

Right knowledge for the right user at the right time

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<p>A globally operating software product company provides online support services such as user assistance and discussion forum for its B2B customers in the building construction industry. Its vision for 2025 states that online services provided to users will reduce mental stress and help customers in digitalization. Backbone of this research was an intelligent user assistance that would shorten the learning curve, expand the knowledge of users, and improve user performance. In this way, the customer's value in use could be realized faster affecting the intention to buy after the trial or renew order and thus reduce churn.</p> <p>In this thesis we deal with two practical topics. The first topic is how the results of the user assistance knowledge search should be ranked to best help the end user. This was explored by innovating and developing a proof of concept of an intelligent search. Another topic was to identify the concrete steps needed to implement intelligent user assistance. The tangible result of this was a roadmap stating the intention and direction using themes and more detailed features.</p> <p>The constructive research and development of the proof of concept was based on data collection among the company's experts. The proof of concept was built in collaboration with an AI partner and evaluated in interviews. The applicability of the proof of concept was considered when roadmap towards intelligent user assistance was created. For the evaluation of the roadmap, it was presented to the steering group of the company.</p> <p>An analysis of the primary data collected clearly showed how search results should be ranked and what types of users the new service should focus on. The abstract concept of "advancedness" developed proved essential to ensure the relevance of the assistance provided. The new intelligent assistance would bring together the target company, customer organization as well as community of practice for co-creation of knowledge. Finally, the roadmap was evaluated and accepted by the target company's steering group.</p> <p>In the thesis, intelligent user assistance was combined with knowledge management theories which created a new perspective and solution that would make it possible to reduce the deep learning curve of the target company's professional software. The approach presented could be extended in the future allowing a customer using multiple products from the portfolio to share and re-use valuable construction domain knowledge that help to successfully complete the various phases of a building construction project.</p>	
Keywords Intelligent user assistance, AI, knowledge management, customer experience, proof of concept, roadmap, BIM	

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Abbreviations

AEC	Architectural, Engineering, and Construction
AI	Artificial Intelligence
B2B	Business to Business
B2C	Business to Consumer
BIM	Building Information Modelling
POC	Proof of Concept
UX	User Experience

1 Introduction

The study was conducted in a software company that develops software products and digital services for the construction industry. It is a globally operating B2B (Business to Business) company having customers in over 100 countries, own offices in more than 20 countries and a worldwide reseller partner network. The target organization is part of a larger technology company headquartered in Sunnyvale, California.

At the heart of the thesis is a professional Building Information Modelling (BIM) software provided by the target company as well as the customers operating in the construction industry: structural engineers, steel detailers and fabricators, concrete detailers and manufacturers, and construction companies.

The BIM product as well as other software products of the company are provided together with online services such as a user assistance where users can browse and retrieve the instructional and support content and discussion forum where users may seek answers to their problems.

The background to this thesis was the knowledge that a steep learning curve for organizations in the engineering and construction industries is preventing digitalisation (Ernst & Young 2017) and that was the broader problem that this thesis sought to solve.

A practical starting point for the study was the service planning project implemented in the summer of 2020. The project was presented at the Teollisuus 4.0 event on 31 August 2021 (Professio 2021, 1:30-5:00). The reason for starting the project was the change in the business model of the target company from perpetual licensing to subscription licenses. The subscription model is based on a satisfied customer: if the customer is not satisfied with the product after one month or six months, the customer may not renew the subscription license. In the post-purchase phase, online services, onboarding, eLearning, and similar supporting services are important as well as the fact that customers support and learn from each other. Another driver for the project was the numerous existing separate online services. Services had been developed over the years for different needs and target groups and did not work together.

One of the findings of the service design project led by the author and implemented by a 3rd party consultant was that a common search over the multiple online services would make software end user troubleshooting and finding relevant information easier and faster and thus maximises productive time of the customer. Simultaneously with this thesis, a new search service was implemented in the target company. The new search was based

on proprietary search engine technology, and it combined the content of several websites into a single search.

Although a technical solution for integrating the content of several different websites was designed and implemented, the optimal ranking of search results was still a relevant and practical problem with research potential (Kasanen, Lukka et al. 1993, 246). How should search results be ranked so that the knowledge returned by the search best helps the end user?

Another practical starting point for the study was the vision of the target company that in the future, help content, be it text, images, video, could be provided to the user in real time directly in the software product when the user needed help. The assistance could fill gaps in basic knowledge and understanding that negatively impact the new user experience. An intelligent service would be faster than finding help online, and on the other hand, various existing help features, such as tooltips or animations, are fixed and can only solve a small fraction of potential problem situations.

Achieving the vision would require, firstly, the intelligence of the BIM software itself, secondly, the knowledge content, and thirdly, a dynamic way to combine the two. One way to combine a product's intelligently perceived usage situation with corresponding help content could be an intelligent search. Another practical research problem, then, was how to make these parts work together and what steps would be needed to develop an assistance service that can get the right knowledge for the right user at the right time.

The objectives and research questions of this thesis are described in the following chapter 1.1. After this, chapter 1.2 clarifies the scope of the research and explains which issues were excluded from the research.

Thorough understanding of the theory and previous studies of the relevant research areas was essential. The research areas contained customer experience from a business motivation point of view and knowledge management and intelligent user assistance from a technical perspective. The research literature in these three areas is reviewed in the chapter 2.

The chapter 3 contains the principles that guided the research and development design and process. The methods selected for data collection, analysis, development, and evaluation are presented in order in which they were used in the research.

The results of the study are presented in chapter 4. At the beginning of the chapter, the results of the research, development, and evaluation of the proof of concept (POC) are

presented in chronological order followed by the relevant user personas defined for this study. Finally, the results of the development and evaluation of the roadmap are presented.

In the end of the thesis the chapter 5 Conclusions chapter summarizes the results of the study and the answers to the research questions. The final chapter 6 Discussion looks at what could have been done differently in this study and, on the other hand, sheds light on how research and development could be continued in the future.

In the following, materials obtained from the target company will be referred to as Company X and its real name and software brand will be hidden.

Thesis has been written using RefWorks application for automatic referencing with Harvard - British Standard style.

1.1 Objective and research questions

The first objective of this thesis was to explore intelligent search by developing a proof of concept (POC).

The second objective was to create a roadmap for building a new, intelligent, user assistance service helping the new users of the BIM software provided by the target company.

This thesis answers to following research questions:

RQ1: What types of users are there?

RQ1.1: What kind of knowledge would different types of users need?

RQ1.3: How different types of users can be identified?

RQ2: How should search results be ranked?

RQ3: What kind of search would serve as a starting point for an intelligent service assisting users?

RQ4: What steps should be taken to develop an intelligent service assisting users?

1.2 Scope

In this thesis, the term proof of concept refers to the process used in software development to determine whether the concept is possible to implement and is it likely that the end users would use it (Prasanna 2021, 1). The concept to be proven is intelligent search, which ranks search results in a new way. Proof of concept is limited to demonstrating whether the concept is appropriate for customer needs and other issues related to, for example, usability of the concept is excluded from the proof of concept. Thesis does not explain the AI algorithms used in detail but focuses on the development process and the resulting value. Proof is sought through interviews. The sample set of respondents was small and thus this research does not claim to be a statistically significant representation of BIM user community.

The other tangible artefact that comes out of this thesis is the roadmap. The roadmap developed in this thesis is a "strategic communication tool, a statement of intent and direction" (Lombardo, McCarthy et al. 2017, Ch. 1). The roadmap is realistic and does not include things that the target company would not be able to accomplish. It also does not include features that are not essential. However, the roadmap does not try to accurately predict the future but leaves open that in future there could be other, better ways to achieve the same result. The roadmap does not include details on implementation, resources, milestones, or specific dates that are better suited to development, project, and release plans

Out of the three stages of B2B customer journey, prepurchase, purchase and post-purchase (Lemon, Verhoef 2016, 10), this thesis focuses on B2B customer experience in the post-purchase stage where the BIM software product is taken into use. The scope is limited to the knowledge related to use of the BIM software.

Ethical aspects related to the use of AI, such as considerations related to collecting usage data, modeling user behavior, and exposing users to intelligent user assistance, will not be addressed. However, ethical issues in conducting the research were carefully considered, such as privacy in interviews and protection of participants' identities. Diversity, equality and inclusion were taken into account, and, for example, the gender of the persons mentioned in the thesis was hidden by avoiding words such as "she" or "he". The researcher's own dual role as a researcher and an active player in the target company was considered.

This thesis did not examine whether the developed ideas or the presented models are already patented or whether they could be patented by the target company. That will remain to be done at the target company later.

2 Literature review

2.1 Customer experience

The customer experience has been studied and defined since at least the 1960s, when initial theories of marketing and consumer behaviour were developed (Lemon, Verhoef 2016, 71). There has been a wealth of literature on the customer experience and the topic has been studied from many different perspectives (see Figure 1).

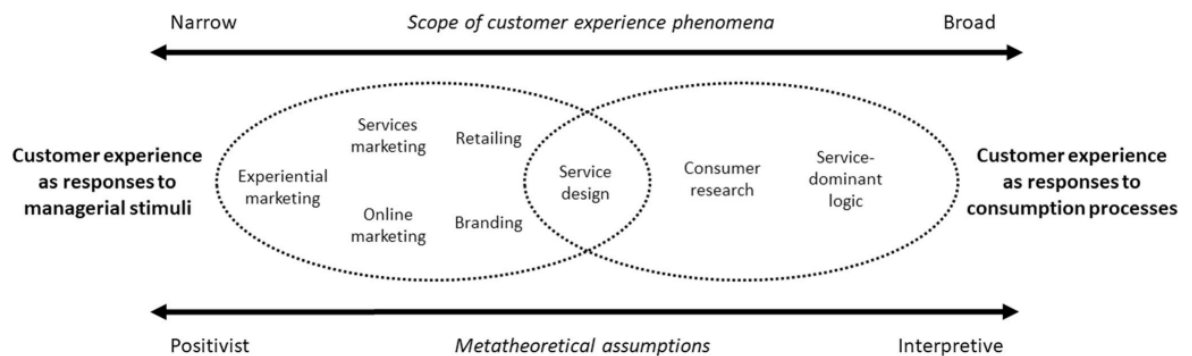


Figure 1. Elements addressed in customer experience research presented in a theoretical map (Becker, Jaakkola 2020, 636)

In 2016, the Lemon and Verhoef (71) went through generally accepted definitions of customer experience and concluded that customer experience is “a multidimensional construct focusing on a customer’s cognitive, emotional, behavioural, sensorial, and social responses to a firm’s offerings during the customer’s entire purchase journey”. This definition belongs to the left side of Becker and Jaakkola's (2020, 636-637) theoretical map, where the customer experience is seen as a response and reaction to the actions and stimulation by the company. In such a research tradition, the company actively seeks to shape the customer experience along the customer path and to measure the effectiveness of the activities.

Vargo and Lusch (2004, 7) argued that instead of marketers segmenting customers, advertising, and doing activities for customers, marketing is done in interaction with the customer. Similarly, value is not formed by the company but by the value-in-use perceived by the customer. They later modified their service-dominant logic theory by specifying that “value is idiosyncratic, experiential, contextual, and meaning laden” (Vargo, Stephen, Lusch 2008, 7). The service-dominant logic belongs to the right edge of Bennett's and Jaakkola's theoretical map in Figure 1. In this type of tradition, experiences are created together by many actors in a particular context. The customer experience arises in

response to the entire consumption processes and all the actors involved in creating the experience. (Becker, Jaakkola 2020, 635-637).

Goods-specific logic sees services as somewhat inferior to goods: a limited type of goods or something that are complementary to goods. Service dominant logic's sees that a service can be provided directly, or the goods can convey the service and value. However, the goods themselves are not an essential source of value creation. The source of value creation is the knowledge and skills of service providers and benefiting individual or organization. (Maglio 2009, 398-399) Service is thus defined as "application of resources (primarily knowledge and skills) for the benefit of another individual or organization" (Greer 2016, 29).

All kinds of individuals, groups, organizations, companies, for example, customers can be service systems if they operate, use resources, and work with others in a mutually beneficial way. Value is co-created in mutual exchange between service systems when the resources of the service provider are accepted and integrated with existing resources. The aim is to apply the knowledge (i.e., service) to improve one's circumstances. (Vargo, Stephen L., Maglio et al. 2008, 145, 149-150)

In this thesis, the service is seen as service-dominant logic sees it, i.e. a process of doing something for and with another party (Maglio 2009, 399), and thesis also follows the service-dominant logic's definition of value creation and customer experience.

There are studies in the literature that seek to explain the relationship between user experience and usability and customer experience and satisfaction. For example, usability was shown to have a direct positive effect on customer satisfaction as well as customer trust when mobile banking users were studied in Tehran (Esmaeili, Haghgoo et al. 2021, 74, 76). Other studies combine the third aspect, brand, with user and customer experience. Lee, Katie et al. (2018, 13-14) tested a conceptual theory that combines user, customer, and brand experience that have usually been studied separately in different disciplines. The study examined smartphone users and found that usability was not relevant to the customer experience. This was explained by the fact that when the study was conducted, smartphones were already advanced, and ease of use was taken for granted. Instead, emotions and user value had an impact on the customer experience. Further, the customer experience acted as a mediator of the user experience and influenced brand equity. (Lee, Katie et al. 2018, 19-20) In a study in Jordan, the user experience variables had the greatest effect on satisfaction of smartphones (Badran, Haddad 2018, 17).

2.1.1 B2B customer experience

Customer experience usually refers to consumer experience rather than B2B customer experience (Witell, Kowalkowski et al. 2020, 420), and there is little literature on B2B experience (Lemke, Clark et al. 2011, 850, Roto, Kaasinen et al. May 07, 2016, 622). For B2B companies, the challenge in creating and managing the customer experience is, among other things, that there are many customer contacts, teams, and roles at different levels of the customer organization. The challenge is that different people may have different experiences at different stages of the customer journey: the buyer may have a positive experience, but the user is dissatisfied. (Witell, Kowalkowski et al. 2020, 424-425)

Practical experience of how to gain a competitive advantage by investing in B2B user experience was gained from a five-year research program in which Finnish research organizations and B2B companies in the metal and engineering industry participated. In B2B, improving the product experience is not enough, but all the contact points in the path, including support and maintenance, are equally important. At the end of the program, the focus had expanded from an initial product user experience to a full-path customer experience and brand experience, and how brand promise and user and customer experience go hand in hand. (Roto, Kaasinen et al. May 07, 2016, 837)

McLean (2017, 664-666) examined whether the quality and credibility of information on B2B websites has an impact on the customer experience when a customer searches for information on websites. The results showed that these variables have a strong link to the customer experience and whether the search was successful. It was further found that when the search was successful, the customer did not need to contact customer support, which contributed to a positive customer experience.

An interview study of Lemke, Clark et al. (2011, 847, 864-865) of 20 B2C (Business to Consumer) firms and 20 B2B firms found support for the service-dominant logic's principles in B2B context. A B2B customer values a supplier who understands the value in use and the customer's own goals for using the product or service and not just deliver the product or service features the customer needs. Even though in B2B offerings tend to be standardized the research showed that co-creation of idiosyncratic value in use and personalization are desirable and supplier should focus on those. The research pointed out important constructs of the customer experience quality, for example, value for time, personalizing the service delivery and taking ownership of the customer's problems. One of the important elements of a B2B customer experience is the knowledge and expertise of the supplier that can be used to add value to the customer (Lemke, Clark et al. 2006, 15).

2.1.2 Customer experience in the implementation phase of BIM

This thesis focuses on the customer experience and value-in-use in the post-purchase phase of a customer journey where the BIM software is implemented and taken into use. At this point, the product itself is the critical touch point (Lemon, Verhoef 2016, 76). The following focuses on the issues BIM customers experience in the post-purchase phase.

According to a literature review (Ahmed 2018, 111), the introduction of BIM in the construction industry has been a slow due to resistance, traditional contract methods, training costs, expensive software, lack of BIM awareness and steep learning curve. A global study by Ernst & Young (2017) showed that the biggest barrier to the digital transformation of engineering and construction companies is related to talent: the lack of trained staff with the right skills and competencies. Digitalisation involves the introduction of new technology such as BIM and learning new skills can be difficult.

Similar results have been obtained from other studies. For example, a study among general and subcontractors in the United States (Ku, Taiebat 2011, 193) showed that the time required for staff training is a significant barrier to implementing BIM. The study also showed a trend to move from formal external training programs to tailor-made self-learning so that teaching can address firm-specific processes and skills in projects. Self-learning could be, for example, learning through trial and error and peer education. In this BIM departments had an important role as central BIM knowledge base that captured and provided lessons.

An obstacle to the introduction of BIM in an organization can be the lack of general BIM knowledge among the users and the time required to learn new software. The successful implementation of BIM software can be hindered by the employees' low knowledge of BIM methodology, as shown in a case study conducted in Lithuania. (Migilinskas, Popov et al. 2013, 767-768, 773-774) The study consisted of four real construction projects where different BIM software were implemented by the same project team. In this study, the team participants had very low BIM knowledge and they did not want to change their work practices but wished to work traditionally without BIM. A barrier in BIM implementation was the low staff skills.

2.1.3 User persona

It was important for the study to clarify who the user of the new user assistance would be. To this end, the user persona concept is useful. Cooper (2004, Ch. 9) defines a persona as a "precise description of our user and what he wishes to accomplish". Personas are hypothetical archetypes of real users that are used in design of software products instead

of real people. Instead of defining the user persona based on demographics and distribution channels, in software development personas are purely user-based and are used to help the development. Personas unique to each project and their goals are defined when the problem area is studied. According to Cooper (2004, Ch. 9), with the help of the personas the nature of the design problem become clear.

This literature review of customer experience helped us understand how improving user support relates to user satisfaction, value in use, and the total customer experience. We learned about the customer experience in the B2B environment and the problems of implementation of the BIM and how the concept of user persona can clarify who the user is. Next, we move on to second important research area that concerns another essential element of user assistance: knowledge and knowledge management.

2.2 Knowledge management

To understand knowledge management, it is good to recall the difference between data, information, and knowledge. Data is facts and figures without interpretation or context. Information is patterns in the data; in text it is something that answers to “when”, “where”, “who”, or “what” in the defined problem space. Knowledge is more than information. Knowledge can be said to be actionable information that in text answers question "how" or "why". (O'Dell, Grayson et al. 1998, Ch. 1, Quigley, Debons Apr 1, 1999, 5-7) Knowledge can be further divided into tacit and explicit. Tacit knowledge consists of both professional knowledge as well as beliefs, perceptions, insights, and intuitions that can be very subjective. Explicit knowledge, on the other hand, is formal, objective and can be processed, for example, by a computer (Bratianu 2010, 44, 48). The differences between data, information, and knowledge can be represented as a knowledge pyramid as in Figure 2.

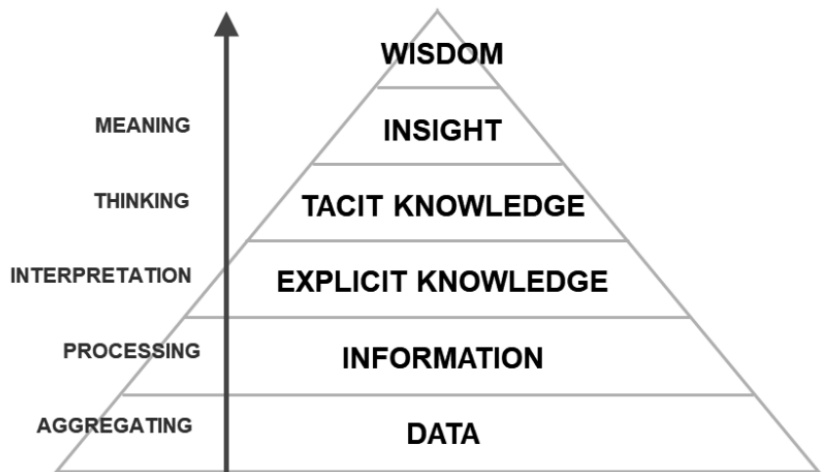


Figure 2. Knowledge hierarchy with associated processes (Kuo 2019, 20)

Nonaka (1994, 19) introduced the theory of the creation of knowledge and of how tacit knowledge becomes explicit and again adopted, tacit knowledge. The Nonaka’s SECI model is shown in Figure 3.

