structured way to share along with the organization. There is an evaluation on a project level, but it is not known that this is documented. This was the cause for interviewee 1 to set-up the managed Excel sheet, whereby managed means the structured documentation of information in a database. From this calculation model, we are expanding step-by-step, from project level general stuff is documented and the internal organization. Future documented data is 'who is the plan preparer, who is the work preparer from construction'. (Slot, 2019, pp. 7, 14-16)

"The art is to identify which internal data could be linked on a smart consist and congruent method in order to be shared." (Slot, 2019, p. 7)

Through the FPD, interviewee 1 is able to enforce data demand linked to the phase of the project, gradually increasing the amount of data from start to finished project. Hereby, interviewee 1 noted that his philosophy is different from the basic ICT methods. Where ICT often demands a complete model with functional systems and all requirements. Whereby when it is implemented, the users are surprised and see room for improvements, resulting in a tough implementation when functional requirements are, in reality, different than thought by yourself. Therefore a 'Scrum' like method is used. In which small steps are made. (Slot, 2019, p. 9)

"it's most important is the flow and that people are willing to go with it. Thereby it is most beautiful when they are willing to go with it out of their own instead of demanding it." (Slot, 2019, p. 10)

According to interviewee 1, knowledge can be shared only when the information is entered into the system. Whereby the assumption is that people are lazy of nature, therefore people must like to insert information into the system. And when it is in the system, it can be used. If not, it cannot be used. In this interviewee 1 underlines his principle of 'I only document it once', which should happen as close to the source as possible. Thereby the source is responsible for the data. As interviewee 1 states:

"For me, there is only one truth" (Slot, 2019, p. 11)

Knowledge sharing

Interviewee 1 notes that he, from his central role in the organization, often is contacted for internal advice and his expertise or previous experiences with actors. This mostly happens by phone or face-to-face, whereby the recommendations are forwarded by email. However, from his point of view, no documentation is conducted that is something to be done by the project developers themselves. (Slot, 2019, p. 3)

"The directors of project development share knowledge about who is used for what advice, but mostly on an informal way" (Slot, 2019, p. 6)

In his function of internal advisors towards project developers, the question is often asked if there are already experienced with an individual person or organization. These experiences are then shared mostly by phone. (Slot, 2019, p. 3)

Interviewee 1 notes that the process of project development consists of a high level of creativity. The project developers make use of their own knowledge and create a place something new. In which creative people are involved combined with advisors on specific technical topics. All of this, combined in an organizational jacked, is the process of project development. Thereby the process is immaterial.

Based on the data collected in the FPD, which is extended on the basis of 'fiddling forwards', experiences can be shared along with the organization. Interviewee 1 hereby has the ability to analyze the data and contract information about the costs and per advisor, type linked to project size. From which a comparison could be conducted picking out the odd cases, after which explanation or additional information could be requested from the project developer. (Slot, 2019, pp. 13-14)

The focus has been on getting the system running. And from there on extending and adding data and linking data. When questions arise, the dialog with project developers is started to discuss chooses and to learn from each other. For the future interviewee 1 imagines that based on the data, project results could be simulated, and the system should be able to suggest the best advisors for the project. Whereby at the front of the project, the system automatically shows the expected costs and revenues based on previous projects, connected with standardized contracts allowing the users to search the database with the help of filters like the 'Vakantiediscouter' and giving the searcher the opportunity to find relevant reference projects. Interviewee 1 strongly underlines the demand to work as much as possible from one user interface. (Slot, 2019, pp. 17-18)

Over the evaluation of the more significant advisors and the sharing of these experiences, interviewee 1 notes that it should stay very basic. The comparison with the France highway toilets is made where after the visit, a screen asks for a thumb up or down. Suggesting that later on, this could be expanded to short questionnaires on the major advisors, such as architects and constructors. Also, linking it to the FPD from the philosophy of one user interface, highlighting the importance of the 'ask-only once principle' and the prevention of losing forms in which all details will be required again. Comparing it to the scoring of a phone-application, with stars and an optional comment.

