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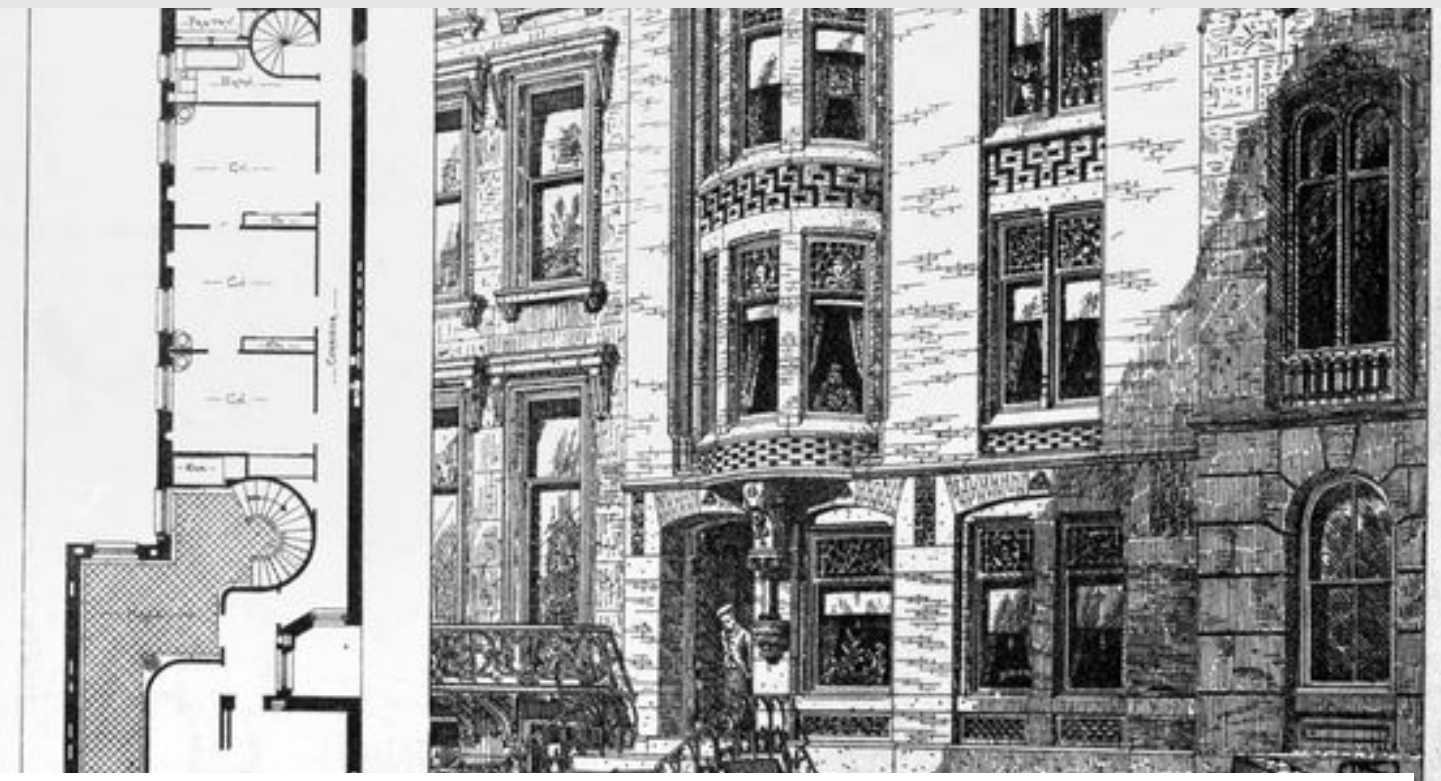
Supervisor: Rikke Magnussen

MASTER THESIS,
INFORMATION STUDIES

“Don't tell - show!”



A study of architect's requirements for a platform that include knowledge about thermal interal insulation in the classical buildings

MASTER THESIS

Information Studies

Aalborg University Copenhagen

A study of architect's requirements for a platform that include knowledge about internal thermal insulation in the classical buildings

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Page number: 94
Number of characters: 173382
Semester: 10th

Date of delivery: 29th May, 2019

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Acknowledgements

The final outcome of this report required guidance from different parties. Therefore, we would like to express our gratitude to all contributors to this dissertation project. Firstly, to ERIK Arkitekter that provided us with the case, especially architect Morten Ørsager who involved us in the RIBuild project and devoted time for several interviews that helped us to proceed with our project and define the project objectives.

Special thanks to our supervisor, Rikke Magnussen, for her constructive feedback and guidance throughout the entire thesis project.

Abstract: This aim of this thesis was to contribute to the architecture field by making knowledge about insulation available to architects in an easy and informative way. If the information regarding thermal insulation is shared in a way that is accessible and understandable between the professionals, there is a chance to reduce energy consumption by 15-20%. Therefore, it is necessary to reduce their energy consumption by spreading the best practices in terms of thermal insulation across Europe. Secondly, our aim was to expand on existing knowledge of how architects perceive and use visual information in their profession by conducting qualitative and quantitative research to find more about our chosen phenomena. Surveys, interviews and workshops provided us with the information about architects' needs and preferences for a digital platform, but also information regarding their perception and behaviour. Results show that architects are naturally driven by visual factors that stimulate their creativity and willingness to use the platform and acquire knowledge more effectively. Even though architects do not like to read technical material, they would prefer to have access to different levels of information and go deeper within the knowledge if needed. By drawing inspiration from those insights and following the theories of Human Computer Interaction, interaction design and information architecture, we developed a prototype of the platform that provides architects with the knowledge regarding thermal insulation in the classical buildings. The usability testing of the prototype provided us with data that highlights the strengths and flaws of the prototype. Based on the data, we proceeded with the development of the final prototype of a website with information regarding thermal internal insulation of classical buildings.

Keywords: architects, insulation, digital interface, knowledge sharing.

1 Introduction

This thesis is done in collaboration with ERIK Arkitekter, a corporate partner in the Robust Internal Thermal Insulation of Historic Buildings (RIBuild) project. RIBuild is an EU research project that develops directions on how to install internal thermal insulation in historic buildings while maintaining their architectural and cultural heritage. The purpose of the RIBuild project is to help reduce energy consumption in historic buildings in order to meet the EU 2020 climate and energy targets.

Today, historic buildings make up 30% of the European building stock. ERIK Arkitekter has an extensive knowledge base, comprised of international researchers' expert in the subject matter. This knowledge, however, is created and consumed primarily by researchers and, as a result, is not easy to consume by other stakeholders, such as engineers, buildings owners and architects. For this study, we chose to focus on one target group - architects. We were based in the ERIK Architecture office; therefore, our chosen group will be easy to access for the project.

Firstly, the aim of this study is to contribute to the architecture field by making knowledge about insulation available in an easy and informative way. If the information regarding thermal insulation will be shared in a way that will be accessible and understandable between professionals, there is a potential to reduce energy consumption by 15-20%. Therefore, it is advantageous to reduce energy consumption by spreading the best practices in terms of thermal insulation across Europe.

Secondly, our aim is to expand on existing knowledge of how architects perceive and use visual information in their profession by using surveys, interviews, workshops and other methods to find out about our chosen phenomena. The overall goal of the thesis, is to highlight, based on qualitative and quantitative research, the architect's requirements for a digital platform with information about thermal internal insulation of classical buildings.

1.1 Problem Statement

From the context and case description, we created our research from the following problem statement: **What are the architects' requirements from a digital platform that presents information about thermal internal insulation?**

In order to answer the problem statement, we formulated four research questions, which will be answered in the report:

RQ1 How does visual information affect an architect's work?

Because architects are the targeted user group of this project, we will conduct user research about them. In order to answer the research question, we will explore the relevant literature and combine with architect interviews. This can enhance our knowledge about the users and influence our design choices when designing the prototype.

RQ2 What type of information do users want to be provided with?

From the interviews, surveys and workshops we will answer this research question and will provide us with the necessary information to start generating ideas of users. We are interested in discovering what their demands of information are and how it should be represented for the users.

RQ3 How can the user needs be transformed into a prototype?

After the identification of the user's needs through user research and literature exploration, we will use methods, including interaction design and information architecture, in order to digitalize the user requirements.

RQ4 How does the prototype meet the user needs?

Through usability testing of an interactive prototype, we will try to discover based on usability metrics and qualitative data, if the proposed solution meets the user's needs.

1.2 Significance to the field

The significance is highlighted by the very limited number of research done concerning visual and informational preferences of architects. Our motivation for conducting this work was to contribute to this unexplored field and identify the requirements for developing a digital environment for architects. With this research and based on our experiences, we provide insights and suggestions on what the needs of architects are when using this type of platform. Additionally, we provide a way to enhance architects knowledge by creating a platform, where one can find necessary information and access information easily; in particular, valuable knowledge about the benefits of internal thermal insulation in the historical buildings that will reduce energy consumption, improve life expectancy of the building and contribute to sustainable architecture.

1.3 Limitations

Despite our efforts to minimise all limitations throughout the research study, there were certain constraints that we could not avoid. Therefore, there is a possibility that future research may raise doubt on the validity of our research's findings (Bryman, 2012).

The nature of the content provided by the researchers was not familiar to us, therefore it took additional time to understand it. Due to the limited time resources, we acquired basic knowledge about the insulation of buildings in order to move further and design the prototype of the platform.

Additionally, the full content of the website (research material) was not delivered, therefore we designed the prototype with limited available content. Furthermore, the collected data was limited in the sense that only Danish architects were participating in our study. Even though this project has an EU context, we did not reach international architects at that point, which might raise reliability concerns in the data collection.

1.4 Project structure

The figure 1 below presents an overview of the structure of our thesis and the methods we used to answer the problem statement and the research questions. The bars marked with light-blue indicate methods, grey bars indicate phases of Design thinking and dark green bars indicate the main parts of the thesis.

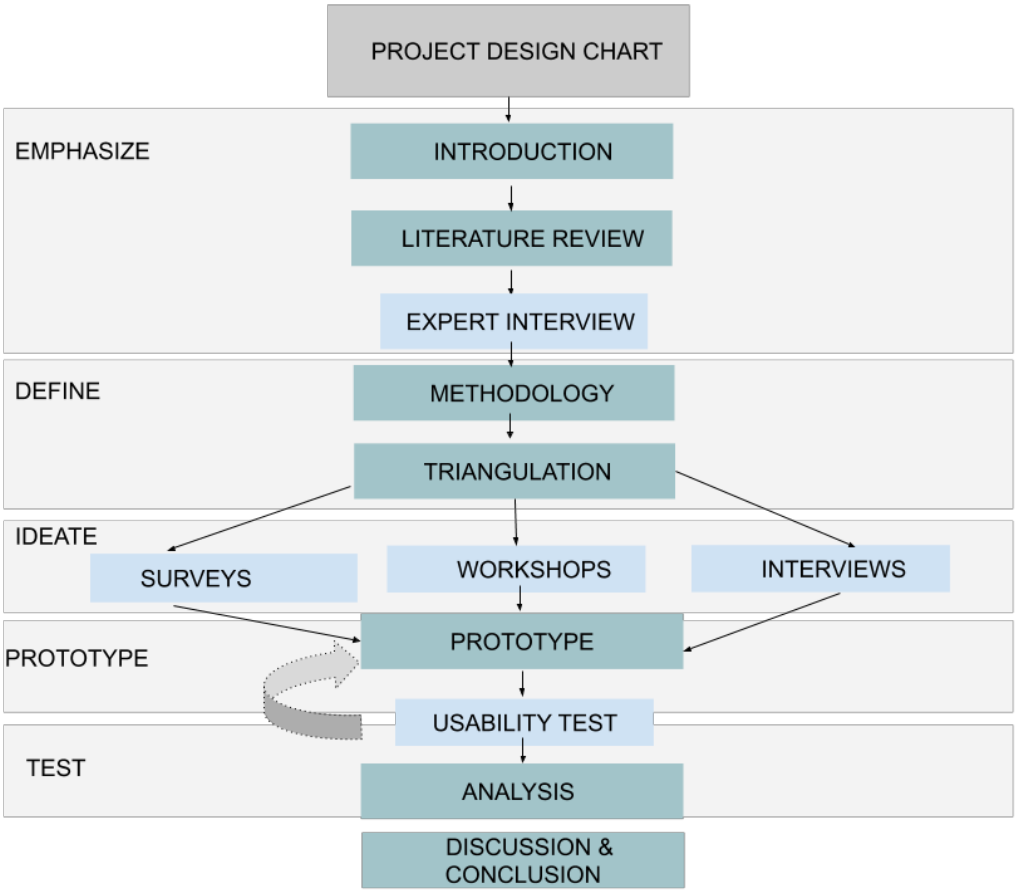


Figure 1 Project's structure overview

This thesis follows the premises of Design Thinking, involving participatory design approach in combination with user-centred methods. It is important to establish a framework that acts as a reference and guide us during the design process. The starting point for our research design is to understand the project scope and pre-define the problem statement. The problem statement describes the case that this project attempts to examine. Based on the problem statement and expert interviews, we created the research questions for this project. Additionally, in this phase, we explored the existing literature to enrich our knowledge about architects.

In the define phase, we established the methods that would provide us with information that about our users. We knew our target group beforehand, therefore based on Human Computer Interaction (HCI) theory we made the decision to use a triangulation of methods: interviews, surveys, workshops and a usability test. While triangulation refers to the usage several methods to investigate one research question in order to ensure validity of the results (Bryman, 2016).

In the ideation phase, we conducted interviews, surveys and workshops in order to collect information from the users about their expertise, habits and personal preferences regarding their work practise and visual preferences that focuses on new knowledge.

After the ideation phase, the collected information provided us with knowledge for our users and the interaction design and information architecture guidelines for the prototype creation. We conducted usability testing and asked architects to conduct several tasks utilizing the interface, in order to observe and evaluate their use with our interface. We followed the iterative process; immediately after the execution of their assigned tasks, we asked them to give feedback regarding their experience with the platform. We then proceeded with changes of the prototype based on the user's feedback.

2 Literature

As Boothe and Beile (2005) state "*A researcher cannot perform significant research without first understanding the literature in the fiel*d", therefore we focused on reviewing all available literature that we found regarding our study topic.

2.1 Literature search

In this section, we present the reviewed relevant literature of the topic being studied. In the literature review, we discovered existing research papers, experiments, and school of thoughts of visual preferences, habits, perception and information retrieval in a close connection to the architectural field. This will benefit us with making methodological decisions, establishing the context of the topic and discovering key insights of the area. The review is divided into sections that each contain what we considered pivotal works to support our research topic and build an understanding of a theoretical concept.

Sources

To make sure that our search was complete, we searched in several databases. We used databases such as ResearchGate, Mendeley, Aalborg University and Google Scholar library catalogue. These databases collect scientific papers across a variety of topics. The choice of using different sources was done to ensure that our findings would cover a broad range of papers and would ensure additional validity.

Search strategy

They keyword search is one of the traditional literature search ways. Keywords should be carefully considered in order to get direct results. Our chosen keywords are based on the problem statement and the research questions of the project. We started out by using most common Boolean operators: AND and OR to increase the number of relevant articles (Cronin, Ryan & Coughlan, 2008). The primary search strings provided us with several relevant articles about architectural practises and preferences when working on different projects. The list of keywords can be seen in appendix 1. Additionally, we used retrieved articles as an inspiration to retrieve more relevant sources based on their references, this is also called “citation pearl growing” which is a useful search strategy for discovering new articles around the topic (Rowley & Slack, 2004).

Example of search development using Boolean operators:

- A visual representation for architects
- Visual representation AND architects
- "Visual information for architects" OR "visual perception" AND “architects”

The keyword list expanded simultaneously based on the various irrelevant research with a number of searches, which provided us with synonyms and relevant terminology. Additionally, the case description provided us with some initial ideas about which areas to include in our search, also some keywords were identified from relevant articles found previously. We found it necessary to break them down into more specific keywords, due to the notably specific area of interest. We also consulted with our supervisor and other experts in the field on how to find available relevant literature in the field. However, the literature also suggested that only a few studies, within the field of architecture, have been conducted.

2.1.1 Search process

Once we obtained relevant literature, it was important, to begin with a more systematic review of the literature using PQRS (Cronin, Ryan & Coughlan, 2008) system, which follows the listed steps: A Preview, Question, Read and Summarize (PQRS) method. PQRS is a method that helps to keep the focus, pick out and retrieve material, especially when a number of publications are larger than usual.

In the Preview phase, the reviewer must go through the collected articles in order to get an overview of the literature. The reader does a preliminary reading of the abstract, skimming the introduction and conclusion. This was done in the first selection phase to find all potentially relevant articles. The initial selection of articles was done in two steps, first by skimming the abstracts and afterwards - reading the introduction more thoroughly. The reading of relevant papers was done individually and later discussed together to decide whether an article could be relevant or not (Cronin, Ryan & Coughlan, 2008).

The Questioning and Reading phases are where the reviewers determine what they need to find out and which literature is relevant for finding answers to the questions, reading the material and taking notes (Cronin, Ryan & Coughlan, 2008). When skimming through the articles, we kept in mind the questions about the methodology used by other researchers as well as their major findings.

The fourth and last phase is called Summarize (Cronin, Ryan & Coughlan, 2008). Once the evaluation of the literature is completed the reviewer collects all the notes and writes a short summary review. As a last part of the process, the articles were discussed collectively to finalize the selection and summaries of each article including problems of interest, methodologies and results.

Review of selected articles

To begin our research, we found it relevant to examine how architects perceive visual information and what practices they have in order to understand the subject better. The collected literature presented below shows that there have been limited studies carried out regarding architects' work; however, it is clear that some papers are relatively old, and we found a limited number of them.

Thus, in the following section, we presented related work that involves studies about architects and how they perceive and retrieve information. We also include knowledge sharing theory and platforms for architects. We decided to present this information, as we believe it provides relevant insights when developing a platform that will be dedicated to professionals in the field of architecture. We divided the review into three sections.

The review is divided according to the following themes:

- How do architects perceive information and visuals?
- Architectural design and the use of technology
- What is knowledge sharing?

2.2 Literature review

In the following section, we present the findings of our search, the relevant work that resulted in the basis for our research.

2.2.1 How do architects perceive information and visuals?

The reviewed literature provided insights into the nature of architects' information activities, behaviour, and preferences when seeking for knowledge. The potential of understanding that could support our design decisions in the prototyping phase and enrich knowledge about the architects.

Representations of information visually are older than the invention of writing (Jansen 2018). Ordinarily, external representations support external perception and visual thinking, and humans developed a rich set of skills for crafting and exploring them. Computers increased the amount of collected data and process as well as diversify the visual representation of it (Jansen 2018). In the opinion of Beaudoin and Brady (2011), visual resources are defined as observable material which can be employed by a professional to complete work tasks. Many professionals acknowledged that they need visual information, especially artists, architects, and archaeologists (Beaudoin and Brady, 2011). Visuals are noted as being used at the start of architectural projects for inventiveness and reference purposes, as well as in the design stage for external art to supplement the structure and create an overall environment (Chidlow, 1991).

Hinda Sklar (1995) have studied design and architecture students and reported that they look for images in a variety of resources that include "periodicals, books, videos, planning reports, maps, drawings, plans, and sketches." Not only the representation of random shapes and sizes can be used to show richer visualizations, but also new input technologies can be used to manipulate them. For example, tangible user interfaces are an emerging input technology that capitalizes on humans' ability to manipulate physical objects (Jansen, 2018).

Researchers state that there is a gap between what designers find appealing and what people like (Yazdanfar et al. 2015). The disagreement between professional designers and the public became a major crisis for many major projects in which the client differs from the user and designer has no direct contact with the users (Yazdanfar et al. 2015). Despite the value of information for architects, particularly when tackling design projects, there are only a few published studies of their information needs and behaviour. There is even less research that supports how architects conduct information gathering activities (Makri & Warwick, 2010).

Goodey and Matthew (1971) interviews and surveys were conducted in the architect's offices across the United Kingdom to discover how information was managed and fit into wider work practices within the offices. The results were that only 57% of the offices considered research literature as the main source of information. Several participants suggested that when undertaking design projects, architects choose more practical ones, such as design-focused books rather than research sources or journals. Even though the study was done several decades ago when getting information was more

complicated, the value can still be gained from this study that presented the nature of architectural information work, which remains the same to a degree (Goodey & Mathew, 1971).

Mackinder (1983) implies that architects prefer to have a private collection of literature in order to quickly revisit information sources. Architects are likely to collect independently published sources but often collect trade publications, whereas these are the most preferred ones because they are thorough and well-illustrated (Mackinder 1983). The author (Mackinder 1983) from her own experience as an architect suggests that *"the ideal information for architects is brief and visual,* saying that architects *"show a remarkable lack of enthusiasm for the written word"*.

Snow (1975) tried to discover architects needs for information from a telephone inquiry service doing follow-up interviews and questionnaires. She found that most information required was for important problems, where prompt solutions were needed and usually consisted of the product or technical information. Additionally, they required information that would update their knowledge regarding new techniques emerged in the industry. Snow concludes that continuous information gathered from architects, leads to better decision making, thus they constantly seek to educate themselves.

We came across an article "Friendly User Interface Design for Architects in An Energy Simulation Tool" that focuses specifically on architects in the field of energy consumption (Paryudi & Fenz, 2015). Another frailty of the traditional simulation tools are problems of communication and lack of intuitiveness and complex user interface (Paryudi & Fenz, 2015). Thus, they carried out a user interface survey to know which user interface for evaluating the building's energy consumption tool is preferred by architects.

The authors (Paryudi & Fenz, 2015) followed the principles of HCI and user interface design which are usability, consistency, simplicity and aesthetics for developing the design of the interface. They made three different screens for inputting the building information and each interface had different usability, but the same function. Some differences were in layout colors, drop menu or the way of the input value. The survey was carried out with 15 architects, who never used a simulation tool before. All participants were asked to play with all three interfaces and answer a questionnaire. The majority chose an interface that had pictures and drop-down menus, the visual interface than textual is more appealing: *"In daily life, architects work with drawings, therefore they like to work with images"*

(Paryudi & Fenz, 2015). Architects need a tool that has a representation of simulation input and output, easy navigation, flexible and customizable control, in addition to intelligent failures (Attia, Beltran, De Herde & Hensen, 2009).

Elliott (2002) in his practice was one of the rare examples who observed architects' work practices, including some information retrieval practices to inform design. She enrolled in a design studio course and conducted an ethnography study as a participant-observer, together with interviews and office visits. She highlighted that it is very common to sketch, make collages or browse images among architects. The author also observed that looking at the pictures, such as historical buildings, site plans or maps are the main triggers to start a design project and share them with colleagues at the beginning of the design process. Another interesting thing was that architects do not like to search pictures online, it either fails to provide the "right kind of information" or provides "just too much information." Instead, they prefer magazines and journals or conversation with co-workers (Elliott, 2002).