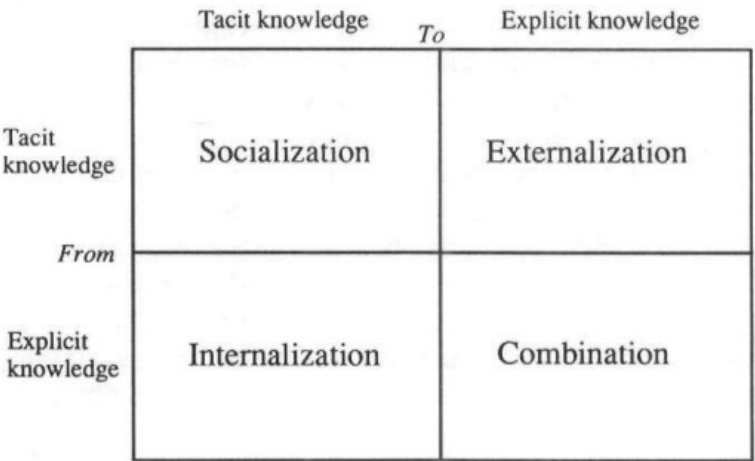


Figure 3. SECI model: Socialization – Externalization – Combination – Internalization (Nonaka, Ikujiro 1994, 19)

Next, we will review what the four fields of the SECI model mean. Socialization means sharing experiences and learning about individuals by exchanging tacit knowledge in daily conversations and interactions, and for example, an inexperienced employee learns from experience by imitating or constantly following an experienced employee. Socialization occurs not only within a team but also, for example, when employees meet with suppliers. Organizations often refer to “best practices” as knowledge that touches on topics deeper than everyday neutral dialogue. Socialization must therefore be about transferring best practice. (Bratianu 2010, 48)

The tacit knowledge is transformed into explicit knowledge through externalization and thus it can be shared and transferred to others. Externalization is an individual process where fuzzy tacit knowledge is transformed to well defined, structured knowledge that can be evaluated and that can be integrated into existing explicit knowledge. However, it takes effort to transform tacit knowledge into explicit. If employees ask themselves why to make the effort, there is a danger to lose a good deal of ownership over their knowledge. (Bratianu 2010, 49-50).

Combination means a process of integrating explicit knowledge with other pieces of explicit knowledge of the organization. This combination process happens in a social context in the organization in contrary to externalization that was purely individual process. It is good to note that there is no knowledge transfer if an individual shares knowledge already known in the organization. Bratianu (2010, 50-51) sees that as a drawback of the SECI model since it may lead to “knowledge perpetuum mobile” where knowledge is generated for ever.

Internalization is the last phase of knowledge creation. Internalization is an individual process where explicit knowledge is embodied as tacit knowledge by learning by doing. Internalized knowledge or technical know-how become an asset. For this to benefit the entire organization and not just the individual, the knowledge learned must be socialized with other members of the organization. A new knowledge creation spiral begins, as Nanoka and Takeuchi (1995, 69) calls it.

Leveraging and sharing tacit knowledge is linked with concept called “communities of practice”, which can be defined as

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

Community of practice is good at creating and keeping up-to-date useful knowledge content since community knows and understands the practical needs and appreciates the field. The most useful knowledge bases are integrated into the work of community of practice. Traditional knowledge bases, corporate universities, or centres of excellence are typically located separated from the employees who would benefit using the knowledge. (Wenger, McDermott et al. 2002, 9-12)

Wiig (1993, 100-101) has defined the degrees of internalization: at the lowest level a person does not know the existence of knowledge and at the highest-level person has deeply internalized all knowledge. The degrees of internalization are illustrated in Figure 4.

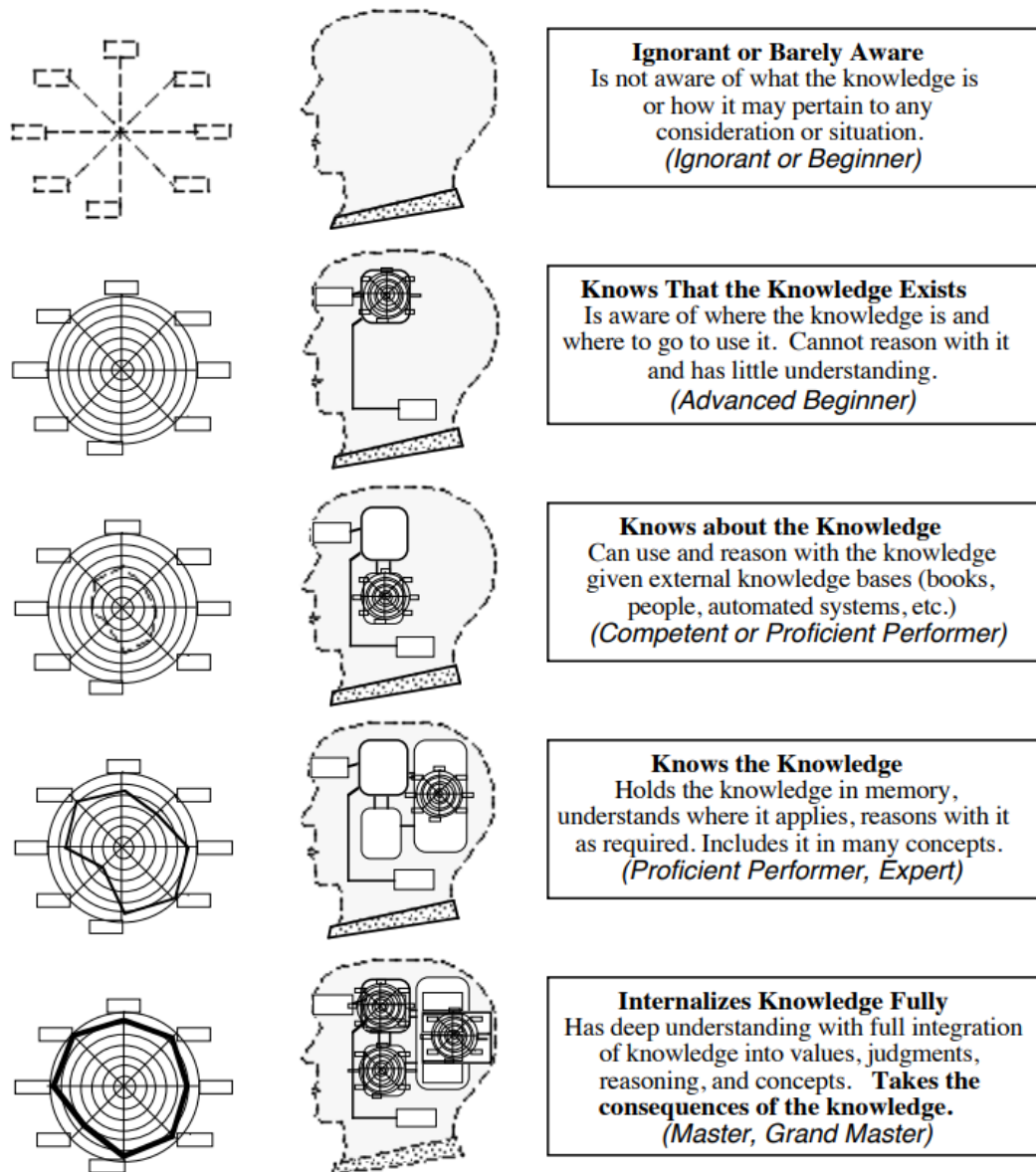


Figure 4. Degree of internalisation and extent of knowledge at different stages (Wiig 1993, 101)

Now that we have talked about the theory of organizational knowledge creation, we can move on to knowledge management. Knowledge management can be defined as a

“conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways

that strive to improve organisational performance” (O'Dell, Grayson et al. 1998, Ch. 1).

An important element in knowledge management is knowledge sharing. Systematic review by Ahmad and Karim (2019, 7-12) on empirical studies of knowledge sharing show the positive impact of knowledge sharing at three levels: at the level of individual employees, teams, and organizations. They are briefly summarized in the Table 1 below.

Table 1. Summary of the positive effects of knowledge sharing (applied from Ahmad 2019, 7-12)

At the individual level	<ul style="list-style-type: none"> • Sharing knowledge improves task performance, problem solving, and decision making and exposure to new perspectives reinforces innovative and creative behaviour at work. • Active tacit knowledge sharing is a source of personal professional development and can psychologically reduce the willingness to change jobs.
At the team level	<ul style="list-style-type: none"> • Knowledge sharing, and different sources of know-how equip the team to deal effectively with problems and obstacles, and team creativity and the creation of new ideas can gain momentum. • The socialization of knowledge can have a positive impact on the team atmosphere, which is reflected in collaboration and acceptance of diversity.
At the organizational level	<ul style="list-style-type: none"> • Tacit knowledge sharing has a positive impact on an organization's performance, both financially and operationally. • Knowledge sharing supports organizational learning, the use of knowledge in routines, the creation of new ideas, entrepreneurial orientation and, for example, the efficiency of business processes.

Some negative effects have also been observed. Sharing knowledge requires time and commitment, and demanding norms in the workplace can lead to information overload, burden individuals, and is, after a certain point, a waste of time. If employees' skill levels and cognitive mental models are very different, sharing knowledge can be stressful as people try to clear up misunderstandings and communication problems. The work atmosphere can suffer if individuals are reluctant to share their knowledge, utilize the knowledge and skills of others to benefit from them themselves, or share information that is not useful for doing the job. (Ahmad 2019, 14-15)

Over the years, the topic of knowledge management has been studied from different perspectives and in different fields. Traditionally the focus has been often on knowledge management within the organization. However, attention has also been paid to external

knowledge and inter-organizational learning. For example, Lane (2003, 700) studied supplier networks where the important hub company is in the centre of supplier firms. Hedberg and Holmqvist (2003, 734) focused on organizational partnerships, more specifically loosely connected organizations that operate as a single virtual or imaginary organization. The more recent research in 2015-2019 on knowledge management in an inter-organizational context has shifted the focus more to the “human side” of knowledge management, taking into account, among other things, human intellectual capital, social interconnectedness, communities, and, for example, user innovation (Agostini 2020, 474).

2.2.1 Knowledge management in construction industry

The construction industry is a knowledge-intensive sector. A huge amount of sophisticated knowledge is needed for construction projects but managing this knowledge can be difficult. (Wang, H., Meng 2019, 170) In construction industry tacit knowledge is created typically in practice through trial and error and includes, for example, problems encountered and solved, expert suggestions, know-how, and notes of experience. Explicit knowledge content helps in contracting, creating drawings, solving problems or, for example, approving proposals and it is documented in many forms such as articles, manuals, pictures, videos, and software. (Lin 2014, 190)

In construction industry knowledge management means management of professional domain knowledge received during the constructions projects. It is important for construction firms to re-use and share professional experience and lessons learned among the engineers to avoid making the same mistakes again (Boamah, Zhang et al. 2021, 5), reduce time and cost to solve problems and improve the process of the construction project (Lin 2014, 186). Companies leverage the internal knowledge of their engineers as well as the external knowledge and experiences of their customers and stakeholders. Many engineers see knowledge management important and necessary in construction projects. (Lin 2014, 186-187) Knowledge management has the potential to improve the efficiency of construction projects, and it is crucial that the construction industry is able to use and integrate knowledge regardless of individual, institutional, process or industry constraints (Boamah, Zhang et al. 2021, 2).

When it was analysed and measured the significant enablers in knowledge management in the construction industry in total of 17 enabling variables was found (see Figure 5). The top ranked enablers were employees' knowledge, motivation, and effective decision. Understanding enablers is one prerequisite for implementing a knowledge management in construction sector. (Boamah, Zhang et al. 2021, 1, 7)

Enablers of K.M	Mean	S.D	Rank
Employees knowledge	4.10	0.86	1st
Effective decision	4.02	0.94	2nd
Motivation	4.00	0.84	3rd
Organizational culture behavior	4.00	3.01	4th
Knowledge integration	3.98	0.96	5th
Infrastructure	3.98	0.87	6th
Information sharing	3.97	0.88	7th
Brainstorming	3.73	1.09	8th
Strategic planning	3.69	0.99	9th
Human resource management	3.66	1.06	10th
Problem-solving habit	3.65	1.06	11th
New techniques	3.42	0.91	12th
Compensation	3.42	1.02	13th
Education and training	3.35	0.99	14th
Team building	3.33	1.03	15th
Business target	3.23	0.33	16th

Figure 5. Enablers of knowledge management in the construction industry (Boamah, Zhang et al. 2021, 7)

The review of knowledge management in the construction industry told us about the meaning of knowledge and significance of knowledge management for the industry. Next, we move closer to the context of the target company and drill into BIM-based knowledge management.

2.2.2 Knowledge management system

Knowledge sharing may happen face-to-face or using technology. In the online world, a user accesses a data repository, an educational website or digital library, takes information and processes it (Doring 2015, 3). Today, information sharing in the workplace often takes place through technology (Ahmad 2019, 17) such as knowledge management system. A knowledge management system is a way for organizations to acquire, create, and use knowledge systematically and thus use the knowledge to, for example, compete in the marketplace (Fibuch 2011, 34).

The knowledge management system is driven by knowledge management process. It contains both employees' tacit knowledge, such as human experiences, external and internal training, and mentoring, as well as precise explicit knowledge that consists of, for example, external and internal data, e-portals, collaboration tools and information systems. (Fibuch 2011, 38) It uses different data storages, delivers knowledge to users at the right time when they need it, and encourages knowledge sharing (Alazmi 2003, 200).

However, there may be a difference between theory and practice. In the article "Do we practice what we preach? Are knowledge management systems in practice truly reflective of knowledge management systems in theory", Wickramasinghe (2003, 313) argued, based on case studies, that in reality, knowledge management systems do not support the subjective aspect of tacit information sharing. According to Wickramasinghe, the solution could be found through greater use of AI and the creation of knowledge management systems that enable and encourage the sharing of knowledge within communities.

The usability of the system is also of great importance. Sharing knowledge face to face is a different matter than technology-assisted sharing. For example, extrovert people may prefer share knowledge in a face-to-face relationship than via technology (Wang, S., Noe 2010, 125). Knowledge management system aims to bring benefit to users' work and improve their performance. The perceived usefulness motivates continuous use of the system. The quality of the system impacts on perceived usefulness, satisfaction, and trust in a system. The quality consists of system's quality and knowledge's quality. System's quality is defined by ease of use, response time, degree of flexibility, and, for instance, stability and number of bugs, while knowledge's quality consists of things like relevance, precision, accuracy, being up-to-date and completeness (Eko K Budiardjo 2017, 205-207, 215).

2.2.3 BIM-based knowledge management

A variety of IT systems have been developed over the years for efficient knowledge management in the construction industry (Wang, H., Meng 2019, 170). Commercial Building Information Modelling (BIM) software began to be developed in the mid-2000s for the design of complex building models. Building information was stored and managed in databases, and BIM tools were able to store, manage, and present the information as desired by the user. (Kuo 2019, 31)

With BIM, an engineer creates a virtual model of the building that contains the exact geometry and information needed for fabrication and construction (Eastman 2011, 1). BIM is not the same as computer-aided design (CAD), which represents objects with fixed geometry and properties. In BIM, geometry and properties are determined by parameters and rules, so objects are automatically updated according to user actions. (Eastman 2011, 25) In addition to parametric modelling, BIM has special features such as virtual visualization and a centralized platform (Wang, H., Meng 2019, 170). The European Union's BIM Task Group defines BIM more broadly as a "digital form of construction and asset operations" that "brings together technology, process improvements and digital

information to radically improve client and project outcomes and asset operations" (EU BIM Task Group , 4).

Much has been invested in managing and representing formal description of a building, but it is problematic to capture tacit knowledge or transform it to explicit. For this purpose, discussion forums have been set up where it has been possible to exchange experiences among the community of practice within the construction organization or across organizational boundaries. (Kuo 2019, 31)nA separate knowledge management software typically focusses on textual content retrieval. In construction projects the retrieval of visual presentation of knowledge is important since it makes it easier for engineers to understand and learn the knowledge directly in virtual 3D environment (Lin 2014, 186-187).

Based on a literature review by Wang, H. and Meng (2019, 182), it is possible to transform from separate IT-based to BIM-based knowledge management. With BIM-based knowledge management, many of the benefits described in the Appendix 1, "IT and BIM-based knowledge management" could be achieved. Admittedly, at present, BIM-based knowledge management research is still evolving. The author of this thesis found few articles in which design knowledge or, for example knowledge of building maintenance operations, was incorporated into BIM or a separate knowledge management system was integrated into BIM (Fangxiao, Jallow et al. 2013, Jasim, Aljumaily et al. 2021, Motawa, Almarshad 2013). In such cases where knowledge is included, one could talk about Building Knowledge Modelling (BKM). The differences between CAD, BIM and BKM are described in Table 2.

Table 2. Definitions for CAD, BIM and BKM applied from Jasin, Aljumaily et al. (2021, 3)

BKM	Building Knowledge Modelling	2D + 3D + information + knowledge
BIM	Building Information Modelling	2D + 3D + information
CAD	Computer-Aided Design	2D + 3D

We have now learned about theory of knowledge creation and knowledge management which are integral areas we address in this thesis. Also, we looked into knowledge management in the construction industry and BIM-based knowledge management. Now we move on to the third research area, which is intelligent user assistance.

2.3 Intelligent user assistance

Perhaps the best-known example of the first intelligent user assistance systems was the unsuccessful "Clippy, the paper clip" which appeared automatically to help Microsoft Office users (Maedche, Morana et al. 2016, 367). Many intelligent user assistance and guidance features were introduced already decades ago. Some of the things studied at the time are still relevant, while some have lost their relevance. Next, we go through some insights that are relevant to this day.

An article published in 1977 (Robertson, Newell et al., 33) described a new man-machine communication interface called ZOG. One of the great advantages of ZOG was that the user was instructed in menu selection during use. This was considered important especially for beginners who need an explanation, but also for situations where everyone is a beginner or does not know the professional language used in the software. At ZOG, the user did not have to read the manual and immediately know how to use the software correctly using the perhaps poorly understood instructions. And the user did not have to make an effort to search for relevant information. The development of ZOG was not only about technology but also about the philosophy of man-machine communication: whether we see the computer as a powerful and man-controlled tool or whether it is an intelligent assistant. The ultimate idea of an intelligent assistant was to free the person from the effort of understanding the software. (Robertson, Newell et al. 1977, 35-36).

A 1981 review of the most recent advances of user assistance (Relles, Sondheimer et al. , 1) found that users consider traditional training and documentation to be inadequate. Instead, in online user assistance systems a user accesses information by typing in a keyword or browses the online document freely. Ideally, users would write questions using natural language, but at the time, in the early 1980s, the broader use of natural language to provide assistance was limited. Using context it was possible to quickly focus only on essential information. The context could be the user's current interaction with the program, the most recent error, or the most recently displayed help topic. At that time, some researchers had already proposed storing a longer-term context in the form of a user profile, and a limited form of this was implemented in systems that tailor messages to a specific user experience. (Relles, Sondheimer et al. May 21, 1981, 1-3)

In 2020, automated, intelligent user assistance was defined as contextual user assistance, where assistance is sought and provided to a specific situation or state while using the software. Unlike other types of user assistance, the help content does not need to be read as a whole. Each topic covers the corresponding state, situation, or feature of the software and may include also procedural and tutorial information. (Acar, Tekinerdogan 2020, 1,3)

User assistance systems have been classified in many studies. Next, we go through the three classifications in more detail. In the first classification (Acar, Tekinerdogan 2020, 2), the lowest level of user support is a manual, typically a paper document. The second level is external electronic assistance that can be launched in the application. In level three the online help is embedded in the program. At the fourth level, user assistance is embedded in the program and aids a user based on certain context parameters. This classification is shown in Figure 6.

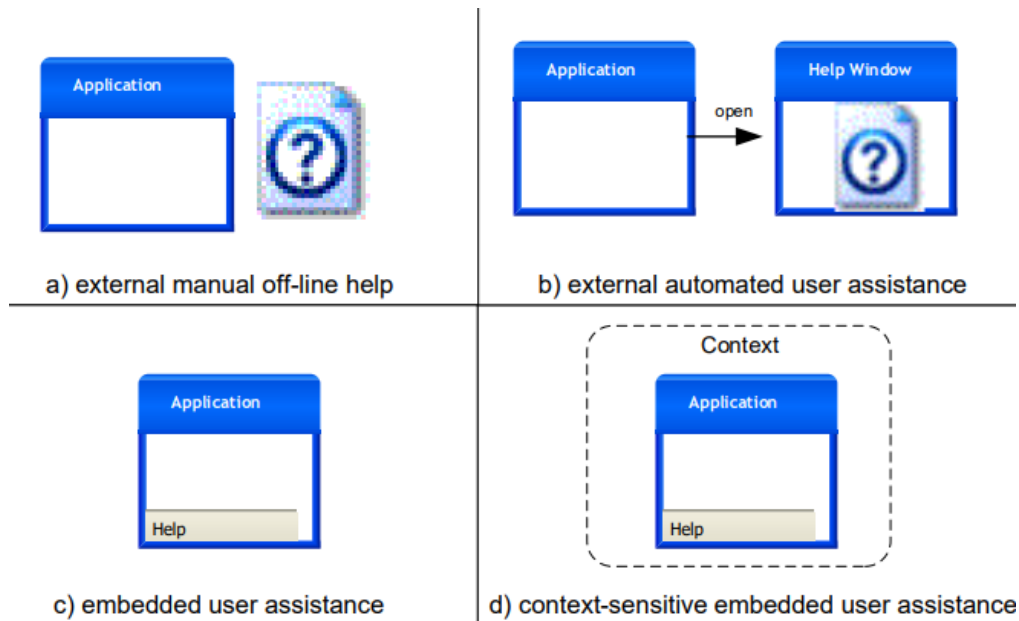


Figure 6. Different types of user assistance (Acar, Tekinerdogan 2020, 2)

The second classification (Maedche, Morana et al. 2016, 369) goes beyond the first classification and divides systems according to the level of intelligence and interaction. Figure 7 illustrates the classification.