8.2.2 Interview 2

Interviewee 2 is a regional project development director with a focus on the commercial side of project development projects. Consisting of scoping new opportunities and potential changes in the market. Interviewee 2 strongly believes in the decentralized organization structure whereby there is local knowledge of the area and market but also budgets for innovation organization-wide. Whereby the focus is on solving social problems with the help of real estate development to create a pleasant living environment. Thereby deliberately choosing for the decentralized organization. Highlighting the power of the decentralized organization with the entrepreneurial focus deeply embedded in the organization with close lines towards the local costumers and at the same time an organization with the financial capacity to be innovative and progressive, which at the moment is insufficiently utilized. (Dousma, 2019)

Advisor search and selection

For the selection of advisors, interviewee 2 has developed excellent relationships with a number of advisors. Of which he knows for a reasonable price, I will get excellent qualitative advice. Which could be delivered with priority when needed. In this, the project developers are free to build on their own networks and have their own favorite advisors for specific tasks. This often makes it easier to quickly get something done, compared to selecting a new advisor.

According to interviewee 2, there is a divergence between the type of advisors. An architect highly depends on aesthetics, whereby the reference of the architect is of interest. To win a tender, it is, often, necessary that an architect can prove he is capable of working with specific requirements. In addition, to the aesthetic and reference projects knowing how the architect works and experiences from within the organization with them still play a significant role in de decision of selection.

In some cases, there are agreements on the office level; in this case, these parties are always involved in particular topics. An example of this is the broker, whereby this party plays a role in the business on two sides. On the one side, it is involved in selling the completed projects to the customers. On the other side it the broker helps the organization with the buying and finding of new exciting development locations.

It is mentioned by interviewee 2 that when a project developer leaves the organization, the network of advisors does not necessary leaves with him. The advisors are bound to the executed project. Thereby when they are involved with many projects for the organization through one person who leaves the organization, they will often make a call. This to get in touch with others in the organization to continue the working relationship. So these links do not just dissolve once a contact person leaves the organization. However, interviewee 2 notes:

“When you have executed a project together, it creates a bond, which makes the relation warmer comparing to working together for the first time.” (Dousma, 2019, p. 9)

Evaluation and documentation

The documentation of the networks and who has been involved in what projects are not documented on a structured basis. There is a Customer Relation Management (CRM) system in which the contact details of advisors are stated, but the link with the projects is often not

made. This is mostly in the minds of the project developers. The financial administration offers the possibility to search in the invoices making it possible to find which advisor was involved with what project. However, this does not include why an advisor was chosen.

The decentralized organization and the spread of the offices also limit the knowledge sharing within the organization. Interviewee 2 has an example of a development opportunity that was deemed as undesirable from the point of view of one office, which was later called by another office for a preliminary acquisition. In which both offices operate under the same brand name, potentially resulting in a strange situation for the property owner. Interviewee 2 identifies the ignorance of these preliminary actions, due to poor documentation, from one another as difficult. And seemingly clumsy.

“... it’s clumsy, and it happens more often that you are not informed of actions from others. So maybe this is a field we can improve on.” (Dousma, 2019, p. 8)

Concerning the evaluation of the selection, it is not documented why an advisor is selected for the project. The primary development process includes a moment for evaluation of the ‘bouwteam’ trajectory. This evaluation happens when building permits are requested. Although it is part of the primary process, the evaluation does happen with every development project. This evaluation form consists according to interviewee 2 of an agenda set-up in which all parties involved during the ‘bouwteam’ are evaluated. This could be done internally but also with the involved parties. Most often, it is done with the external parties, whereby all parties evaluate the cooperation. This focusses both on the quality as on the soft side of doing business. Interviewee 2 hereby mentions that the documentation of the outcomes of these evaluations is highly doubtful. This is mainly stored in the mind of the involved parties. (Dousma, 2019, pp. 8-10)

Interviewee 2 recalls a project in which an architect was involved, whereby the cooperation was unfortunate. The architect was specialized in unique projects, and the projects consisted more of systematic construction. Leading to difficult cooperation, this mismatch between architect and project type is not documented. There is no blacklist of advisors, and interviewee 2 suggested that an ‘orange list’ could be an option with a warning to involve the advisor only on a particular type of project. These struggles are something that could be stated in the project evaluation; however, at the moment, this is not done. It is only documented in the minds of the involved persons. A link between the evaluation and the CRM system is suggested to allow project developers to study previous projects of an advisor by means of references, enabling the connection between the advisor and a colleague who has worked with him. So the personal experiences of this colleague can be requested.