In the paper "Learning from architects: the difference between knowledge visualization and information visualization" Burkhard delves into how architects use visualizations to increase perception and share the knowledge (Burkhard 2004). The author presents that architects are generalists and experts when transferring knowledge among experts from different fields (engineers, lawyers, customers). The results he found during the analysis of the visual representation for sharing knowledge was that architects combine several visualization examples that supplement one another to illustrate different levels of details. A promising way to reduce information overload and improve decision making is to connect traditional visualization with the new information visualizations (Burkhard 2004).

2.2.2 Architectural design and the use of technology

The thesis "Conceptual Design for architects" (Parthenios, 2005) examines if technology can bridge the gap between analogue and digital and if the extra tools that were presented with technology can improve the architects' ability to design. The use of information technology improved the architectural practice with the introduction of new tools that allowed architects to create more accurate designs, quicker and easier (Parthenios, 2005). The traditional architectural practice expanded and allowed the architects to expand the area of their services. Architects are now able to

involve clients earlier in the design process by presenting them with analyzes of former project information and can use digital expertise to assist *"...facility management and control life-cycle costs"* (Parthenios, 2005).

The perception of a number of researchers is that designing relates greatly to solving ill-defined or ill-structured problems (Goel, 1997). The problems fall under such a category because they do have an unclear target state and usually not a set of processes that must be followed (Simon, 2006). This was supported by other authors, such as Parthenios (2005) and Simon (1979). Holyoak (1990) expanded the definition of ill-defined problems by stating that they require a restructuring of the problem description in contrast to "ordinary" problems that normally where there are algorithms to conduct a step by step search in the process of solving a problem.

Architects draw their ideas on paper and as they inspect their sketches, they imagine ways to transform their ideas. Schon and Wiggins (1992), describe this practice as a conversation between the architects and their ideas. Through the design of incomplete or vague sketches, they are exploring alternative design ideas which can lead to many design solutions (Koutamanis, Timmermans & Vermeulen, 1995).

According to the research of Parthenios (2005) the majority of architects believe that designing a concept is an individual process, not a collaborative one. They explore a couple of ideas at the start before they select one to advance with the evolution of the idea through designing. The results of the survey with 242 respondents demonstrate that the least experienced architects explore more ideas than their most experienced counterparts. In addition, eighty percent of the architects during the initial phase of designing use hand-drawn sketches. Less than three percent of the survey respondents stated that they conduct their work on advanced 3D modelling software. The survey showed that the building information (BIM) tools, even though are able to cover the whole designing process, very few architects use them during conceptual design.

Additionally, they stated in the survey that paper and pencil is the most preferred tool regardless of the computer software they possess. In case they use computer software, they evaluate the ease of use of the platform, the speed, the ability to work in 3D and the flexibility it provides in order to decide which tool to use. Digital tools should empower an architect to design with the freedom and make

the process as simple as possible, because eventually *"The goal is to empower the architect, not the tools"* (Parthenios, 2005).

Laseau (2007) states that when architects search for finished projects, they say that sketches are necessary to understand the step-by-step process, but they prefer photos of the finished work. The architects pay attention to spaces, lights, color, textures, patterns or shapes and how those elements are combined. Architects are considered problem solvers, but the design problems by nature are considered difficult to solve with just practical expertise, thus architecture is an art as well as a science.

2.2.3 What is knowledge sharing?

In the scientific world, a way of transferring the created or found knowledge from one another is called knowledge sharing (Sergeeva & Andreeva, 2016). Thus, knowledge sharing plays a key role into a team's success and effectiveness (Wang & Wang, 2012) and can potentially support a team to be ahead of the competition (Renzl, 2008). Knowledge sharing as a process is more effective when there are healthy interpersonal relationships (Lin, Wu & Lu, 2012) between the parties that share knowledge and the combination of the individual's knowledge elevates the knowledge level of a team (Wang & Noe, 2010).

Competitive environments do not exclusively exist in the corporate world but they often appear in academia, thus scientists may embrace the idea of collecting knowledge but not share, so they have a competitive advantage (Park & Gabbard, 2018). As a result, a number of scientists decide not to share the knowledge, despite the individual benefits (Cabrera & Cabrera, 2002). Even though the results-sharing process can lead to an increase of the citation rates (Piwowar & Chapman, 2010), in certain situations the form of the data is considered unshareable due to ethical or legal reasons (Borgman, 2012).

This project focuses on the construction industry and specifically to thermal insulations of classical buildings. The industry is identified as knowledge-intensive and the requirements of knowledge sharing between professionals that have the expertise are considered invaluable (Egbu & Robinson, 2005). Knowledge sharing in the construction industry can improve innovation, work efficiency and decision-making processes (Fong & Chu, 2006). Another important factor of knowledge sharing in

the industry is the transferable knowledge from one project to the next, which leads to the reduction of errors and the utilization of previously tested methods (Ma, Qi & Wang, 2008).

The knowledge sharing practice is relatable to RIBuild project because of the immense amount of research conducted during the multiple work packages of the project. The generated data from the scientists that worked for the project will be transformed into user guidelines to a public web platform. Hence, the knowledge generated by researchers will be available to architects, for the purpose of improving their understanding of the field they operate on.

Knowledge sharing in architect's environment

Authors Farenhorst & Vliet (2009) did a four years research study in the software development company (CAP) to observe and build an understanding of knowledge sharing activity in architects' environment (Farenhorst & Vliet, 2009) They been following a research cycle to understand what architects in practice do and what support they need in regards to architectural knowledge sharing, by conducting interviews with architects, desk research of documentation and tools they use during architecture process. They found out that support tools for knowledge sharing should be easy to use and understand, intuitive and responsive in order to engage architects in using them. Also, to provide architectural knowledge should be easily accessible. The efficiency of fast search through the piles of data to find the right knowledge pieces at the right time is essential for architects. Since architects are decision makers, who keep a backlog of smaller needs, issues, problems, and challenges, they definitely benefit from access to and delivery of relevant architectural knowledge at the right point to make well-founded decisions in time (Kerschberg and Jeong, 2005).

Another discovery was that architects were not so motivated in sharing knowledge because of the poor usability of knowledge management tools and outdated content (Farenhorst & Vliet, 2009). Supporting architects for reusable architectural guidelines or practices and search support for relevant information are one out of many things that architects need for expanding and enriching their knowledge (Farenhorst & Vliet, 2009). Also, the authors explored the benefit of using knowledge management system Wiki for sharing architectural knowledge. Wikis are strong in community building, supporting collaboration which makes them perfect for the architecting process. Facilities to have discussions, grouped editing features and intuitive user interface make Wikis informal yet convenient platform. Moreover, wikis create the "community of architects", therefore everybody that

is a part of it knows where specific expertise or knowledge comes from. Only these lightweight knowledge platforms such as wiki motivate architects to visit these sites (Farenhorst & Vliet 2008).

Knowledge sharing platforms for architects

In the following section, we describe knowledge sharing platforms SBi (Statens Byggeforskningsinstitut) and BYG-ERFA that provide information for professionals in the construction field. We found it relevant to explore these platforms and get familiar with the architect's information sources.

SBi - Statens Byggeforskningsinstitut

SBi is also called Danish national building research institute and is broadly used by architects, engineers and researchers within the construction industry, more specifically within knowledge sharing of internal building insulation. SBi is part of Aalborg University and is located in Copenhagen's South Harbour, together with the rest of Aalborg University in Copenhagen.

According to SBi's[1] website their main goal is to create research-based knowledge that improves the construction industries' processes and to improve the building environment. The effort is based on application-oriented research in the international class, and the customers of the organisation are from spanning from authorities in municipalities to building designers (architects, engineers) and building owners. Throughout the years SBi has been recognised for its independent position and strong relation to many large construction companies and organisations in improving practical solutions in construction and housing sector. The institute's guidelines are known in the industry for the new, researched and feasible solutions that meet the authorities' requirements. In some instances, SBi is also affecting decisions that are regulating building codes in Denmark, meaning that SBi has a strong and proven position in the construction industry.

BYG-EFRA

BYG-ERFA[2] is an independent organization whose mission is to help improve the technical quality of the construction. BYG-ERFA is organized as the foundation and was founded in 1977. BYG-

[1] https://sbi.dk/

[2] https://byg-erfa.dk/

ERFA processes building technical experiences collects and disseminates building technical experiences from construction practice and research. The distribution takes place primarily through an experienced sheet written by experts. These experience sheets are quality approved and certified by BYG-ERFA's Engineer Group. The intention is to prevent and improve failures in the most appropriate way and to incorporate good building technical experience from practice as far as possible.

The dissemination of experience is especially aimed at professionals in the construction industry, such as project designers, supervisory architects, engineers, constructors, craftsmen, contractors and others. Through the website, users can to read about the specific by material or issue.

The interface of the page is relatively minimalistic, easy to navigate, especially the part where users can select building part, material and problem and get specific information about that. There is also a search option, for etc. single keyword of an article publication. Moreover, users are able to log in and share their experiences with others, however, this experience sheet is accessible only with a paid subscription.

2.2.4 Expert interview

We conducted an expert interview with Morten, project leader of RIBuild, at the beginning of the study. The purpose of the interview was to ensure the quality of the research, strengthen the research intentions and gain a valuable perspective of the project. Since the interview validates the viability of the given information, we chose to place it at this point in the report. The interview questions can be found in appendix 5.

The purpose of this project is to gather information about internal insulation because as Morten explains, there is definitely a need for it in Denmark. There were many failures with insulation process in classical buildings: *"Many historic buildings are retrofitted with insulation, but often the insulation creates new problems such as moisture damage. We need knowledge on how to handle internal insulation in historic buildings,"* says project coordinator and senior researcher Ernst Jan de Place Hansen from the Danish Building Research Institute at Aalborg University Copenhagen.

Professionals in the field visit SBi website for different purposes when working within construction projects, however, in terms of thermal insulation, the information is quite vague. There is no step by step process or advice on how to use internal insulation and when the right time is to do it. Therefore, there is a good reason for creating an online website that will present more comprehensive knowledge. Morten, the project supervisor, argues that it is important to get more knowledge and inform users on what happens with a different type of material.

Furthermore, it would help local partner countries to get new recommendations based on the knowledge that the platform provides. The motivation for ERIK Arkiteker is to become the most experienced architect firm with this knowledge, especially as they have many projects concerning the topic. Additionally, it is a good way to contribute more information to the RIBuild project and work closely with research material. This helps not only for the employees but also for the company's business prospects.

Professionals in the field are afraid to damage buildings because they are not knowledgeable enough on how to start the insulation process and maintain the building. Especially in Denmark, there are a lot of buildings with mould growth and other damages, therefore there is a need to make a tool that advises on how to make the correct decision and save city heritage. And that is a genuine motivation for them to become users of this platform.

The stakeholders of this project are seven universities from Europe, AAU and DTU universities from Copenhagen, European Commission, board members and private engineering companies. They are not fully integrated into the process but involved as an advisory board.

There are similar research projects with a holistic perspective on how to automatize insulation processes, but none are focused on internal insulation. That is the reason why this project is funded by the EU, because the topic is narrow and was demanded by professionals in the field.

3 Theory

The theory of choice that would provide us with the necessary theoretical knowledge for creating a methodological structure for this study is Human-Computer Interaction, which is presented below.

3.1 Human-Computer Interaction (HCI)

The HCI term appeared in the 1980's and is a discipline which involves the design, implementation and evaluation of digital environments created by designers in relation to the users (Dix, Finlay, Abowd, Beale, 2004). The relatively recent growth of digital technology and applications brought HCI in the spotlight due to the evaluation and research of people that interact with digital systems (Colombo, 2011).

The HCI focuses on understanding how humans interact with technology, however, design is also a part of HCI. The designers should understand computers and people before they proceed in the design phase, as well as identify the goals of the design (Dix, Finlay, Abowd, Beale, 2004). We assume that people have built mental models, that is, psychological representations of the ways in which computers and websites operate (Zaphiris, Panayiotis & Ang, Chee Siang, 2009). In the human-computer interaction book, the authors advice the designer to ask questions like, what is the purpose of the product, for who we design and why they need it, is important to know before the implementation phase (Dix, Finlay, Abowd, Beale, 2004). Based on that suggestion, our scope was to do research about our users and familiarize with their preferences and behaviors. We selected the participatory design method, which is presented in the methodology chapter, as our socio-organizational approach. According to our evaluation, the architects as identified end users, due to the nature of their work would be ideal subjects for collaboration in design.

In addition, we selected interviews as a way of receiving structured and direct inputs from the users (Dix, Finlay, Abowd, Beale, 2004). The qualitative research and the selected method of interviewing is presented in the methodology chapter. Additionally, we selected surveys as an early contributor to the design (Dix, Finlay, Abowd, Beale, 2004). The survey method is discussed in the methodology chapter along with the usability testing which was selected for the evaluation of our prototype based on the users' feedback (Dix, Finlay, Abowd, Beale, 2004).

It is a common theme in the industry that designers and users are unaware of problems (Thimbleby, 2018). The users do not pay attention to poor design due to their busy schedule and it is the designer's responsibility to produce the best solution (Thimbleby, 2018), which supports our decision for conducting research related to the users' behaviour and needs.

According to the Wiley Handbook of Human-Computer Interaction Set (Norman & Kirakowski, 2018), HCI interaction in numerous cases directed the creations of products by designers that were not based on reliable reasoning about design through mathematics. The observation of users through empirical experiments and statistics only is lacking valuable information that can assist the designers with the development of design principles for products (Norman & Kirakowski, 2018). During experiments that were conducted for the purpose of evaluating user interfaces, HCI alone assisted the researchers in identifying which solution is better, but without mathematical evidence, the reasoning behind the decisions is lacking.

That leads to less insightful projects and the designers that will continue the work on or create similar solutions lack critical data (Norman & Kirakowski, 2018). There is a trend between designers, researchers and psychologists to rarely use mathematics in order to validate their results due to their inexperience with mathematics (Norman & Kirakowski, 2018). This is problematic because their job could be acceptable even if they ignore these issues, but it lacks reasoning and depth (Norman & Kirakowski, 2018). This is another reason for combining the HCI theories, with usability testing of the prototype. We estimated that this would provide us with enough mathematical evidence in order to evaluate the user interface we designed. The usability testing results are presented in the analysis section of the report

A product operates as a problem-solving solution with the purpose of improving human lives. (Thimbleby, 2018). He argues that by observing the world and through empirical experiments and statistics, the obtained knowledge is not sufficient in order to create design principles for systems. Thus, we expanded our research with the theory of interaction design and information architecture for the purpose of educating ourselves with the fundamentals of designing for digital environments. The theories that we extracted from interaction design and information architecture literature are presented in the methodology chapter.

The authors of the "Human-Computer Interaction" book describe the prototyping as a hill climbing process (Dix, Finlay, Abowd, Beale, 2004). Meaning that an individual moving steadily to the top and eventually they will reach it (Dix, Finlay, Abowd, Beale, 2004).

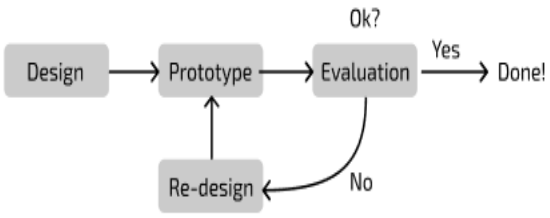


Figure 2 Prototype process in HCI field.

This description fits our process, because the goal is to create a prototype and improve it until it meets the user needs. We created figure 2 based on the book's description about the prototype role. The following section presents the chosen methodology of this study.

4 Methodology

We used the following methods based on the Human-Computer Interaction for collecting data that establishes the bases for our analysis. In the section we describe the actions taken in order to gather relevant data. The ethical concerns that were considered throughout our data collection process are described in the end of this section.

4.1 Participatory design

As mentioned in HCI theory, participatory design was selected as our socio-organizational approach for the study. In order to develop a prototype, we found it relevant to include the primary users in the design process, this decision was highly affected by the motivations to assure that the prototype meets the user requirements.

Participatory design represents an approach in which stakeholders attempt to be actively involved in the designing process as a means of meeting and understand the user needs (Schuler & Namioka, 1993). Participatory design firstly appeared in Scandinavia in the 1970s and was called cooperative design, however, the wording did not resonate to the actions, therefore it was later on changed to Participatory design (Kensing & Blomberg, 1998). Participatory Design differs from traditional design in several ways and reflects a fundamental change in the traditional relationship among different stakeholders. It enables a wide range of people to contribute to the formulation of a given problem, technology or discipline. It can also be used in circumstances that are culturally sensitive or hard to observe (Schuler & Namioka, 1993). Participants are invited to cooperate with researchers, designers or developers in the innovation process, define potential issues, create ideas and discuss. The method is a collaborative activity where participants represent real-users in various situations and activities.

A key principle of participatory design is that participants become the center of the design process. Selected participants are usually experts in the field and are affected or attempt to resolve a particular challenge. Then, it becomes natural to get insights based on real needs of the potential users rather than assumptions, which higher the chances of ensuring a successful outcome. Furthermore, end-user's participation in the design process helps to accelerate the process and the final solution is closer to their needs (Kensing & Blomberg, 1998). Participatory Design approach is valuable for both

parties, because it also focuses on a participant's strengths rather than weaknesses, by harnessing each person's qualifications, knowledge, and resources. Moreover, there are different ways to facilitate the ideation process, involving users. For example, personas, card sorting, user journeys, storyboards, workshops or future workshops to aid a "*...common language, to discuss existing reality, to investigate future visions.*" (Schuler & Namioka, 1993). All participants are involved throughout the entire development process, as well in the decision making. If the end users do not have any influence in the decision making, and all the final choices are made by the others, the participatory design fails its goal (Kensing & Blomberg, 1998). Facilitation is the key to achieve an effective participatory design process, whereas the facilitator is responsible for the engagement of each participant by guiding and comforting. (Sanoff, 2011)

Participatory design is already inherent in architects' practice as stated by Lim & Rahman (2016), the perception of the design itself, no matter if its space, building or product always starts from understanding the user, the goal and the stakeholders. Bringing the community in decision making, the ultimate object is to design something that is purposeful. *"At the end of the day we leave them with what we designed together, it is about empowering them to take ownership of their space"* (Lim & Rahman, 2016). Considering the project at hand, developing a digital platform for architects makes the participatory design the ideal approach to implement when designing a sustainable platform.

Inspired by the participatory design method we decided to conduct co-creation workshops. We engaged our target users in design activities in order to uncover new ideas, refine concepts or flows and developed the final interface based on given inputs.

4.2 Design Thinking

Design thinking perceived as a powerful methodology for innovation and user enablement (Pourdehnad, 2011). We aim to develop a digital prototype for architects by following the design thinking process.

Nobel prize laureate and cognitive scientist Herbert Simon was one of the pioneers of design thinking (Liedtka, 2014). He shared many ideas during the 1970s which are now acknowledged as principles of design thinking. Design thinking is widely used across a range of industries, such as healthcare, business, education, and architecture, and is still explored and enhanced by others (Liedtka, 2014).

Design Thinking refers to a cognitive, strategic and creative approach that presents solution-based practices from embracing to solving complex problems that are unknown or hard to define by starting from the human-centered perspective (Liedtka, 2014). As a solution-based approach design thinking is especially useful for approaching the so-called "wicked" problems. Wicked problems are hard to define because of their unfinished, different, and changing requirements that are often difficult to recognize, as well Buchanan (1992) opposed to the wicked problem "tame" or "well-defined" problem is with known solutions from the beginning. Defining and shaping the problem is a big part of the Design Thinking process.

Problems and solutions are tested through experimentation rather than analysis (Beckman and Barry, 2007). Moreover, Design Thinking focuses on creating products and services that are human-centered, but the process itself address the needs of the people who will use the product or service and the infrastructure that enables it (Brown & Wyatt, 2010).

We decided to follow Design thinking due to its supported empathy for people, a direction to define problem faster and explore more options with its iterative nature. By including the users from the beginning of the design process, we were more certain that we will identify the right problem and design the solution that will satisfy users. Design thinking encourages to follow the iterative and non-linear process by having overlaps, rapid prototyping and in-depth analysis. There are five stages in the Design Thinking process based on Brown (2008).

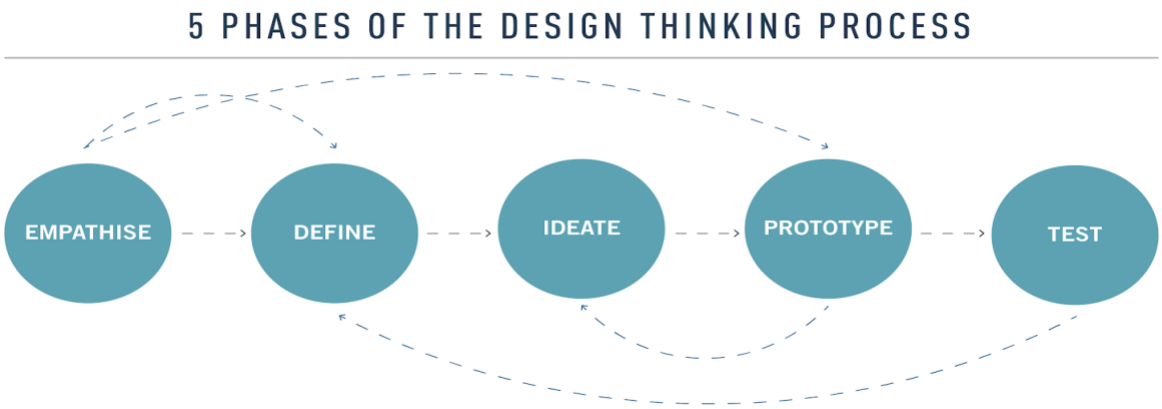


Figure 3 The five stages of the Design Thinking process. (Brown, 2008)

Stage 1. Empathize

The first stage of the Design Thinking process is to gain an empathic understanding of the problem and the issues that we are trying to solve through user research (Brown, 2008). This involved consulting with the experts of the RIBuild project to find out more about the area, experiences, motivations and collect relevant information to proceed to the next phase (Brown, 2008). We started with the meetings with several experts from ERIK Arkitekter office, Aalborg University and DTU that are all a part of the development process. In order to understand the environment and people we are designing for, we were located at their office for the period of our study, therefore the context soon became familiar. We observed their daily work habits, environment, the material they work with as well as their interactions during work processes. Additionally, we searched for relevant literature to gain a better understanding of architect's characteristics regarding their visual preferences, habits and information seeking.

Stage 2. Define

The second stage of Design Thinking is the define stage. During this stage the information from the empathize step is derived and analyzed (ALTEN Calsoft, 2018). After the initial background interview with a project leader, we defined the problem we needed to solve based on the project scope and objectives. In the define phase, we ended up revising solutions and exploring opportunities on which methods would be ideal for understanding the user. Eventually, we reframed and defined the problem from the user-centered perspective and proceeded with the ideation phase.