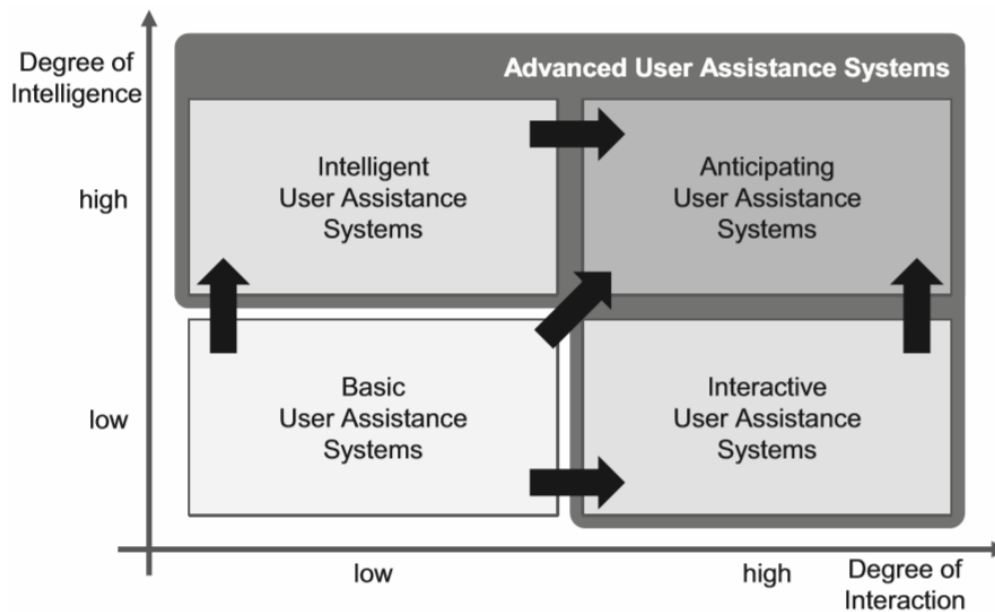


Figure 7. Basic and advanced user assistance systems (Maedche, Morana et al. 2016, 369)

A basic system provides manuals in computerized form without intelligence or interaction. The first of the three advanced user assistance system categories is an interactive system. The interactive system can ask and give feedback to the user, or, for example, a knowledge management system uses gamification methods or user-to-user support features. In the intelligent user assistance system, the assistance adapts to the user's actions, preferences, and context. The anticipating system combines intelligence and interactivity: it is very aware of the user's situation, needs and context and can anticipate the following events and inform the user about them. The assistance to be provided is not predetermined or fixed. (Maedche, Morana et al. 2016, 368-369)

The third classification (Morana, Schacht et al. 2017, 31, 41) provides pragmatic integrated taxonomy described in Figure 8 that helps practitioners analyze the completeness of their guidance systems and justify the design of their systems.

Target (32)	Choosing (13)		Using (21)	
Directivity (39)	Suggestive (31)	Quasi-suggestive (0)	Informative (22)	
Mode (31)	Predefined (23)	Dynamic (8)	Participative (5)	
Invocation (36)	Automatic (18)	User-invoked (19)	Intelligent (1)	
Timing (32)	Concurrent (12)	Prospective (9)	Retrospective (20)	
Format (45)	Text-based (41)	Image (17)	Animation (1)	Audio (2)
Intention (34)	Clarification (4)	Knowledge (17)	Learning (7)	Recommending (13)
Content Type (23)	Trace (16)	Justification (19)	Control (8)	Terminological (2)
Audience (16)	Novice (16)		Expert (8)	
Trust-Building (5)	Proactive (5)		Passive (0)	

Figure 8. Guidance design features taxonomy (Morana, Schacht et al. 2017, 35)

For clarification, the following Table 3 describes what intelligent user assistance means in this thesis. The definition has sought clarity and includes only the major characterizations: contextuality, anticipation, and dynamism.

Table 3. Definition of intelligent user assistance used in this thesis (applied from Acar, Tekinerdogan 2020, 372, Maedche, Morana et al. 2016, 369)

Contextual	Assistance is sought and provided to a specific situation while using the software.
Anticipating	User assistance is very aware of the user's situation, needs and context and can anticipate the following events and inform the user about them.
Dynamic	The assistance to be provided is not predetermined or fixed.

2.3.1 Text analytics and usage pattern recognition with AI

The following focuses on the aspects of AI and machine learning essential to the intelligent user assistance definition used in this thesis provided in previous chapter 2.3. In addition, we will review definitions that we will address later in the thesis.

Before we go any further, it is a good idea to first create an understanding of the types of machine learning. According to Andrew Ng (2019), 99% of the recent wave of economic value driven by AI is through supervised learning. Supervised learning uses training data that has labels identifying its content whereas unsupervised learning data is unlabeled. The third main type of machine learning, semi-supervised learning uses a combination of both labelled and unlabeled data. (Campesato 2020, 25-26) In this thesis, the proof of the

concept of intelligent search was developed by unsupervised learning, which did not require effort from the target company to create the labeled training data.

Earlier, we defined that intelligent user help is not predetermined or attached to specific user actions, but knowledge is retrieved dynamically when using the software. Next, we'll cover few topics related to understanding text and retrieving knowledge and explain what the terms that appear later in this thesis mean.

Unstructured textual data can be turned into actionable information and knowledge with text analytics and text mining and with help of natural language processing. Text analytics is used for information retrieval, information extraction, and, for instance, web and data mining. With text mining it is possible to classify documents or search for patterns and useful information and knowledge from large amounts of unstructured textual data.

(Sharda 2017, 277-278) To understand the relationships between different disciplines, Figure 9 below shows text analytics and text mining with their typical applications, as well as other related disciplines.

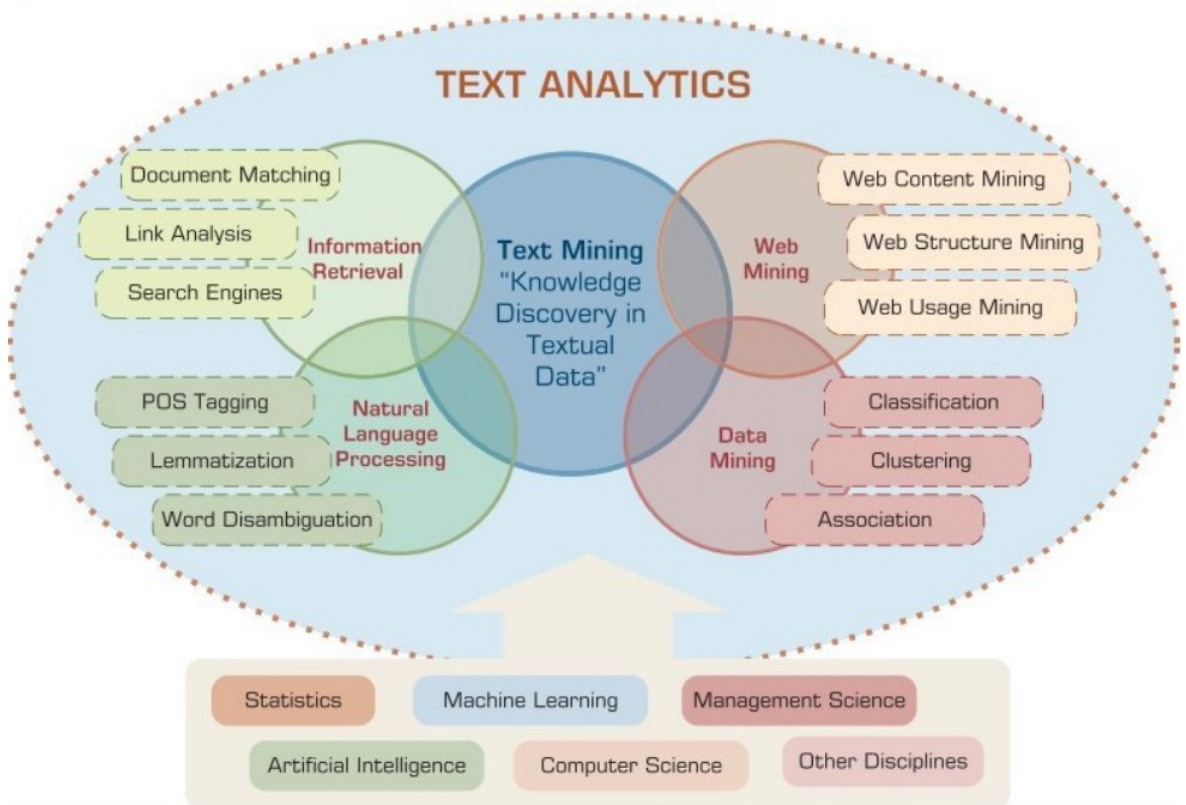


Figure 9. The overview of text analytics and text mining, and the main disciplines (Sharda 2017, 277)

For retrieving the right knowledge, it is essential to be able to analyse the meaning of texts. Latent semantic analysis (LSA) is a theory of meaning that originates from pattern

recognition and AI. The research of Kuo (2019, 1, 49) brought together knowledge management, AEC (Architectural, Engineering, and Construction) knowledge management systems, and LSA. LSA helps sense-making and knowledge creation and the research of Kuo confirmed its pertinent role for knowledge creation in AEC. In addition, it allowed valuable information comparable to tacit information to be automatically inferred from a wealth of unstructured AEC documentation. While the LSA may not be able to understand all text or answer abstract questions as a human tutor could, it can help develop intelligent systems. (Kuo 1, 214, 216-218) The different steps of LSA are illustrated in Figure 10.

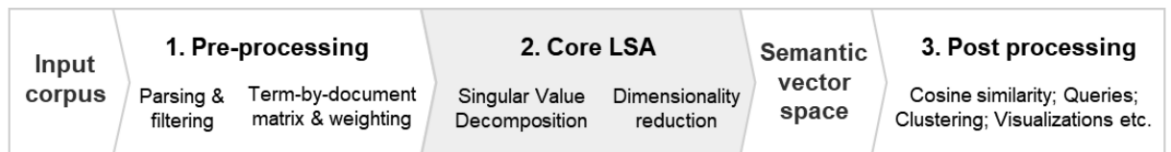


Figure 10. General steps of latent semantic analysis (Kuo 2019, 52)

In a corpus, i.e., a large number of electronically stored texts (Sharda 2017, 297), certain words are more likely to appear in a series than some other words. For example, in this thesis, three words, "intelligent", "user", "assistance" are often repeated together. Such sets of n words are called n-grams. (Nasser, Karim, et al. 2021, 2).

Regarding the proof of concept it was important to find out what was the main topic that each user assistance text spoke about. Words that occur very frequently, such as "construction", "building", or "project" in AEC documentation, do not describe the topic of a particular text as well as words that appear less frequently only in a subset of all documents (Kuo 2019, 55). A method called TF-IDF (Term Frequency times Inverse Document Frequency) identifies important words in corpus meaningful for determining what the text is about (Leskovec, Rajaraman et al. 2014, 8, 17-18). Further, to know if two texts are similar, the natural cosine distance of texts treated as vectors can be measured (Leskovec, Rajaraman et al. 2014, 313).

The goal to provide the user with knowledge in a timely manner while user is having trouble means analyzing the user's actions and usage patterns so that potential problems can be identified and predicted using AI. To achieve this, user behavior must be modeled using actual data collected from user actions in the software.

Providing the right user manual content has been studied by Park and Lee (2021) who utilized usage sequences of menus, buttons, pop-ups, and other similar interactions to create user models about users' preferences, behaviours and interests. In their study, the

user interface elements of the smartphone were already linked with corresponding help pages. Using AI, it was possible to predict the usage sequences. Moreover, based on the user modelling and help content usage data they were able to place the most valuable and appropriate help content item on top and, on the other hand, hide those of no interest.

A prototype innovated and developed by Stoica, Tselios, et al. (2017) was able to predict a student's next action in an educational system. Utilizing the usage data collected, student behaviour was modelled, and the prototype predicted the user's most likely next action, second most likely action, and third most likely action. Each subsequent action was linked to a help topic and thus the user could be offered three relevant instructions the pupil could choose from. An example of proactive help was a situation where a pupil was having problems in connecting two objects and asked for help, in which case instructions on how to use a "connect relation" were provided.

This review of definitions and classifications of intelligent user assistance and previous studies clarified what intelligent user assistance means and how modern machine learning and natural language processing technologies enable the implementation of important features such as contextuality and intelligent knowledge retrieval.

We have now gone through all three research areas relevant to this study. Next, we move on to how the research and development of this thesis was designed.

3 Research and development design

This chapter contains the principles that guided the research and development design and process. The general methodological approach is described first, followed presentation of primary and secondary data. The methods used for data collection and analysis, development and evaluation are presented in chronological order at the stage where they used.

When considering the appropriate approach, the quantitative approach was one of the options. The study could have analyzed data about how users use the search: how many unique users there are, what the most popular keywords are, which keywords do not return any search results, or which keywords are such that the user does not open and read any of the results returned. By analyzing the available numerical data, it would have been possible to find ways to improve the technical performance of the search, but it would not have been possible to delve into what the end user really needs and why. Such questions are best answered by qualitative research (Oyegoke 2011, 152), which was chosen as the thesis approach.

A central perspective of this study is the philosophical tradition of pragmatism. In pragmatism, the nature of reality is seen as complex and rich, and pragmatic philosophy accepts that the world can be interpreted differently and not a single perspective or study can give an unambiguous overall picture, but there are several realities. Pragmatism is more interested in practical results in certain contexts than in abstract ideas or concepts. Theories and research findings are seen as a way to find a successful practical solution to a problem. The problem of research is at the heart of the philosophy of pragmatism: research is guided by the researcher's doubts and beliefs that something is wrong. A researcher can use multiple research methods in the same study and different types of knowledge are accepted, but the emphasis is on practical results. (Saunders, Lewis et al. 2019, 145, 151)

3.1 Research and development approach

The research and development approach followed the process of constructive design defined by Kasanen, Lukka et al. (1993, 246) and illustrated in the Figure 11. The numbered phases in the image will be used later in the thesis to explain to the reader the progress of the research as well as the actions in each stage.

1	2	3	4	5	6
Find a practically relevant problem	Obtain understanding of the topic	Innovate and construct a solution	Demonstrate the solution works	Show the theoretical contribution	Examine the applicability

Figure 11. The phases of the research and development process (applied from Kasanen, Lukka et al. 1993, 246)

In the thesis, the researcher played an active role in the target company and in development of the proof of concept and as researcher was giving recommendations to the target company regarding the future intelligent assistance. This involves the dilemma: researcher should be able to look at the problem from above and create a solution model and at the same time take part of the activities of the organization. One may ask to what extent the researcher can express his or her own opinions and on what information those opinions are based. (Hyötyläinen 2005, 34-35) Good constructive research is based on sincere critical reflection (Lukka 2000, 13). In analysing the data of this study, the researcher sought to maintain neutral attitude and criticality and was wary of taking an unreasonably positive view of the study results and construction. This was done by identifying and distinguishing between the two roles as researcher and active change agent, and by carefully considering the counterarguments and analysing the results of the research.

The approach of this study combined elements of several purposes (Saunders, Lewis et al. 2019, 186-188) that changed as the process progressed. After the practical and relevant problem with research potential was found, the understanding of the topic was gained conducting an exploratory study where research literature was read and interviews conducted. In the early stages of primary data collection, exploratory approach was particularly valuable in growing understanding of how search results should be ranked and what is possible with AI. Next, explanatory study sought an answer to what kind of denominators can be found in the data collected that could explain the preferred search results ranking. When an explanation was formed implementation of a concrete construct, proof of concept of intelligent search, followed. The evaluative study looked at how well the proof of concept works and if the explanation was correct. The theoretical connections of the results were demonstrated and applicability of the proof of concept for forming a basis to a new intelligent service was considered. In the end a proposal for a roadmap towards an intelligent user assisting service was developed and evaluated.

3.2 Primary and secondary data

According to philosophy of pragmatism and constructive research approach the required data can be collected in multiple ways (Ojasalo, Moilanen et al. 2015, 68, Saunders, Lewis et al. 2019, 151). Suitable methods include, for example, interviews, surveys, and observations, also many methods used in service design fit well since they take the end user's point of view into account.

During the research, primary data were collected in two phases marked in darker colour in Figure 12. In both phases, data collection was forced to take place electronically without physical presence. The reason for this was, firstly, study participants, many of whom were geographically around the world and, secondly, the COVID-19 situation that prevented physical contact and visits.

The primary data consists of results of three online video interview rounds conducted in two research phases, phases two and four, as shown in Figure 12. The interviews were conducted using Google Meet. The advantage of online interviews and remote working caused by COVID-19 was that the interviewees were able to participate from home or another familiar environment. This may have helped to make them feel more relaxed and freer to answer questions (Eriksson, Kovalainen 2008, Ch. 8, Irani 2019, 4).

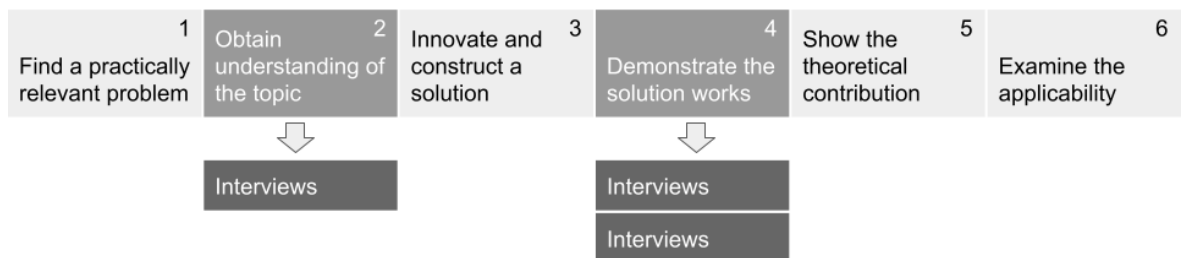


Figure 12. The phases in the research process in which primary data were collected (applied from Kasanen, Lukka et al. 1993, 246)

All online interviews that were conducted as semi-structured interviews. The semi-structured interview was appropriate to the nature of the thesis since the research involved an experimental element, a proof of concept and thus semi-structured interviews provided an opportunity to ask and understand what reasons have influenced the interviewee's opinion or choice (Saunders, Lewis et al. 2019, 444). In a semi-structured interview, it is possible to deviate from a pre-defined plan and thus gain access to issues that the interviewee considers important (Brinkmann 2013, 21) or the discussion may lead to areas that the researcher has not previously considered, but that are relevant to understanding and that help answer research questions (Saunders, Lewis et al. 2019,

445). On the other hand, however, the interviewer was able direct the dialogue by focusing on themes relevant to the research. In a semi-structured interview, the interviewer's own role is more prominent than in a fully structured interview (Brinkmann 2013, 21) and this fact was carefully considered during the data collection and analysis.

This study did not address issues that were highly sensitive to the interviewee, so the interpretation of the interviewee's emotions, body language, or facial expressions was not critical to data collection. Nor was it necessary to assess the participant's physical environment to collect contextual data. (Irani 2019, 4-5) Thus, there was no problem for the study in that the recorded interview contained only a small video image of the interviewee photographed from the waist up.

Although the approach was qualitative, it also used the possibility to merge quantitative and qualitative methods. Qualitative data were quantified by calculating the frequency of occurrence of certain themes from the primary data. The author was aware of the risks of the mixing method and made sure calculations were not excessive and no explanatory richness was lost. (Saunders, Lewis et al. 2019, 183)

One source of secondary data in the thesis was an observational study carried out during a user training course in the UK in February 2021. The data collection was designed in collaboration with the trainers, and the actual observation was carried out by the UX (User Experience) team of the target company. The UX team attended a 10-day fundamentals level course to observe new users participating in the training. The goal was to observe what is difficult or easy for a new user. In addition to the observation, data were collected at the end of each training day with a questionnaire asking the trainees themselves what felt difficult and easy each day.

Four main user interviews from January 2017 provided the perspective of experienced end users and thus helped to validate the results of this study. The semi-structured interviews provided the necessary understanding of the problems experienced by the customers and helped in the preparation of the roadmap. The semi-structured interviews were conducted by a Solutions Portfolio Manager of the target company together with the author. Two of the interviews were online interviews and two were conducted face to face in Oulu, Finland. The list of interviewees is included in the Table 4 below. The interviews were not recorded but the author wrote notes while the colleague asked pre-planned questions. Of particular interest to this study were the answers given by the interviewees

to questions about the need for the main users to create and share knowledge inside and outside their own organization.

Table 4. Participants in the main user interviews in January 2017

Participant	Company
Main user 1	A Finnish design and consulting company belonging to a Canadian group.
Main user 2	A Finnish engineering office in Oulu, Finland.
Main user 3	A Finnish structural design company belonging a Swedish group.
Main user 4 & 5	A UK-based company specializing in the design, supply, manufacture, and installation of complex steel structures.

A survey conducted in the summer of 2020 asked visitors of the websites "How could we improve the website". The results of the survey were also used to a small extent.

Research and development design and methods are described in more detail in the next chapter, where the phases of the process are gone through in chronological order.

3.3 Execution and evaluation of the research and development

The following describes how the research and development took place. The methods selected to collect and analyse the data as well as develop and evaluate a construct are presented in the order in which they were used in the study.

At first, to increase the understanding of the topic, in addition to a comprehensive literature review, AI and its possibilities were explored, and interviews were conducted. Figure 13 clarifies the actions performed at this stage of the process.