Knowledge sharing

Interviewee 2 notes that on a national level, there is a team looking at the improved knowledge sharing. This team focusses on the knowledge sharing for tenders, why did we win or why did we not win this tender? From the 5 regions, it should not be that hard to find the linking pin for knowledge directly. However, these experiences and methods are shared too little. (Dousma, 2019, p. 10)

Within the offices, the experiences with advisors are shared among each other in an informal way. When working in the same office, also to incorporate the tacit side of knowledge, information is transferred, and people know who is working on what. The knowledge is shared on a highly local level. Colleagues in other offices are often not involved, let alone other regions. On a national level, there is a project developer day once a year, and in the region, there is a project developers meeting once every quarter. Whereby lessons learned are shared, not focussing on how advisors perform. (Dousma, 2019, pp. 14-15)

Interviewee 2 mentions that it is sometimes hard to know what question to ask. As the asker does not know what type of answer it can expect. Mentioning that it could work to have a platform in which questions could be asked company-wide. Whereby the input and willingness of the employees are essential. It occurs that when a question is asked to someone of another region, the answer stays omitted. However, when it is asked through the senior management or direction, the answer finally comes. (Dousma, 2019, p. 15)

The directors of project development of the regions have set-up a group WhatsApp to swiftly share new developments such as won or lost tenders. Whereby also, the reason for winning or losing can be shared. At this moment, there is a director meeting every two months in which half an hour is reserved to share tips and tops. Whereby the choice of advisors is not on top of mind. And it should be asked if the development of a tool to share this knowledge is of interest to the organization. The sharing of the failed and successful practices between regions, of course, could benefit each other. Of course, all tenders are different; however, the ingredients used could be mixed and matched to suit your context. (Dousma, 2019, pp. 15-16)

Interviewee 2 notes, the current method of knowledge sharing with project development is based on a map pinpointing the location of the project with factsheets and pictures. From this point, a continuous deliberation on what is missing and what should be added is held. Leading to step-by-step improvements of the knowledge sharing. When developing a project, there is a demand for reference projects and factsheet of costs and who was involved. Allowing to contact this person and request additional information, which often is collected by face-to-face contact. Highlighting the importance of knowing who is involved with what project and what are the specialties of what region and project developer. Not just focussing on the visuals but also including 'what was the winning tender strategy?' (Dousma, 2019, pp. 17-18)

8.2.3 Interview 3

Conceptual plans and sketch designs are the main focus of interviewee 3. Making the plan financially feasible is a large part of this, but also piloting the plans through the municipality and other stakeholders that are involved. Interviewee 3 operates as a senior project developer for a regional office. When a project continues to the preliminary sketch, it is transferred to another developer. (Reeze, 2019)

Advisor search and selection

Interviewee 3 notes that the search and selection of an advisor are mainly based on previous experiences. And the, often, local expertise of the advisor. Where it is undesirable to have an advisor who comes from the other side of the country. From the previous projects, a network is created, in addition to the personal network, there is a network of the local office and the regional project development organization. Noting that when a project developer starts, the network is transferred from the senior colleagues on the new one. The knowledge of the advisors from colleagues is extracted by simply asking and discussing which advisor could be a good match for the project with colleagues. These consultation is going by phone, e-mail or face-to-face. u For the selection, especially of the architects, it is good to know the work method of the architect matches that of organization. This both consists of gut-feeling as the ability to work with BIM, for example. To see if an advisor is able to work with specific systems, the internal expert and the advisors are invited for a meeting, and they should be able to find out if they could work together with a particular method. (Reeze, 2019, pp. 4-5, 9-11)

Interviewee 3 prefers advisors who are already known within the organization. This allows for hand-on experiences with them. Which could directly be contracted from the colleague involved. Naming on which points the advisor is stronger or weaker. (Reeze, 2019, pp. 9-10)

For the selection of advisors, it is when they are no technical advisors, often difficult to rate their work objectively. For an architect, it is often more critical that there is a 'click', making it difficult to argue the selection objectively. Suggesting the creation of a national database in which focusses on pictures, enabling to scroll through projects, and when a project seems interesting, a call can be made to the involved colleague. (Reeze, 2019, p. 12)

According to interviewee 3, in the past, it was reasonable to invite three architects to present a plan and select one of these. Nowadays, the architect is more selected on gut-feeling. Saving a month of time and speeding up the process. Hereby it is questionable if taking more time for the decision makes for better choices. It rarely happens that an architect is a kick-off of the project due to adverse work.