Stage 3. Ideate

The ideate phase is the most critical phase in the design thinking process. The team was challenged to brainstorm and think about ideas and solutions or alternative ways to look at the core problem. Information gathered in the Empathise and Define phases was used as an inspiration for the Ideate phase. With this solid background and information, it is important to get as many ideas or problem solutions as possible at the beginning of the Ideation phase: *"Quantity is key here, the more ideas the better"* (ALTEN Calsoft, 2018). Several activities as sketching, card sorting or brainstorming workshop help to generate ideas faster. We decided to conduct a co-creation workshop in order to gather diverse ideas for the next phase. The workshop was a convenient method, where we were able to observe and understand our users in their work environment. Moreover, by including users in the ideation phase, we got a higher amount and more quality ideas as they were suggested by the users

themselves. We used card sorting activity where participants played with different layout of the design to create a desirable interface. Also, we carried out four interviews with four architects to find out about their visual practices. Additionally, we conducted surveys to gain an understanding of their current knowledge regarding insulation topic.

Stage 4. Prototype

During the prototyping phase, a number of the inexpensive, scaled down versions of the product or specific features within the product are developed. Some examples are paper prototypes, wireframes or paper boxes. It allows quickly visualize and identify the best solution among several concepts (ALTEN Calsoft, 2018). The level of interactivity is not so important here, as the goal is to collect users' feedback, progress and re-examined on the basis of the users' experiences. Prototypes can be shared with an internal group of people outside the design team. After workshops, interviews and surveys we collected enough information to proceed with the prototyping phase. We developed several layouts of the interface containing different features in order to be prepared for the usability test.

Stage 5. Test

This is the final stage of the Design thinking, an iterative process, the results are generated during the testing phase and used to redefine one or more problems and inform the understanding of the users, the conditions of use, how people think, behave, and feel (ALTEN Calsoft, 2018). The goal of this is to collect feedback and change or improve accordingly. We conducted usability testing with employees with four architects to evaluate usability, navigation, and functionality of the interface. Also, we conducted usability testing with given scenarios to measure time, clicks and evaluate overall navigation. In this case, we were able to see if the structure and website flow makes sense for the users.

4.3 Qualitative Research

One popular methods of qualitative research are interviews. It is usually used in an exploratory practice which tries to investigate the subjective interpretations of social phenomena. We chose to do interviews in an attempt to understand architects' point of view, expand on the knowledge collected and generate insights in the area we are investigating (Kvale and Brinkmann, 2008).

There are three types of interviews, the structured interviews, the unstructured interviews, and the semi-structured interviews. Structured interviews use questionnaires that have identical and standardized questions that follow the same pattern. In semi-structured interviews, the researcher prepares the list of questions, but the flow of the interview may vary depending on the nature of the conversation (Bryman, 2016). The purpose is to encourage the participants to speak their mind while remaining on the topic chosen by the researcher. Additionally, the researcher also has the chance to ask emerged questions that build on the responses discussed. Interview guide questions might change slightly change from the answers given by participants (Bryman, 2016).

Conducting unstructured or semi-structured interviews can be separated into steps: development of the interview guide, recruitment of participants, execution of the interview, and processing the collected data. Moreover, it is suggested to test the interview guide before conducting the final interviews, same as practicalities of the interviews should be handled beforehand. One of the cons of interview methodology that the process is time-consuming, which is one of the main disadvantages of the interview methodology (Bryman, 2016).

The most common way to conduct interviews face-to-face, even though there is a possibility to do it on the phone or on the social media. Face-to-face interviews enables to notice opinions, expressions and perceptions of the interview topics. This also higher the chances of recognizing non-verbal signs, like body language or emotions (Hanington & Martin, 2012).

4.3.1 Semi-Structured interviews

We chose to proceed with semi-structured interviews in order follow up or add clarifying questions, also to give the freedom to the interviewee and to reply in an open manner. The interview resulted in the collection of qualitative data, which gave us valuable insights into their work process, materials and tools use the use in their practice. The collected responses complemented us in answering RQ1 (How visual information affects architects work?) and RQ2 (What type of information users want to be provided with?) and will support in understanding the user needs, practices and experiences with technology for the purpose of implicating design (Dix, Finlay, Abowd, Beale, 2003). The interview guide we created is presented in the appendix 6.

Participants

We interviewed four architects working at ERIK Arkiteker office. All the participants were from Denmark and they use English as their second language.

Setting

The interview took place at ERIK Arkitekter office. One of the authors was responsible for carrying out the interview while the other ensured that recorded audio was functioning through the interview and taking notes. We informed the interviewees beforehand about the duration of the interview and our aim was to have 20 minutes for questions and some spare time to examine topics of particular interest for our research purposes.

Those are the themes of the created questions.

1. Personal information
2. Tasks at work
3. Work environment
4. Visual information
5. Sources and methods of finding information
6. Features of desirable digital platform

There was no time restriction and the interviewees were able to ask clarifying questions if needed. One of the criteria of a successful interview is to interpret, clarify and extend on the meaning of the answer (Kvale and Brinkmann, 2015). In addition, we set several criteria for our interview questions in order to obtain knowledge regarding our case. As mentioned, we created our questions based on the research questions. We proceeded with clear and precise communication with the participants of the interview, in order to maximize our changes of getting quality responses from their part.

The interview questions were created in an easy to understand language, due to the fact that the communication was in English and neither us nor the participants were a native English speaker. The participants of the interview were considered as a potential user of the end product.

Furthermore, we created the questions in a manner that would discourage to give us “yes” or “no” answers and we avoided leading questions. The questions were designed with the purpose of

imagining the world interviewees live in and the interviews were recorded by a smartphone device so it can be re-listened to ensure a full comprehension during analysis (Bryman, 2016).

Before the start of the interview Kvale and Brinkmann (2015) recommends for the interviewer to describe the interview goals to the interviewee. By providing this information, the interviewee will have a better grasp of the goal and us as interviewers, thus allowing them to engage in more open discussion. This also increases the chances to build the relationship faster and encourage respondents to want to participate in the interview and speak up (Bryman, 2016). Therefore, we created introductory questions to the interviewee and their typical day at work to get started. Some of the questions were: "*Tell us about the goals that you strive to achieve in your work?*", *"Can you walk me through a typical work day?"* From this, it was easy to transition to more specific questions.

4.3.2 Content Analysis

For analyzing our interview data, we followed the stage-by-stage process by Burnard (1991) and Erligsson and Brysiewicz (2017) for content analysis, with some variations. The purpose was to understand main concepts, identify themes and patterns in participant's answers and summarize these concepts in a quantitative manner.

We used COREQ (Consolidated Criteria for Reporting Qualitative Studies) to structure, guide and prepare for analysis of our incoming data (Appendix 4).

The process of content analysis

We read the transcripts and we created condensations, which assisted us with the theme identification. Then we individually read the condensed text and identified general themes and compared our findings. The next task was to create codes for each condensed unit and by merging the similar or duplicate codes. The categories based on the coded units were connected to the transcripts. We created a table that presents all the themes, categories and codes of the process, which is presented in chapter 5.1. Additionally, we created examples of the categories based on the transcript. The last step was to connect the gathered data with the literature. In addition, we followed the suggestion from Erlingsson and Brysiewicz (2017), "*use and trust your own intuition during the analysis process.*"

Validity & Reliability

Validity along with reliability should be the main concerns to any qualitative research, starting from the research design to analysis of the results and measuring their quality (Golafshani, 2003). The validity of the categorization process needs to be considered. The researcher should balance out his own biases and subjectivity, to make sense of the interview data and understand other's perceptual world (Burnard, 1991) One of the methods on how to measure the validity in the interviews, is to invite a researcher who is not familiar with the project to go through the transcripts and identify categories. However, as mentioned before, we decided to offset this process and that might affect the validity of the results. Nevertheless, we did code and created categories from the interviews that were conducted following content analysis method. To ensure reliability, we coded the same text in the same way, also generated similar results when repeated under identical conditions. This allowed us to evade from individual interpretations of the data and construct a valid and reliable procedure for analysis (Lazar, Feng & Hochheiser, 2010).

4.3.3 Co-creation workshop

Inspired by the participatory design approach we involved architects in the designing phase, because they are users of the platform (Schuler & Namioka, 1993). Based on the research, group discussions stimulate the ideation process (Stembert, 2017), we decided to conduct co-creation workshops. According to Stembert (2017) workshops can start with an open question or a very specific challenge that needs to be solved. Our objectives for the workshop were to understand the users and their needs. An addition goal was to facilitate the co-creation process with them in order to produce paper prototypes.

We were facilitating and guiding participants through the session, kept the track of time and made sure the participants followed the structure (Stembert, 2017). With every step users were guided in the process, observed and listened to, while they were working (Stembert, 2017). During the process, the architects generated ideas, which were discussed and noted. Moreover, pictures and video recordings obtained from the session. Based on Stembert (2017) the material should be digitalized right away, and video reviewed several times to gather insights, identify topics or patterns, requirements and about needs of the participants. It is recommended to write down quotations of the participants and interpreted by the researcher or left originally (Stembert, 2017). However, there is

no fixed method on how to analyse workshops, because the data collected varies depending on the case as well as the objectives. Thus, it is not recommended to draw major conclusions from the data, which was also confirmed in workshops study by Ørngreen & Levinsen (2017). Participants were given the task to collaborate in pairs and produce wireframes. It is also important to mention that the goal was not to define a perfect solution for the interface, but rather understand the users needs.

Participants

We recruited four professionals from ERIK Arkitekter office in the field of architecture for the workshops. Since the group size group was relatively small, it was possible to keep group discussion going, as well as to have an individual contribution if asked (Stembert, 2017). Participants were redirected by our supervisor at ERIK Arkitekter office.

Materials

We video recorded the workshop using a smartphone. During the workshop, we printed out different design cards figure 4,5 prepared sticky notes, white papers and board so the participants found everything that they need to build their mock-ups without with ease. The goal of the workshop was to produce paper wireframes, knowing that the paper prototyping enables people to create designs based on their ideas (Zaphiris & Ang, 2009). We made approximately 10 different cards, mostly navigation options, homepage and guidance cards for different features of the website.

Figure 4,5 Set up of the workshop and design cards that were on the participants disposal for use.

Validity & Reliability

During the workshop, we were aware that not everyone will be equally expressive. Several factors could influence validity, which indicates whether we examine what was intended. One argument could be discomfort among the participants, which could have caused some participants not expressing their honest opinion. According to Ørngreen & Levinsen (2017) participants in the workshops usually find it difficult to express themselves especially if talking about technological development or changes, due to the lack of common language (Ørngreen & Levinsen, 2017).

Another issue with doing workshops in English, which is the non-native language of the participants, might predispose difficulties in expressing both the explanations of tasks and the feedback session (Bryman, 2012). When we noticed that some of the participants felt uncomfortable speaking in a group in English, we asked another participant to translate in Danish. This could have caused a misunderstanding of words and potentially have influenced the validity (Bryman, 2012). To prevent uncomfortable feeling in the session, we tried our best to create an informal atmosphere and highlighted that participants have full freedom when doing the task. However, we can only make the assumption that we made the participants feel comfortable. In order to increase the reliability of the results, Stembert (2017) proposes to show researchers' interpretations from the workshops to the participants and ask if they agreed with them. However, this was not possible due to the participants availability.

4.3.3.1 Card sorting

We carefully chose methods that involve users in the designing process, especially that the content has many features and design elements, we decided to have a card sorting to give the full control for the users. Architects will be the users of the website; it is reasonable to include them in the construction and evaluation of the menu and layout of the website. One of the complementary user research techniques for obtaining relevant information and classifying or sorting the cards in order to improve interface design is card sorting (Spencer 2009). It is a valid way to evaluate the information architecture of a site and gain quick input on how users think to assure systems are structured to fit their way of thinking and their motivation in the decision making. The name of the technique is pretty straightforward, users are given a set of cards with the content in it and they are asked to group them, give labels and organize items. Card sorting is the most effective when the content and information

is provided, but there is no fixed way of how it should be organized (Goodman, Kuniasky & Moead, 2012).

There are two types of card sorting: Open and Closed. Open card sorting is when users can create their own cards and add missing thoughts, while closed means that the participant can use only the cards that are provided by the interviewers (Spencer, 2009). Often participants follow their intuition and place the cards naturally, relating one to another. Therefore, it helps to understand grouping patterns and people we are designing for, discuss, argue and talk about the card content. This initiates a discussion, which is especially valuable and sometimes more beneficial than the outcome of the card sort (Spencer, 2009).

Afterwards, the similarities and differences among participants are compared and analysed and outcomes are applied to the project. Even though this method could be done individually, in small or large groups, it is recommended to have a smaller group of people where it is easy to start a debate or a discussion, also avoid dominant behaviour in the team that could force his opinion on others (Spencer, 2009).

We chose this technique because it is inexpensive and convenient for us and participants to have a card sorting session at the ERIK Arkitekter office. Card sorting activity will be incorporated as part of the workshops and will give us an idea on the participant's mindset and which elements from the interface make sense and which do not. Also, this will provide insights about information structure on the website. We chose to have an open card session, where the cards are features, elements or content of the website. In this scenario, we split participants into groups where they will be asked to choose which cards, they need for navigating in the website and which creates a logical user flow.

4.4 Quantitative data

Quantitative data collection focuses on numerical variables and values that can be measured, categorised and analysed (Williams & Babbie, 2006). The data is usually collected in a structured manner, and all aspects are carefully considered before quantitative data is collected. The data received is in the form of numbers and statistics, visualised in tables or figures. Due to the benefit of the method and convenience sampling we decided to proceed with survey as one of our research methods (Williams & Babbie, 2006).

4.4.1 Survey

Survey use is a popular data collection method within the Human-Computer Interaction (HCI) context since the early days (Baecker, Grudin, Buxton, & Greenberg, 1995). We included surveys as a part of our research method to find out the architects' awareness regarding thermal internal insulation

Survey is a quantitative research method that effectively allows to find out who our potential users are and what opinions they hold (Goodman, Kuniasky & Moead, 2012). Surveys are also called self-completion questionnaires where the respondents complete the questionnaire on their own and fill the information about themselves. As opposed to the interviews, self-completion questionnaires have some benefits, such as speed, efficiency, and convenience. Surveys tend to collect results faster, as they can be easier to distribute to more people at once by reaching a diverse group of people (Bryman, 2012). Although, it is still recommended to choose surveys when the current population of users is decided in order to collect usable data that fit to the research question (Bryman, 2012).

Surveys are often more convenient for a participant to fill-in, especially if its web-based (Bryman, 2012). After preliminary qualitative research is done, it is suggested to continue with the survey, because the values and behaviours that are defined, could guide to formulate the questions to examine user's prevalence (Goodman, Kuniasky & Moead, 2012). Particular survey focus can be on various sorts of topics such as behaviour questions, preferences or factual information questions depending on the aim of the project (Bryman, 2012).

Even though surveys have advantages mentioned above, there are some things that need to be considered. One of the biggest challenges in web-based survey research is the lack of capacity to

guide the respondents and elaborate on the questions (Bryman, 2012). There is no direct interaction with the respondent, hence it can be hard to tell whether their answers of themselves and their habits are accurate and honest. There is also a chance that respondents may have trouble evaluating their own behaviour or have a weak recall of the details surrounding their behaviour (Bryman, 2012). In order to prevent confusing questions, the pilot test of the survey should be done before sending it out to the users.

Our population sample, architects, were accessible online through the emails in the current work placement, therefore, to acquire additional data for our research we chose to use web-based surveys. We divided the question into common categories to have a better overview of the purpose of each question. The questions can be found in Appendix 7.

The questions were split into sections, namely:

- Demographics
- Level of expertise
- Profiling and examining similar sources of information
- Knowledge question
- Test of knowledge
- Check hardware
- The intention of trying something new
- Expectations of content

Based on Goodman, Kuniasky and Moead (2012) the survey has to be as short as possible, preferably under 20 questions to bypass the risk of losing respondents attention and incompletion. Therefore, we created 10 relatively short questions.

To reduce any delusions from the respondents we made the questions simple and specific. In addition, to assure that the questions are not ambiguous, and terminology is correct, we conducted a pilot test with an architect who matched our population sample. Knowing that no changes can be made once the survey is sent out to keep statistical validity, it took additional time to finalize the questions, but, nevertheless, it was necessary to do a pilot test (Goodman, Kuniasky & Moead, 2012).

Questions

Respondents were asked their occupation and year in the industry in order to collect information on their level of experience within the field. It was important to know whether they have ever been involved in a project that is related to the thermal internal insulation of classic buildings (*Have you ever been involved in a project that is related to the thermal internal insulation of classic buildings?)*, as well as if they are confident enough with their current knowledge about internal insulation and, lastly, if they are aware of what causes algae to a building's wall and what is the procedure of removing it. This helped us to explore the demand for existing content of research papers. Based on Bryman (2012) respondents do not want to write a lot in the surveys, therefore we asked only one question *(What you would expect to find in a website that its sole purpose is to provide information about thermal internal insulation?)* that provided us with the relevant information which was taken into account when proceeding with prototype creation. All questions can be found in Appendix 7.

Survey Pilot test

In order to fine-tune the usability in our survey and receive more reliable and valid results, we piloted the survey on Morten from the expert interview, who works with insulation projects and corresponds to our population. To pilot test a survey is a significant part of its development and can reduce errors, evaluate the feasibility, identify problems or improve terminology in question formulation. A pilot test is implemented prior to large-scale research, ideally, with the participants that represent the sample population (Goodman, Kuniasky & Moead, 2012). To make sure that questions are clear, especially within the topic, we conducted a pilot test to get the feedback from the employees at ERIK Arkitekter. We attempted to carry the pilot test under the same conditions the real survey would be run. After the pilot test, based on participants feedback, we changed some vocabulary and answers' options. For instance, in the last question (*What you would expect to find in a website that its sole purpose is to provide information about thermal internal insulation?* (E.g. legislation information, pictures with examples, instructional videos, etc.) we added examples of the content, in order to help the respondents, understand different possibilities. Also, some minor changes were added, for e.g. in the third question (*When you are missing knowledge when you are conducting your daily work, where do you usually search for information?)* we added additional option where users can specify their source of knowledge if it's not mentioned in the options.

Validity & Reliability

We sent the survey link to every employee working at ERIK Arkitekter, however, respondents cannot serve as a representative sample of the entire architect population. Therefore, this can affect the reliability of the survey results. We asked the exact same set of questions in the same order; therefore, we can argue that our survey is reliable. In survey results, reliability relates to whether there is a consistency in the answers (Bryman, 2012). The accuracy of surveys depends on participants' willingness honestly tell their opinions or preferences. However, without direct contact with the respondents, it can be difficult to understand whether their answers are true. In most of our questions, we used predefined answer options then it is possible to replicate the survey and obtain similar results (Bryman, 2012). However, predefined answer options ensure that we measure what was intended, additionally increasing validity (Bryman, 2012).

4.4.2 Usability testing

Usability testing is recognized as a practice in creating Web sites and web-based products (Buller, 2014). It is described to be especially important for those, which require user interaction to be effective (Buller, 2014). In addition, it evaluates the easiness of use of a product, assists in the evaluation of the specific features or the functionality for a representative user group of the product. The users participate in the design phase, so direct input and feedback is obtained (Goodman, Kuniasky & Moead, 2012). Typically, end users are required to participate in a session where they need to interact with the product. The range of tasks can be very different this can be arranged in both settings: online and offline, with a smaller or larger group of people (Goodman, Kuniasky & Moead, 2012).

There are many techniques to conduct a usability test (Goodman, Kuniasky & Moead, 2012). Online studies such as surveys or e-mails is a simple way to reach out to a larger group of representative participants, but miss out the interaction part, while face-to-face studies provide feedback for the interaction of the users with the product, but lower number of people is reached. Usability tests in the lab are usually one-to-one sessions between the moderator and test participants. The moderator's job is to ask questions and lead the conversation by giving a set of tasks to perform. A common practise of the usability testing is to ask from the participants think aloud while performing various tasks. As explained by Lazar, Feng & Hoschheiser (2017) "*...the three most common measurements are task performance, time performance, and user satisfaction*" (Tullis & Albert, 2013).

Usability testing ensures that navigation of the system or product provides a flawless experience for the user. Usability applies to all aspects of the product where the user interaction is required. Even though the tests can be done at any stage of the development, yet it is more effective to conduct it early, so there is enough time to identify possible issues and make changes. An impediment for the usability testing we conducted, was that we had to design a fresh prototype. Thus, the usability testing unfortunate was conducted during the last phase of the project. (Goodman, Kuniasky & Moead, 2012)

The evaluation of the usability of a product or service is either formative or summative which depends on the goals the designers set for the evaluations. The formative evaluations aim to gather user feedback for further improvements. In contrast, the summative evaluation operates as a requirement checking for a product. (Hewett, 1986)

Jakob Grue Simonsen (2018) proposes that during the planning and scoping phase before the evaluation of user experience, the designers should create a set of considerations. We chose several of his proposed considerations which were relevant to our case.

- What is the purpose of the evaluation?

The purpose was to identify major flaws in our design, observe the users while interacting with our prototype in order to see the easiness of use and evaluate the navigation of our design.

- Measure the user experience?

The use of several metrics for tracking the effectiveness, the efficiency and the satisfaction are recommended, for example, binary task completion, error tracking or quality of outcome Hornbæk (2006). We measured the effectiveness based on the tasks completed and the errors for every task. The efficiency was measured based on the task time and the number of clicks. The satisfaction was measured based on the comments of the users while they interacted with the prototype. We chose those attributes for our measurements, based on the definition of usability by Bevan and Earthy (2018).

- Compare the experience in different prototypes?

We conducted two usability tests, the initial one provided with data based on the metrics and the think aloud method and we repeated the process for a second time, with what we considered, an improved version of the prototype.

- Interactive prototype?

Our prototype was interactive, and users could perform the assign tasks on it. The prototype was created in Figma software and programmed to respond to the users' inputs.

- Is the evaluation formative?

The evaluation was formative and aimed to improve initial design the design for future testing and continuous testing.

Participants

There is no ideal number regarding the participants of a test study and there is not a proven connection between the test users and the number of usability issues (Molich, Ede, Kaasgaard & Karyukin, 2004). Lewis (1994) states that when conducting formative testing the researchers are advised to recruit five participants and they would find approximately 80% of the issues in the platform, especially they test a simple system (Nielsen, 1994) (Virzi, 1992). To conduct a usability test we aimed to recruit five participants, as the theory suggests, but the usability testing was conducted with four participants, due to one cancelation. All the participants were architects working in ERIK Arkitekter office.

Material

The users should be presented with realistic test data, while they have all the tools available to conduct the testing (Bødker & Madsen, 1998). As mentioned, we used Figma software, which is an interface design tool for producing interactive prototypes. The interactive prototypes were functional in a laptop or desktop computers. We provided a laptop for the participant in order to perform the usability testing.

Validity & Reliability

Generally, it is difficult to guarantee reliability in tests due to the individual difference in people's abilities (Nielsen, 1993). Reliability refers to whether we will get the same time, click and errors measures from all participants, while validity is if the results are actually accurate and reveals usability issues (Nielsen, 1993). It is necessary to have a representative group of users of the platform to get valid results from a usability test. Therefore, we chose participants who had some preliminary knowledge of the insulation process. We were conscious of the observer influence, i.e., how we, as interviewers and observers, could affect the users and the test situation with our presence. Especially

when the screen recorder was on, users possibly felt under time pressure. During the usability test, we noticed that especially one of our questions (Where would you go press to register your building?) was slightly confusing to the test performance; particularly, our choice of words when presenting the tasks. Consequently, our choice of words may have affected the participants' action in the test situation. In addition, in order to ensure the validity of the testing, for the second usability test, we recruited different set of test users, so they had no interaction with the platform before. This way we ensured that the comparison of the two tests would provide us with reliable data.