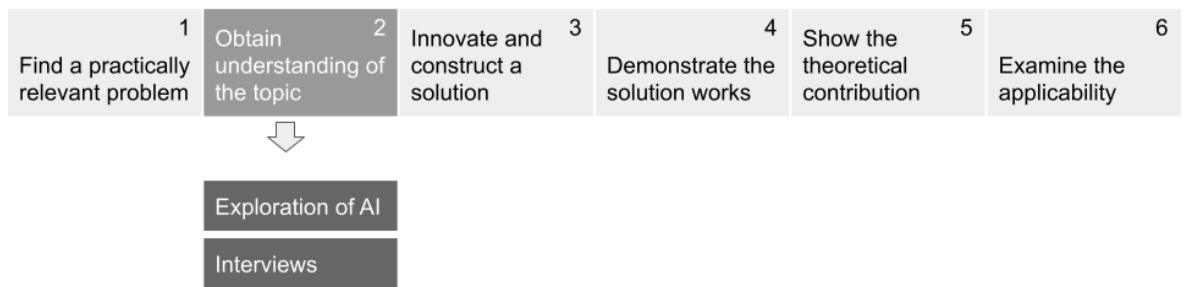


Figure 13. Improving the understanding of the topic in the second phase (applied from Kasanen, Lukka et al. 1993, 246)

It was important to increase understanding of the AI and its potential. To answer the question how AI could help in providing better search results, a project team was set up, led by the author. According to Andrew Ng (2018), it is good to utilize external technical AI expertise and combine it with the company's internal domain expertise. Starting an AI project without knowing what you can do with AI often leads to failure. Thus, the problem area was explored with the help of an external AI partner who worked closely with the target company's team. The work was done on sprints, with regular video meetings. The risks that often occur in a constructive study were avoided in this study: to solve the problem, a real project was created that was carried out at once instead of being done from time to time and little by little. Moreover, creating a team and hiring an external partner demonstrated the target company's commitment to the project. (Lukka 2000, 12-13)

The first interview sought more insight into what search should return and how users might like to rank the search results: what kind of results should show up first in the list and which ones should show up only later. The target population (Saunders, Lewis et al. 2019, 295) of the study was subject matter experts working in the target company. Interviewees had to be in close contact with end users and, on the other hand, had practical knowledge of the target company's online support site and its help content. But it was difficult to name the right people. Therefore, self-selection sampling was used. Self-selection sampling is a voluntary sampling technique where people are allowed to express their willingness to participate in the study (Saunders, Lewis et al. 2019, 323).

The author posted an invitation on company's social intranet for subject matter experts to join (see Appendix 2) and in total six experts accepted the invitation. They had expertise in various matters, and they were from four different countries. Common to all of them was that they knew the BIM software as well as the end user workflows very well. During the interviews, it became clear that they had also used the online support site a lot and

remembered much of its content. The participants are presented in Table 5. One of the participants preferred sending comments via email.

Table 5: Demographics of the company internal experts.

Participant	Title	Country
#1	Senior Software Specialist	Finland
#2	Technical Manager	Russia
#3	Technical Support Professional	India
#4	Product Specialist	Finland
#5	BIM Specialist	Finland
#6	Technical Support Consultant	UK

The online semi-structured subject matter expert interviews were conducted by the researcher independently. The interviews were held within a week from November 13 to November 19, 2020. The dates of the interviews were agreed by e-mail and at the same time the interviewees were told more information and purpose of the interview. Thus, the interview situations were rapid and typically lasted from half an hour to one hour. The researcher shared screen where the search page of the online support site was visible. The interviewee decided on a keyword or chose one of the 1000 most used keywords.

The analysis started already during the interviews when the researcher tried to understand and interpret what the interviewee said (Saunders, Lewis et al. 2019, 640). The interviewee's comments on the search results were documented so that the interviewee saw the notes written by the researcher. In this rather simple way, the expert was able to always ensure that the comments were properly understood and documented and interviewee in situ validation (Brinkmann 2013, 61) were obtained.

The company's subject matter experts commented on a total of 20 different keywords. The transcribed report included 136 slides of comments and screenshots. When choosing the method of analysis, it was considered that the respondents' answers were easy to understand, clear and unambiguous. Also, the amount of data was not very large. Therefore, thematic analysis was used to find main themes for further research

(Saunders, Lewis et al. 2019, 651). In the thematic analysis, points of interest were gathered from the data and reduced. The material was then organized into named themes and formed into a mind-map. (Tuomi, Sarajärvi 2018, 105)

Next the project group and the AI partner sought an explanation and causation between variables and answers “why” or “how” questions (Saunders, Lewis et al. 2019, 188): why subject matter experts would like rank to certain topics to the top and some should occur only later? How could the search return result similar to what experts preferred?

A constructive approach was best suited to answer questions “why” and “how” and RQ2 on the right ranking of the search results, and RQ3 on the starting point for a more intelligent user assistance. By developing a concrete construct, the role of AI in knowledge retrieval could be tested. Constructive research means creating an innovative and working solution to practical real-world problem and demonstrating its theoretical connections as well as examining potential for broader usage in other contexts and companies (Kasanen, Lukka et al. 1993, 261). In this case, the construct was proof of concept from AI-assisted search that retrieved user assistance knowledge. The aim of the proof of concept was to validate the solution idea and find out its usability. This step of the process is illustrated in Figure 14.

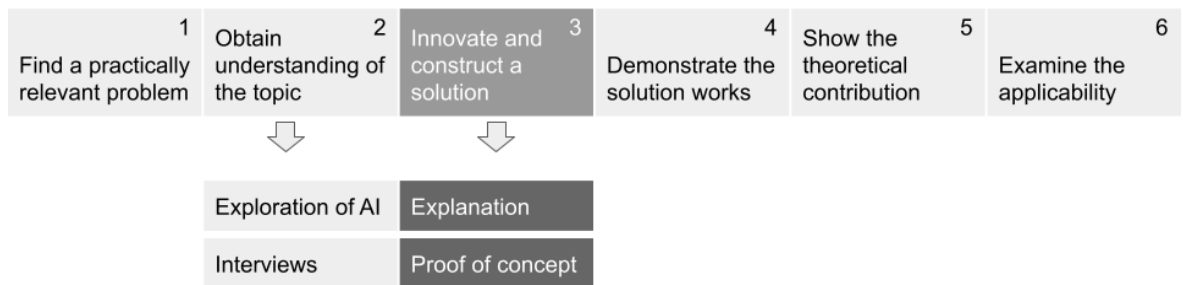


Figure 14. In phase three, an explanation was sought, and a proof of concept was developed (applied from Kasanen, Lukka et al. 1993, 246)

The user expectations collected from internal experts in the previous phase were important for AI algorithms to come from the users' workflow. The AI partner turned user expectations into specifications. In addition, some other documents were used, such as the most common Google Analytics keywords, guidelines for content creators and tags added by content creators as content metadata.

Next the proof of concept was developed by the AI partner in collaboration with the target organization's project team and the author. When creating the proof of concept construct, different configurations with different algorithmic processes were tested and compared

one by one. The strengths and weaknesses of each configuration was analysed and how each of them tends to promote and demote certain aspects of the search results. The retrieval was tested in a separate test console developed by the AI partner.

Following the ideas of philosophical tradition of pragmatism, the practical usability of the construct shows the truthfulness and validity of the study (Kasanen, Lukka et al. 1993, 261). Product testing and validation is closely related to evaluative research (Nunnally, Farkas 2016, Ch. 4). The aim of the validation was to find out what if the solution works and what the difference was between the new solution and the existing search and thus help answer question RQ3, “What kind of search would serve as a starting point for an intelligent service assisting users?”.

Evaluation of the proof of concept was conducted using semi-structured interviews with two different sample units, as illustrated in the Figure 15.

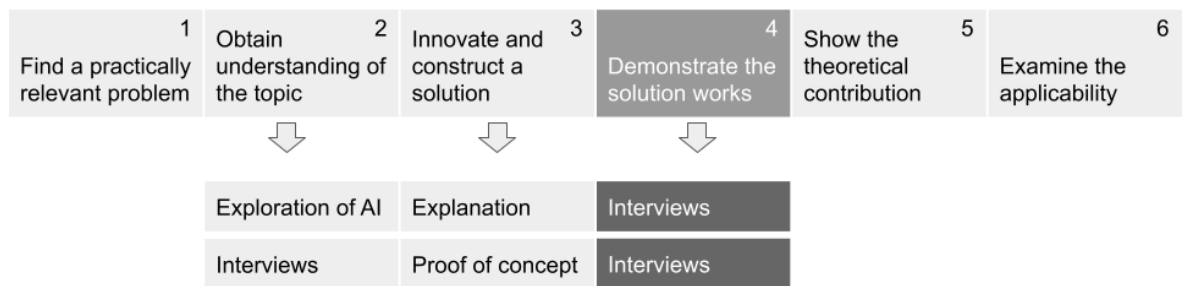


Figure 15. Two interview studies were conducted in phase four (applied from Kasanen, Lukka et al. 1993, 246)

The first sample unit was the same internal subject matter experts as before in the earlier research phase. This time, four experts participated in the study (see Table 6). The data collection method was, like last time, an online semi-structured interview, but this time the experts were shown the proof of concept instead of the existing search. The test setup was familiar to them, which helped the testing sessions run smoothly.

Table 6. Company internal experts participating the validation interviews

Participant	Title	Country
#1	Senior Software Specialist	Finland
#2	Technical Support Professional	India
#3	Product Specialist	Finland

#4	BIM Specialist	Finland
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Once again, the researcher wrote the notes during the interviews so that the expert could see and validate them directly. Based on the notes and screen shot images, an 83-slide report was created by the researcher. The report included the search results and experts' comments for 19 keywords in detail.

The second round of validation was with end users. When designing the validation with end users and selecting appropriate data collection method, there were some constraints. Due continuing COVID-19, the researcher was not able to meet directly with any of the users and observe in real time how they use the proof of concept. The structure under validation, proof of concept, could not be distributed to users for their free use either. Therefore, it was not possible to provide the construct to users and ask them to reply to a research survey.

A good alternative to moderated validation in a lab or users' work place was unmoderated remote interviews with recordings in conjunction with the audio (Nunnally, Farkas 2016, Ch. 4). Therefore, the data was collected again using online semi-structured interviews. With the help of interviews, it was possible to find out in depth why the end user considers the search results and their ranking to be correct or incorrect and why user prefers either the existing search or the proof of concept. It had to be considered that the existing search was fully implemented but the proof of concept did not have finalized user interface. The testing would be more realistic with existing search than with the proof of concept (Nielsen 1993, 79). Interviewees were asked not to pay attention to the deficient and raw user interface of the proof of concept.

Regarding qualitative interviews, there is no unambiguous answer to the number of interviewees (Brinkmann 2013, 58-59, Tuomi, Sarajärvi 2018, 74-75). It was virtually impossible to recruit many end users or continue interviews for several weeks. The schedule was tight, as end user interviews had to be conducted in one week from June 7 to June 11, 2021. That's why goal to interview about 10 people was set. If possible, it would have been better to recruit more than was needed because it was known that there might be people who are left out for one reason or another.

The aim was to select the sample unit so that they represent different customer segments and different levels of expertise. Volunteers were sought by posting to the target company's User Feedback Program's discussion forum. Through the User Feedback

Program, it would be possible to reach professional, experienced users. It was estimated that between 8 and 30 volunteers could join. The aim was also to find beginners who understand the vocabulary of the field. They were searched among students participating target company's Student Ambassador program and summer workers of the target company. The target of 10 interviewees was not reached, as there were only 7 volunteers. However, the difference was not large, and the number was considered appropriate. The interviewees are presented in the Table 7.

Table 7. Interviewees' demographics

Interviewee	Construction position	Experience in Company X's BIM software
E1	BIM Manager at a Finnish construction and structural design company employing 700 people.	At least 8-9 years' experience.
B2	Civil Engineering student at a University of Applied Sciences in Finland. A Student Ambassador of the BIM software.	Learned bit at school, now using the software at work (2 years).
B3	Trainee at the target company. Civil Engineer's bachelor's degree in Egypt. Has used other technologies at work.	Most of the experience is from school, not much from work.
E4	BIM Manager at a Finnish design and consulting company belonging to a Canadian group, 700 employees in Finland. Takes care of the internal support in Finland.	Long history, started 23 years ago.
E5	Director of concrete and technical services at a Canadian steel detailing and design services company employing ca. 100 person.	Over 20 years' experience.
B6	Student at a University of Applied Sciences in Finland. Trainee at a Swedish-Finnish engineering, consulting, and design company. A Student Ambassador of the BIM software.	1 online course at school, using the software at work (1year).

E7	Development Manager and BIM Manager at a Finnish structural design company belonging a Swedish group, 750 employees in Finland. A main user.	20 years' experience.
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Participants in the User Feedback Program had already signed and accepted the terms of the non-disclosure agreement. Students signed it online before the interviews were conducted.

To assure the validity of the research and to maintain the flow in intensive and short interviews two persons, the author, and a user experience specialist, conducted the interviews. The author was the facilitator who coordinated and guided the discussion and ensured that the discussion moved on. The user experience specialist wrote notes and organized observations for later analysis.

The interviews were conducted using think-out-loud user testing method: in the beginning of each session the interviewees were encouraged to verbalize their thoughts and express their opinions freely (Paz, Pow-Sang 2016, 170). With the method, a lot of qualitative information was collected even if the number of interviewees was small. On the other hand, thinking-out-loud could also give a potentially wrong picture of the causes of problems in search, as interviewees created their own theories about the causes of problems or how a problem could be fixed. (Nielsen 1993, 195)

In the interviews, end users were asked to compare the search results returned by the existing search and proof of concept and explain which of the rankings works better for them and why they think so. The term "proto" or "prototype" was used in the interviews instead of proof of concept as it was thought to be a more familiar and self-explanatory term for the interviewees. The interview guide in Table 8 lists the themes and key questions that were covered.

Table 8. End user interview guide

Search term selection	First, you should choose the topic we use to test the searches. You can select any term. It's good to choose a topic you already know.
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	[Observe if the user does not know what to search for. If the user doesn't come up with anything, ask the person to choose from the list of the 1000 most searched terms.]
Performing the search	You will now see search results in both tools. On the left you see the search in User Assistance and on the right, you see a new prototype.
First impression	How does it look like? What is your first impression of these results? What differences do you see?
Going deeper	Do you think the first search result [the facilitator reads aloud] or [the facilitator reads aloud] is correct? Should something else be displayed first? Now let's look at the following search results, are they in the correct order in either search tool? [The facilitator slowly scrolls down in both] Do you think any of the search results are ranked too high? Are there any relevant topics missing from the search results you see on left, or right?
Overall assessment	What impression did you get from these two search tools? If you had to choose, which one would you prefer to use? What worked well in the tools? What didn't work well?

Prior to the interview, researchers went through the pre-session arrangements and assurances that everything was working (Table 9).

Table 9. Pre-session check list

NDA	Verify that the participant has signed the NDA.
Close and silence other tools	Turn off programs that may interrupt the interview. Mute your phone.
Open the two search tools	Open the User Assistance search and the AI-powered search. Place them on the screen so that they are easy to display when you share your screen.

The planned interview schedule is described in Table 10

Table 10. End user interview schedule

5 min	Introduction and opening	Introduce ourselves, explain the objectives, explain that we are not testing the person and there are no wrong answers. Encourage the interviewee to think aloud. Ask consent for recording the session, repeat the question when the recording is on.
20 min	Test tasks	Introduce the test scenario and conduct the comparison testing on the facilitator's shared screen. Utilize the list of questions included in the interview guide. Let the interviewee speak freely.
5 min	Closing comments	Thank the interviewee for taking part. Ask if we can send follow-up questions if needed.

Content analysis was used to classify the data from the video recordings and the additional information provided by the notes written by the user experience specialist. The content analysis was planned and performed as described by Bengtsson (2016). The process started from decontextualization and ended in presenting the results, as illustrated in Figure 16.

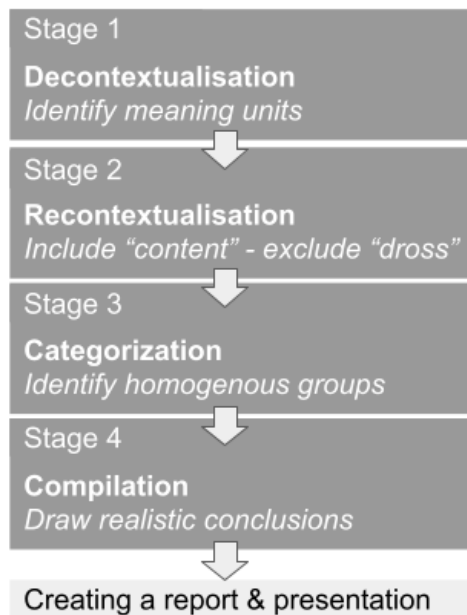


Figure 16. Qualitative content analysis process applied from Bengtsson (2016, 9)

The following steps were performed in the analysis:

- Interview recordings were listened several times
- Meaningful units for the research were separated from the data and transcribed
- Irrelevant information was identified
- The transcribed texts were organized into categories based on their similarities and differences
- The categories were further divided into subcategories
- A report of the results was created

The interviewees had familiarized themselves with the data already during the interviews and the sense of the whole was obtained while listening the recordings. The collected data was not going to be used afterwards for other purposes, so the recordings were not transcribed word by word. Time was saved when it was possible to focus on research-related issues. On the other hand, the interpretation of transcribers played an important role in deciding which parts of speech were taken into account and which were not. It was thus important for the credibility of the research that both the author and the user experience specialist collaborated in decontextualization of the data into meaning units containing insights needed in the research during transcription (Bengtsson 2016, 11).

Data anonymization was done during transcription. Instead of the names of the participants, they were called "beginners" or "experts" or the corresponding abbreviations "B" and "E". In addition, each participant was given a number. This made it possible to identify the person and to validate the correctness of the transcription and interpretation afterwards.

In the recontextualisation stage the check was done that all needed information was transcribed and all meaningful data was taken into account, and on the other hand, as Bengtsson (2016, 12) points out, it was important to let go of the insignificant information not related to the aim of the study. Irrelevant information was separated and collected as an appendix to the final report. Peer review was used to ensure the validity: three author's colleagues who were not involved in the research process reviewed and commented on the report and the results.

In the next process phase of constructive research, the findings of the study were reflected in the literature. The theoretical contribution of the thesis is presented in the next Results chapter. In the final phase, the applicability of the proof of concept was considered when the roadmap was created as shown in the Figure 17 below.

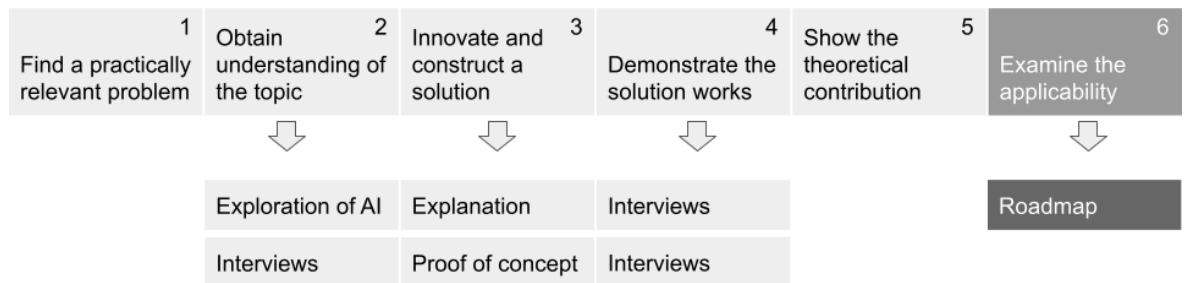


Figure 17. Exploring the applicability of the proof of concept was one part of the development of the roadmap

In this study, a product roadmap creation method was applied in the preparation of the roadmap. A product roadmap can be defined as a plan that describes both the way in which a product will meet business objectives in the future and the work that will be done to get there (Munch, Trieflinger et al. Jun 2019, 1). Roadmap answers questions: where we are going, where we are now and how to get there (Munch, Trieflinger et al. Aug 2020, 285).

A literature review of the existing roadmap research literature (Munch, Trieflinger et al. Jun 2019, 7) found only few scientific studies on product roadmapping. Those did not address modern product management practices or digital products that are typically created in a dynamic, ever-changing environment. The roadmap as a feature list with completion and release dates, detailed pre-made assessments and decisions does not meet today's, or this thesis', needs. Thus, the researchers (Munch, Trieflinger et al. Aug 2020, 284, 290) went on to look at so-called grey literature, i.e., white papers, articles, blog posts, and similar. The researchers found four different roadmap formats: feature-based, goal-oriented, outcome-driven, and theme-based roadmap. The feature-based

format is static, and the goal-oriented format may not consider the value generated for the customer and the business. According to the researchers, the appropriate format for a dynamic and uncertain environment should be a format that goes to a more accurate level of detail the closer they are in time. Outcome-driven and theme-based formats are best suited for a changing and uncertain environment, especially when they are customized to the organizational context. The differences between the four roadmap formats are illustrated in Figure 18.