Evaluation and documentation

Interviewee 3 highlights that from the quality system evaluations are required to be performed on advisors. However, admits this only happens on a small scale. When the evaluation form was introduced, the question was, what is the reason to use it, and what is going to happen with it? This was not sufficiently thought out, and there was no ability to use each other's evaluations. Then the tendency was that it did not work, so we will not take time to use the form. (Reeze, 2019, p. 10)

The previous work with advisors is not documented on a structured basis. Of which for future projects, a search can be conducted for suitable advisors. (Reeze, 2019, p. 11)

The evaluation and documentation of bad advisors mainly happen by mentioning the experiences to the colleagues. It is suggested that it could be noted in the database that an architect or other advisor is better used for certain kinds of projects or should not be used on a specific type of project.

According to architects interviewee 3 says:

“It would be handy if there would be a kind of reference pages of projects. Which could easily be browsed” (Reeze, 2019, p. 14)

The difficulty in reviewing advisor offices is that it is often more important who is involved than what office is involved. When a person is leaving the advising company, the quality or process could drop. Whereby the flow of people in an organization makes it hard to document and keep track of performance. Noting whom you should have within a company is mainly transferred directly face-to-face and not documented. (Reeze, 2019, p. 14)

According to interviewee 3, for the proper documentation of data, it is essential to understand that the link between the numbers makes them valuable. Giving that there will come new durability legislation, the costs before those are no longer relevant. Also, the methods for calculating basic measurements must be standardized. Or, for the costs of an architect, it is essential to know what work is included and excluded. (Reeze, 2019, p. 22)

Knowledge sharing

With the region, there is a project developer meeting every six weeks. In which the current projects are shortly named. And problems, if present, could be named. This allows the developers to find each other on specific topics and outside the meeting discuss further. Sometimes also, knowledge sessions are organized whereby external parties bring new knowledge into the organization. (Reeze, 2019, pp. 6-7)

The new FPD model allows regions to access each other's project data. At this moment, this is not used much. Reference projects are mainly found via-via, simply because someone knew the other regions were working on like-wise projects. This knowledge from other regions helps, in this case, helped to get through the pre-selection. In this individual case, the durability was essential, so the durability manager was involved who knows the durability managers of other regions and is able to connect the right persons to each other. Another way of connecting projects and people is through the project developers directs. They see each other on a regular basis and have an app-group to consult each other and share news. (Reeze, 2019, p. 7)

The knowledge transfer of new project developers freshly from the university is firstly conducted by looking along with a project, gradually increasing the number of tasks and when something is unknown, the ability to ask senior developers. According to the selection of advisors, this is done with the help of the other developers and the experiences they build on. Therefore making the link with someone from within the office is seen as very important to

interviewee 3, stating that selecting a party based on documented experiences does not feel right. The personal connection is vital. And the FPD allows searching on project data and names. However, it should be nice to have an image of the project, which directly allows seeing if the project can be related to you. (Reeze, 2019, pp. 15-16)

Interviewee 3 notes that the decentralized structure makes it harder to transfer knowledge. Even within the region, the different offices make it more challenging to communicate compared to seeing each other at the same office. Noting that from the view of knowledge sharing, it is preferred to have one office all project developers work from, enabling simple shout-out to a colleague or the group when needed. But meeting with all project developers once every 6 weeks allowed for a good enough connection that there are no barriers in connecting to each other. And the direct connection between project development and the construction site of the organization is seen as a significant advantage. (Reeze, 2019, pp. 16-17)

The knowledge sharing between project developers on a regional scale is perceived as quite optimal, according to interviewee 3. However, on a national level, it could be improved, a part of this is the new FPD. Highlighting:

“The most important is to know who possesses what knowledge on a national scale.” (Reeze, 2019, p. 19)

Thereby when someone is found with specific expertise, it is easier to call when you have a face with him or know them personally. (Reeze, 2019, p. 19)

8.2.4 Interview 4

The 4th interviewee is a junior project developer, now working for one and a half years at the organization. Operating from one of the local offices at which four project developers are active. (van der Vlugt, 2019)