4.5 Design Practises and Principles

In this section we describe two fundamental methodologies for designing interactive platforms. The first is Interaction Design and the second is Information Architecture.

4.5.1 Interaction Design

The selected content for the interaction design section was selected from the book “About Face: The essentials of interaction design” (Cooper, Reimann, Cronin, & Noessel, 2014). “Interaction Design is the practice of designing interactive digital products, environments, systems and services”. It is tightly connected with Human-Computer Interaction and it heavily focuses on the behavior of the users when they interact with digital environments.

The interaction design principles operate as guidelines that are associated with the behavior, the form and the content of a digital product. They are conceptual principles that assist us to define what makes a reliable digital product and how to satisfy the user requirements. The behavioral principles describe the ideal behavior of a product and the interface level principles describe strategies for optimizing the navigation through the system, the communication elements of the platform and the presented information. The primary purposes of interaction design are to secure fluid user experience when an individual interacts with a digital product, reduction of design time and effort on new products, along with the improvement of quality of the existing products. This is achievable through education of the designers and through communication between designers and developers (Cooper, Reimann, Cronin, & Noessel, 2014).

The digital products developed for several platforms, with the most notable being, desktop software, website, web applications, mobile devices and home entertainment systems like consoles. As a platform, we define the product's hardware and software that enables it to function. Additionally, we define the product's posture as the behavioral stance it has towards the users. The platform and the posture of the product are related because different platforms may promote different behaviors from the users.

The initial implementation of the interaction design techniques was for desktop computers. The desktop applications usually have three types of postures: the sovereign, the transient and the daemonic posture. The sovereign posture reflects on applications that capture the attention of the user for a long period of time. They usually use the full screen of the computer and they typically have a flow and they operate as the primary tool in the user screen. Those types of software target the intermediate PC users, due to the time devotion and attention they require by them. Thus, while creating a sovereign application the designer assumes that the novice user will quickly grow to an intermediate level user. The sovereign applications are usually designed for full-screen use and the colour palette should be conservative due to the long time we expect the users to interact with the platform. A lot of sovereign applications in the real-world focus on document viewing or creating and can be heavy in text (Cooper, Reimann, Cronin, & Noessel, 2014).

The transient posture products present a single feature and they appear on the screen when needed. After they operate their role, they leave the interface, so the users are able to continue their initial work. Thus, a transient product is a simple, very specific, clear and to the point feature like a calculator or a calendar. The daemonic posture software applications operate in the background and perform important tasks for the user but with the minimum amount of human intervention, like the speakers' volume in a Windows computer.

The websites can be separated into three categories, the informational websites, the transactional and the web applications. The informational websites are approached by the designers in the same manner as a sovereign application for a desktop computer. The purpose of those websites is to provide information to the user, and they should be designed in a way that they display useful information but with attention to the density of the page and designed to be user-friendly to first-timers or infrequent users. One might say that this leads to a combination of a sovereign and transient webpage design

and usually, the design is purely based on the target personas that will use the website and by the frequency of usage.

The pages that are text heavy should be designed under the assumption that the users will use their full-page mode. Navigational tools and the function of a responsive approach while developing is generally recommended. The transient posture while developing a web page can assist with first time users or the non-frequent users, due to the assistance that can be provided with the navigation and the orientation.

The users of digital applications are divided into three main categories, beginners, intermediates and experts. The idea is to design for all the three segments of people's experiences. The design of those applications is based on the assumption that the beginners will quickly transition into the intermediacy category with the minimum amount of effort. In addition, the intermediates should transition to the expert level of expertise without unnecessary obstacles. One of the major goals of design is to keep the users satisfied while they increase their level of experience through practice. One of the characteristics of the beginners is that they become easily demotivated but at the same time they recognize that most of their frustration comes from the lack of experience, thus they want to progress into becoming intermediates. The designers should image that the beginners are very intelligent and very busy therefore they need generic instructions in order to proceed further in the web platform. The design of the product should ensure that the new users will learn it quickly or they will soon reject it. As a result, the designers should guarantee that the product covers the beginners' scope and is comfortable for them to manage until they reach the intermediate state (Cooper, Reimann, Cronin, & Noessel, 2014).

"When people concentrate wholeheartedly on an activity, they lose awareness of peripheral problems and distractions, the state is called flow" (Harper, 2008). The simplicity is something that has been highlighted by designers' overtime and usually, the ideal solution for an interface is the simplest one. The interface features should be present to assist the users in finding their objects instead of impressing them with their fancy design. There are no universal rules or a simple model that highlight a harmonious interaction between the users and the interface but there are several guidelines that educate the designers so they can apply to their work in order to create a more desirable product.

It is advisable for the designers to explore the perceptions of their users in order to understand their requirements when entering a web application. In addition, the “less is more” approach is advisable to every designer due to the limited noise in the application which enables the users to find the information they need efficiently. A good example of simplicity could be Google’s search page, which includes the company’s logo, a search bar and a, “I'm feeling lucky”, button.

The animations, timing and transitions is a relatively new design focus and it improves the user experience greatly. Motion can illustrate the relationships between two icons or features in an application. Dan Saffer (2013) argues that the purpose of animations and transitions is to assist with the following: Target the users’ attention to the place the designers desire it to be, show relationships among objects in the platform, provide a progression of an activity they perform and create an immersive platform. The motion should be short and responsive, simple, natural and smooth.

Regarding the users, when they interact with the digital platform, they perform four types of activities, cognitive, memory, visual and physical. Cognitive ability is defined as the overall understanding of the product’s behaviour and structure, memory ability is the location of each feature or piece of information along with the relationship between features. The visual work is identified as the required object identification and the physical work, the button pressing and the mouse movements. The navigation plays an important role when the users interact with a platform and it generally occurs in multiple levels. Across multiple pages or frames, menus within the information displayed in a panel.

The navigation is important to be smooth due to the distraction that causes to the user, who shift their attention from a specific place of the application to the menu. General guidelines for improving the navigational excise could be the reduction of pages that the user can access, the points of reference in a page and overviews that help with the user orientation. The navigational behaviour of a digital product plays more important roles when designing for mobile due to the swipe left or right or click functions rather than a web application.

In addition, several design principles can be used as guidelines when designing a web application. The use of high contrast text in order to increase readability. The font selection is important for pages that are text heavy, Verdana or Tahoma are designed for that reason. The type size should be bigger

than 10 pixels and the text should be understandable by using the fewest words necessary. The layout of the page should be designed in a way that the users have an easy time to follow.

4.5.2 Information Architecture

The book “information architecture: for the web and beyond” was used as source material for this section (Rosenfeld, Morville & Arango, J. 2015). Information architecture is the structural design of information environments along with the combination of systems concerning the organization. Labelling, search and navigation in web platforms play a vital role in the structure of a digital environment too. Additionally, one could describe information architecture as the science behind the information shaping of products for usability reasons and the introduction of design and architecture principles in the digital world where It must not be confused with graphic design, software development and usability engineering which serve different purposes.

Information architecture assists the users in the information searching process which leads to a satisfactory user experience, which is fundamental for creating a successful product (Rosenfeld, Morville & Arango, J. 2015). A well-designed platform affects the users experience even if in most situations they are unable to apprehend it. The practice of information architecture requires the classification of the users, the context and the content of the digital environment the digital architect strives to create. The context defines the deliverables and the strategy of the project and the content covers the information or services users aim to discover in a web platform (Rosenfeld, Morville & Arango, J. 2015).

There are two primary ways of structuring a web platform. The top-down information architecture and bottom-up information architecture. While creating a web platform with a top-down approach the information architects attempt to understand the questions that the users search when they visit a digital platform. Those questions could be: “where am I?”, “I want to find this information, where to look for it?”, “what this website offers me”, etc. After the identification of the questions, the information architect seeks to structure the information in a way that the users could receive an answer for their questions several moments after visiting a web platform for their first time (Rosenfeld, Morville & Arango, J. 2015).

The bottom-up information architecture allows the material that the users are seeking to rise to the surface, through searching and browsing. In that type of system, the users avoid the top-down information architecture and they use search tools like Google, hyperlinks and social media ads in order to access the web platform. That gives the user a short period of time to adapt to a different environment of top-down information architecture and the information architect must provide them with the opportunity to efficiently bounce to a different area on the website (Rosenfeld, Morville & Arango, J. 2015).

Organizational systems in information architecture are based on the classification of the material that will appear on a web platform. There are schemes to support the content organization, for example alphabetical, chronological and geographical. In addition, there are vague organization schemes, like topical, task-based and cross groupings. The way the information architect structures the schemes plays an important role in the design of a digital environment. The classification of the material is not an easy task and thought to be very challenging by information architecture experts (Rosenfeld, Morville & Arango, J. 2015).

Labelling systems are referring to the description we provide to our organization schemes in our system. The information architects attempt to label based on the users and the content (Resmini, 2014). The most common way of labelling the material is through text for the majority of digital environments and icons for the devices that limited screen space. The design of labels is a difficult task but there are sources of inspiration, like the content of the web platform and the log analysis of an existing website that can aid in the creation of the labels.

Navigation systems encourage the users to decide their journey on a platform or determine their position in a digital environment and find their way back. The most popular types of navigation systems that are being used in the industry are global, local and contextual systems. The navigational systems primary purpose should be to allow users to locate their position in a digital environment. The global navigation systems show on every page or screen of a platform and the local systems work as complementary to the global ones and allow the users to navigate through the specific page they accessed online. The contextual navigation is presented in the content and regularly serves the idea of exploring relationships in the content. Examples of contextual navigation are related links or hyperlinks (Rosenfeld, Morville & Arango, J. 2015).

Search Systems operate as a mechanism for the user to find information, but it is not necessary to be implemented in all digital settings. The search bar normally is easy to use by the user, but it has confirmed to be complicated to developed by the software engineers. The search algorithms vary, along with the style the information is displayed back to the user.

The information architecture process requires thorough research before proceeding to the design of the final product. Background research is a great idea to gain knowledge of the task at hand and help the architects explore the goal, the business plan, the schedule, the audiences, the content and previous work. The content that the architect has, includes all the text, documents, services images and videos that should be included in the platform. The findability, meaning the ability of the users to attain the information they require, precedes usability. In order to identify the material that will be available to the users' close examination is required for the purpose of distinguishing the topics of the content (Rosenfeld, Morville & Arango, 2015).

After identifying the content of the website, a heuristic evaluation can be conducted. During the heuristic evaluation, an expert usually critiques the product based on a set of design guidelines. The ideal candidate to perform this task is an individual outside of the organization in order to avoid any bias. The expert will help the architect by identifying major problems and opportunities for improving the product. The user then evaluates what works and what does not work in the product based on his/her knowledge from interactions with similar digital applications (Rosenfeld, Morville & Arango, J. 2015).

4.6 Ethical considerations

When conducting a study that involves human participants in data collection process it is important to treat those with respect and in the ethical manner (Bordens & Abbott, 2002). Even though none of the participants expressed dissatisfaction or concerns about their data, we still followed fundamental principles, to the ethics when involving human subjects to have a fulfilling research. There are three core principles by Belmont Report (1979) are: Respect for personas, beneficence and ustice (Bordens & Abbott, 2002).

Respect for persons - participants should enter the study voluntarily and be fully informed in advance. Further, participants should be capable of making their own decisions and treated autonomously. Participants need to be treated with respect during their involvement in the study and also afterwards when processing their data (K. Bordens & Abbott, 2002).

Beneficence - Requirements that falls under beneficence is to guarantee that participants feel comfortable by minimizing hazard and maximizing the benefit during the research study (Bordens & Abbott, 2002).

Justice - Potential value of the study should be split equally to both parties: participants of the study and researchers. The principle of justice splits the burden and benefits equally for both parties: researchers and participants. Each should gain potential value out of this study. The participants should be chosen equally, regardless of their gender or race (K. Bordens & Abbott).

To meet the principle of *respect for persons* each participant was informed about the purpose of the study. For the interviews, workshops and usability study the purpose was explained and what kind of data will be collected when contacting a participant in advance. For the survey and usability test, information was presented in the survey form, but also in the email where the link to the survey was attached. To respect people with autonomy means that we as researchers had to listen to the opinions or judgments and respect their decisions.

To meet the principle of *beneficence* we did not ask for names of any of our respondents in the survey, as this would not bring any additional value to information. In this way, we kept the privacy of our respondents and ensured that the data would not be shared with other parties. During the workshop participants agreed to have their names and identities exposed at the beginning of the session.

With every participant, we were clear that if they have any questions or topics they want to discuss before the test, they were welcome to ask at any time, in order to ensure that they feel comfortable and well informed and have a solid foundation to base their decisions.
The burden of the participants is minor, even though the participants used their time to assist us in surveys, interviews, usability session and workshops. The initial purpose of this study is to develop the digital environment that would improve their work-quality which both parties will benefit from.

5 Analysis, Results & Discussion

This section presents findings from the semi-structured interviews, surveys, design workshop and usability testing. The results are based on collected data and supported by the literature and the methodology. Within HCI, it is not enough to design and implement an interface, it is also about identifying users' opinions, social drives, motivations and identity (Kurosu, 2015). Therefore, interviews, surveys, workshops enriched our insights about architects' practices that were taken into account for the design of the prototype (Adams, Lunt & Cairns, 2008).

5.1 Visual practises of architects

We transcribed the interviews and the transcriptions are presented in the appendix 6. After the transcriptions we condensed the replies from the participants. The process of condensation shortens the text without it losing its core meaning. This leads to a text that is shorter and easier to analyse.

We read the condensed text in order to create themes, which covers a broad range of the replies. We identified five themes that are personal information, tasks at work, visual information, sources of information and platform desires. The personal information was mostly the introductory questions we conducted for the warm up. The tasks at work are relevant to the architects' daily tasks and responsibilities while conducting their work. The visual information themes are related to what the architects prefer to see or work with, but in relation to their profession. The sources of information theme cover the sources where architects search for knowledge related to their profession. The platform desires are related to what they consider a platform that they would be willing to explore and interact with.

Then we created codes for the condensed replies, which are short descriptions of what the replies specifically describe. In the table which can be accessed in the appendix 6.1 we presented a table with the themes, the condensed text and the codes that we used to label the text. Several of the replies labeled by the same code when their meaning was similar. This was a long process with changes over the labeling being constant for the purpose to create codes that are easy for the researchers to understand and assist them with the creation of categories.

The categories were created by adding the codes that are related to each other together. During the initial phase of category creation, we produced a plethora of categories which were merged on the later stages of categorizing based on their theme and content. The category names were kept short as the literature suggests (Erlingsson and Brysiewicz, 2017). The table in the appendix 6.2 presents the categories and the codes that were used for analysing the interviews. The figure 5 presents, the five themes, the nine categories and the fifty-five codes.

Themes
Personal Information
Tasks at work
Visual Information
Sources of information
Platform Desires

Categories
Persona
Digital Work
Creative Work
Other Tasks
Preferences
Group Work
Online sources
Offlines sources
Usability Requirements

Codes	
Name & age	Insulation
Profession	Calculates
Personal Development	Users paper for notes
Technical Savviness	Planning
Service mentality	Feels he misses knowledge
Likes Sketching	Worries about time
Likes Headspace	Excited for architecture
Does not like text	Likes Architectural work
Worries about regulation	Does not understand
Does not like books	Easy to use
Does not like long texts	Likes reliable information
Dislikes complexity	Wants to control information
Likes specific info	Needs a search function
Prefers digital drawing	Need Keywords
Prefers to not get inspiration	Need familiar Terms
Does not like reading books	Likes table of content
Need more headlines	Likes whitespace
Digital Drawing	Needs teasers
Software Knowledge	Likes text
Transfer paper to digital	Not SBI user
Does not draw	Pinterest
Visual	Google
Draws	Wikipedia
Inspiration	Regulations
Collaboration	Events
Field work	Magazines
Colleagues	Friends
	Office Library

Figure 5 The themes, the categories and the codes that were created from the content analysis of the interviews.

We named the first category Persona, because it provides information about the individuals that participated in the interviews. The data we received is not relevant to the design process, nevertheless

the questions that filled this category are warm up questions which are recommended by Bryman (2012). The respondents replies that cover this category are presented in the table below.

Persona	
Ane	I am 33 years old and I work as an architect with old buildings, churches and things like that.
Elen	Elen, I am 32, I work at ERIK for 2 years. I bike, draw and do yoga.
Steen	Steen, 50 years, hiking. I have spare time, not every architect has it. I go hiking in Norway.
Peter	I am Peter, I am 31 years old, constructing architect for last six years.

Table 1 Sample of replies from the interview that coded under the persona category.

The next category that we created based on the coded transcripts is the digital work. In the table below we present several examples of replies that we consider that belong in this category. It is apparent from the replies that the architect requires some level of software knowledge in order to be efficient in their work. In previous studies, digital tools were also mentioned as a way to produce design faster and more accurately (Parthenios, 2005). The state that they use paper but there is a requirement to be able to transform the paper to digital drawings or 3D models.

Digital Work	
Elen	Not so much on the paper, I am writing notes on the paper to remember things. I am using Revit.
Ane	Most of my job is digital but everyone is printing out now.
Peter	I am a guy who helps with drawing, with different softwares.
Peter	Sketches are transformed into Autocad or Revit, with basic calculations. Focusing on 3D modelling, because it is less work.

Table 2 Sample of replies from the interview that coded under the digital work category.

We named the next category creative work because the answers related to sketching and drawing. The participants are used to sketching while they produce or communicate ideas or concepts, that was also validated by Koutamanis, Timmermans & Vermeulen (1995) who said that sketching is a first tool to express architectural concepts. After they produce the sketches, they transform them digitally.

Creative Work	
Ane	I sketch sometimes, today actually I have to sketch, because of these waterworks we are doing, I need to look for references concepts, and draw very rough, where the different rooms should be etc. and then transform it into 3D.
Steen	For trying ideas and communicate ideas quickly I do sketch.
Steen	Interesting job for me is actually doing an architecture, sketching, designing, drawing, I also like to do jobs afterwards, but I am not a fan of excel
Elen	I put transpiring paper and then I made different sketches and then we used one of the three to choose which one to digitalize.

Table 3 Sample of replies from the interview that coded under the creative work category.

Based on the answers we created the category group called work. The architects tend to collaborate with colleagues, building owners and engineers. Steen states in the interviews that they are responsible not only to produce quality design but also communicate the knowledge effectively between each other, which supports findings from Parthenios (2005) that said that architects need to communicate with the team on a daily basis. The table below presents some of the answers from the transcription that fall under the group work category.

Group Work	
Ane	I work a lot with the building owner and the builders as well.
Elen	The phase is different, the technical phase where we talk with an engineer and then calculate yourself if you have a software for that
Steen	Important skill for architect is not only to be a brilliant designer but also be good at passing stuff for another person that he can understand and take over and receive information from other people.

Table 4 Sample of replies from the interview that coded under the group work category.

The other tasks category was created because architects also conduct other activities in their work that are not related to design. The have projects assigned to them, calculations and assignments. The table below presents a sample of the transcripts that belong to the other tasks' category. However, this was not brought up in the literature findings.

Other Tasks	
Elen	Put more information about the production in the kitchen drawing, I have to finish calculation. I do both things, calculating and drawing.
Ane	I am responsible for projects, and the economics of a project, making the budget and checking everything that has to do with the economics.
Steen	I do less architecture, mainly emails, meetings, giving jobs to others.

Table 5 Sample of replies from the interview that coded under the other tasks category.

The preferences category includes answers that were related to what the participants like, dislike, interested in or prefer. It is the category that related to the emotions of the participants. A sample of the replies that belong to the preferences category are presented below. Based on the answers the participants look for inspiration in order to conduct their work, they feel excited by interesting projects and they prefer to sketch because it is faster than digital design. In addition, two of the participants stated that they look for inspiration online, this tendency has shown similar results by

Beaudoin and Brady (2011) where he states that architects need visual information to start designing process. Interestingly, one participant had an opposite opinion, Steen stated that he prefers to create his own ideas in order to be primed from an idea he saw in another source.

Preferences	
Ane	I am interested both about the internal and the external look of a building.
Steen	I prefer to start without it, in order to keep my mind straight, think about concepts and my ideas, instead of block on something that I saw. Our minds tend to block the same idea that we saw before
Ane	I will first find inspirational pictures about the concept, looking at Pinterest about different architectures, to take some inspiration.
Peter	I like to take pictures and analyse them myself, make notes around them.
Elen	I look for inspiration, then I make the sheet with inspiration "moodboard".
Steen	I am involved in interesting projects which is exciting
Elen	I like that because it was faster than drawing on computer.

Table 6 Sample of replies from the interview that coded under the preferences category.

We asked the participants about the sources of information related to their profession. The two categories that we created were based on their answers about offline sources and online sources. The main sources of information mentioned were books from the office library, colleagues and online sources like Google and Pinterest, books and colleagues are the main sources, just like in 1995 (Sklar, 1995). Tables 7 and 8 present a sampling of the answers for online and offline sources.

Offline Sources	
Elen	Books at home, but not technical, about architecture.
Steen	I have books at home and magazines, that I don't read. Papers are not searchable. I designed the bookshelf for my magazines.
Elen	Colleagues, friends, magazines. Events. I just went to "female constructing architects networking"

Table 7 Sample of replies from the interview that coded under the offline sources' category.

Online Sources	
Ane	Then I use Pinterest inspiration, most of the architects need pics and drawing to understand
Peter	We have folders on intranet at work.
Elen	I don't use SBI or BYG-EFRA.
Ane	Pinterest, we also have a library at the office but it's hard to understand, so google mostly, different sites about different subjects.

Table 8 Sample of replies from the interview that coded under the online sources' category.

The last category is named usability requirements and we created it based on the answers of the participants that were related to the ease of use of software, their requirements from a digital platform and the information they would like to have when searching for information. The table below presents a sample of the answers that justify the creation of the usability requirements category. The participants express their needs for an easy to use digital environment and some of them express their distaste for text heavy informational sources. Farenhorst & Vliet (2008) argue that only simple platforms motivate architects to visit them.

Usability Requirements	
Ane	I would prefer 3 lines instead of the whole text. a teaser of what mould damage is in the first page instead of a long text.
Ane	It depends, it should be simple, not too many questions, simple in the beginning and you can go deeper if you want
Elen	You need to read long text before you find what you are looking for.
Elen	I need search function, sometimes the search is really not functional.
Steen	Easy of use, minimalistic, simple as possible, possibility going deeper if you require. I prefer digital platform with quick answers. We are architects, we are better than with text

Table 9 Sample of replies from the interview that coded under the usability requirements category.