Roadmap format	Product vision	Themes	Outcomes	Goals	Outputs	Specific dates
Feature-based Roadmap					X	X
Goal-oriented Product Roadmap				X	X	(X)
Outcome-driven roadmap	(X)	(X)	X	X	X	
Theme-based roadmap	X	X	X	X	(X)	

Figure 18. Components of the four roadmap formats (Munch, Trieflinger et al. Aug 2020, 290)

This study used a theme-based format described by Lombardo, McCarthy et al. (2017). The main components of the roadmap are illustrated in Figure 19: product vision, timeframes, themes, business objectives, features, stage, and disclaimer.

Product Vision
Perfecting people lawns and landscapes by perfecting water delivery

Timeframes	Q1 2020	Q2 2020	2021	Future
Themes	Indestructible Hose Objectives: <ul style="list-style-type: none"> Increase unit sales Decrease number of returns Decrease overall defects Features: <ul style="list-style-type: none"> 20' & 40' lengths No-leak connection No-kink armor Stage: Pre-production	Delicate Flower Management Objectives: <ul style="list-style-type: none"> Double ASP Stage: Prototype	Putting Green Evenness for Lawns Stage: Discovery	Infinite Extensibility Objective: Pro Market
		Severe Weather Handling Objective: <ul style="list-style-type: none"> Expansion Stage: Materials Testing	Extended Research Stage: Discovery	Fertilizer Delivery Objective: Pro Market

Disclaimer → Updated 04 April 2020, subjected to change without notice.

Figure 19. An example of using a theme-based format of Lombardo, McCarthy et al. (Munch, Trieflinger et al. Aug 2020, 289)

In the beginning of the roadmap creation the relevant information and context was gathered (Lombardo, McCarthy et al. 2017, Ch. 3). In addition to the results related to the proof of concept reported above, secondary data and research literature was used as to create better understanding.

The backbone of the roadmap were the themes through which the vision could be achieved (Munch, Trieflinger et al. Aug 2020, 289). In this study, the themes of the roadmap were tied to strategic business objective of the target company. The themes represented the real problems that the customer needs to solve. Describing the themes on that way ensured that the new intelligent user assistance would bring added value to the target company's customers. Moreover, the features under each theme were related to results, not outputs: themes left open the possibility that there would be other, even better, ways to achieve the same results. (Lombardo, McCarthy et al. 2017, Ch. 5)

The roadmap was evaluated by a steering group at the target company. The evaluation took place in an online meeting where the author presented the vision and roadmap. In preparing the presentation, the author utilized instructions of Lombardo, McCarthy et al (2017, Ch. 8-9) on presenting and sharing a roadmap, as well as important aspects related to buy-in of a roadmap.

In addition to the actual members of the steering group, important stakeholders had been invited. Total of eight people attended the steering group meeting in addition to the author. The participants are presented in the Table 11.

Table 11. Participants in the roadmap evaluation

Position in the target company	Role
Senior Director, Sales and Revenue Marketing	Steering group member
Global Marketing Director	Steering group member
Manager, Solution Management	Steering group member
Subcontracting Manager (manager of Online Presence program)	Organizer of the steering group, Stakeholder
Solution Manager (of the user assistance knowledge base and discussion forum)	Stakeholder
Manager, Information Content Management	Stakeholder
Customer Experience Professional	Stakeholder
Group Manager (of the user assistance unit)	Stakeholder

4 Results

This section focuses on the results of the research and development. The results are presented in chronological order, starting with obtaining understanding of the topic and ending with the applicability assessment and user personas.

Intelligent user assistance and AI literature review that was presented earlier in the chapter 2.3 were utilized in the innovation and implementation of the proof of concept and later in the preparation of the roadmap.

The definition of knowledge management by O'Dell, Grayson et al. (1998, Ch. 1) presented in chapter 2.2 was the best fit for the scope of this study. The results include the practical implications of the definition for intelligent search and the new user assistance service.

In the area of customer experience, the value creation and experience were seen in accordance with service-dominant logic described in chapter 2.1. The customer experience in the B2B environment, as well as the problems of the BIM implementation, were strongly present in the results.

Some relevant direct quotations have been included in the results to improve the reliability of the study.

4.1 Beginner content first

The second constructive research phase sought to increase understanding of the topic. At this point, it was explored what AI could do to improve the search, and interviews gathered information to answer the research question RQ2: "How should search results be ranked?". Figure 20 recalls the actions taken during research phase two, "Obtain understanding of the topic". Next, we will look at the results of this phase.

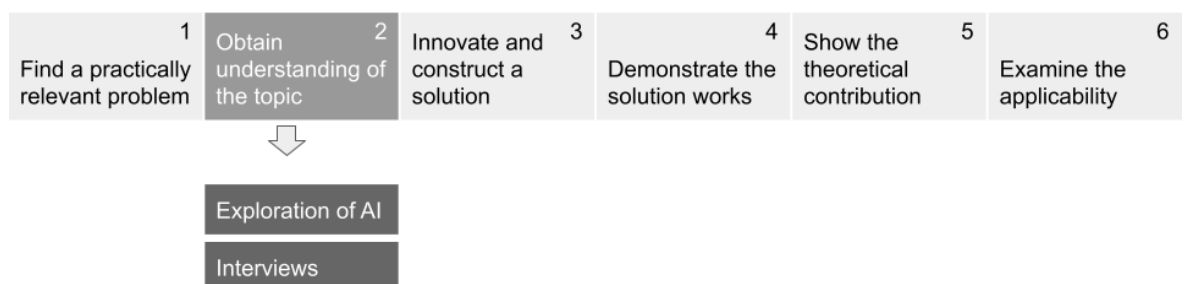


Figure 20. The results of phase two relate to exploration of AI and interviews (applied from Kasanen, Lukka et al. 1993, 246)

After establishing the corpus, it was possible to explore and conduct AI experiments such as automatic classifying and tagging the content. The tags generated by the AI partner were exported to the target company's staging system as index terms, an example of which is given in Appendix 3. However, classification was not enough, weight should be given to each piece of content based on how well it fits the tag. At this point, technical limitations in the target company's search system prevented the classification from being further examined.

The other action conducted during the phase two were interviews with internal subject matter experts. Interviews clearly showed how the results should be ranked. All the experts expressed in different ways the same idea that the results should show basic content first and more detailed and difficult content only later. They commented, for example, that a topic called "Check the exported IFC model" was ranked too high: "it's about a detail thing" (interviewee #1) or "do not show any advanced options on the first page" (interviewee #4). When the search ranked the right content to the top, interviewee #1 commented that a topic called "IFC" had the right rank, it was a basic guide with good links to further info. The interviewee #3 explained that the assumption is that when a user searches "rebar" user expects to first find some basic info about creating and modifying rebars, after that search results could show info about reporting and drawings. More advanced articles about e.g. "advanced options" and ".inp" should be ranked lower.

The interviewed experts also wondered why some content was either too high in ranking or why relevant content did not rise in the search results. The two main themes are described in the mind-map in Figure 21 including the number of mentions involved.

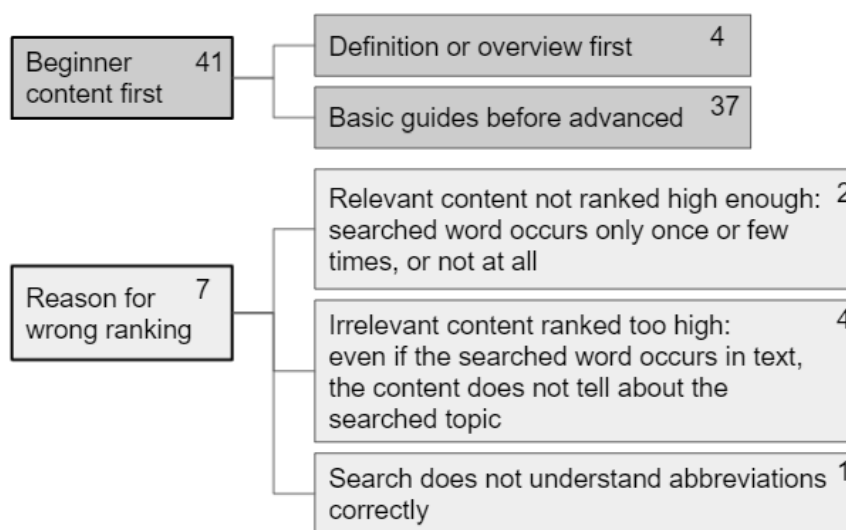


Figure 21. Thematic mind-map

Of the two main themes, the theme, “Reason for wrong ranking”, was an interesting technical issue that could be resolved with AI. However, this thesis did not focus users own theories of the problems (Nielsen 1993, 195). The theme relevant to research question RQ2 was “Beginner content first”. The Appendix 4 contains the themes and interviewees’ comments that were gathered from the data.

When conducting thematic analysis (Tuomi, Sarajärvi 2018, 105) of the data, both the verbal communication of the interviewees and the screenshot images taken from the search results were taken into account. The attached image in Appendix 5 is an example that shows the difference of the ranking returned by the search and the ranking suggested by the interviewee #3.

While exploring the problem area the initial view of two user personas (Cooper 2004, Ch. 9) called “beginner” and “expert” began to form (RQ1) as well as what kind of content these user personas might prefer. According to the analysis the beginner content often seemed to be knowledge that explained “how to”, for example, “get started”, “create”, “define”, “add”, “insert”, or “modify” or answers question “what is”. Advanced content, on the other hand, was one that told how to “customize”, “check”, or was already meant for more demanding use: “administrator’s” or “advanced”. Also, topics that explained in great detail about some special issue such as "example of a variable formula: determine the stiffening position using building planes" were considered advanced knowledge content. These findings were relevant to research question RQ1.1, “What kind of knowledge would different types of users need?”.

4.2 Proof of concept of intelligent search

Now we move on to the results of the next phase of the research. In phase three, an explanation was sought, and a proof of concept was developed (see 22).

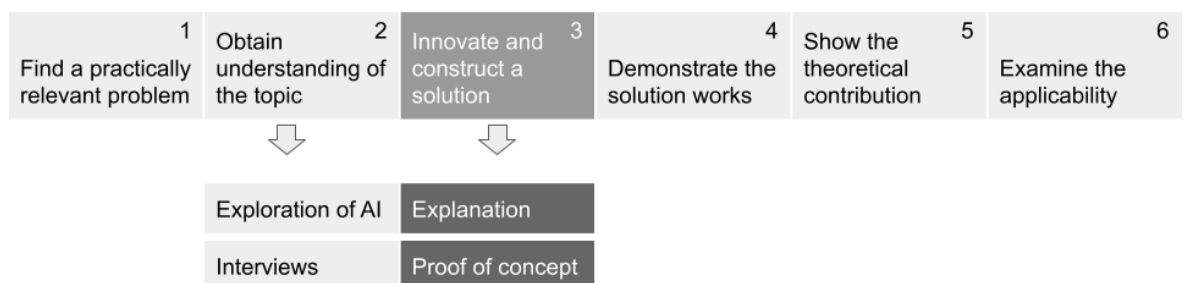


Figure 22. In the third phase, the POC was developed (applied from Kasanen, Lukka et al. 1993, 246)

The third phase of the research looked for a relationship between ranking suggested by the interviewees and the user assistance content itself. We wanted to know how AI could be used to rank the search results like the internal subject matter expert had preferred. The interviewees said things like “the second article is a very difficult article, and should not be ranked to the top“. Therefore, when a user queries, for example, “concrete” the proof of concept should rank concepts like “create”, for example, “create a concrete beam” higher than more specific topics such as “view cast-in-place concrete structures”.

A handful of different algorithms and configurations were tested to find the best one. One of the configurations in the system was related to subdocuments. Behind the scenes the machine divided the content into two subdocuments: the title and content. Dividing the documents to smaller units enabled tuning. According to the AI partner, subdocument weights have typically one of the biggest effects on how the retrievals are done. For example, when there is a match between the query and one of the subdocuments, how do we use the similarity as a ranking? Do we get an average of all subdocuments within a document, or do we take the maximum, or do we take the logarithmic distribution? These variables were tested in the proof of concept. If we would divide the document into multiple subdocuments such as title, different paragraphs, and different sections, we could define how we handle the subdocuments: do we promote and push to the top a document where there is one subdocument that is very strongly matching, or should we take the average of the subdocuments. These were available as parameters in the test console.

Since the AI was unsupervised, expert feedback was the ground truth to which the AI was calibrated. Out of the multiple configurations the internal tests narrowed down to two configurations that most often returned the results like what the subject matter experts had suggested. In addition to the AI algorithm the weights and parameters were applied and benchmarked by the subject matter experts' results. Some weights were not a big factor and thus the solution was narrowed down to more simplified weights.

It turned out that latent semantic analysis didn't work best because it made semantic vectors “too semantic”, and the search results weren't clear. For example, a word search can yield high-quality results that do not contain that word because of a "semantic effect". In some use cases this is desirable, but in the proof of concept's case, rather not because it seemed to create confusing user experience. The final configuration consisted of a similar pipeline as in the Figure 10 except that second step "Core LSA" was skipped. Instead, AI partner expanded on the TF-IDF to create the semantic vector space. Therefore, the semantic vectors in the proof of concept were created via an advanced derivative/variation of the TF-IDF function. The cosine similarity in the third “Post

Processing" section of the latent semantic analysis was also used. The query vectors were created using the advanced TF-IDF variation that was used to create the semantic vectors. That basically allowed for the cosine similarity to be used between those vectors to calculate similarity score.

An abstraction called "advancedness" was introduced and AI partner investigated where does the advancedness correlate at. For instance, were there numerical indicators such as multiple subtitles or links that might tell that a piece of content is a beginner level document where a user gets a lot of different guidelines from a one document? It might be possible to start to see and make assumptions of patterns involved. The underlying phenomena of advancedness was investigated and defined, such as intent modelling of queries and appropriate retrieval logic, by the AI partner.

The AI partner discovered that the abstract concept advancedness consisted of many things that needed to be considered. The studies done found that advancedness of a document cannot be achieved through just the match. You couldn't look at just matching of terms: no matter how you were weighting, what kind of synonyms or abstract semantic links you used. Instead, we needed to focus on what was not matching. The non-matching is a way to look at what kind of topics, concepts or words that are in the content or title, but not matching to the query and to use that to demote. The demotion would then rank the results that would be otherwise mixed: concepts like "define", "import and export", "add" or "edit and save" versus other concepts like "wizard", "variable formula" or "modifiers". The demotion of non-matching concepts or words was not implemented through heuristic technique meaning not codifying a rule that would tell the machine what to do but the machine figured those out by looking at the distribution of a topic such as "define custom components" in the whole corpus.

One of the assumptions or insights that arose from the advancedness investigation was that titles and contents that are generic, tend to have topics that are more evenly spread in the whole corpus. On the contrary very specific topics may occur many times within a document but only in a specific number of documents. That was the way to get the advancedness as a side effect. Of course, that might not always work, it was not a rule as such. A subject matter expert may say that, for example, "arrange" should be less demoted, and that was one of the dilemmas. But the solution was a better than having heuristic rule over heuristic rule. Now, it didn't matter what corpus or data we put in; the logic would still stand.

Another insight that the AI partner's machine figured out was that the generic topics tend to be, at least in terms of the title, much shorter and more specific. There was less

semantic variation in beginner level topics meaning that in a title there are fewer topics that are interrelated compared to those that are fuzzier, such as “Custom component properties in the Custom Component Wizard”. There was no fine line, but it was like a continuum and looking at the title was one way. Also, the content varied in terms of length, semantic variety as well as number of unique terms. Unique terms such as “wizard”, “custom”, “component” differed on their distribution through the whole corpus. All these were the factors involved in the advancedness.

In addition to abstract advancedness concept, finding patterns could be used also otherwise. When a user searches concepts like “IFC” we could ask from the user “did you want to insert IFC or create IFC” and the user could go directly to the results she or he wanted without having to go through a lot of search results. The ability for letting the users define what they are actually looking for would be possible with the help of AI algorithms.

A concept called "ANDness" optimized the ranking when two or more query terms were used together. This was to encourage results that match strongly to all the search terms together, as opposed to just single terms separately. The ANDness was applied as a post-process (refer to Figure 10).

To improve search results further an n-gram module indexed common 2-word phrases (bi-grams) such as “advanced option”, “custom components”, “property pane”, “dialog box” and “reinforcement bar” as discrete tokens. N-gram handling were under the early pre-process tokenization step, under “parsing and filtering” sub-part in the Figure 10.

4.3 The new concept evaluated suitable for beginners

Next the proof of concept was evaluated using semi-structured interviews. The evaluation was performed in two parts. First, the proof of concept was tested by internal subject matter experts, after which the AI partner slightly modified the AI configurations and improved the proof of concept. The second evaluation was conducted with end users.

In both rounds of the interview, the proof of concept was tested using a separate test console that was running independently from the target company's systems which accelerated the implementation of the evaluation. The test console showed, for example, the ranking, similarity, and quality score. Similarity score told how much semantic similarity there was between the query and the document. In the interviews, the existing search and test console were placed on the interviewee's screen in accordance with Appendix 6, “Screenshot of the interviewer's screen”.

The first test round took place with subject matter experts from the target company. The following Figure 23 recalls how the first interview round fits into the process of constructive research.

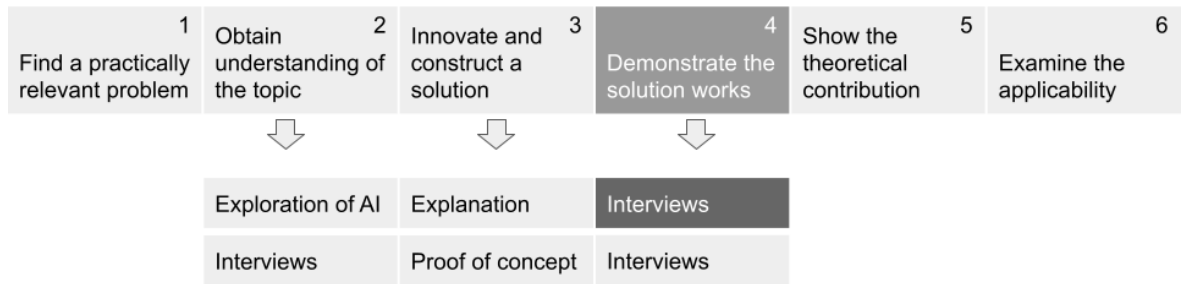


Figure 23. The first interview evaluated whether the solution worked as desired by internal experts (applied from Kasanen, Lukka et al. 1993, 246)

Internal experts selected in total of 19 keywords for testing. Of the 19 keywords tested, 3 were those for which the subject matter experts were completely satisfied with the results and their ranking. These keywords were "IFC", "reinforcement", and "rebar set". For example, the keyword "IFC" was tested by two experts, and both thought the search worked well: "Looks fine. It's in the right order: first, what is IFC", said one of them.

Of the 19 keywords tested, 5 keywords, "import IFC", "custom component", "rebar shape manager", "split", "view properties" were those for which the experts suggested only a small adjustment and found no other errors in the results or their ranking. For example, the tester #3 mentioned regarding the search term "import IFC" that "a user is looking for "IFC insert" so that should be the number one". The "IFC insert" place was fourth, so the search result was close to what was desired.

For the remaining 11 keywords, the experts found errors in the search results. The first results returned might be correct, but as the results were scrolled down, they noticed something that was not correct.

Let's now look at the themes that appear in the answers. The themes and comments are included in Appendix 7. As we seen from the thematic mind-map of recurring comments in Figure 24, there were 27 comments where the topic in the search results was in or near the right place. All experts gave such comments.

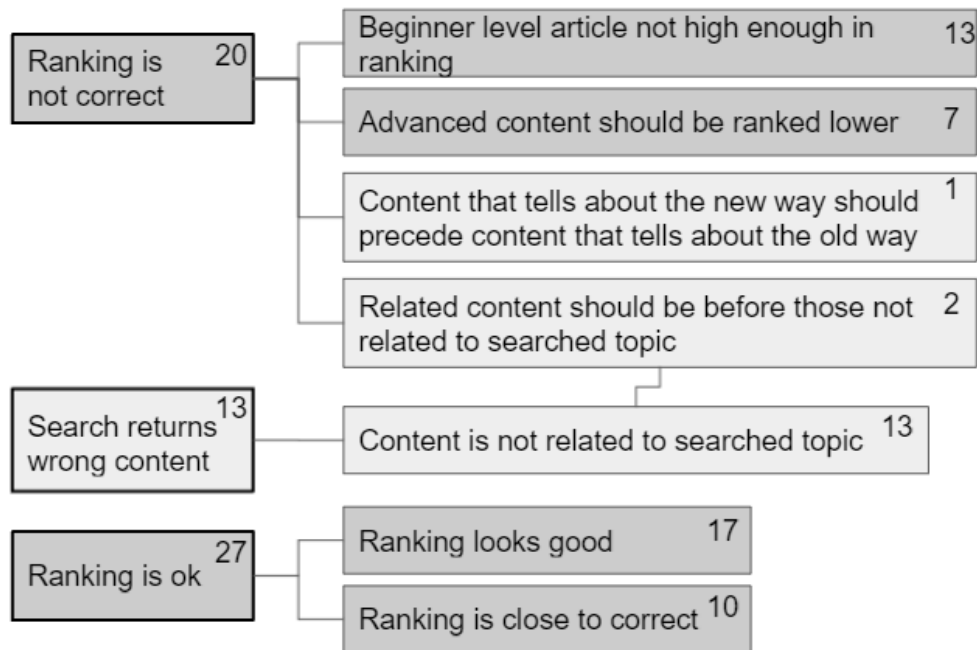


Figure 24. Thematic mind-map of internal experts' evaluations

Experts found that the search results were ranked sometimes wrong, for example, a beginner-level content was ranked close the bottom of the list, or, conversely, demanding content was too high in the results. When we look at the results in Figure 24, it can be seen that "advanced content should be ranked lower" was mentioned in total of seven times. The comments (available in the Appendix 4, "Thematic analysis of expert interviews in exploratory phase") were from two testers out of four. On the other hand, all testers mentioned that the "beginner level article not high enough in ranking". The theme was mentioned 13 times. This was seen as a significant issue as beginners should easily find all the content they need.