Advisor search and selection

According to interviewee 4, mostly the advisor search is conducted with the help of colleagues, simply asking direct colleagues which advisors are used in previous projects. It is highlighted that the decentralized organization allows every office to work with their own preferred parties. Many of the advisors depend on the location and local. When no advisor is known in the personal network, or that of the direct colleagues, a google search for potential advisors is conducted. Or colleagues in another office of the region are contacted. Typically three to four quotations are demanded of which the selection is made based on a combination of price and personal feelings. Also, thoughtfulness is named as an essential aspect. This consists according to interviewee 4 of taking time, submitting a non-standardized quotation, and excellent cooperation and swift communication. (van der Vlugt, 2019, pp. 1-4)

Evaluation and documentation

According to interviewee 4, the experiences with advisors are not documented. However, when the cooperation was very unpleasant, this is communication within the office. And when this advisor is considered for future projects, it is discouraged. This mainly happens by hearing the considerations in the corridors of the offices or in meetings. Also, it is more or less common knowledge in which advisors are good or bad within the office. (van der Vlugt, 2019, p. 5)

In practice, when advisors operate according to the agreements, there is no evaluation, and there is no further discussion about their performance. However, when they do not perform as agreed, this is discussed with them and also shared with colleagues. (van der Vlugt, 2019, p. 7)

The FPD is the dossier that is used during the entire development project. This dossier consists of all costs involved with the development and construction and profits.

“Actually it keeps track of everything, and then, in the end, it’s the trick to project the desired profits” (van der Vlugt, 2019, p. 7)

Recently the FPD is extended to incorporate GPS coordinates to link with Google Maps, and pictures are added. It allows project developers from other regions to search for likewise projects when needed. Interviewee 4 guesses that she will mostly use the FPD for reference construction costs, noting that she needs to search the projects. These references are purely used as an inspiration due to the difference associated with the locations and the difficulty to compare prices between them.

The consideration of why an advisor is selected or is not selected is not documented. Internally there is a discussion about which advisor to choose, but these considerations are not formally documented. This documentation is also not missed when searching for an advisor. It is mentioned that when an advisor is searched, the advice is needed fast, and at that moment,

you will not go through all documentation or record all steps. However, a sort of black-list could be considered.

Interviewee 4 sees a future for an extensive database in which it can be found which advisors are used frequently and which could better not be asked. Thereby it is highlighted that a proper introduction is vital for success. Everybody has to know how to use it. In which also, the evaluation of advisors after a project is finished could be added. At this moment, during the project team meeting at which a project is transferred to the construction organization, there is no evaluation of the advisors unless something is urgent or incorrect.

Knowledge sharing

Interviewee 4 notes that the trade of project development is learned by doing. In the beginning, this is done by watching and working along with experienced project developers. Step-by-step getting to know what is needed to develop projects independently. In addition to this, a lot is learned from asking questions and just doing. (van der Vlugt, 2019, pp. 2, 4, 5)

On a regional level, the project coordinator collects and shares knowledge on certain specific subjects. They are operating as the middleman and linking supply and demand. In addition to this, there is also a central person for 'Innovation and Durability' at which questions related to subsidies and Energy prostrations could be asked. (van der Vlugt, 2019, p. 6)

For the sharing of knowledge, there is no perceived barrier. However, it is mentioned that it is easier to call someone that is familiar — noting that project developers are often pro-active persons who are not afraid to speak up. The ability to call someone from another region to get some information. (van der Vlugt, 2019, pp. 11-12)

Interviewee 4 foresees that the extension of the FPD could allow for a more comfortable and more targeted search in the reference project. Whereby the first evaluation of usefulness could be done by the searcher before asking for additional information from the involved project developer, adding that it is good to be familiar with colleagues when asking for information. Often when a colleague is not familiar, the request is not given priority. (van der Vlugt, 2019, p. 12)

According to Interviewee 4, there is a regional 'Focus & Learn' session for project developers once a month. For each session, a different topic is picked to learn about. The sessions have no strict set-up, it is possible to visit a project, have an external party to present a new design, or have training on specific corporate tools. On a national level, no meetings are organized. There are some workshops which it is possible to sign-up for concerning products. There is a national day of the project developer organized by an external party, the NEPRON. At which project developers of different offices and regions meet-up. This is positive for the familiarity among them but does little for the knowledge sharing. (van der Vlugt, 2019, pp. 13-14)

Interviewee 4 tries to work on the regional office once every two weeks. By doing this, she thinks the connections with the colleagues are better. Ensuring she is familiar with her direct colleagues. On a national level, this is difficult, and there is little familiarity among the project developers.