Summary

This summary highlights the important findings from the interviews based on the content analysis. According to the categories that we created from the interview transcriptions; the architects conduct both digital as well as physical drawings. Ane said: "I do mostly digital(...) and physical drawings"; Elen states that she sketches different options for facades. The digital work that they conduct requires software knowledge, as Peter said: "*Insulation process starts in Revit* (...)". They use it in order to produce 3D designs and digitize drawings (Ane, Peter). Their creative work often includes getting inspiration from online sources, such as Pinterest. However, on the contrary, Steen highlighted that he avoids searching for inspiration online and wants to stay open to the new ideas instead of being primed to ideas that he finds online. They also engage in note taking on printed material (*Elen: "I am writing notes on the paper…").*

In addition, we discovered that they collaborate with colleagues, stakeholders of projects (e.g. building owners, engineers, etc.) and other companies. The collaboration is more often based on their replies when they are conducting field work or work of technical nature; as Steen described: *"It's a collaboration between everyone, architect is not one genius that does everything by himself, opposite, it's a very collaborative process".* Their responsibilities in their work environment do not end with design and field work. We discovered from the interviews that they also have diverse list of tasks,

such as calculation, project planning, etc. As Elen expresses: *"I do both things, calculating and drawing."*.

In the category about preferences the participants expressed that they like sketching: "*Interesting job for me is actually doing an architecture, sketching, designing, drawing*" (Steen). Steen openly expressed his opinion about books and print material by stating that he does not use them because they are not searchable and long texts are not in their particular interest. This was also expressed by Elen. Such answers about avoidance to use text and print material was also supported by Mackinder (1983) who writes that ideal information for the architect is brief and visual. Some prefer digital drawing, like Elen *"Not so much on the paper(...) I am using Revit"*. They also expressed their worries about the change of regulations: "*...regulations might change, and I am not aware" (Elen)*. Elen also expressed concern that they do not have enough time to conduct some elements of their work, such as "*create moodboards and get inspiration*".

Regarding the information seeking process, they visit mostly online sources. The most popular among the online sources were Google and Pinterest. They stated again that they visit pinterest for inspiration, Ane mentioned: "(...) *I use Pinterest inspiration, most of the architects need pics and drawings to understand"*. Elen expressed that they also share information with their colleagues: *"I need examples from other projects from my colleagues (...)"*. The library at their office is also at their disposal however they rarely use it: *(...)we also have a library at the office but it's hard to understand"* (Ane). That confirms what we earlier described that architects seek to avoid using print and text material.

Based on the replies, the digital platform that they would use for information, should be easy to use, with a search function and a language that they understand. This connects with Flynn's (2018) paper, where he states that it is advised to use the technical terms related to the field. In a text heavy page, they would like to see a table of contents with more headlines as well as have the ability to control which level of information they can access: "(...)*simple in the beginning and you can go deeper if you want"* (Ane).

5.2 Survey results and analysis

This chapter presents the survey results and the analysis of the provided by data participants. The participants answers gave us an overall insight regarding the architects' experience in the field, their knowledge regarding the thermal internal insulation topic, the sources where they usually search for information and hardware requirements which are important to know when designing the prototype. The most relevant findings of the survey were also visualized.

Setting

In order to increase our chances to get results only from our target group - architects, the survey was distributed only in ERIK Arkitekter and sent out from the official work email. According to Bryman (2012), sample errors decrease as the sample size increases. Therefore, our goal was to get at least 20 individual responses since we wanted to present our potential responses as reliable and representative as possible.

Materials

We used online survey tool SurveyMonkey (surveymonkey.com) which is online cloud-based software that allows distributing surveys and provides with detail analysis of responses.

Results

The completion rate of the survey was 100 % and average time spent filling it 3 minutes. The survey was filled by 37 architects (n=37). The year of experience distribution of the participants is visualized in the figure 6 below for the first question. The group with the most representation was the 10+ years of experience 49% (n=18), second was the people with 1-4 years of experience 40% (n=15) and the least represented group had 5-10 years of experience 11% (n=4).

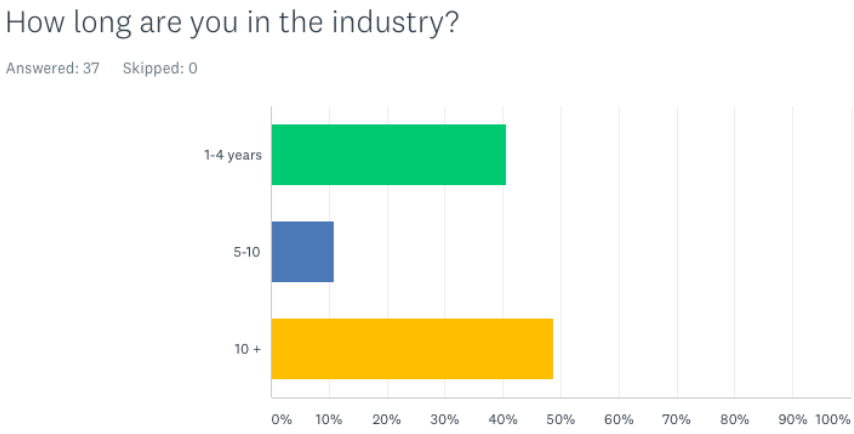


Figure 6 Survey answers regarding years of experience

The participants that filled our survey represent all age groups that exist in a business environment. The least represented group in the survey were people above the age of fifty with only five answers. We asked demographic details such as age, years of experience to be able to compare different variables between more experienced and inexperienced respondents. Additionally, we combined demographic questions with questions about behavior and attitude based on Goodman (2012). Interesting remark was that people with less experience replied to the survey earlier from the hand-out date than the experienced ones.

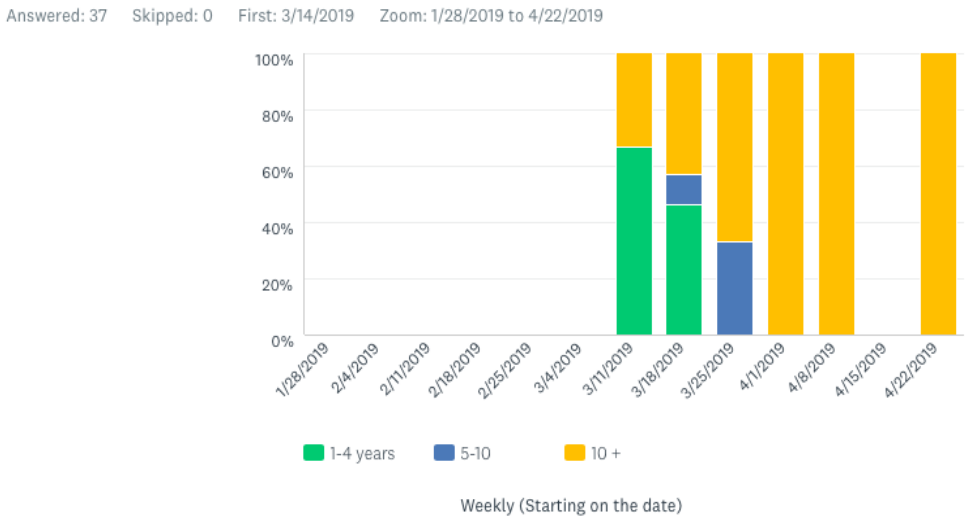


Figure 7 Survey results of weekly responses to the survey.

In regard to thermal internal insulation, question 3 (Have you ever been involved in a project that is related to the thermal internal insulation of historical buildings?), 54% (n=20) of the participants replied that they participated in a project that was related to the topic. It gives a fair number to analyze ones that have participated in project and have some experience, and with others that do not have any experience from before.

Then we asked them a technical question regarding insulation (figure 8) in order to identify which of them have general knowledge and which have deeper knowledge about the field. However, this can be justified to some extent that architects tend to ignore technical questions about thermal insulation as also mentioned in Cabrera & Cabrera (2002) study. Survey results showed that 54% (n=20) of the respondents were not aware of this issue.

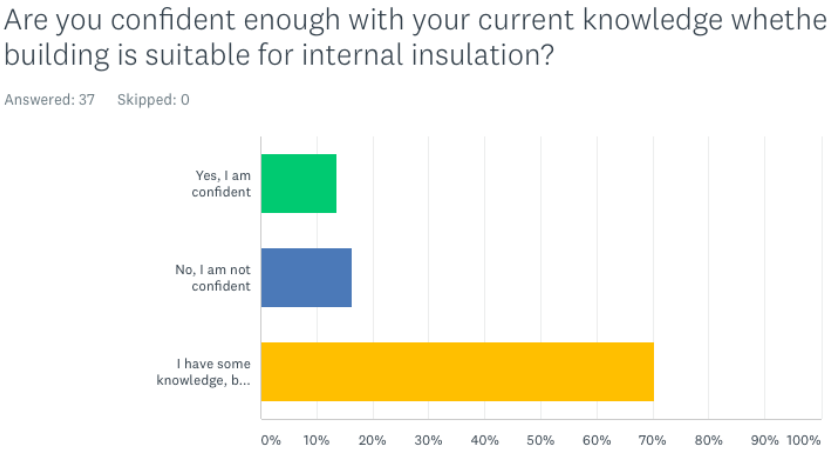


Figure 8 Survey results about the confidence level of architects regarding thermal internal insulation.

Regarding question 7 in the survey (*The process of installing thermal internal insulation involves several risks that have to be considered before starting the process of insulation. Are you aware of the risks?)*, the majority (70%, n=26) stated that they are aware of them.

One of the areas that we wanted to explore was the tools the architects use for educational purposes related to their profession (figure 9). The majority of the architects (54% n=20) replied that they mostly visit online sources, with the second being books and research papers (13% n=5). That contradicts with Elliot study (2002), where she states that architects do not like to search visuals online due to over-burdened information available online. However, part of Elliot's (2002) findings

states that architects choose to communicate with coworkers in the process and this has been confirmed in our survey. If they chose "other" they could fill their own choice in the survey. The majority of the replies in the "other" category were colleagues, engineers, experts and SBi. This was also supported by Burkhard (2004) where he mentions that architects are experts when exchanging knowledge between each other.

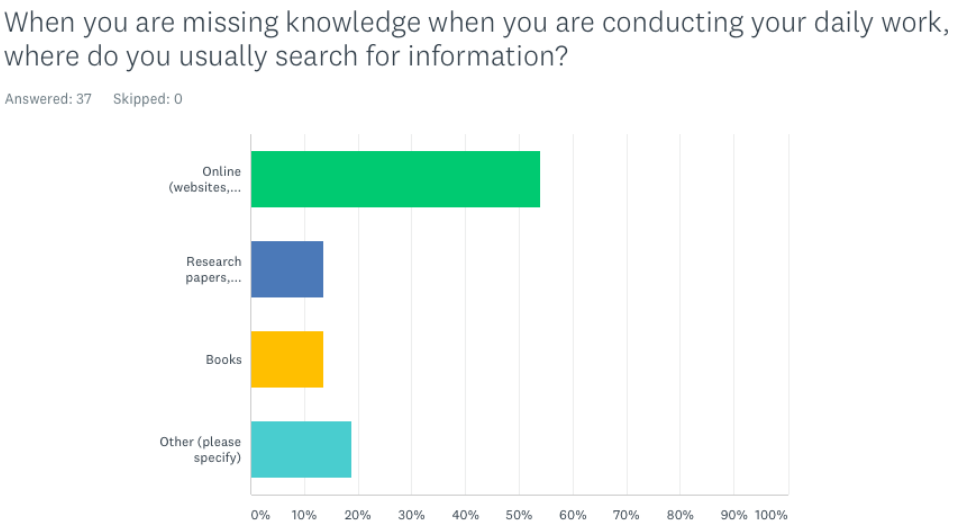


Figure 9 Survey results about the sources the architects seek for information.

Goodey and Matthew (1971) conducted a survey where they discovered that 57% (n=21) of the architects considered the literature search as a source of information. If we combine the results of the respondents that replied research papers, articles and books, 27% (n=10) consider literature search as a source of information nowadays. We assume that this is an indication of the change in online databases of information brought to the architects' profession over the years.

We also prepared two questions for the purpose of identifying their confidence when they work on a project involving thermal insulation and their willingness to learn more about the topic. Presented in figure 10, 70% (n=26) of respondents answered that they possess some knowledge about the topic, but they feel they would learn more in order to work on a project with confidence. Additionally, it confirms interview findings where architects highlighted their willingness to seek knowledge and become better at their field. 13% (n=5) respondents feel comfortable about insulation knowledge, additionally, out of those five respondents, four of whom has 10+ years of experience. 16% (n=6) of

the respondents do not feel comfortable with the insulation knowledge, which is mainly answered by architects who have 1 - 4 years of experience, that shows their level of experience in the field.

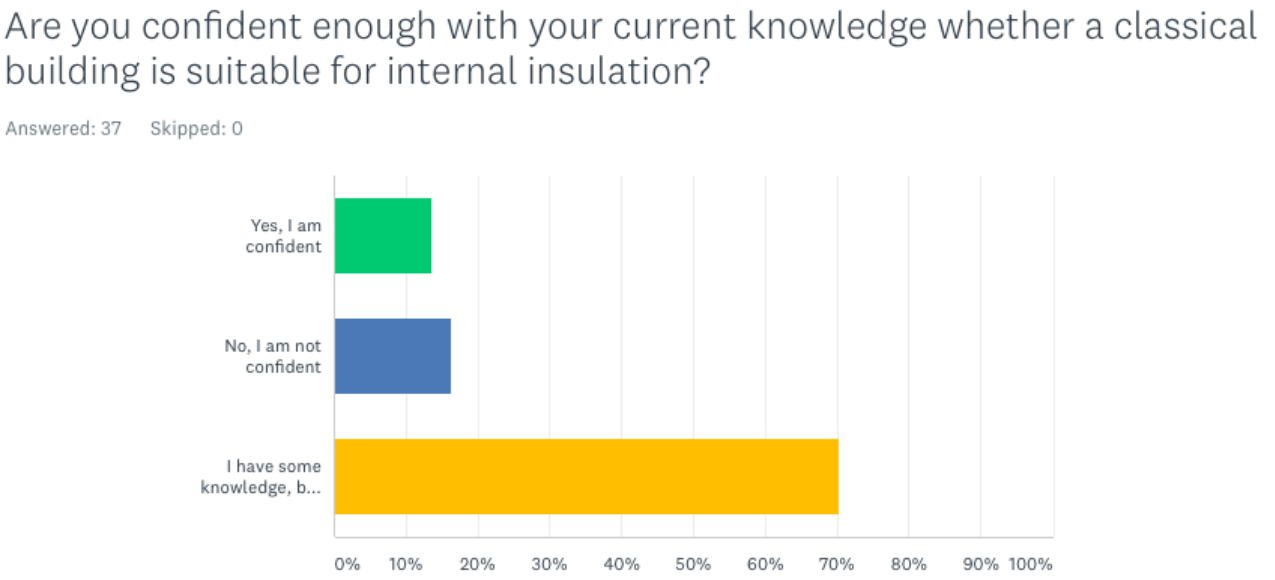


Figure 10 Survey results about the level of confidence of architects for working in a project related to thermal internal insulation.

In addition, responses for question *nine* "We are currently creating a website where information about internal insulation will be available. If you were involved in a similar project, would you consider visiting this website?" 92% (n=34) of the respondents claimed that they would consider visiting a website that provides information related to the topic. Snow (1975) argued that architects make a continuous effort to educating themselves because it leads to a better decision making. The vast majority of the respondents confirmed that finding in Snow's research.

The next question "If you were to visit the website, would you consider reading it from your desktop, laptop or smartphone?" was related to the choice of hardware that they would use if they were to access the website. This was to find out what platform they would use to gain the knowledge. The majority 37% (n=13) would use a laptop, a desktop computer and a smartphone and 31% (n=11) of the users replied that they would use a laptop with the exact same number replying that they would use a desktop computer.

In the open-ended question, we granted the opportunity to the participants to give us their input regarding the content they would like to find on the website. The question was optional to answer, therefore we expected that not everyone will reply. We had only 1 open-ended question as survey's respondents do not like to manually write in the surveys, as researched by Bryman (2012).

The open-ended question we asked "What you would expect to find in a website that its sole purpose is to provide information about thermal internal insulation? (E.g. legislation information, pictures with examples, instructional videos, etc.)" was answered by 59% (n=22) of the respondents, where most of them expressed the need for drawings, pictures, visual graphs, examples and guidelines. This can be referred to Chidlow (1991) study, where she argues that architects need visual information for their profession. One of our limitations of this project is that the material that goes in the website is not controlled by us, nevertheless, this was a valuable question to ask and get the feedback for the parties involved in delivering the final material for the website.

The study provided insights from a diverse group of respondents about their habits and knowledge particularly to insulation. The topic of internal thermal insulation is somewhat known to the participants, at least as a general theme and they are mainly aware of the risks that it carries. Additionally, the vast majority of the participants are welcoming the chance of educating themselves about the topic, that also connects with the interview findings and literature, where participants highlighted the importance of seeking more knowledge to become better at their job. The source of knowledge for architects remains colleagues and experts in the fields, that substantiate the knowledge sharing in architecture field.

5.3 Co-creation workshops

The following chapter present findings from the workshops, we found evidence to answer our second RQ2. We present activities in the workshop with supported literature and we acknowledged that some of the findings had emerged due to the nature of the collaborative problem-solving in the workshops (Ørngreen & Levinsen, 2017).

Previous research focuses on how to conduct workshops and present findings, while how to generate and analyze data is nearly absent (Ørngreen & Tweddell, 2017). In our case, we used the card sorting technique to get tangible results at the end of the workshop, such as wireframes, also we reviewed the video several times to write down their quotations, insights and statements that were interpreted and reflected with the literature (Stembert, 2017). A short discussion after the workshops enabled to clarify notes that were taking during the workshop.

While participants were designing, we were guiding, observing and noting down participants' thoughts. At the end of the session, both pairs had to present their navigation's flows and ideas. Throughout it, each suggestion and idea were discussed in a grouped conversation.

Figure 11 A moment captured in workshops, presenting a facilitator and the participants.

Setting

We introduced ourselves and explained the purpose of this session. We prepared the presentation slides to illustrate what we did so far and what are the plans for the future regarding the project. To engage participants from the beginning, we started with a warm-up exercise, where each participant was asked to draw a portrait sketch of someone in the room, this can be referred to a quick 'break the ice' exercises. (Stembert, 2017). This brought a genuine laugh to the room and a good atmosphere to start with. The workshop was held in their familiar environment for participants to feel comfortable and at ease, it is argued that in this way it is easier to stimulate people's creativity (Stembert, 2017). We used a card sorting technique in order to understand what is important to have for the users in the interface (Spencer, 2009). The goal of the workshop was to produce paper wireframes, knowing that the paper prototyping enables people to create designs of their ideas (Zaphiris & Ang, 2009). More pictures of the workshop can be found at Appendix 8. The video from the workshops can be accessed in this link[3].

The participants were introduced to the case and content, which is the summaries of the research papers. Research papers are narrowed down to 1-2 pages of written information. Researchers split the information into five main steps, figure 12, that users need to follow in order to analyze the suitability of internal insulation for the buildings properly.

[3] Workshop Link

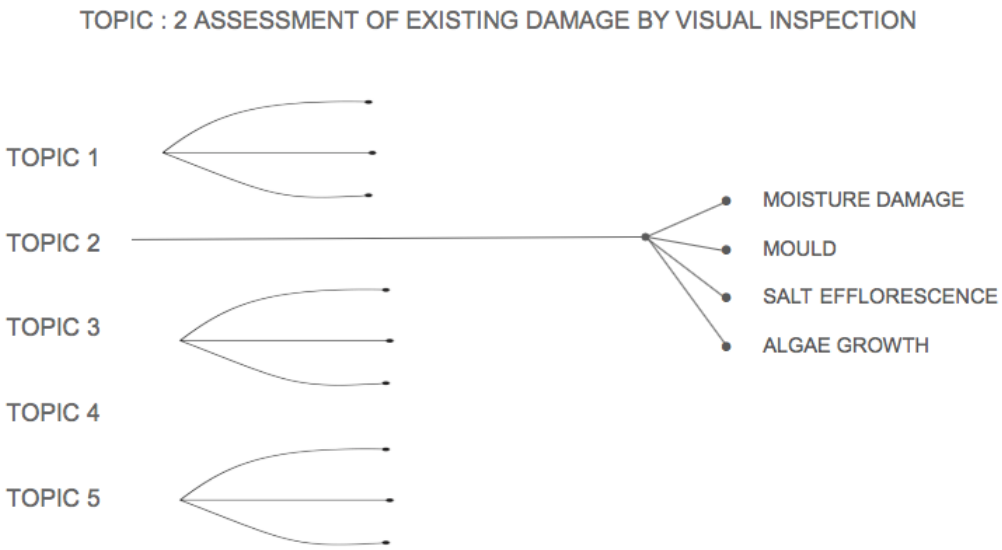


Figure 12 The content of the website, five main topics that split to several subtopics.

Step 1: Decision-making process - here the user read about the reduction of energy consumption, environmental impact, cost and indoor climate.
Step 2: Assessment of existing damage - here the user can assess the type of damage on the building. Damage type can be moisture damage, mould, salt efflorescence and algae growth (figure 12).
Step 3: Collection of information - here the user can access sensitive parts of moisture, such as embedded wooden parts, beam ends, window aisles. Also, assess of rising groundwater and reducing groundwater entrance.
Step 4: Assessment of materials - here the user inspects the exterior finishing and current composition of the wall.
Step 5: *Assessment of interior climate* - here the user can assess internal moisture sources and evaluate critically which climate classes are acceptable.

Each main topic has an extra subtopic, that contains extensive information. The task was to design low fidelity wireframes and navigation flow in the website to find information about mould, starting from the landing page and further. The precise task to design website flow was: Home page → Main topics → Subtopics. The picture below illustrates the content distribution. The content of the second topic leads to subtopics, such as mould, moisture damage etc.

The reason to find out about the navigation part was that the website will have a lot of written information, therefore the layers of information should be based on different user needs, notably that the navigation flow plays and important part in the usability of the product (Rosenfeld, Morville & Arango, J. 2015).

We decided that showing examples of low fidelity wireframe sketches would provide some inspiration, thus help them start designing faster. Parthenios (2005) influenced our decision to prepare the sketches in advance, as he states that "*...the right tools for the right task at the right time"* are an important asset in order to start thinking, express themselves and play with their own ideas. Participants were given cards and pieces of the website navigation where they were able to play around and try different visual options. Later we started a card-technique session. At the beginning of the session, both groups needed clarification and guidance. We expected it to happen due to the complex knowledge and content provided, also the language barrier. Majority of participants during workshops have difficulty expressing their thought about technology due to the lack of intangible nature of digital interfaces (Ørngreen and Karin Levinsen, 2017). We tried to confront participants with design examples and clarification of the task. The tasks were also clarified by our project expert by translating them into Danish language. We created two menu cards (horizontal - vertical), one with a vertical menu but with the menu icon and one with horizontal navigation. They had the freedom to choose the cards and create as many screens as they wanted to reach the subtopic page, and also add their own preferable content. Participants were divided into pairs to have a better dynamic in the room.