When taking a closer look, a single beginner topic found by a tester was typically ranked in place 30-40 or even place 61, for example. In many of those cases the logic why those topics should be ranked high was based on knowledge that only the subject matter expert would have and the machine without any a-prior knowledge would not be able to figure out. Therefore, the possibility to user to define what they are actually looking for was introduced: a feature called "add to query". The suggested terms underneath the query box with label "Click to add query", as seen in Figure 25, was meant to capture some searches related to the query that the user may be interested in but may not have thought to enter the terms to the query. The user may want to read about, for example, "spiral" that is not among the top ranked items but is included in the suggested terms list. The user may want to re-execute the query using the suggested term. The feature's development was not finalized in the proof of concept.



Figure 25. Proof of concept suggested terms to be added to the query

Two testers found cases where the returned topic did not really talk about the issue that was typed in the search box. There was a total of 13 such comments. It could be that the searched item was mentioned in the content and therefore the search returned a result.

Significant to the research question RQ2 were the comments of the experts regarding whether the results returned by the search have the correct ranking or not (marked in dark in Figure 24). Previously, the same experts had determined that beginner-level content had to be displayed before experienced user material. As a result of the evaluation, it could be stated that the proof of concept returned the beginner content correctly enough and the search results corresponded to what the experts had considered the best in the previous interview. Individual cases where a topic suitable for the beginners was too far in the results were enhanced with experimenting a new “add to query” feature.

After the first internal expert interviews, the AI partner improved the proof concept, followed by a second round of interviews with end users, as illustrated in the following Figure 26. Although the target company's internal experts worked close to the end users and were aware of their workflow, it was important to obtain end users' assessment of the proof of concept. Next, we review the results of the end user evaluation.

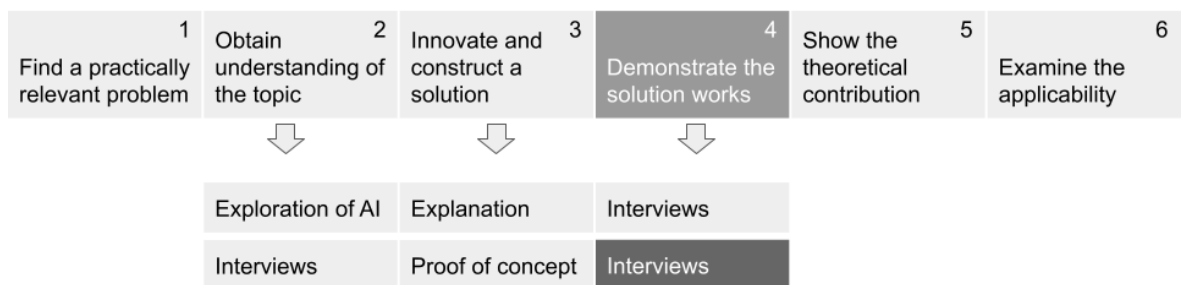


Figure 26. The proof of concept was evaluated by end users (applied from Kasanen, Lukka et al. 1993, 246)

The following describes how end users saw the new proof of concept compared to the existing search. The aim was not only to evaluate the ranking (RQ2) of the new concept but also to get an answer to the RQ3, i.e. “What kind of search would serve as a starting

point for a more intelligent service assisting users?”. First, we look at the end users’ comments and the themes that recur in them and after that we take a brief look at the numerical results in terms of which search end users preferred.

Search difficulties with the existing search was mentioned 8 times and both beginners and advanced users had problems with keywords: “It is really hard at times when you don’t know the name of things”, said B2. You need to know the right keywords that you learn when you have used the software for a long time, or you have searched for the same thing many times. The following quote is from a user who responded to the online survey in 2020. It confirms well the issue raised by the testers:

"Now you don't get any answer if you don't search on the right word. If you don't type the word right (spelling), you don't get an answer." (Target company’s Website User Experience Survey 2020)

As beginners do not know the right keywords used in the BIM software, they may use their own words. When searching for answers to problems they may use sentences like “rebar doesn’t appear” (B2). B6 wanted to learn how to model “not square concrete”. B6 refined the search term using the words suggested by the proof of concept’s “add to query” feature and remembered the right term could be “spiral”.

Beginners experience difficulties in search more often than the expert users as was mentioned by a main user 1 in the interview conducted in January 2017: basic users use little of the online services, but veteran users find materials well. The main user continued, that newer users may not find what they are looking for right away: you need to find the right keyword. According to the interviewed main user, the target company’s user assistance search should be closer to the Google search.

Users are using Google to navigate to the content. This theme was mentioned 7 times. For example, B3 said that although the content existed, the search didn't work properly and because B3 wanted to make sure doing things the right way the user typed the name of the brand and “user assistance” in Google search field not to end up in a random YouTube video not created by the target company. Google returned the right article right away on the top and B3 was able to find what was needed. New users might be used to using Google search and find using the target company’s search difficult: “there are all those filters that you are not used to using” (B2). Also, E4 said that new users are not familiar with the target company’s search but prefer to search on Google.

As a young designer whose title is trainee, B6 didn’t always bother to ask everything from more experienced colleagues or mentor. Therefore, the user used Google to search how

to make something after which the user ended up on target company's pages. The comment demonstrates how socialization (Bratianu 2010, 48) works in that organization: tacit knowledge and best practices are shared in daily conversations between the inexperienced trainee and mentor. But trainee felt sometimes asking questions bothered more experienced colleagues and took too much time from them. So instead, the trainee used Google.

The counterargument to building an own intelligent search is to use Google's search. This argument was raised by an employee of the target company (see Appendix 2, "Invitation for internal experts"), and the same can be asked after the analysis of the end user interviews of this study. Why not to embed and utilize Google's search instead? If the target company would use Google Programmable Search it would have to pay the cost for Google not showing ads or their brand (Google 2021a). However, the real barrier to its use can be found in the Terms of Service (Google 2021b), which prohibit starting a search from outside the website and displaying results otherwise than on the full and complete results page. This condition effectively prevents embedding the search in the BIM software and thus the development towards intelligent service assisting the user.

The results of the end user interviews confirm the earlier findings of Aalto University students about the pain points in the young and / or inexperienced user's journey shown in Figure 27 (Company X 2017). The students collected the primary data by interviewing a young beginner user and a support person working in the target company and distributing

a questionnaire to Aalto University students who had studied or worked with the BIM software.

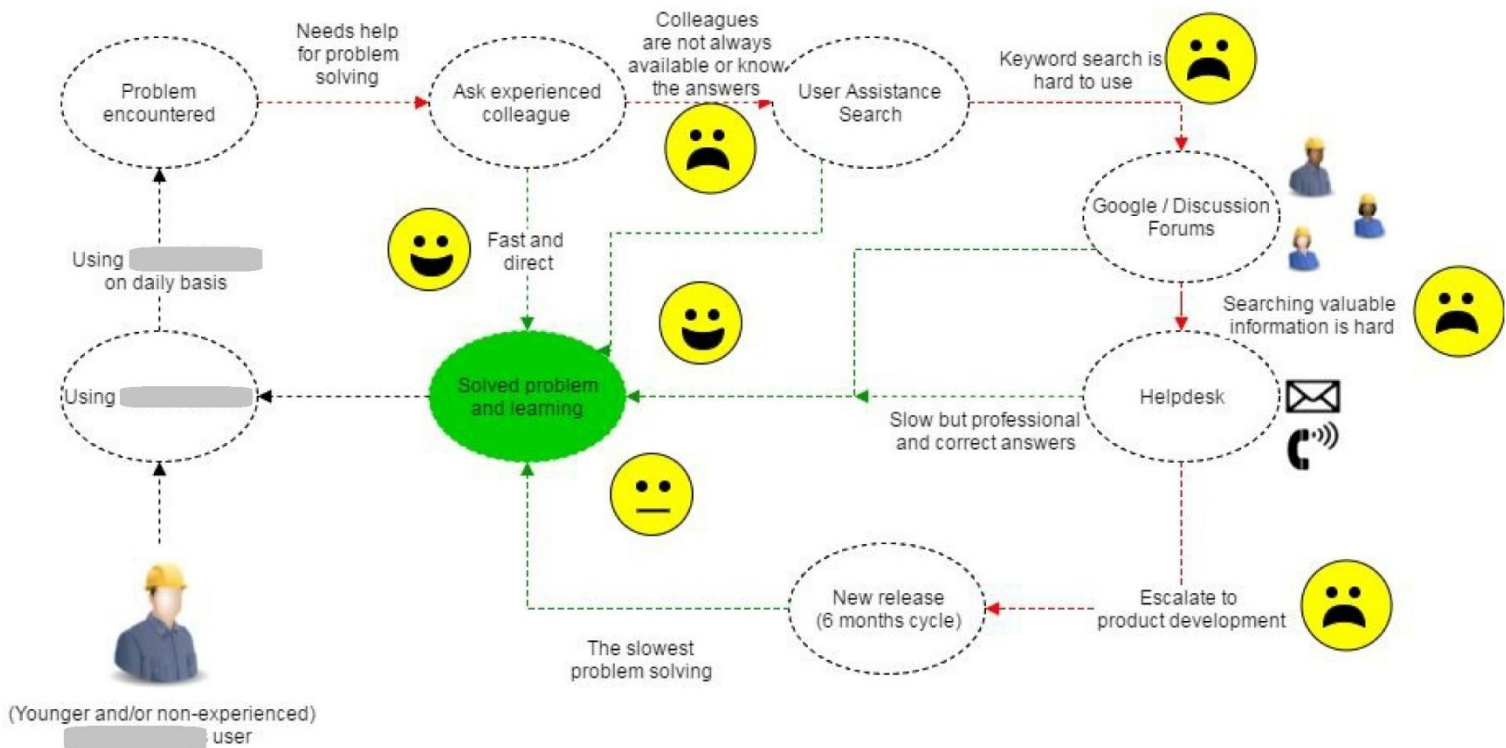


Figure 27. Pain points in the beginner user's journey by Aalto University students (Company X 2017)

End user experiences of using an existing user assistance search are interesting and important to consider. However, the end user assessments of the new proof of concept are more relevant to the ranking related research question RQ2 and RQ3 about the new search as a starting point for an intelligent service assisting users. These relevant themes are marked in dark in Figure 28.

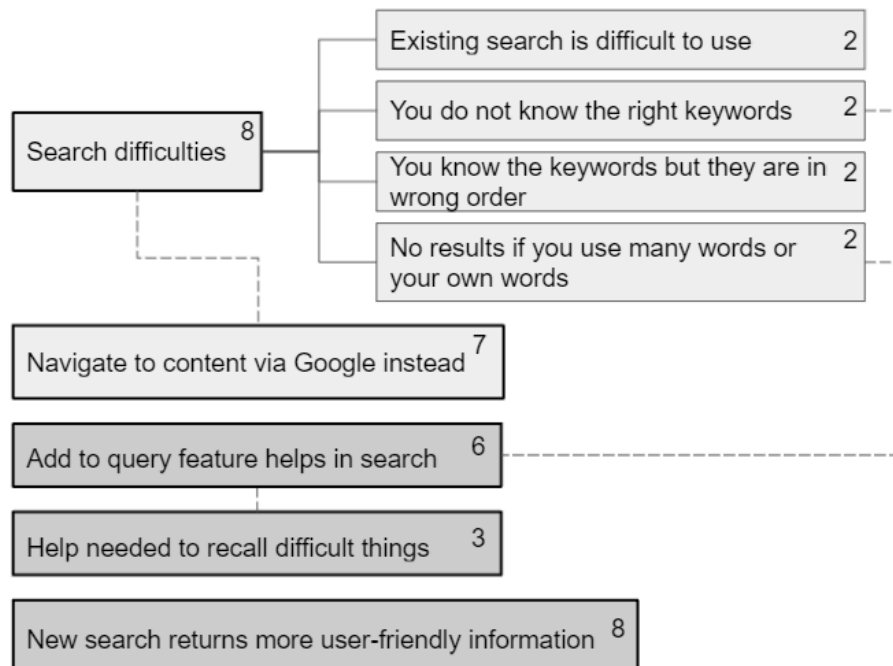


Figure 28. Thematic mind-map of end users' evaluations

The “add to query” feature suggesting words help searching. The theme was mentioned both by beginner and expert end users. E5 mentioned, the words point the user in the right direction. E4 tries often to find out what is wrong and in those cases suggestions like “troubleshooting” would help (the proof of concept suggested the word “troubleshooting”). The feature would help non-native English speakers. B6 said the “add to query” feature would be good because even if your working language is English the correct terms are not always remembered, but the proposals would help forward.

End user comments quite often repeat the difficulty of remembering things: the difficulty of remembering an English term, remembering the right keyword used by the BIM software, or, for example, the difficulty of experienced users to recall infrequently used difficult things (see Figure 28) such as advanced options. Regarding the RQ3 it can be added that the intelligent search should support users so that they do not have to remember things themselves.

According to the subject matter expert interviews conducted, the novice user wants knowledge on the basics and does not yet need to know the details of, for example, rarely needed BIM features. The test results (see Appendix 8, “Thematic analysis of end user interviews in the evaluative phase”) include many cases where testers said the new concept is better because it returns content that is appropriate for the novice user. The theme “new search returns more user-friendly information” was mentioned a total of 8 times.

Many beginners were looking for "how" knowledge. Based on their comments the new proof of concept was able to retrieve such content better than the existing search. For example, B6 searched "how to make drawings". As a newbie B6 would use the third hit in the new search tool, "Create drawings", right away because basic knowledge was needed. The existing search did not return that until the third page. B3 wanted instructions on how to create corbels. From the existing search the user was not able to find modelling instructions about how to do corbels: the right content was only on the second page, and the user would not bother to go to the second page. For B3 the new search gave better modelling related topics that B3 could use. B2 was looking for information on how the filtering logic works but the existing search did not return anything that was typed in the keyword; however, the new search was better and opening the search results would have helped B2 to understand the thing. The answer to RQ3 is therefore completed by adding that the new search should be able to provide knowledge content that answers the practical question "how" of novice users.

However, a simple answer to the "how" question with step-by-step instructions is not enough for beginners. This is shown by both end user comments and secondary data from January 2021. Next, we will look at the above-mentioned data.

Observations in January 2021 from beginners who participated in a 10-day software training in UK showed that it is possible to follow instructions step by step without a general understanding of the operational logic of each command. The ultimate idea of an intelligent assistant is just that, freeing a person from the effort of understanding the software (Robertson, Newell et al. 1977, 36). However, just following the instructions without a BIM knowledge and understanding can be an obstacle to the successful implementation of BIM software (Migilinskas, Popov et al. 2013, 767). BIM knowledge might be missing because of reluctance (Migilinskas, Popov et al. 2013, 767) or long history of using non-BIM software: an observed person said, "Hold that thought, im a slow learner with new software like this, spent far too long on Inventor [a CAD software] to know much else".

In interviews of this study both experienced and novice users used terms and phrases that indicate that the "general knowledge" is suitable for beginners. For example, a basic user needs content that provides "general understanding" (E4), topics returned by the proof of concept help to "understand the thing" (B2), the content found by proof of concept was better since it showed more "common things" as the existing search showed results that the average user would not need (E5), and even if the searched term was "quite general" the existing search went into "detail" (B2).

The new intelligent search should therefore provide general BIM and data model knowledge that assists beginners in creating a basic understanding of BIM. In addition, beginners should not be provided with detailed information that is more suitable for more experienced users. (RQ3)

Next, we will briefly look at the numerical results. The table in Appendix 9, “End users’ comments for each tested keyword” lists the keywords used and the users’ comments. For each keyword, the aim was to determine which of the search engines was better for the user. This was not always possible as users did not always comment on the results. Out of a total of 35 keywords tested, the users provided relevant comments for 25 keywords. In the following, we will focus on those 25 keywords.

A closer look at the test results shows that out of the 25 keywords, for 15 keywords (60%) testers reported getting better results from the proof of concept than from the existing search. Existing search returned better results than proof of concept for 3 keywords (12%). According to the testers, the searches were just as good for 7 keywords (28%). The shares are summarized in the following Table 12.

Table 12. End user evaluations on which search was better

Which was better?	Number of tested keywords	Percentage
POC	15	60%
Existing search	3	12%
No big differences	7	28%
In total	25	100%

When we look at the test results depending on whether the user was a beginner or an expert, some differences are noticed. Beginners did not prefer the existing search for any of the keywords they tested. Beginners preferred the proof of concept for slightly more keywords than experts. Experts rated both as equally good on clearly more keywords than beginners. These results are shown in the Table 13.

Table 13. Beginners' and experts' evaluations on which search was better

Which was better?	Number of tested keywords, beginners' evaluation	Number of tested keywords, experts' evaluation

POC	9 (36%)	6 (24%)
Existing search	0 (0%)	3 (12%)
No big differences	1 (4%)	6 (24%)
In total	10 (40%)	15 (60%)

Out of the seven users six said that if they would need to choose, they would prefer using the proof of concept. One expert user did not answer the question. The Table 14 lists the users' responses.

Table 14. End users' answers to the question in the end of interview of which search they would choose

Interviewee	Preferred	User's comment
Expert 1	POC	In some things it was better.
Beginner 2	POC	Provides more sensible results and clearer headlines.
Beginner 3	POC	Has the additional tool ["Add to query" feature] that helps in search. Gives a variety of topics that contain the thing that was searched for.
Expert 4	POC	Prefer to use a proto, although it didn't work better with the "wall layout" search term. As a rule, however, proof of concept was better.
Expert 5	POC	Clearly better when searching for e.g. "template editor". Would select the proof of concept although in some cases both were just as good.
Beginner 6	POC	More general level content for newbies and clearer layout.
Expert 7	-	(The user did not answer the question.)

From these results, it can be concluded that experts found the right knowledge content not only with proof of concept but also with existing search, while beginners better found what they were looking for with the help of proof of concept. Thus, it can be said that the intelligent search developed as proof of concept would serve as a starting point for a more intelligent user assistance (RQ3) that would provide right knowledge for the novice user.

4.4 User personas: beginner, expert, and main user

In answer to question RQ1: "What types of users are there?" user personas were defined. User personas unique to this research were formulated while studying the problem area and analyzing the data (Cooper 2004, Ch. 9). Personas were necessary in clarifying the level of expertise of the user for who the future intelligent knowledge management service would be designed for. The user personas previously created in the target company, and in particular a user persona called "New software user" (Company X s.a.), were a good benchmark when studying what kind of different users there are.

The end users interviewed for the evaluation of the proof of concept were both experienced and novice users. This basic division remained throughout the study. The ranking based on the abstract concept called "advancedness" was implemented with the needs of beginners in mind, as beginners were an important target group for the business of the target company. This thesis thus focused on the beginner user persona.

A beginner user persona is a person whose internalization degree is low, the explicit knowledge is not embodied as tacit knowledge yet. The person is ignorant or barely unaware of the existence of the knowledge, or if the person knows the existence of the knowledge, person cannot reason with it and has little understanding (Wiig 1993, 101).

According to results of the primary data analysis beginners need information that in text answers question "what" such as "what is model sharing" and knowledge that answers question "how", for example "how to make drawings". The literature emphasizes the importance of knowledge of the general BIM methodology in the implementation of BIM. The end users interviewed for this thesis also emphasized the general understanding, and it came up in secondary data when beginners were observed in January 2021. The issue has also been included in the definition of the "New software user" user persona of the target company (Company X s.a.). Thus, information suitable for a beginner is also knowledge that helps in the transition from 2D or CAD way of working to BIM. Such knowledge helps to understand the basic concepts of BIM methodology as well as helps to internalize the basic functions of 3D BIM software. (RQ1.1)

As users of the intelligent user assistance service beginners and experts may have different needs, purposes, and ways of using the user assistance. For example, experts tend to try to understand the problem, think about the problems conceptually and generalize them while beginners may focus on the details and simply try to solve the problem without understanding it using the method that comes to mind first. (Morana, Schacht et al. 2017, 37) Beginners may try to fix the wrong thing when they don't figure out the real cause of a problem. For example, beginners may think bolting is the issue, when it was a misplaced point, as was observed in training course in the UK. The findings of this thesis are consistent with Fraser, Dontcheva et al. (Feb 27, 2016, 1223) in that novice may have very high level goals, such as "how to make drawings", and may not know what features or steps are needed to achieve the goals.

An expert user persona is a competent user who knows about knowledge available and keeps the knowledge in memory (Wiig 1993, 101). A knowledgeable, expert user persona is important in the sense that different knowledge is appropriate for him or her: detailed, non-basic, more advanced knowledge. In some situations, an expert needs help to remember things or concepts that are rarely needed. On the other hand, the expert knows where to find help and may only need the "add to query" type memory refreshment as experimented in the proof of concept. Experts might not appreciate the assistance service as much as beginners who need more advice and explanations (Morana, Schacht et al. 2017, 37).