According to interviewee 4, there is no demand for tooling to ask other project developers outside the own region for help or ideas concerning a particular location. When a problem or an obstacle is perceived, it is often solved with the help of direct colleagues or via the director. (van der Vlugt, 2019, pp. 16-18)

8.3 Appendix III: Wireframe concept

See separate 'Conceptual Wireframe PDF'. In the PDF file it is possible to slide through the pages by clicking on text blocks, pictures or pictograms.

8.4 Appendix IV: Validation meeting presentation

Towards a platform to find and select advisors for housing development projects

"THE ONLY IRREPLACEABLE CAPITAL AN ORGANIZATION POSSESSES IS THE KNOWLEDGE AND ABILITY OF ITS PEOPLE. THE PRODUCTIVITY OF THAT CAPITAL DEPENDS ON HOW EFFECTIVELY PEOPLE SHARE THEIR COMPETENCE WITH THOSE WHO CAN USE IT."

ANDREW CARNEGIE

Why

Dwelling shortage even the term 'Woningnood' in the news

- Unique projects – prototype building
- Focus of academic studies on knowledge sharing within projects
- Knowledge stays within the projects
- Long duration of project on both development as construction

Learning from each other instead of reinventing the wheel again and again

What

How could the (knowledge) information, which is used by real estate developers in the selection of advisors during a housing development project, be shared and exchanged within a decentralized development company?

A framework for better knowledge sharing

How

Literature

- Sub-question 1: How is knowledge collected and transferred between individuals?
- Sub-question 2: How is knowledge management incorporated within the AEC-industry?

Interviews

- Sub-question 3: How do real estate developers of housing projects find and select advisors?
- Sub-question 4: How are experiences with advisors documented and exchanged with the decentralized organization?

Conceptual improvements

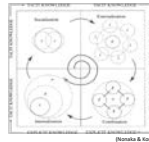
Validation

Re-design

Knowledge and knowledge sharing

- Tactic vs Explicit knowledge
- Different methods of transferring and storing knowledge

SECI model



The revised knowledge-KM pyramid



Knowledge Management in the AEC-sector

1st generation Knowledge Sharing; (Intra-company)

2nd generation Knowledge Conceptualisation & Nurturing; (Inter-company)

Communities of Practice & BIM

3rd generation Knowledge Value Creation, (Domain)

- Creating knowledge repositories;
- Improving knowledge access;
- Enhancing cultural support for knowledge use;
- Managing knowledge as an asset.

Barriers

- Ignorance of subject matter experts;
- Ignorance of Knowledge Management Systems;
- Ignorance of the corporate knowledge trust;
- Lack of trust;
- Lack of time

Drivers

- Senior management support
- Trust
- Face-to-face

Interviews

Advisor search and selection

- Socialization (via-via) from senior onto junior
- Previous experiences, based on feeling
- On specific topic through central point in organisation
- Multiple quotations → selecting based on costs, time and feeling

Documentation and exchange

- Financial project dossier
 - Only ask once principle
- Evaluation form
- Reference projects on intranet

Improve database

1. Extent database on basis of FPD

- Pre-selection advisors
- Contracts
- Consideration during selection, why chosen/why not chosen
- Experience with advisors
- Include pictures, sketches and designs
- What makes this project unique or good
- What can be learned from this project

Collecting explicit data

Reference platform

2. Reference platform

- Linking data from PFD with platform
- Focus on visual information, do I like the design? (data → information)
- Each project developers has his own reference page, proud on developed projects
- Explain ideas and suggestions during development
- Search for reference projects
- Easy to use, fast screening through projects
- Who is working on what? (roadmap to knowledge)
- Discussion and question page



Events and meetings

3. Personal interaction

- Reduce barrier for calling after personal acquaintance
- Building trust between project developers
- Improve willingness to help eachother
- Multiple set-ups
 - Learning session
 - Socializing
 - New insights, both from within the organization as from external parties
- Involvement of project developers for topics and event set-ups
 - Freedom to take initiative

What does this contribute

Insights in

- The different dimensions and types of 'knowledge'
- Methods to share knowledge and experiences
- The process of selection of project developers

8.5 Appendix V: Wireframe

See separate 'Wireframe PDF'. In the PDF file it is possible to slide through the pages by clicking on text blocks, pictures or pictograms.