Each pair produced wireframes and their ideas were as below:
Pair 1 - We observed that they started sketching straight ahead using navigation cards. They expressed and idea to have the option to upload a photo and have comments on each damage. *"We register what we see in order to document what we see, based on some information that would lead as to some sort of decision-making process, for example: "is it a good facade or full of moisture". (Gitte).* This is the case where a digital tool assists the architect in conveying what was in his mind by visualizing and improving the process in order to get results that would satisfy him (Parthenios, 2005). For this to happen, it would be convenient to access and save the characteristics of the building, such as internal or external damages. Additionally, they mentioned having an admin on the page that would take care

of the content and comments. However, this seemed not possible right now, due to the limited resources, which did not evoke more discussion around that topic.

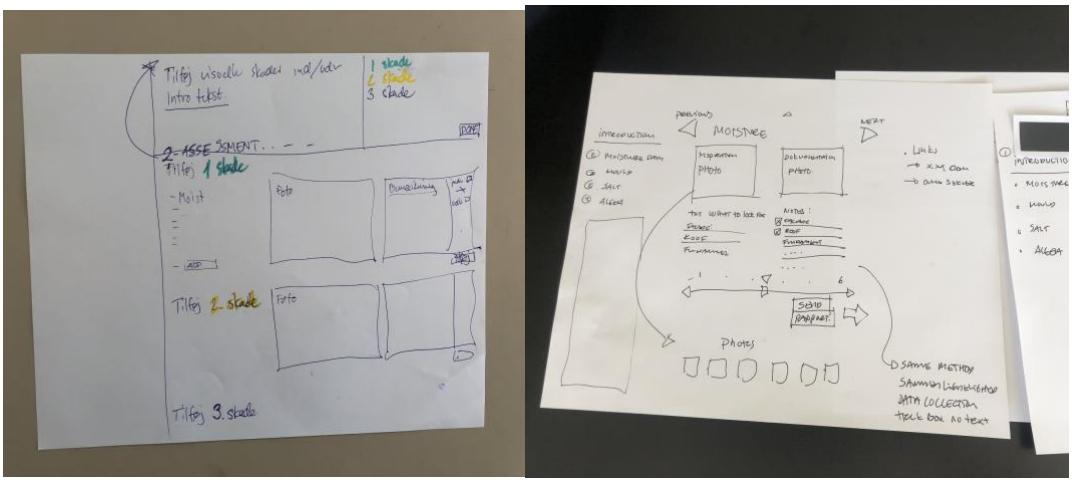


Figure 13 & 14 Paper wireframes produced by participants during the workshops.

All participants agreed that architects prefer to have an option to read less text: *"We don't like to read; we don't want to have too much text'.* This was supported in the Mackinder (1983) work, where she stated that architects *"show a remarkable lack of enthusiasm for the written word".* Therefore, a good solution for that would be to have a summaries of research articles and a quick "step by step guide" with infographics. Also, they drew in both their sketches (Figure 13 & 14) they prefer more pictures than text. They also mentioned that the website should be easily understandable for the general user, who is not so proficient in insulation processes; they argue that "*is not only architects who need this knowledge." (Gitte)* The separate column only for the ones who are interested in reading the deep knowledge should be identified as "research" or "databases". What is important for them is to have an evaluation process, where they would input or evaluate if the building is suitable for internal insulation: "*We are practical, we are not researchers, therefore we would like to know in which condition my building is, a guideline for that in the website." (Gitte)* They want technology to work both as facilitation of a process but also a key on how to improve the process, which is quick and does not require additional resources. Evaluating their building based on the interactive guide would save time and enhance the quality of their project process (Dix, Finlay, Abowd, Beale, 2004).

Pair 2 - Both architects had a similar opinion to the content *"We are not knowledgeable enough to read about technical details, and we don't like to do that." (Morten)* This again proves the need for simplified reading material and confirms literature findings. Architects prefer visual graphs because

it helps to understand and perceive information faster (Parthenios, 2005). We noticed that second pair chose different navigation card which was placed on the top of the page; they argued that in this case they want to be only two clicks away from the topic. They would like to have topics implemented in the navigation so the user will have a fast way to get the specific information. This was also mentioned in the interview with one of the participants (Steen), who said that he prefers to access answers as quickly as possible. It is important to have a "light" introductory part, that explains the reason for all five topics and what benefit it brings when planning an insulation process. Additionally, they mentioned that the hyperlinks or web links on the side would be helpful in order to redirect the user if he is interested to read more about the specific topic: *"It should give you suggestions, go read more if you still have doubts" (Lars).* Participants suggested to have an account just to be able to collect data about European building regulations; they also mentioned the possibility to assess the building based on the characteristics.

To sum up, both participating pairs would like a platform that would help them with their profession in order to document their building. This can be supported with Parthenios (2005) statement that "*the goal is to empower the architect, not the tools*". Dix, Finlay, Abowd, Beale (2003) argued that humans expect that the digital system to assist in their context of daily work.

Architects tend to read more general information (Farenhorst & Vliet 2008) however our interviews (Elen, Steen) showed that they would like to have an option to go deeper in the knowledge. The general knowledge with content in the form of a visual infographic appeared as a good solution for complex knowledge. In order to explore issues and solutions and make progress with their projects, architects need tools like sketches, drawings or 3D models, and these tools influence the quality of project's output (Parthenios, 2005).

For the users that require a deeper knowledge of the summaries of the research, material should be split into 5 categories (1. Decision-making process, 2. Assessment of existing damage, 3. Collection of information, 4. Assessment of materials, 5. Assessment of interior climate). The vertical and the horizontal menus tied in the first impression, half of the people found visually appealing the vertical and half the horizontal. In terms of information architecture, the horizontal one made more sense to the majority of them and considered it less confusing for a first-time visitor. Video content was a popular topic among the participants; however, this should be considered as an option for future

opportunities when the content is ready. Cross (1995) also reports that design relies fundamentally on non-textual media and communication which is understandable why participants mentioned other communication tools than textual. In terms of usability, the majority considered that in the long run, the horizontal menu will allow faster guidance through the website.

On the outcome of the workshop, ideas and information were collected in order to start the prototyping phase and create an interface to meet primary stakeholders' needs. These collected demands built the basis for the next phase.

Key Takeaways	
Morten	Ability to take a photo of the building, check the damage and make the report of it.
Gitte	Would like to evaluate building characteristics and download the material later on.
Rick	Prefers to have a toolbox of links, tutorials or Wikipedia next to the content.
Lars	Information should be also thoroughly described so it would help them in the decision making the process.
Sum-up	Users would like a platform that would help them with their profession in order to document the determination of whether the building is suitable for internal insulation. Only a few 'clicks' to the relevant information

Table 10 Key takeaways from the co-creation workshop.

5.4 Prototype Development & Usability testing

In this section we present the development of the prototype based on the data gathered from the semi-structured interviews, surveys and workshops. The structure of this section includes the prototype development, the first usability test, the changes that we implemented on the prototype based on the results, the second usability test and the comparison between the tests.

5.4.1 Prototype Development

The prototyping process started from the creation of the user flows based on the inputs we obtained from the theories mentioned in previous chapters and the research material that would serve as content for the website. After the user flow, we created wireframes for the website that assisted us with the workshops and promoted the design process further. The next step was to create the actual prototype for the purpose of usability testing.

Based on the interaction design theories and the nature of the product which will operate as an informational website we chose to treat is as a sovereign application for desktop computers. That means a minimalistic design of the application with the purpose of creating a pleasant experience for new or infrequent users and designed under the assumption that due to text-heavy pages the users will use their full-screen mode (Cooper, Reimann, Cronin, & Noessel, 2014).

The content for the final product is divided into four parts, the home page, the guidelines for thermal internal insulation, the web tools and the research material. This decision was made after several meetings with the stakeholders of this project, the DTU party responsible for the development of an insulation tool, a probabilistic tool and a deterministic tool and the researcher's party from Aalborg University responsible for reviewing and delivering the research material. The tools mentioned will be included on the website as a service where the architects will be able to use several insulation metrics in order to identify which is the optimal solution for their real-world projects. We were responsible for organizing the overall navigation of the website and the guidelines part.

Information Architecture

The next step was to decide how the user is going to access the information on the website. In order to do so we followed the guidelines from the information architecture chapter of the report (4.5.2).

The landing page of the website will present to the user the features of the website. The users will get an insight into what is the content of the website, what it offers and where is the information they are looking for in the website. As a navigational system, we will use a menu that persists in all the pages, for the purpose of identifying where they are in the digital environment we created. This global navigation system will give the users an overall overview of the main features they can access. A dynamic menu for local navigation will exist below the global navigation system. For the pages that are heavy on text, we will implement an internal page navigation system that will assist the users to navigate through the different topics in long one-pagers. Due to some of the topics being connected in a narrative form, there will be also footer navigation that will allow the users to move from one page of information to the next logical page in order to continue their reading. The figure 14, presents a hierarchical information architecture model that we created.

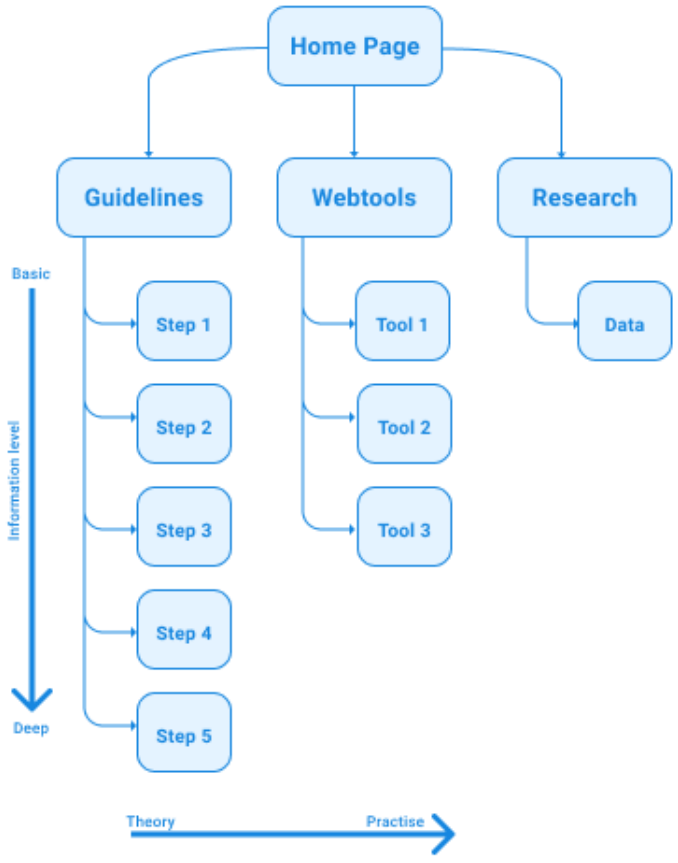


Figure 14 From the home page the user presented with three options. From there we present a set of steps that she can follow in order to reach more complex knowledge.

In this Top-up approach, the home page will present information regarding the content of the website and as the users' progress from step one to step five, the provided knowledge will be more complex, meaning that the knowledge will be deeper and more technical. The creation of this feature was inspired from the interviews, where participants mentioned the possibility to go deeper with the knowledge if preferred. The content was developed and written by researchers from European Universities. In addition, if the users read all the material in the guidelines, they will have all the required knowledge to use the web tool and transition from the theory to practice, however this part is not depended of us.

User flow

In the initial user flow of the prototype we created, the users access the homepage of the website and then they mouseover the menu where they presented with five options. Those options are the decision-making process, the assessment of existing damage, the collection of information, the assessment of materials and the assessment of interior climate. From there they can select one of those options and access the content in one of the subpages of the website. The user flow is presented in the picture below with a horizontal menu on top of the webpage.

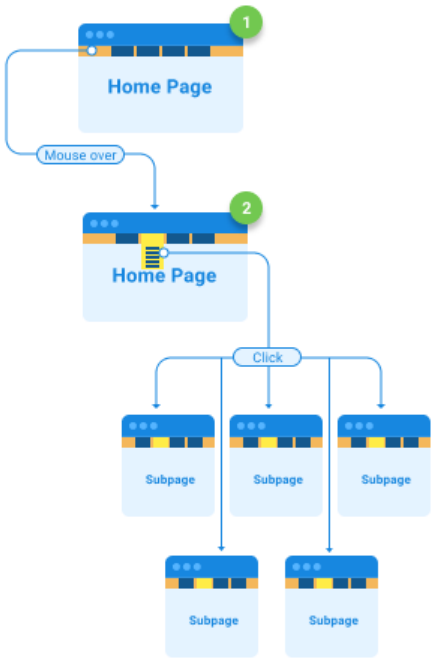


Figure 15 From the home page the user can access the 5 subpages of the website by hovering the mouse over the horizontal menu on top.

The user flow demonstrates what we consider an easy to learn website, but our design was only influenced by design theories. We tried to cover the learnability and the efficiency part of our design which are mentioned in the usability section of this report (chapter 4.4.2) by designing a very simple solution. The intention was to reduce the distractions for the user by applying everything in the menu and to make sure that the user could recover from a wrong choice, by either clicking back on the browser or by accessing the menu again and make a different choice. The assumption behind the design was that if every option the user has is kept in one place, the website will be easier to memorize.

Wireframes

Based on the diagram that presents the information architecture of the website and the user flow we created several wireframes for the purpose of assisting us with the design process during the workshops. The wireframes used as a material that could inspire the participants in case, they were unable to progress or design their own solution in a blank sheet. The workshop process is described in detail above. Nevertheless, the outtakes from the workshops that would influence our design decisions were the need for pictures by the architects, the requirement for a minimum amount of text, the accessibility to deeper information and the documentation of actual buildings they handle as projects in their profession. Based on the workshop and interviews we concluded to implement two additional features in the prototype and more pictures depicting examples from the real world. The first new feature under the guideline's category would be an infographic with guidelines presented on an actual building with the minimum amount of text and an interactive questionnaire where the architects would be able to answer a set of questions and download the option they selected. This file would serve the purpose of the documentation of the project they work on. We changed the user flow by adding the new two features that would be included after the workshops. We present the improved user flow below.

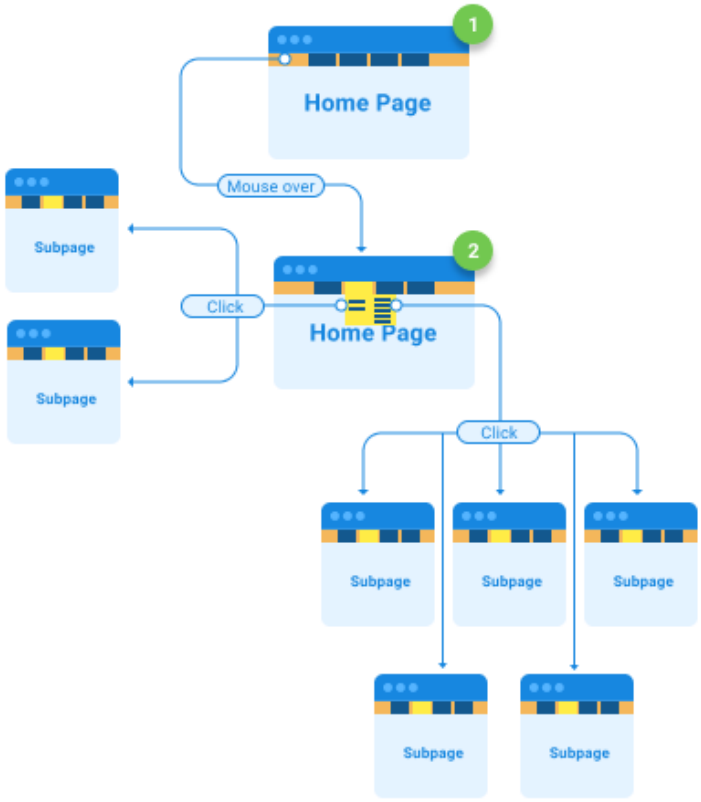


Figure 16 From the home page the user can access the 5 subpages of the website by hovering the mouse over the horizontal menu on top. We added two more options (on the left) based on the workshops and the interviews.

The two new features will be kept separate in the menu than the rest of the guidelines, in order to indicate that they are not fully connected to the other options the user has. The figure 17 presents the wireframe that was the base for our prototype before the usability testing.

5.4.1.1 Prototype Version 1

Before we proceed with the usability testing, we developed a prototype based on the wireframes we created. The prototype was developed in Figma software and it was interactive. The transfer of the design from hand-drawn wireframes to a high-fidelity prototype followed by implementing design techniques from the interaction design. The prototype was created under the assumption that the new user will transition to intermediate users quickly and effortlessly (Cooper, Reimann, Cronin, & Noessel, 2014). The digital prototype is visually simple, it is responsive to the user, motion techniques are implemented to make the prototype immersive and indicate relationships between two objects.

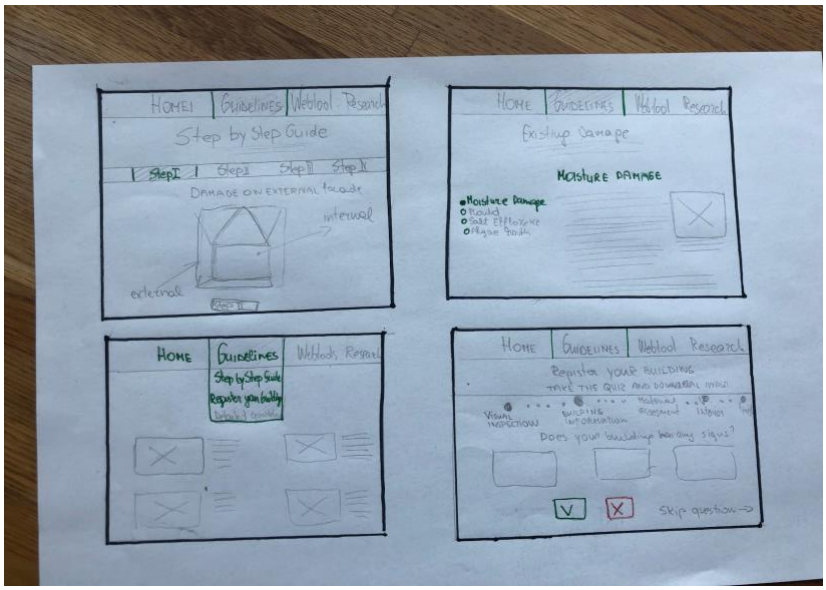


Figure 17 Paper wireframes that were used as guidelines in order to create the prototype in Figma.

The prototype presented a horizontal menu, with four categories: home, guidelines, web tools and research. The menu is presented in the figure 18. Home page is the main page on the website, that contains general knowledge about RIBuild. This page is carried out by other stakeholders; therefore, we only made a preliminary design for that. Guidelines page is for accessing the summaries of the research material, like existing damage in the building where the user is able to read about mould, algae etc. The webtool is the online tool where users can actually place their input and values of their material or building to get the results. Webtool is developed by engineers from DTU. Research page stands for research material pdf files.

Figure 18 The horizontal menu of the prototype that users can interact with.

While the user hovers the “Guidelines” box, another box appears that presents the option that the user can access by clicking. The figure 19 presents what the user sees when hovering the guidelines box.

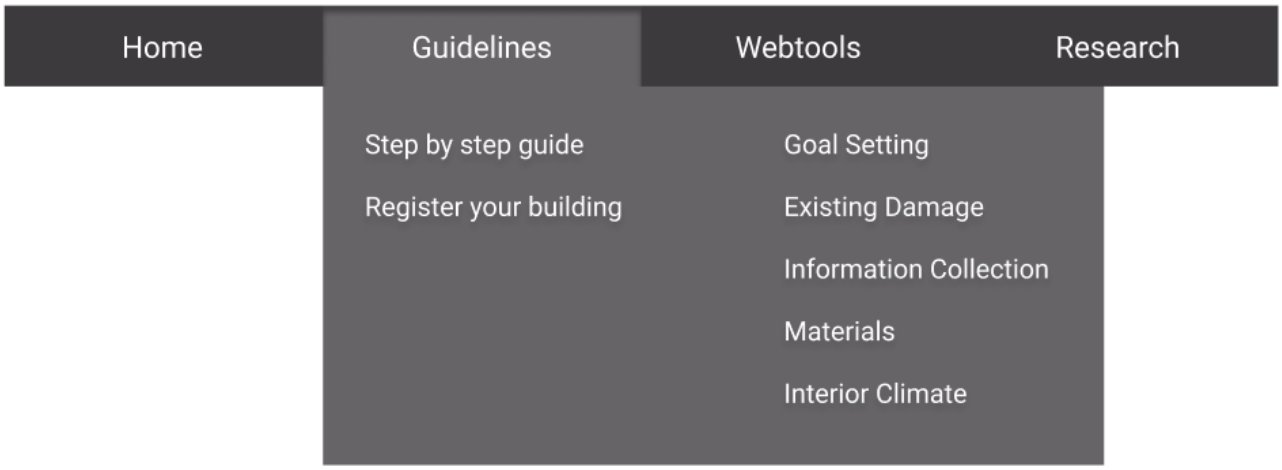


Figure 19 When the user hovers over the Guidelines, a drop-down menu appears.

The rest of the pages created in order to give the feeling of progression to the user and the menu appeared in the same position for every page to ensure that the user is not distracted by the surroundings. The pages that are heavy on text, created with the mindset of having a contrast, thus black text with color was a reliable option. The font size was set to sixteen pixels, according to the theory it should be above ten pixels and the interaction design theory suggested Verdana or Tahoma (Cooper, Reimann, Cronin, & Noessel, 2014). We selected Verdana for the text and Roboto for the menu and the headlines which seemed visually appealing.

5.4.2 First Usability Test

The analysis of the results is important for the researchers to understand the issues of the product (Riihiaho, 2018). The problems that occurred during the test and identified in the analysis should be organised based on their importance and severity (Dumas & Redish, 1993). The scope refers to the issues this problem causes to the platform as a whole, the severity refers to the frequency, impact and persistence of the problem (Nielsen, 1994).

The first stage, collecting observations includes gathering the moderators' and observants' notes. Moreover, it includes going through the test video recordings and noting down the mistakes, confusion as well as the opinions the test person expressed about the product and its features. It is crucial to note down the features people had a problem with during the test.

The usability evaluations are organized in the following steps, the design and preparation of the tests, the test sessions, the analysis of the results and the communication of the results (Riihiaho, 2018). We followed some of the steps for conducting test sessions as presented by Gomoll (1990). An introduction to the process and ourselves, along with a description of our goals. We informed the participants that they were able to terminate the session at any point and we provided them with an example of the think aloud method. Additionally, we explained that they can receive minimum amount of help during the test and we provided them with a solid instruction of the product and its purpose. The next step was to proceed with the session and analyse the provided data.

Setting

The usability sessions took place in different meeting rooms at ERIK Arkitekter office. In addition to the participants, there was a moderator and an observer in the test-room during the test. The presence of a moderator encourages the participant to complete the tasks with more confidence (Schulte-Mecklenbeck & Huber, 2003). The moderator guided the entire test and made sure to present the different tasks and scenarios in a clear manner. In addition, interruptions and time pressures should be noted by the moderators (Bødker & Madsen, 1998). Most of the time, the observer's role consisted of tracking the time spent on the tasks and ensure that key points were noted down.