There are situations where everyone is a beginner (Robertson, Newell et al. 1977, 33), such as an expert user using a new feature for the first time or, for instance, starting a very first design project using concrete as a material. What distinguishes these situations from the beginner is that the expert knows where to find the information, how to search for it, and how to use it (Wiig 1993, 101). Therefore, experts who experience beginner situations are not within the primary focus of the future intelligent user assistance service.

The main user profile can still be distinguished from the experts. The main user has typically fully internalized the knowledge and has a deep understanding (Wiig 1993, 101). Main user profile was not at the center of this thesis, but they may play a role in making tacit knowledge explicit and sharing knowledge within their organization and community of practice. This issue should be further explored in the future.

The distinction was clearly identified between expert and novice users in their behaviours and needs. In future there could be a spectrum of user personas or optimal personalized profiles to suite the individual user. For example, more specific beginner profiles could be distinguished from a beginner's user persona when the new more intelligent assistance is

created, and data is analysed. This also relates closely to the advancedness concept, which may be different for different personas, or another concept than advancedness may be needed for a different user persona.

4.5 Roadmap towards intelligent assistance service

In the last process phase of constructive research, the applicability of the solution was pondered. In this research it was not meaningful to consider if the solution might be transferrable to other organizations (Lukka 2000, 7) since it was not something that anybody can try out (Kasanen, Lukka et al. 1993, 258): it would be difficult to implement similar construct in other organization. Instead, applicability was examined within the target organization, regarding whether the developed proof of concept could be used for the new intelligent user assistance. The final step in the constructive research phase was therefore the development and evaluation of a roadmap that would answer research question RQ4, “What steps should be taken to develop an intelligent service assisting users?”. The the final step in the constructive research process is illustrated in Figure 29.

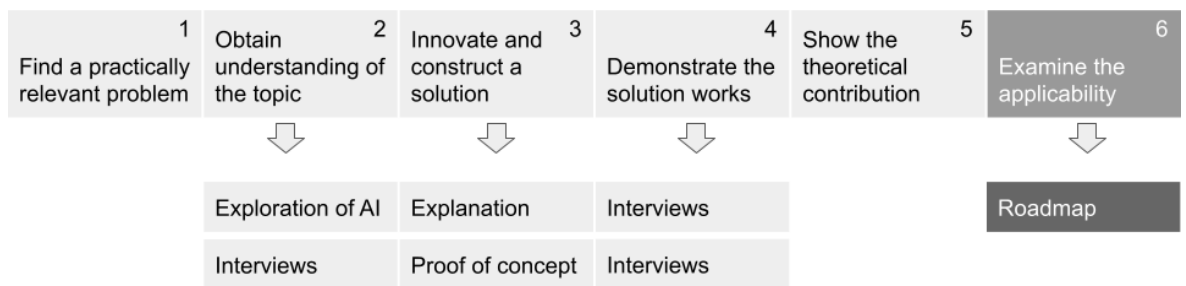


Figure 29. In the final phase, the applicability of the POC was considered when the roadmap was created (applied from Kasanen, Lukka et al. 1993, 246)

In this study we were interested in the customer experience in the customer journey's post-purchase phase which is crucial to the target company's B2B business. The target company has a new business model where the BIM software is sold using subscription licensing model. The value in use must be realized more quickly than before when the target company's business model was based on perpetual licensing. As the Global Marketing Director of the target company said in the Teollisuus 4.0 event (Professio 2021, 1:30-5:00), the first month or six months of the usage are important: if the users are not satisfied the customer may not renew their subscription licenses. In the BIM implementation phase the BIM software itself is the critical touch point (Lemon, Verhoef 2016, 76). Customer experience is closely related on practical value in use (Becker, Jaakkola 2020, 635) and when customers analyze their investment and productivity gain in order to make a purchase decision after a trial or to renew a subscription, much

depends on perceived value in use, user satisfaction, and, for example, the learning curve.

In contrast to the goods-dominant logic, the customer is seen here as a co-creator of value and the value is not created by the target company producing the assistance service. Adapting the service definition of service-dominant logic (Greer 2016, 29), the new intelligent user assistance is a service that applies knowledge and skills of the target company, customers, and community of practice for the mutual benefit of individual engineers and customer organizations. By further adapting the definition of knowledge management (O'Dell, Grayson et al. 1998, Ch. 1) it can be added that the new service aims to get the right knowledge to the right users at the right time and help them share and utilize knowledge in ways that improve customer organization performance.

The literature tells that one of the obstacles in digitalization and implementing BIM is the lack of skilled people and time required to learn the new methodology and software (Ernst & Young 2017, Migilinskas, Popov et al. 2013, 767). The results of both the subject matter expert and end user interviews of this study shows the importance of the beginner level knowledge that helps the novice user to understand BIM methodology and answers practical questions how to use the BIM software.

The new service would contain all the content a beginner user needs from general BIM methodology knowledge to step by step instructions. Moreover, the new service would take advantage of tacit information stored and explicitly expressed in discussion forums (Kuo 2019, 31) owned by the target organization. The extensive experience gained over the years in communities of practice across organizational boundaries could thus be better utilized.

The vision of the roadmap is to reduce the steep learning curve by intelligent knowledge service assisting the beginner user. The Figure 30 illustrates the service at a high level.

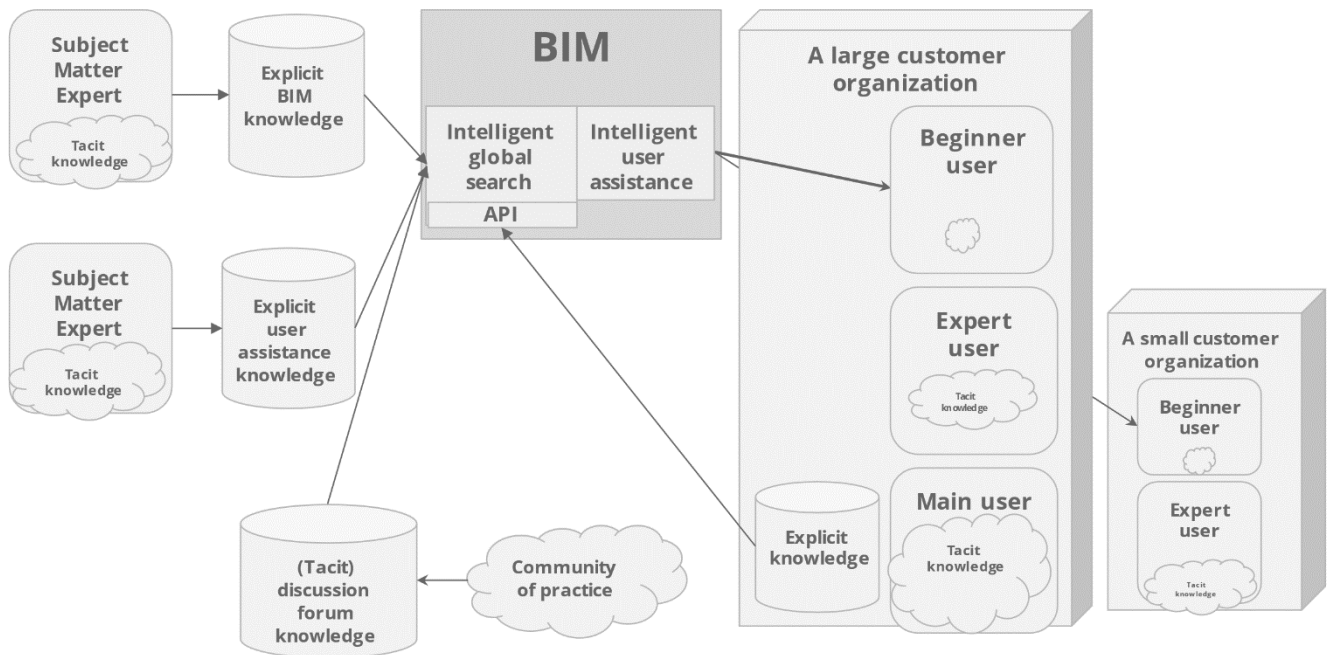


Figure 30. The new intelligent BIM-based knowledge management service assisting a beginner user

On the left the picture shows the subject matter experts of the target company, whose tacit knowledge is transformed explicit and combined with existing knowledge. In the middle is the BIM software that retrieves knowledge intelligently and provides it to beginner users. On the right are customer organizations and different user personas. In small organizations there might not be a main user or internal knowledge bases. The community of practice consists of the employees of several organizations, whose tacit knowledge is shared in the forum.

The features of the new service were viewed utilizing the intelligent user assistance taxonomy defined by Morana, Schacht et al. (2017). In Figure 31, the dimensions describing the service are circled. Next, we'll go through what they mean for the new service.

Target (32)	Choosing (13)		Using (21)	
Directivity (39)	Suggestive (31)	Quasi-suggestive (0)	Informative (22)	
Mode (31)	Predefined (23)	Dynamic (8)	Participative (5)	
Invocation (36)	Automatic (18)	User-invoked (19)	Intelligent (1)	
Timing (32)	Concurrent (12)	Prospective (9)	Retrospective (20)	
Format (45)	Text-based (41)	Image (17)	Animation (1)	Audio (2)
Intention (34)	Clarification (4)	Knowledge (17)	Learning (7)	Recommending (13)
Content Type (23)	Trace (16)	Justification (19)	Control (8)	Terminological (2)
Audience (16)	Novice (16)		Expert (8)	
Trust-Building (5)	Proactive (5)		Passive (0)	

Figure 31. The dimensions of the new service applied in the taxonomy by Morana, Schacht et al. (2017, 35)

The purpose of the assistance is to support users in using BIM. The guidance includes both suggestive and informative guidance. Beginner users will benefit from suggestive instructions that provide a clear procedure for performing less complex task. Suggestive help speeds up their decision-making and increases satisfaction and perceived reliability. Informative guidance would help the expert users in their complex tasks, and beginner users will also benefit from declarative information that will increase their understanding of BIM. (Morana, Schacht et al. 2017, 34-38)

The mode of the current embedded user help is predefined, for example, the F1 key opens a predefined html page. However, manuals and online help functions such as F1 help may not be as effective as thought. On the contrary, they can distract the employee from the work itself and impair efficiency. (Maedche, Morana et al. 2016, 367) Instead, dynamic guidance improves the quality and performance of decision making, learning, and reduces information overload. In the new service, guidance is dynamic, i.e., it learns from the user and gives instructions if necessary.

The invocation is intelligent instead of user-invoked or automatic: the guidance will be initiated and delivered to the user based on monitored user behavior. Timing is prospective, meaning the service provides guidance before a specific activity, not after or at the same time. The format is text. However, the guidance may also include images and animations, including videos, if a video script or alternative text to the image is available. The intention or reason for guidance is knowledge. All content types would be possible in the new service: trace, justification, control, and terminological. The audience for the guidance is novice users and the service proactively seeks to increase users trust and

confidence by providing explanations of how proactive guidance and recommendations were made. (Morana, Schacht et al. 2017, 34-38)

Let's now move on to how the roadmap was created and what it contains. In the roadmap the vision and themes are in line with the target company's strategic business goal (Lombardo, McCarthy et al. 2017, Ch. 4) of improving recurring returns and reduce customer churn. The real problems worth solving were presented as themes (Lombardo, McCarthy et al. 2017, Ch. 5). Under each theme, the roadmap has features to achieve the theme. In this roadmap, the feature is a probable solution, which means that it is not final and another, better solution can be found in the later stage (Lombardo, McCarthy et al. 2017, Ch. 6). The implementation of a feature is divided into two stages: discovery and delivery. This is because the many things the roadmap has are new and require research. New proof of concepts and user surveys are likely to be needed. This will all take time, so maintenance is one of the stages in the roadmap.

The roadmap answers to the RQ4: "What steps should be taken to develop an intelligent service assisting users?". The roadmap, presented in Appendix 10, includes four themes, which are described next.

4.5.1 Speed up beginners' performance

One of the four themes in the roadmap is called "Speed up beginners' performance". The purpose is to help a beginner user to perform faster and better by providing novice-level content for the novice user. To this end it is important to identify the beginner from other users. This is possible by analyzing the use of the software license. A beginner is a user who has just started using the software license. In addition to the start time of the license, the intensity of use must be considered. The user may still be a beginner, even if the license was activated some time ago, if the user has not used the software regularly and for long periods of time.

The definition based on license usage data may include incorrectly experienced users if the new licensee has used the target company's BIM software in a previous workplace or is otherwise an expert in structural design and modeling. This counter argument is valid; however, this weakness is acceptable due to the straightforwardness and simplicity of the method. In the future, more accurate identification can be implemented if the problem is significant, for example, if such a user does not benefit from intelligent user assistance. The problem could be solved by modeling an expert user. We will return to user modeling shortly.

The available license data provides a basic distinction between beginners and experts. More precise time limits for the use of the license should be determined by analyzing the license usage data. At the same time, the beginner user persona can be defined more precisely or divided to several beginner use personas. (RQ1.3)

Park and Lee (2021) have used usage sequences of menus, buttons, pop-ups and other interactions successfully to model smartphone users and organize instructional content. Also, Stoica, Tselios, et al. (2017) predicted users next actions in an educational system. In the new service, the AI analyzes the sequences of user interface interactions and notices where the novice user has problems, e.g., the user does not understand the BIM or cannot find the correct commands for the task at hand. Indicators of the problem could include, for example, use of the F1 key or repeated use of the Undo command. Other commands and command sequences that novice users usually do but advanced users do not can be identified by anonymously collected command usage data. Such a difference may be, for example, that novice repeats the same command sequence over and over again when expert performs the same task using a single or only few commands. The novice user may not be aware of a feature that would make the task faster.

A counterargument to detecting the beginner in trouble is to identify the typical situations manually or with help of AI and write guidance or encode an html link to them, as in F1 Help. However, problematic situations can happen with any command or task and in a wide variety of contexts. Adding predefined guidance or links would only solve a small portion of potential situations and would not make the necessary impact. It would not be possible to significantly speed up beginner learning or productivity with point solutions.

First feature under the theme concerns AI algorithms to detect a novice user in trouble. The second feature would generate an automatic, programmatic search query. For example, the names of commands, dialogs and functions could be used in a search query. For the search to return contextual knowledge, the query could contain relevant information about the user's context of interaction with the software, for example, commands used before Undo or F1, the most recent error, or the most recently displayed help topic. The long-term context in the form of a user profile (Relles, Sondheimer et al. May 21, 1981, 3) could be exploited in the query. To personalize the search results, the service could include the software version used, the user's primary language, and the user's geographical location. As one of the end users (E5) mentioned in the interviews, the search should not show knowledge that is not relevant in the location of the user, such as topics related to building products only sold in the UK when the user is from Canada. This all would be further examined and tested in the discovery stage.

The automatically generated query would be created and executed in real time. A rapid response would be essential for the user assistance service, as stated as early as 1977 (Robertson, Newell et al.) as it would impact the perceived usefulness of the service (Eko K Budiardjo 2017, 206).

The AI would learn and develop based on user choices. If the user did not use the content provided, it could indicate that the search returned the wrong knowledge. Or the service could ask the user directly if the topic provided was useful and learn from the answers.

In the first phase, the user assistance service's timing would be concurrent, and it would provide aid with the commands currently in use. Later, once AI has been researched and developed, it would be natural to move on to anticipating the problem and providing the assistance proactively. That is the last feature included in the roadmap under theme "Speed up beginners' performance".

4.5.2 Provide the right knowledge with intelligent search

The next theme is "Provide the right knowledge with intelligent search". Knowledge quality, such as relevancy, precision, and accuracy, are important when users evaluate the usefulness of a knowledge management service for continuous use (Eko K Budiardjo 2017, 204). The new service would provide the user with relevant knowledge that is as close as possible to what the user needs. This is accomplished through intelligent search that retrieves information from a vast mass of knowledge.

Based on the results of this thesis relevant knowledge for beginners answers practical questions such as "how" and "what" and provides general BIM methodology knowledge. Irrelevant knowledge is detailed, advanced knowledge that suits better for experts. Earlier in this study, it was proven that the abstract concept of advancedness implemented in the proof of concept works. It therefore makes sense to use the proof of concept already implemented in the roadmap as a starting point for a new intelligent user assistance service (RQ3). The relevance of the information could be further increased in future by personalization so that the search results would not contain information related to the wrong software version or, for example, geographical area.

The intelligent search would use natural language processing and methods such as latent semantic analysis and text mining, which were experienced in the proof of concept. In addition to the concept of advancedness developed and evaluated in the proof concept, the development of other abstract concepts would most likely be needed when new types of knowledge are included and more user personas are defined. The development would be done similarly as in proof of concept, by experimenting different AI

configurations and tuning parameters, or removing and adding parameters. It can therefore be stated that the developed construct is applicable (Oyegoke 2011, 587) as a starting point for the roadmap taking into account the need for further research.

4.5.3 Make BIM a centralized knowledge platform

The theme called “Make BIM a centralized knowledge platform” aims to bring together all relevant knowledge sources owned by the target company and provide customers a platform to integrate their own knowledge into the service. The literature talks a lot about the internal knowledge management of local organizations, but nowadays also about the knowledge of international companies and external suppliers and partners. The new service would combine the knowledge of the globally operating software vendor i.e. the target company, their customers and the global community of practice. In this way, these different service systems could work together to create and use knowledge for the benefit of all parties. When the producer-consumer distinction disappears, everyone would be involved in creating value for themselves and others. Still the new service would meet the customer’s goal of applying the knowledge to improve their own conditions. (Vargo, Stephen L., Maglio et al. 2008, 149-150)

The knowledge and expertise of the target company is an important part of the B2B customer experience when it adds value to the customer (Lemke, Clark et al. 2006, 15). One source is the target company’s user assistance website and its support articles, how to guides, definitions, troubleshooting guides, tips, best practices and so on. Typically, knowledge is created by converting the tacit knowledge of the internal subject matter experts into explicit information together with professional technical writers, and the explicit information is then combined into the existing explicit user assistance knowledge. This work is done by the target company’s skilled experts and technical writers, so motivation or capacity of creating new explicit concepts is not an issue. (Bratianu 2010, 49)

In addition to the user assistance content, the new service should include the content of the forum service owned and operated by the target company. The target company’s forum service supports the subjective aspect of tacit information sharing (Wickramasinghe 2003, 313), is a place for community of practice to exchange experiences (Kuo 2019, 31) and socialize the best practices (Bratianu 2010, 48). The new service would be most useful when integrated into work of community of practice (Wenger, McDermott et al. 2002, 9-10). Community would combine aspects of tacit and explicit knowledge; it understands practitioners and is good at creating and maintaining useful knowledge content.

Customers should be able to include their own knowledge in the service. The customer company must be able to trust the service and that its best practices do not leak to competitors. The customer company would always own its own knowledge and the knowledge would only be available to the employees of the customer organization. Based on secondary data, there is a need for such knowledge storage and transfer service, especially within larger customer organizations. When main users were asked in January 2017 if they would be interested in a service, where they could distribute support materials to their own users, the main users 4 & 5 from UK said they understood why the service would benefit large companies and mentioned that internal guidelines should be gathered in a common place. Another interviewee, main user 2, said they would add their material to such service and main user 1 was interested in company-specific support service and a search that would include their company's online sites. Main user 1 continued that the search results should have filtering on showing own/not own content.

The main user 1 pointed out that one should map out how many companies have the resources to create help content themselves. This comment supports the finding of Ahmed (2018, 14-15) that sharing knowledge requires time and commitment. The motivation is a significant enabler of knowledge management in the construction sector (Boamah, Zhang et al. 2021, 7). Thus, the new service should encourage knowledge externalization i.e., it should not just retrieve content for knowledge re-use, but it should make it easy for individuals to post new forum topics and replies or write new company specific knowledge content and combine that with other pieces of explicit knowledge of the organization.

Main user interviews conducted in January 2017 revealed that many companies have created their own ways and introduced tools for BIM user assistance knowledge capture and re-use. The company of the main user 1 was collecting the necessary links to OneNote, but the information collected was difficult to maintain. Another company offered its own instructions which were, for example, links, videos, recorded training materials, and written instructions. As a tool they used Confluence, which also had a question-and-answer section (main user 3). The finding confirms the trend observed by Ku, Taiebat (2011, 193) to move from formal external training to a self-learning and company-specific knowledge bases.

The existing knowledge bases of customers could be integrated into the new service by allowing customer companies to copy their material to the service or letting developers to use an API provided by the target company; larger customer companies may nowadays have a software developer or even team of developers.

The new BIM-based knowledge management using AI to assist the user would be different than what has been done before in the target company. The customer experience of the new service would not be influenced only by the target company itself, also, customers as well as community of practice, both outside of the control of the target company, would be co-creating the value is use and user experience (Becker, Jaakkola 2020, 637).

In the beginning the focus would be in user assistance type of knowledge. Later the focus could move towards examining Building Knowledge Modelling and how to expand the service towards more comprehensive building knowledge management service. It is crucial for the construction industry to be able to use and integrate knowledge without constraints (Boamah, Zhang et al. 2021, 2). For example, users could consider professional experience and lessons learned from previous construction projects in order to eliminate bad approaches that contribute to project failure. The goal would be move up in the knowledge hierarchy from building information to building knowledge (see Figure 2). The examination of Building Knowledge Modelling for the benefit of all users is the last feature under the theme "Make BIM a centralized knowledge platform".