The fundamental part of any usability test is to have the list of tasks, some aspect to test and well-defined aims to get needed insights (Tullis & Albert, 2013). We created three tasks and we presented them to the users in a scenario format. Three scenarios were presented to the participants in order to test the design of the prototype. In the first scenario, the participants were asked to find on the website where they could evaluate if a building is suitable for thermal internal insulation. In the second scenario, they were asked to find the page where the instructions of the thermal insulation basic instructions were presented. For the final scenario, we presented them with a real-world picture of a building that had mould issues and asked them to search on the website for further information regarding the issue. The words that were presented as menu items on the website were not mentioned during the presentation of the scenarios so we could avoid leading the participants based on keywords.

Results

We demonstrate in the tables (appendix 9) the data that we gathered from each user for each individual task. We tracked the time each individual required to complete each of the scenarios given and the

number of clicks. The number of clicks is a metric that indicates the efficiency of the prototype (Bevan and Earthy 2018). The time performance is one of the most common measurements in usability testing (Lazar, Feng & Hochheiser, 2017). An additional reason for tracking the duration of the task is that architects value the efficient and fast search when they search for information (Farenhorst & Vliet 2009).

In addition, we present the average and the median numbers for all the users (appendix 9). We chose to evaluate the success of the test based on the median number which is slightly different from the average number. The reason behind this decision is that in some recordings there are some values very separate than the rest which makes a big impact on the average values, but the median values remain stable (Tullis & Albert, 2013). This is not a choice for convenience, that is the reason for presenting both values, which indicates that in some cases the median would make the usability results better for us and in other cases the average values (Tullis & Albert, 2013).

Furthermore, we tracked the number of errors each participant made during the usability test, in order to measure the effectiveness of the prototype Bevan and Earthy (2018). The errors can help us identify specific issues in the prototype and address them quickly by improving the design of the next version. The three tables in appendix 9 presents the errors the participants made during their assigned tasks.

While executing the tasks that were assigned, the participants were expressing their thought process while navigating through the platform. We tracked the comments in order to measure the satisfaction of the participants with the product Norman & Kirakowski (2018). The observant during the usability study created notes of the thoughts that were expressed by the participants, which are presented on the table in appendix 9.

It is clear from the results of the usability testing that the users were confused mainly due to the naming of the items on the menu bars. The prototype was designed based on the principle that all the features the user wants to access are no more than two clicks away from reaching. Out of twelve attempts, only three participants managed to reach the desired feature with two clicks or less.

The time that it took the participants to reach the required feature at a time is a consequence of the misunderstanding of the item names on the menu, thus we consider that for first-time users the results

are acceptable in that field. In addition, through observation, we noted that the participants were not in a hurry to achieve the best score. They took their time looking around the website in order to understand where the correct feature might be rather than searching it by clicking every option. That was the instruction that was given to them by us at the beginning of the task and we also made it clear that we were testing the product and not the participants.

Regarding task one, which took the most time to be completed (73.5 sec Median) and as a result, the most clicks to be completed (4.5 Median) the results indicate that the process of finding the feature in the website is not ideal. In addition, we noticed that the majority of the participants went straight to the web tool menu instead of the guidelines.

In task two, the time and the clicks reduced almost in half compared to task one. This could be an indicator that the task was clearer to them but based on our observation we assumed that those few minutes they spend to the prototype initially made them aware of the platform and the content they were exploring. The reasoning for that assumption is that the users made three mistakes during the second task instead of four that they did during the first task. They were appearing still unsure of where to click, but due to their experience the first time, they were able to navigate through the prototype faster.

During the third task, the users recorded the best median time for completing it and they were half a click worse than the second task. The third task is considered more successful due to the reduction of errors the participants did while navigating.

The comments of the participants confirm the issues they had while searching for specific features on the website. The majority of them was confused by the labelling of the menu items. One comment that stood out was the comment of participant three, where she mentioned that due to the lack of involvement with any insulation project, she would like to have some form of guidance in the page. The purpose of the usability test was to observe how our prototype works with first time users.

5.4.2.1 Prototype version 2

We mentioned above that the labelling of the menu items was proven to be confusing for the users. This could be an indicator that the labels have to change or due to the fact that the home page is not

completed yet, users lack some general knowledge about the features when they access it. Nevertheless, the creation of the home page does not fall under our responsibility, thus we re-designed several aspects of the prototype that caused issues during the usability testing.

Regarding the labelling of the items on the horizontal menu of the page, we changed the “research” button to “database” in order to indicate to the user, that this option when it comes to the research material of the website. We assume that with a simple explanation on the homepage of the website, the users will understand that in the database section all the research paper can be accessed.

In addition, we changed the menu that drops down when the users place their mouse over the “guidelines” items. Instead of providing seven options to the users, we provide three. We merged all the buttons for reading about internal insulation into one button which we named it “detailed guidelines”. The new menu we created is presented below.

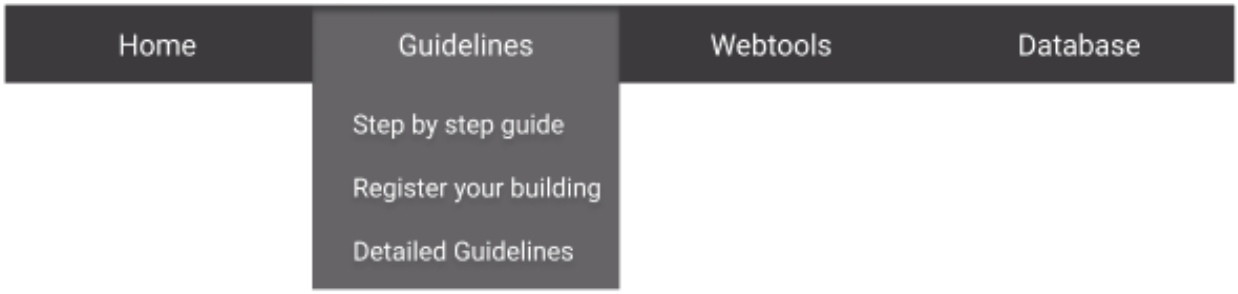


Figure 20 The drop-down menu when the mouse of the users hovers over the guidelines.

When the user clicks the “detailed guidelines” item, they basically enter a new page, where they can select which step of the insulation procedure they would like to know more about. The five steps are:1. Decision-making process, 2. Assessment of existing damage, 3. Collection of information, 4. Assessment of materials and 5. Assessment of interior climate. This change is also related to the comment from the usability, where the user mentioned that due to inexperience with the topic, they would like to know which steps they should follow in a real-world example.

5.4.3 Second Usability Test

The second usability test was conducted with the implemented changes mentioned above. We repeated the same procedure as the first time while doing to usability testing, with the same tasks assigned to the users for the purpose of comparing the results of the two tests.

The table in the appendix 9 demonstrate in the same manner as the tables of the first usability test the data that we gathered from the users. We tracked the time it took for the users to complete the scenario and the number of clicks. Average and median numbers were calculated, and they will assist us comparing the results of both tests.

The numbers of errors per tasks were noted, with the difference between the two tests being in the fact that the users did not make an error in task 2 and task 3.In addition, the same process with the think-aloud method was followed and we noted down their thought process while they were going through the tasks. The comments of the second usability test are presented below.

The users spend on average 25 (25 Median) seconds for task one, 11 (10.5 Median) seconds for task two 9.75 (10.5 Median) seconds for the third task. Task one took 25 seconds (Median) to complete and it was the task that the users spend their most time with. By observing the users, we were able to identify the reason behind that result. The users are new to the platform and they tend to try and explore a bit when conducting the first task. Due to some mistake they make during that task they learn some of the features of the website and they are able to execute the rest of the tasks faster and with fewer mistakes.

The inability to the home page to explain the features of the website to the users was noted down as a comment from the first participant. In addition, the word guidelines confused some of the users and we will consider replacing it with a more self-explanatory label. The order of the features that appear in the menu is a fair comment and it is something that was mentioned by the users and it will be implemented in the final prototype. The difference in the results between the two tests can be found in the next section.

5.4.4 Comparison of usability tests

The results of the second usability test were more encouraging than the first one. The two graphs below compare the differences in the results between the first usability test and the second.

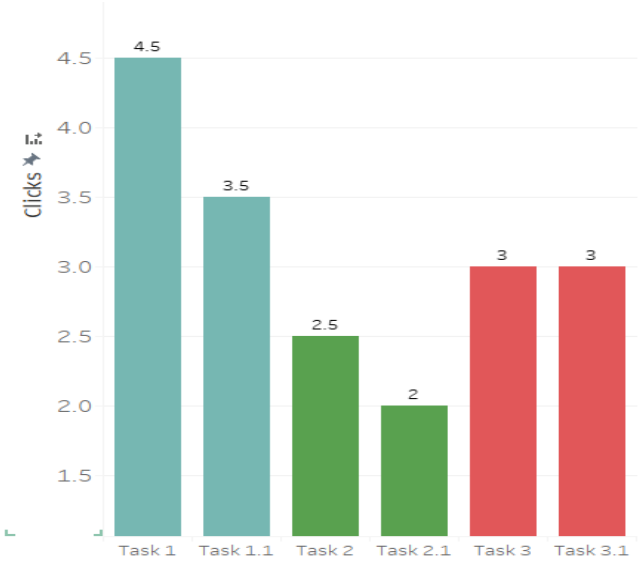


Figure 21 The comparison between the required clicks for the two usability tests. Task 1,2,3 are the results of the first usability. Task 1.1, 2.1, 3.1 the results of the second.

The bar chart above demonstrates the difference between the two tests by the number of clicks through the three tasks. We managed to reduce the click number to the first and second task, but the third task resulted in the same number of clicks in both tests.

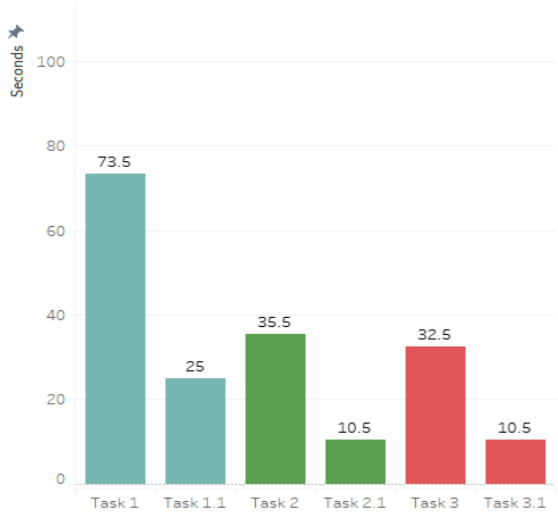


Figure 22 The comparison between the required time to complete the tasks in seconds, for the two usability tests. Task 1,2,3 are the results of the first usability. Task 1.1, 2.1, 3.1 the results of the second.

Regarding the time spent during the three tasks, it is obvious that the time the users required in order to execute those tasks increased greatly. One of the reasons for that result could be the relabeling of

the menu items along with the reduction of errors. The users during the first usability test made eight errors but the number was halved in the second test.

Overall the minor changes we made in the prototype improved the usability of the prototype based on the results. The feedback that we received from the second prototyping stage will guide us through the changes that we have to implement to the prototype with the focus of increasing the usability of the product.

6 Prototype

The final prototype we describe in this section developed by taking into consideration the theories, methods and the analysis results. Figure 23 demonstrates the main menu of the website. As mentioned before, the home page will operate as a newsfeed and description of the features, the information section will present general information about insulation, the detailed guidelines and an insulation test for the architects. The web tools will be developed by DTU and the database is the page where all the research for this project is available for download.

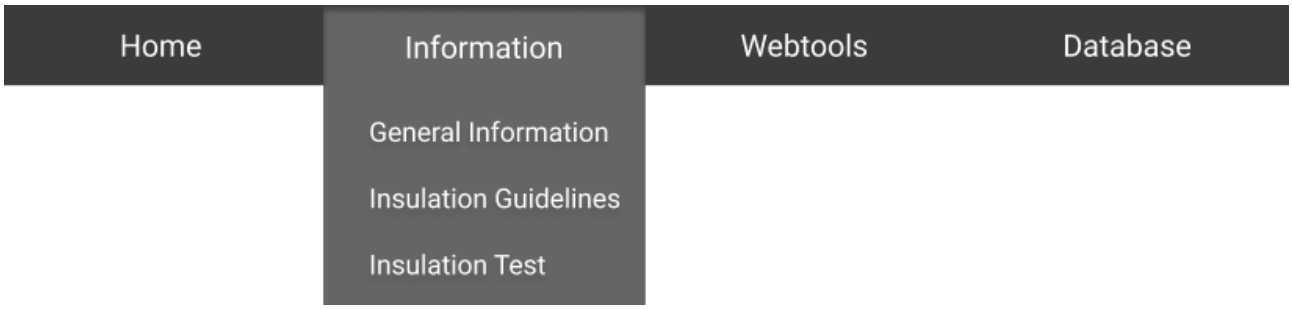


Figure 23 The horizontal menu and the drop-down menu when the users hover their mouse over guidelines.

The users by clicking the general information option, they will access the page presented below. The design of the page is simple with a minimum amount of distractions, knowing that architects prefer minimalistic design and tend to avoid websites with complex interfaces (Paryudi & Fenz, 2015). As mentioned in the interviews and in the workshops, architects prefer to have internal and external visualization of the building. Therefore, we created the additional steps of insulation process in a graphical demonstration.

Figure 24 The general information page about building damage of the prototype. The visual in the middle should be replaced by a visual created from RIBuild stakeholders.

By clicking insulation guidelines, the users will access the page presented below. From there they will be able to read the description of the five-step process. The text presented in the picture is a sample text, due to the fact that not all the final material is delivered yet.

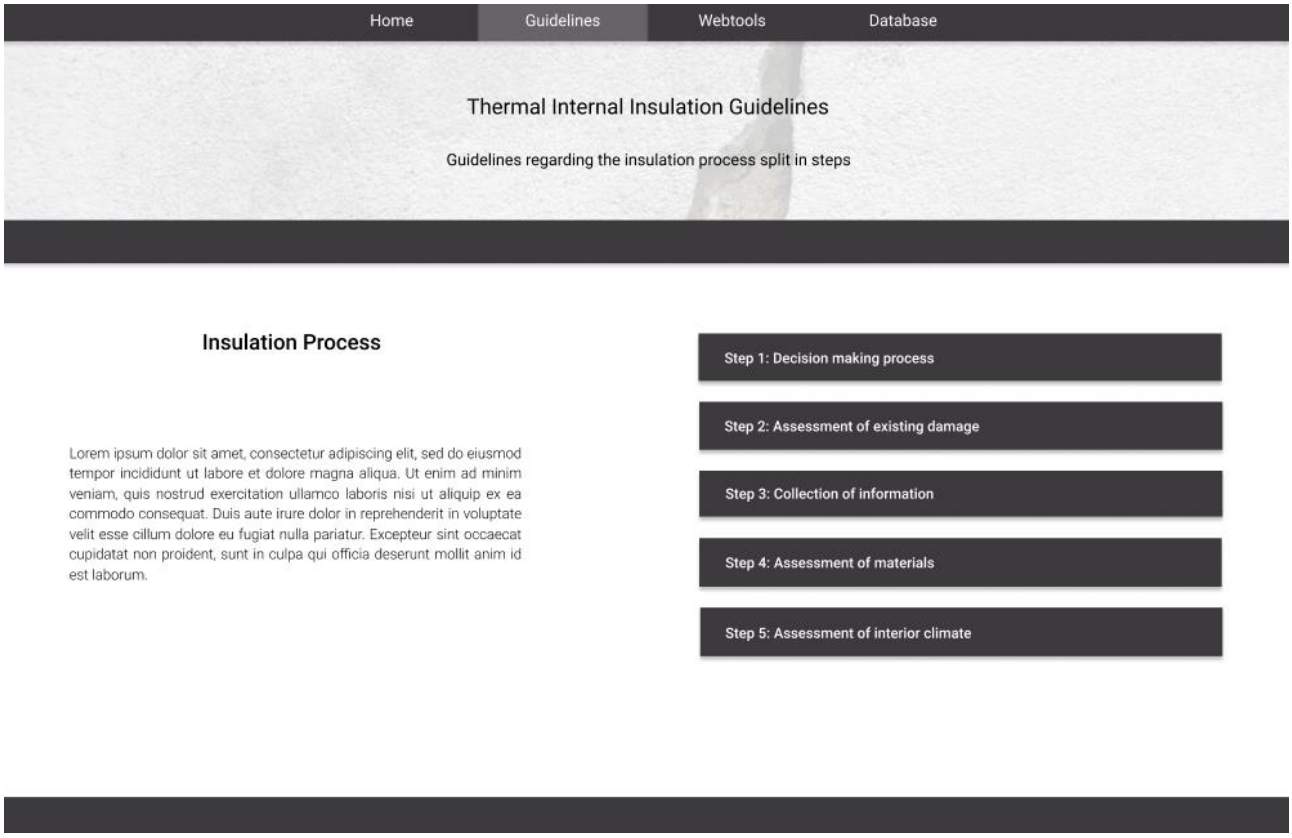


Figure 25 The figure presents the page that the users will interact with if they press Insulation Guidelines. From here they can choose the topic for accessing a page with related information.

If the users click on "Step 2: Assessment of existing damage", they will access the page that the figure 26 presents below. The content of this page describes the damage of the building that is caused by the external and internal facade. The content is split into four topics, moisture damage, mould, salt efflorescence and algae growth. Figure 26 presents a part of the picture due to the limitations of Microsoft Word. Nevertheless, this sample of the page demonstrates the main layout of the second step.

We decided to include a lot of pictures, which was also elaborated in the study of Elliot (2002), where she states that pictures, especially maps, drawings of buildings are the main triggers in architect's process. Based on the information we obtained from the interviews and due to the length of the page we added a navigation feature on the left of the page. By clicking the navigation menu on the left the users will be able to scroll automatically to the option they clicked. In addition, we added the option to navigate fast from one step to the other by adding two buttons on the bottom of the page.

Figure 26 When the users select "assessment of existing damage" they access this page, where they can learn more information about the topic. The page is not fully presented due to being in MS Word.

By clicking the insulation test option, the users will access the page presented in the figure 27. There they will have the opportunity to answer questions based on pictures in order to decide if the building they are working on is suitable for install internal insulation. At the end of the test, the users will have the option to download their answers as an excel sheet file. It is a beneficial feature to implement, as it was mentioned in the workshops and also in previous studies. Architects are decision makers, based on Kerschberg and Jeong (2005) who confirmed that they tend to document and create a backlog of their materials, therefore they benefit from access to relevant knowledge at the right point to make well-founded decisions in time. The bar we created demonstrates how many questions the users should reply before completing the test.

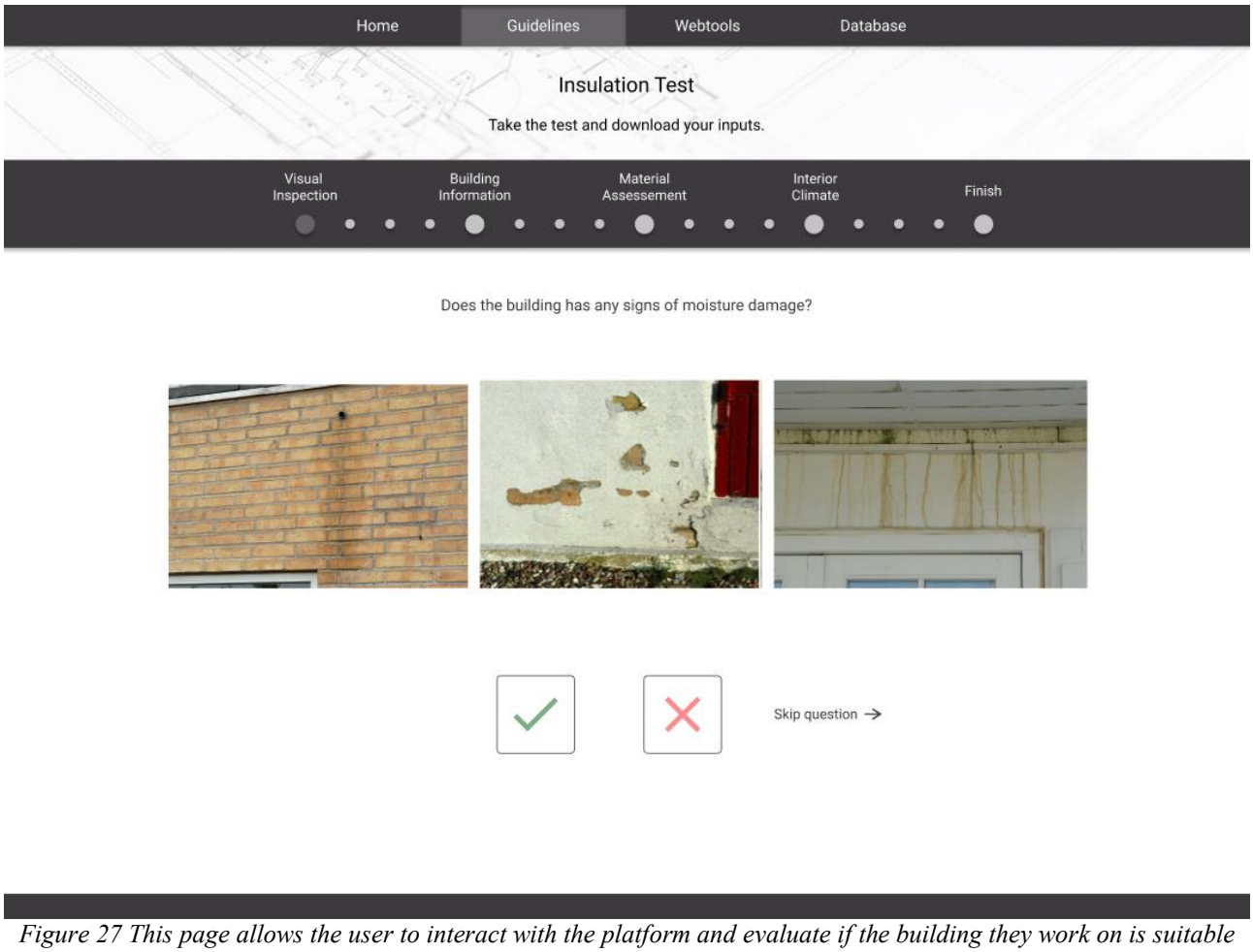


Figure 27 This page allows the user to interact with the platform and evaluate if the building they work on is suitable for thermal internal insulation by answering questions.

7 Reflections

In the reflections chapter we discuss future work that could enhance our research and our reflections regarding the methodological approach we applied.

Firstly, we discuss an impediment that affected the project's course and as a consequence the usability testing process. The arrangement among the stakeholders was to deliver the research material on the 31st of March. In reality, the only research material we received until the 15th of May was the evaluation of the damage in buildings. There were four additional research papers that were not ready for delivery. Thus, we did not have the content to create a final version of the prototype. That was the reason for shifting the focus of the usability testing toward measuring the navigation instead of overall satisfaction. Our proposal for researchers and designers that face the same circumstances would be to conduct heuristic evaluation instead of usability testing.

When collecting the data from the users, we focused only on Danish population what does not represent all the European countries participating in the RIBuild project. Therefore, in order to increase the validity of the data, we recommend expanding the focus of the research by including architects from different European countries.

8 Conclusion

In this section, we answer the research questions and consequently our problem statement: "**What are the architects' requirements from a digital platform that presents information about thermal internal insulation?**

RQ1 How does visual information affect architect's work?

The content analysis of the interviews indicated that architects work with visual information in their profession. They sketch both digitally and physically in order to express their ideas, communicate ideas with their colleagues and create 3D models. They stated that they tend to look for inspiration from online sources like Pinterest, and that they take pictures of buildings in order to analyze them. Based on interview and workshop data, they expressed the opinion that they prefer visual representation of buildings in their work and have a tendency to avoid reading long text when it is possible. Additionally, when the participants of the survey were asked what they expect from a website with information related to thermal internal insulation, they expressed their need for visuals and graphics. The decision-making process and the creative work they produce is affected and inspired by visual stimulations.

RQ2 What type of information do users want to be provided with?

Regarding the level of information, they require in their daily tasks, the data shows that architects do not like looking for information in books or research papers. If the information is presented in long texts, the architects tend to search for alternative sources of information. This finding is supported by the survey where 54% (n=20) replied that they prefer online sources. An encouraging finding of the project is that 70% of the respondents answered that they have some knowledge about thermal internal insulation, which is the content of our website's prototype, but not enough to work confidently on a project of that nature. An insight that we gained from the workshops and interviews is that architects search for information that would assist them with their decision-making process in their field of expertise.

RQ3 How can user-needs be transformed into a prototype?

The interview data indicates that architects prefer to search for information via digital sources. Nevertheless, they have certain requirements from those platforms, like simple design, ease of use,

layers of information and pictures. Based on workshop data, they do not desire to visit a platform which serves only educational purposes, but they would rather like to use it in order to make their tasks at work easier. We used the following methods based on Human-Computer Interaction theory for collecting data that establishes the bases for our analysis. In the section we describe the actions taken in order to gather relevant data of high Validity & Reliability. The ethical concerns that were considered throughout our analyses are described in the end. Before presenting the methods applied, the target population of this study is described below. Furthermore, we aimed for simplicity and reducing the amount of distractions by creating a simple navigation structure.

RQ4 How does the prototype meet the user needs?

We conducted two usability tests in order to measure the user experience of the architect. The data was both qualitative and quantitative, and we measured efficiency, satisfaction and effectiveness. We considered usability a success, due to the lack of errors from the participant's side in two out of the three tasks. The participants completed the assigned tasks with very encouraging metrics, including the number of clicks and the time required to complete the tasks. We improved the prototype based of the results of usability in the domains that we observed and noted complaints.

What are the architects' requirements from a digital platform that presents information about thermal internal insulation?

This study highlights the importance of visuals in the daily life of architects, the lack of satisfaction that they feel when they interact with large amounts of text. Additionally, the expressed the significance of digital design and sketching as a method of communication in the collaborative process of their work. The research demonstrates proves that in digital platforms architects value simplicity and usability above all. Furthermore, they are willing to improve their knowledge in the fields related to their profession only if the medium presents more visual information than text. If the medium does not satisfy their preferences, they will hastily search for a different source of information.

References

Abbas Yazdanfar, Seyed & Heidari, ali akbar & Aghajari, Negar. (2015). Comparison of Architects' and Non-Architects' Perception of Place. Procedia - Social and Behavioral Sciences. 170. 690-699. 10.1016/j.sbspro.2015.01.071.

Adams, A., Lunt, P., & Cairns, P. (2016). A qualitative approach to HCI research. In Research Methods for Human–Computer Interaction (pp. 138–157). Cambridge University Press. https://doi.org/10.1017/cbo9780511814570.008

ALTEN Calsoft Labs Design Thinking Playbook, 2018, issuu.com/fredzimny/docs/1512384333-design-thinking-playbook

Attia, S., Beltran, L., De Herde, A., & Hensen, J. (2009). "ARCHITECT FRIENDLY": A COMPARISON OF TEN DIFFERENT BUILDING PERFORMANCE SIMULATION TOOLS. In Eleventh International IBPSA Conference (pp. 204–211). Glasgow. Retrieved from http://staging.ecobuild.co.uk/var/uploads/exhibitor/207/6wq29uz321.pdf

Beaudoin J. E. and Brady J. E, "Finding Visual Information: A Study of Image Resources Used by Archaeologists, Architects, Art Historians, and Artists," Art Documentation: Journal of the Art Libraries Society of North America 30, no. 2 (Fall 2011): (pp. 24-36), https://doi.org/10.1086/adx.30.2.41244062

Beaudoin J. E. and Brady J. E., "Finding Visual Information: A Study of Image Resources Used by Archaeologists, Architects, Art Historians, and Artists," Art Documentation: Journal of the Art Libraries Society of North America 30, no. 2 (Fall 2011): (pp. 24-36)

Beckman, S. L., & Barry, M. (2012). Innovation as a Learning Process: Embedding Design Thinking. California Management Review, 50(1), 25–56. https://doi.org/10.2307/41166415

Bevan, N., & Earthy, J. (2018). Benefiting from ISO Standards. In The Wiley Handbook of Human Computer Interaction Set (pp. 51-69). John Wiley & Sons, Inc.

Boote, D., & Beile, P. (2005). Scholars Before Researchers: On the Centrality of the Dissertation Literature Review in Research Preparation. Educational Researcher, 34(6), 3-15.

Bordens, K. S., & Abbott, B. B. (2002). Research design and methods: A process approach .Pediatric Hematology-Oncology (Vol. Eighth edi, p. 628). The McGraw Hill Companies. Retrieved from http://informahealthcare.com/doi/abs/10.1080/08880010290057291%5Cnhttp://psycnet.apa.org/psycinfo/2001-18329-000

Borgman, C. L. (2012, June). The conundrum of sharing research data. Journal of the American Society for Information Science and Technology, (pp. 1059-1078), https://doi.org/10.1002/asi.22634

Brown, T. (2008). Design thinking. Harvard Business Review, 86(6), 84–92, (p. 141) Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18605031

Bryman, A. (2012). Social research methods Bryman. OXFORD University Press (p. 766). https://doi.org/10.1017/CBO9781107415324.004

Bryman, A. (2016). Social Research Methods. Social Research (Vol. 5th) https://doi.org/10.4135/9781849209939

Buchanan, R. (2006). Wicked Problems in Design Thinking. Design Issues, 8(2), 5. https://doi.org/10.2307/1511637

Burkhard, R. A. (2004). Learning from architects: the difference between knowledge visualization and information visualization (pp. 519–524). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/iv.2004.1320194

Burnard, P. (1991). A method of analysing interview transcripts in qualitative research. Nurse Education Today, 11(6), (pp. 461–466), https://doi.org/10.1016/0260-6917(91)90009-Y

Bødker, S., & Madsen, K. (1998). Context: An active choice in usability work. interactions, 5(4), (pp. 17–25), doi:10.1145/278465.278469.

Cabrera, Á., & Cabrera, E. F. (2002). Knowledge-sharing Dilemmas. Organization Studies. Walter de Gruyter and Co., (pp. 687-710), https://doi.org/10.1177/0170840602235001

Chidlow, J. (1991). Information needs of architectural practices. Art Libraries Journal, 16(03), 18–24. https://doi.org/10.1017/s0307472200007264

Colombo, L. (2011). Designing highly engaging eBook experiences for kids. In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (Vol. 6966 LNCS, (pp. 531–534), https://doi.org/10.1007/978-3-642-24469-8_66

Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). About Face: The Essentials of Interaction Design, 4th Edition. Wiley (p. 722). https://doi.org/10.1007/s13398-014-0173-7.2

Cronin, P., Ryan, F., & Coughlan, M. (2008). Undertaking a literature review: a step-by-step approach. British Journal of Nursing, 17(1), 38–43.

Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2004). Human-Computer Interaction. Human-Computer Interaction, Third(January), 834. ISBN-10: 0-13-046109-1

Dumas, J., & Redish, Janice C. (1993). A practical guide to usability testing (Human/computer interaction). (pp. 322-324). Norwood, N.J: Ablex Pub.

Egbu, C. O., Robinson, H. S., Anumba, C. J., Egbu, C., & Carrillo, P. (2005). Construction as a knowledge-based industry. 31-49, DOI 10.1007/s12205-013-1607-z

Elliott, A. (2002). Computational support for sketching and image browsing during the early phase of architectural design. Unpublished doctoral thesis, University of California, Berkeley.

Erlingsson, C., & Brysiewicz, P. (2017, September 1). A hands-on guide to doing content analysis. African Journal of Emergency Medicine. African Federation for Emergency Medicine. https://doi.org/10.1016/j.afjem.2017.08.001

Farenhorst, R., & Van Vliet, H. (2008). Experiences with a Wiki to Support Architectural Knowledge Sharing. Context. Retrieved from http://farenhorst.eu/publications/Farenhorst-vanVliet-Wikis4SE2008-CRC.pdf

Farenhorst, R., & Van Vliet, H. (2009). Understanding how to support architects in sharing knowledge. In Proceedings of the 2009 ICSE Workshop on Sharing and Reusing Architectural Knowledge, SHARK 2009 (pp. 17–24). https://doi.org/10.1109/SHARK.2009.5069111

Fong, P. S., & Chu, L. (2006). Exploratory Study of Knowledge Sharing in Contracting Companies: A Sociotechnical Perspective. Journal of Construction Engineering and Management, 132(9), 928-939. doi: 10.1061/(ASCE)0733-9364(2006)132:9(928)

Goel, V. (1997). Sketches of thought. Design Studies (Vol. 18, pp. 129–130). MIt Press. https://doi.org/10.1016/S0142-694X(97)83288-7

Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research. e Qualitative Report, 8(4), (pp. 597-606), Retrieved from h p://nsuworks.nova.edu/tqr/vol8/iss4/6

Gomoll, K. (1990). Some techniques for observing users. The Art of Human Computer Interface Design, (pp. 85–90), Retrieved from v:%5CResearch%5CResources%5Cpapers%5CRM_3314%5CRM_3314.pdf

Goodey, J., & Matthew, K. (1971). Architects and Information. Institute of Advanced Architectural Studies, Research Paper 1, York, United Kingdom, University of York.

Goodman, E., Kuniavsky, M., & Moed, A. (2012). Observing the User Experience – A Practicioner's Guide to User Research. Observing the User Experience (2nd ed., pp. 419–437). Waltham (USA):Elsevier Inc. https://doi.org/10.1016/B978-155860923-5/50041-3

Hanington, B., & Martin, B. (2012). Universal methods of design: 100 ways to research complex problems. Develop Innovative Ideas. Retrieved from https://www.iitgn.ac.in/sites/default/files/library_files/2016/04072016.pdf%5Cnpapers3://publication/uuid/FD316216-3845-47B5-B7DA-0E68CD4B3014 (pp.102-103)

Hewett, T. T. (1986). The role of iterative evaluation in designing systems for usability. In Proceedings of the Second Conference of the British Computer Society, human computer interaction specialist group on people and computers: Designing for usability (pp. 196–214). New York, NY: Cambridge University Press

Holyoak, K. J. (1990). Problem solving. Thinking. D. N. a. S. Osherson, E. E. Cambridge, MA, MIT Press.

Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. International Journal of Human-Computer Studies, 64(2), (pp. 79–10), doi:10.1016/j.ijhcs.2005.06.002.

Jansen Y., (2014) Physical and tangible information visualization. Other [cs.OH]. Université Paris Sud - Paris XI, https://tel.archives-ouvertes.fr/tel-00981521v2

Kensing, F., & Blomberg, J. (1998). Participatory Design: Issues and Concerns. Computer Supported Cooperative Work, 7(3–4), 167–185. https://doi.org/10.1023/A:1008689307411

Kerschbergand L. & Jeong H., (2005) Just-in-Time Knowledge Management. In Professional Knowledge Management, volume 3782, Springer Berlin / Heidelberg, (pp.1-18)

Koutamanis, A., Timmermans, H., & Vermeulen, I. (1995). Visual Databases in Architecture. Recent Advances in Design and Decision Making (pp. 67-68). Avebury.

Krischkowsky, A., Wurhofer, D., Perterer, N., Tscheligi, M (2013).: Developing patterns step-by-step a pattern generation guidance for HCI researchers. In Zimmermann, A. (ed.) Proceedings of the 5th International Conferences on Pervasive Patterns and Applications, PATTERNS 2013, (pp. 66–72). ThinkMind

Kruschitz, C., & Hitz, M. (2010). Are human-computer interaction design patterns really used?. Proceedings of the 6th Nordic Conference on Human-Computer Interaction Extending Boundaries - NordiCHI '10, 711-714. doi: 10.1145/1868914.1869011

Kvale, S., & Brinkmann, S. (2008). InterViews: Learning the Craft of Qualitative Research Interviewing (2nd edition). Los Angeles: SAGE Publications, Inc. p. 1 - 61

Lim J. & Rahman M. (2016) Designing with people [Pdf]. Singapore: Cubes, 79.

Laseau, P. (2007). Graphic Thinking for Architects & Designers. Journal of Experimental Psychology: General (Vol. 136, pp. 23–42).

Lazar, J., Feng, J. H. J., & Hochheiser, H. (2010). Research methods in human-computer interaction. Evaluation. https://doi.org/10.1002/asi.21187 (pp. 288-302)

Lewis, J. R. (1994). Sample sizes for usability studies: Additional considerations. Human Factors: The Journal of the Human Factors and Ergonomics Society, 36(2), 368–378. doi:10.1177/001872089403600215

Liedtka, J.(2014) Batten Briefing: Understanding the Power of Design Thinking. Retrieved from https://issuu.com/batteninstitute/docs/designthinking-121814-issuu (pp.14)

Lin, T. C., Wu, S., & Lu, C. T. (2012). Exploring the affect factors of knowledge sharing behavior: The relations model theory perspective. Expert Systems with Applications, 39(1), 751–764. https://doi.org/10.1016/j.eswa.2011.07.068

Lindgaard, G., & Chattratichart, J. (2007). Usability testing: What have we overlooked? In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 1415–1424). New York, NY: ACM. doi:10.1145/1240624.1240839..

Ma, Z. Z., Qi, L. Y., & Wang, K. Y. (2008). Knowledge sharing in Chinese construction project teams and its affecting factors: an empirical study. 2(2), 97-108, aisel.aisnet.org/amcis2010

Mackinder, M. (1983). The architect's information needs. Architects' Journal 178, pp. 103, https://doi.org/10.1002/asi.21338

Makri, S., & Warwick, C. (2010). Information for inspiration: Understanding architects' information seeking and use behaviors to inform design. Journal of the American Society for Information Science and Technology, 61(9), 1745–1770. https://doi.org/10.1002/asi.21338

Molich, R., Ede, M. R., Kaasgaard, K., & Karyukin, B. (2004). Comparative usability evaluation. Behaviour and Information Technology, 23(1), (pp. 65–74), doi:10.1080/0144929032000173951.

Nielsen, J. (1993). Usability Engineering. Morgan Kaufmann Publishers Inc (pp. 321–361). Elsevier. https://doi.org/10.1145/1508044.1508050

Nielsen, J. (1994). Estimating the number of subjects needed for a thinking aloud test. International Journal of Human-Computer Studies, 41(3), (pp. 385–397), doi:10.1006/ ijhc.1994.1065

Park, J., & Gabbard, J. L. (2018). Factors that affect scientists' knowledge sharing behavior in health and life sciences research communities: Differences between explicit and implicit knowledge. Computers in Human Behavior, 78, (pp. 326–335), https://doi.org/10.1016/j.chb.2017.09.017

Parthenios P., (2005). Conceptual Design Tools for Architects, ISBN:0-542-16411-6

Paryudi, I., & Fenz, S. (2015). Evaluation of User Interface Design of Semergy System (pp. 469–473). Association for Computing Machinery (ACM). https://doi.org/10.1145/2684200.2684349

Piwowar, H. A., & Chapman, W. W. (2010). Public sharing of research datasets: A pilot study of associations. Journal of Informetrics, 4(2), 148–156. https://doi.org/10.1016/j.joi.2009.11.010

Pourdehnad, John & R. Wexler, Erica & V Wilson, Dennis. (2011). Systems & Design Thinking: A Conceptual Framework for Their Intergration. 55th Annual Meeting of the International Society for the Systems Sciences 2011. 807-821.

Renzl, B. (2008). Trust in management and knowledge sharing: The mediating effects of fear and knowledge documentation. Omega, 36(2), 206–220. https://doi.org/10.1016/j.omega.2006.06.005

Resmini, A. (2014). Reframing Information Architecture, (p. 26). Cham: Springer International Publishing. http://doi.org/10.1007/9783319064925_3

Riihiaho, S. (2018). Usability Testing. In The Wiley Handbook of Human Computer Interaction Set (pp. 255-275). John Wiley & Sons, Inc.

Rosenfeld, L., Morville, P., & Arango, J. (2015). Information architecture : For the web and beyond. Retrieved from https://ebookcentral.proquest.com

Rowley, J. & Slack, F. (2004). Conducting a literature review. In: Management Research News, 27(6), 31 - 39, https://doi.org/10.1108/01409170410784185

Saffer, D. (2013). Microinteractions. Smart Design(I, p. 170). O'Reilly Media, ISBN: 9758-1-491-94592-6

Sanoff, H. (2011). Multiple Views of Participatory Design. Focus, 8(1), Focus, 04/01/2011, Vol.8(1). (pp.10)

Schon, D. A., & Wiggins, G. (1992). Kinds of seeing and their functions in designing. Design Studies, 13(2), 135–156. https://doi.org/10.1016/0142-694X(92)90268-F

Schuler, D., & Namioka, A. (2017). Participatory design: Principles and practices. Participatory Design: Principles and Practices (pp. 1–319). CRC Press. https://doi.org/10.1201/9780203744338

Schulte-Mecklenbeck, M., & Huber, O. (2003). Information search in the laboratory and on the Web: With or without an experimenter. In Behavior Research Methods, Instruments, and Computers (Vol. 35, pp. 227–235). Psychonomic Society Inc. https://doi.org/10.3758/BF03202545

Sears, Jacko, Jacko, Julie A, & Sears, Andrew. (2009). Human-Computer Interaction: Development Process. Human Factors and Ergonomics.(pp.253-273)

Sergeeva, A., & Andreeva, T. (2016, July 1). Knowledge Sharing Research: Bringing Context Back In. Journal of Management Inquiry. SAGE Publications Inc., 240-261. https://doi.org/10.1177/1056492615618271

Simon, H. A. (2006). Models of Thought. The American Journal of Psychology, 93(4), (p. 730), https://doi.org/10.2307/1422381

Simonsen, J. G. (2018). User Experience. In The Wiley Handbook of Human Computer Interaction Set (pp. 191-206). John Wiley & Sons, Inc.

Sklar F.H, "Why Make Images Available Online: User Perspectives, "in RLG Digital Image Access Project, ed. Patricia McClung (Mountain View, CA: Research Libraries Group, 1995), (p.13),

Snow, C. (1975). Architects' wants and needs for information, demonstrated through a university-based information service. Aslib Proceedings, 27(3), 112–123.

Spencer, D. (2009). Card Sorting: Designing Usable Categories. In Card Sorting: Designing Usable Categories (1st ed., pp. 4–25). New York: Rosenfeld Media.

Stembert N., (2017). Co-Creative Workshop Methodology Handbook. (p. 51), Ref. Ares(2017)3243743

Thimbleby, H. (2018). Interactive Critical Systems and How to Build Them. In The Wiley Handbook of Human Computer Interaction Set (pp. 7-31). John Wiley & Sons, Inc.

Tullis, T., & Albert, B. (2013). Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics: Second Edition (pp. 1–301). Elsevier Inc. https://doi.org/10.1016/C2011-0-00016-9

Virzi, R. A. (1992). Refining the test phase of usability evaluation: How many subjects is enough? Human Factors: The Journal of the Human Factors and Ergonomics Society, 34(4), 457–468. doi:10.1177/001872089203400407.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. Human Resource Management Review, 20(2), 115–131. https://doi.org/10.1016/j.hrmr.2009.10.001

Wang, Z., & Wang, N. (2012). Knowledge sharing, innovation and firm performance. Expert Systems with Applications, 39(10), 8899–8908. https://doi.org/10.1016/j.eswa.2012.02.017

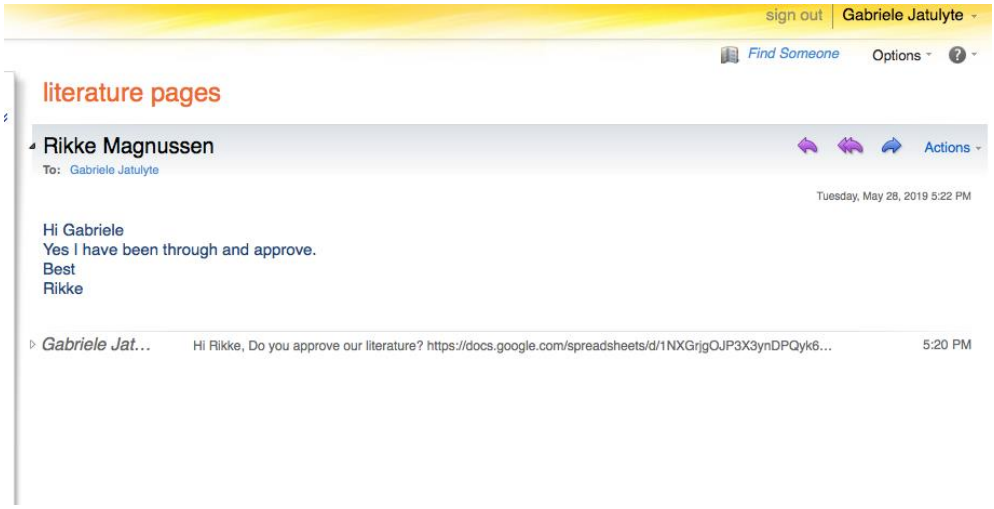
Williams, D. G., & Babbie, E. R. (2006). The Practice of Social Research. Contemporary Sociology, 5(2), 163. https://doi.org/10.2307/2062956

Zaphiris, Panayiotis & Ang, Chee Siang (2009). Human computer interaction concepts, methodologies, tools, and applications. (pp. 52-80). Hershey, PA Information Science Reference

Ørngreen, R., & Levinsen, K. T. (2017). Workshops as a Research Methodology. Electronic Journal of ELearning, 15(1), 70-81. [569].

APPENDICES

Literature Approval



Appendix 1: Literature search; keywords and blocks
Appendix 2: Work packages and related work of RIBuild
Appendix 3: Related projects and platforms to RIBuild project
Appendix 4: Consolidated criteria for reporting qualitative research
Appendix 5: Expert Interview questions
Appendix 6: Interview guide & transcriptions
Appendix 6.1: Coded interviews
Appendix 6.2: Coded categories
Appendix 7: Survey questions

Appendix 8: Workshop material
Appendix 9: Usability test