4.5.4 Present knowledge directly in BIM

The fourth of the themes is "Present knowledge directly in BIM". Observations in January 2021 from beginners who participated in a 10-day BIM software training in UK revealed obstacles related to the use of the instructions. When it was asked after the training day what felt difficult, one of the participants answered "making the manual for the large model tie with the actual model getting made" i.e. learning the BIM software was difficult because the manual's text or images and the BIM model were not equivalent. The same thing was repeated in the comments of several beginners: "utilizing the UI information in the manual to performing the task" was difficult; and "I have none of the same profiles or materials as the guide". Beginners found it difficult to follow the instructions in a separate manual. In addition to the fact that the novice had to shift attention between the manual and the software, the predefined guidance did not always correspond to the situation in the BIM software. The intelligent service should not provide guidance separately from the BIM software. Instead of predefined guidance associated with a specific use of commands or features, it should provide context-specific knowledge so that the right content is retrieved for each user and use situation separately and displayed in the same use context. The new intelligent knowledge management service would not be a separate service such a corporate university, an intranet, or the like, as it has traditionally been (Wenger, McDermott et al. 2002, 12). The knowledge would be presented in the virtual 3D

environment, which helps engineers to learn and understand (Lin 2014, 187) and allows the user to view the instruction and the BIM 3D model simultaneously.

Customer organizations would also benefit if their knowledge were readily available in the BIM software used by employees. As a reason for the large number of company's own instructions, one interviewee (main user 3) said in 2017 that not everyone understands the content offered by the target company or the content does not answer the question of the design situation. But, some of the company's users had hardly used the internal instructions at all.

An in-product search could be implemented first: the search field and search results should be included in the BIM product. The main user 2 liked the way how F1 opens the browser, and thought that it would be convenient if the search box would be visible in-product. The intelligent search directly available on the product would make it easier and quicker to find help.

When a civil engineer who worked as a main user was asked for an opinion in 2017 on providing existing online support services in-product, the main user had a divided opinion: it could help, but some might feel uneasy, so it should be easy to approach, not distracting (main user 1). The service would show the results returned by the intelligent search to the user at the right moment when the service detects that the novice user needs help. Guidance of the intelligent user assistance should be not disturbing but subtly helping the beginners to internalize the new knowledge, understand and learn. The new service should provide answers to the beginner's questions so that the beginner no longer needs to use Google or any search tool that interrupts the work and takes the attention away from the task at hand. Beginners should no longer need feel ashamed to ask more experienced colleagues too often, as the young designer B6 did, since the answer is available in the software itself.

4.5.5 Evaluation of the roadmap

To ensure its realism and feasibility of the vision and roadmap the author shared and discussed with the target company's experts participating to the corresponding Objects and Key Results group. It was important that the people in the target organization who would eventually be involved in the development and design of the proposed new construct were involved in the creation of the roadmap (Oyegoke 2011, 592).

After considering and applying the ideas and comments of colleagues, the author asked to speak to the Online Presence steering group of the target company. At the event, the author presented the roadmap and the underlying findings that emerged in this thesis.

At the beginning the author explained what intelligent user assistance is and what the new service means and linked it to the business objectives as well as the enablers already existing in the target company. The roadmap was then presented one theme at a time and participants were finally asked to provide feedback on the following four issues:

1. Is the direction correct? Is the proposed roadmap in line with the strategy and business targets?
2. Do you see obstacles or problems? What could be a significant factor that would prevent the development of intelligent user assistance?
3. What would you like to add or advise? What has been left out of the roadmap or what should be paid attention to?
4. Can the roadmap be accepted as a preliminary plan? While the future is uncertain, can we take this roadmap as our first guideline and update the roadmap when we know more?

The steering group and stakeholders agreed that the direction was right, and the roadmap fit well with the business goal of getting the users up and running more quickly and thus less likely to churn. No significant obstacles were found, but participants discussed about confirming the resourcing, need for internal collaboration, how quick the target company could adopt the roadmap and what kind of technical challenges there might be. The third question sparked a debate on the use of assistance for expert users in certain situations and, for example, on the scaling of the new service to several products. On the last issue, it was stated that roadmap is in line with strategy, it is logical and creates clarity and acknowledging the future uncertainties the roadmap was accepted.

5 Conclusions

The thesis dealt with the steep learning curve problem of BIM implementation observed in the literature and confirmed in this thesis. The goal was to develop a proof of concept of an intelligent search and a roadmap towards an intelligent knowledge service to assist the beginner BIM software user.

Today, AI makes it possible to implement the idea of freeing the user from reading a manual or searching for the necessary knowledge. In this study, AI was successfully used to develop a proof of concept of intelligent beginner-level knowledge retrieval.

Next, we return to the research questions. The RQ1.0 asked, "What types of users are there?". This question was answered by creating user personas called beginner, expert, and main user. Relying on primary and secondary data as well as the literature of degrees of knowledge internalization, a clear division between beginner users and expert users was confirmed during the study. It was possible to further distinguish main users from expert users.

The RQ1.1 was "What kind of knowledge would different types of users need?". Based on the primary data, a beginner user needs declarative information that answers question "what" as well as knowledge of how, for example, to "create", "define" or "add". The finding is consistent with Morana, Schact et al. (2017, 37). Based on the literature and secondary data, it can be added that a beginner also needs knowledge and understanding of the BIM methodology. Instead, experts, including main users, no longer benefit from basic knowledge but from advanced knowledge that explains how to, for example, "customize", "check", is intended for more demanding use, or explain a specific issue in detail.

The practical follow-up question, RQ1.2, "How different types of users can be identified?" was answered in the roadmap. The new assistance service would determine whether a user is a beginner, or a long-time expert based of the use of the software license: factors examined would be time from the license activation and intensity of use.

The RQ2 was "How should search results be ranked?". Empirical results of this study showed that the novice-level knowledge content should be ranked to the top.

The RQ3 asked, "What kind of search would serve as a starting point for an intelligent service assisting users?". Search should understand the advancedness of the knowledge content to provide the right information and knowledge for the beginner user, and free users from remembering the right terms and keywords.

The last research question, RQ4 was “What steps should be taken to develop an intelligent service assisting users?” The necessary steps were described in the roadmap using the four themes and features, as described in the chapter 4.5. The roadmap was evaluated and approved by a steering group of the target company.

From the business perspective of the target company, the value in use of the BIM software must be realized as quickly as possible. Important fundamental basis in this thesis was the shift from the goods-dominant logic, which sees the BIM software as a product, to service-dominant logic. Thus, the value in use is not formed by the target company, but it is co-created, and the core source of value is knowledge and skills, in this case literally the knowledge that assists a user of BIM.

The topic of knowledge management was studied in perspective of inter-organizational learning where the target company, customer organization as well as community of practice was brought together for co-creation of knowledge. It was noteworthy in this study that the Nonaka’s (1994, 19) SECI model (Socialization – Externalization – Combination – Internalization) can be used to explain the creation of knowledge related to the target company’s BIM software.

In the thesis, intelligent user assistance was combined with knowledge management. Combining the two created a new perspective and roadmap for a solution that makes it possible to reduce the problem of the deep learning curve of BIM. In the future, the target company could offer its B2B customers a unique value proposition for a service that provides the right knowledge for the right user at the right time.

6 Discussion

In the development of the proof of concept, the expertise of the AI partner was of great importance, as the target company did not have the necessary competence of its own. At the same time, the weakness of this thesis is the exclusion of in-depth examination of machine learning methods and algorithms. However, the use of an AI partner was justified in the first intelligent user assistance development project. In the future, more will have to be invested in the target company's own expertise.

Another weakness relates to a review of the literature, in which the theory and previous research related to the three research areas could not be thoroughly reviewed. Here, the focus was only on the definitions and studies best suited to this thesis to give the reader an overall understanding of the problem area of this particular thesis rather than a long overview of the different research trends and definitions.

In addition, the study did not find out the suitability of the existing user assistance knowledge content for the intelligent user assistance service. The content has been originally created for a different purpose, to be browsed on a website, and it remains the subject of a new study on how well the content can be utilized to solve the problems faced by a beginner user.

Along the path proposed by the roadmap, research and development should be conducted in relation to machine learning, UX, reuse of existing knowledge and creating new knowledge as well as value in use and post-purchase customer experience. Continuous discovery and development will take several years and thus requires the support of the top management of the target company as well as the motivation and perseverance of those involved in the work.

The approach presented in this work could be extended in the future to several products of the target company, new user personas, and, for example, construction project and design knowledge. A customer who uses multiple products from the portfolio would be able to share and receive valuable knowledge and help to complete the various phases of a construction project. This would have an even more significant impact on the business of the target company, not only because of the positive customer experience but also because of its unique competitive advantage and brand equity.

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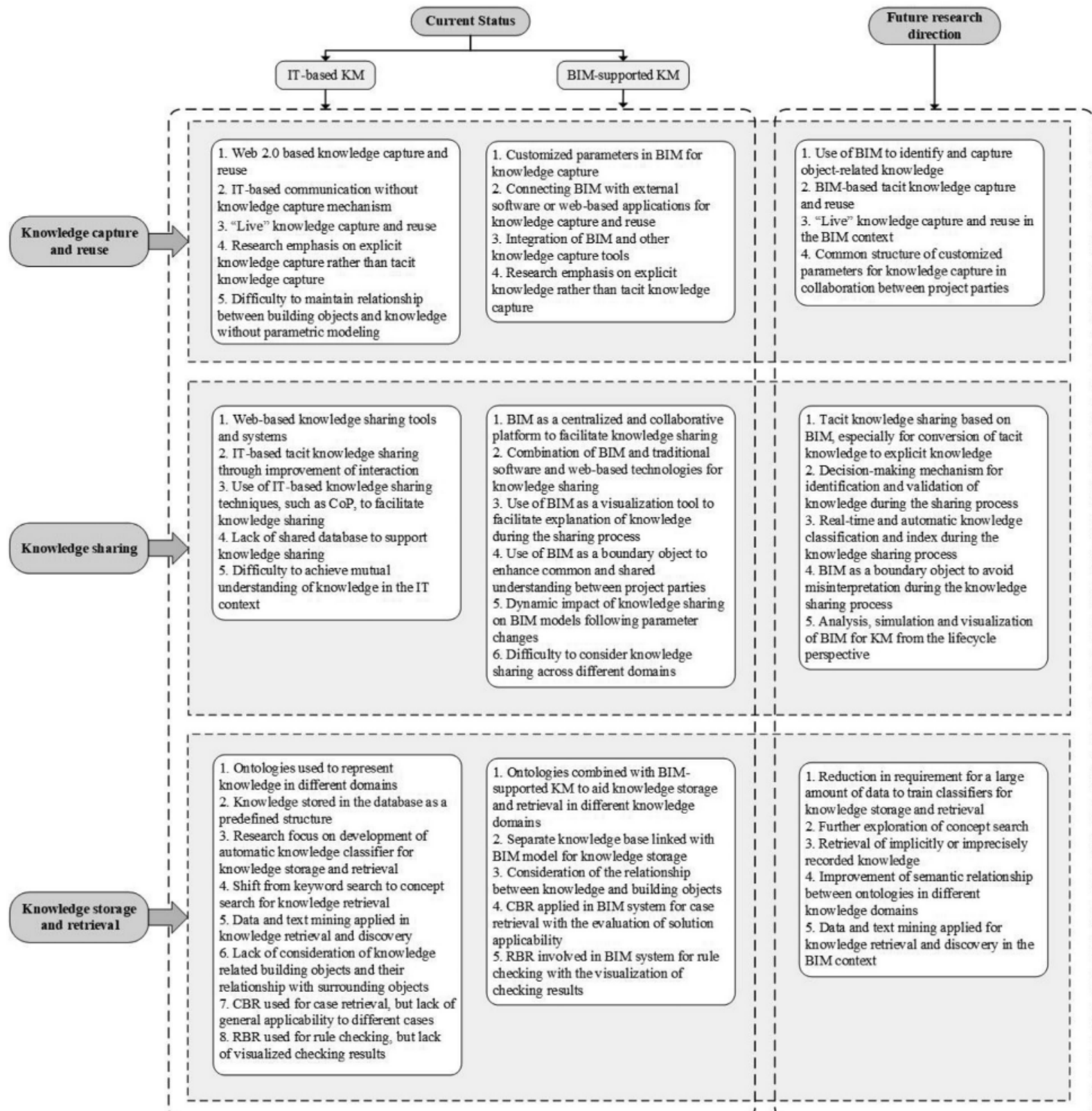
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Attachments

Appendix 1. IT and BIM-based knowledge management

The following figure shows the integrated framework of current and future trends in IT and BIM-based knowledge management (Wang, H., Meng 2019, 181).




Appendix 2. Invitation for internal experts

 Jaana Hannila 10 months ago



Want to help improving User Assistance search?

Do you know when TUA search is not working properly? We need someone to say what content TUA search should return for certain keywords. You would need to tell if an article the TUA search returns is "right", "wrong", "maybe ok", and if some article is missing (that information would be really valuable). We will use the results to improve machine learning based content tagging.

If you know TUA and have experience in using the search, please volunteer by emailing .com">jaana.hannila@.com by November 17th .

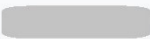
#tua #_user_assistance #machine_learning



1 comment

 Like  Comment




I mostly use Google search as TUA's own search very seldom finds the right content. Why just give up with own search and use Google instead?



Like Reply 10 months ago



Write a comment...



Appendix 3. Example results of classification.

Among other things, during the exploration it was tested how well AI can classify the user assistance content of the target company. In the image below, the “Index terms” column contains the results of the classification i.e., tags that describe the content.

Title ▲	Index terms
2D Library in drawings	detail, library, 2d, insert, scale, explode, subfolder, new, capture, update
3D cut (10)	cut, plane, cutplane, offset, explode, three, concrete, picture, 3d, side
About analysis applications	analysis, application, analyze, deflection, structure, calculate, displacement, stress, warp, link
About analysis part properties	analysis, accord, current, unchanged, display, structure, call, identical, override, different
About bolt gage lines	gage, diagonal, bolt, line, tower, l, batten, s85, windbrace, s67
About clash types	clash, overlap, another, inside, intersect, occur, identical, manager, several, cut
About load combinations	load, combination, permanent, incremental, situation, real, process, represent, id, unique
Access rights in multi-user mode	privilege, lock, access, domain, nn, defined, organization, uda, multus, affect
ACN	control, assign, information
Activate [redacted] licenses	license, server, activate, activation, administration, notification, notify, flexnet, solution, tool
Activate [redacted] licenses using automatic server notification	license, server, activate, administration, notify, tool, notification, flexnet, activation, contact
Activate [redacted] licenses using manual server notification	license, server, activate, notify, administration, licensing, service, reread, lmtool, notification
Activate [redacted] licenses	license, server, activate, notification, notify, administration, certificate, entitlement, flexnet, activation
ACTIVE_DESIGN_CODE	code, active, material
Add a bolt assembly to the catalog	bolt, assembly, catalog, character, maximum, stud, ok, confirmation, box, enter
Add a bolt to the catalog	bolt, washer, nut, catalog, element, assembly, character, maximum, distinguish, new

Appendix 4. Thematic analysis of expert interviews in the exploratory phase

Main theme, Subtheme	Interviewees' comments	# comments	# interviewees (out of 6)
Beginner content first		41	
Definition or overview first		4	3
	The first ranked guide should be "Custom components" , now it is much lower. (mentioned also in email received from one of the participants).		
	"IFC" has the right rank , it is a basic guide with good links to further info.		
	The two first guides should be these: 1. Work with [redacted] Model Sharing 2. What is [redacted] Model Sharing .		
	"[redacted] Connector" should be ranked on top, it's generic and have useful links.		
Basic guides before advanced		37	6
	"Import and export custom components" and the two other guides on top are ok , those are for the users using ready made components .		
	"Example of a variable formula..." is really specific guide, this is wrong rank for it .		
	"Edit and save custom components" is ok .		
	"Customize the dialog boxes of custom components by using a text editor": wrong rank, should no be this high .		
	"Examples of a variable formula : Rebar set modifiers in custom components": wrong rank, not this high .		
	The "Define custom components" that tells about creating custom components should be among the top search results .		
	"Add variables to a custom component" should be right after "Define custom components" .		
	"Default properties of a custom component dialog box", should not have this high ranking .		
	"Add custom components to a model" could be higher in rank than the examples (see the multiple "Example of variable formula: ..." guides).		
	"Create a variable formula" is a basic thing for users creating their own custom components : could be higher on the results list.		
	"Check the exported IFC model" is now ranked too high, it's about a detail thing .		
	The next guides on the list should be "IFC insert", "IFC export", "Convert IFC objects into native Tekla Structures objects", "Example: Convert IFC objects into [redacted] objects in one go", "Export a [redacted] model objects or selected model objects to an IFC file", "Insert a reference model" .		
	"IFC interoperability concepts" could be ranked near the bottom of the list, it is a very advanced guide .		
	"Administrator's release notes: Rebar shape manager": ranking should be lower .		
	Top ranking guides should be these: 1. "Add new bending shape rules manually in Rebar shape manager" 2. "Define reinforcing bar bending shapes in Rebar shape manager" 3. "Tips for reinforcement shape recognition in Rebar shape manager" 4. "Hard-coded bending type identifiers in reinforcement shape recognition" 5. "Reinforcement shape recognition" 6. "Rebar shape manager in reinforcement shape recognition"		
	"How to calculate the reinforcing bar leg length", maybe this guide should not be have this high ranking .		
	The assumption is that when a user searches "rebar" s/he expects to first find some basic info about creating and modifying rebars . After that search results could show info about reporting and drawings . More advanced articles about e.g. advanced options and .inp should be ranked lower .		
	The ranking could be like the following: 1. "Create a rebar set" should be ranked the highest 2. "Group reinforcement" 3. "Create a reinforcing bar group" 4. "Create a curved reinforcing bar group" 5. "Create a reinforcement strand pattern" 6. "Create a circular reinforcing bar group" 7. "Create a single reinforcing bar" 8. "Create a reinforcement splice" 9. "Ungroup a reinforcement" 10. "Work with groups in the rebar catalog" 11. "Create a reinforcing bar group using Rebar shape catalog" 12. "Modify reinforcement" 13. "Modify a rebar set" 14. "Modify a rebar set using leg faces" 15. "Modify a single reinforcing bar, bar group, or mesh" 16. "Use handles to modify a reinforcement" 17. "Modify a rebar set locally using modifiers" 18. "Reinforcement for foundations" (an example) 19. "Rebar sets in curved structures" (another example).		
	The next guides (after the two first) should include these: "Join a shared model in [redacted] Model Sharing", "Update the model with other users' changes", "Share your model changes in [redacted] Model Sharing", "Share a model in [redacted] Model Sharing", "Create a baseline for a model in [redacted] Model Sharing", "[redacted] Model Sharing settings", "[redacted] Model Sharing and multi-user for administrators", "Best practices in [redacted] Model Sharing", "What is shared in [redacted] Model Sharing", "Repair [redacted] Model Sharing issues", "What is shared in [redacted] Model Sharing, "Repair [redacted] Model Sharing issues"		
	"Detect sharing changes and view the sharing history in [redacted] Model Sharing" do not need to be included on the 1st page .		
	"Collect model history in [redacted] Model Sharing" does not need to be on the first page .		
	"Set object locks, drawing locks, and privileges in [redacted] Model Sharing" does not need to be on the first page .		
	Do not show any advanced options on the first page : "XS_CLOUD_SHARING_PROXY", "XS_...."		
	Do not include advanced options in the first page : "XS_IGNORE_CUT_VALUE_IN_TEMPLATE".		
	"Copy objects" should be ranked on top , it contains (among other commands) instructions of using the "copy from another model" command .		
	"User-defined attributes in numbering" should not be this high in ranking .		
	"Sequencer" should not be included in the first page .		
	"Save analysis results as user-defined attributes of parts" and "Customize drawing grid labels" should not be included in the first page .		
	The first ranked "Resize and reshape model objects" is ok, it contains good links .		
	"Modify items" should be second , "Modify a construction object" is good general guide .		
	Not to be included on the first page : "Delete a single grid line".		
	Not to be included on the first page : "XS_DISPLAY_DIMENSIONS_WHEN_SELECTING_OBJECTS", "XS_DISPLAY_DIMENSIONS_WHEN_SELECTING_REBARS", they are telling about a very special case .		
	Not to be included on the first page : "Example of a variable formula : Define the stiffener position using construction planes", it is about a special case when Direct Modification is turned off.		
	"Create a template" should be the first . "Reports", and "Templates" are ok . The next articles should include these: "Create and edit drawing layouts" is important because it can be difficult to understand that template editor is being used to that, "Tables in drawing layout", "Create a template in HTML format", "Create a .pdf report template", "Files related to templates, reports and drawings", "Create a template for nested assemblies" is an example, "Create a template for bending schedules or pull-out pictures" an example, "Content types", "Template attribute files (contentattributes.lst)"		
	Do not include the template attributes in the first page , such as "CLASS", "PERIMETER", "DR_DEFAULT_WELD_SIZE".		
	The top articles should be the following: 1. "Create a concrete beam" 2. "Create a concrete slab" 3. "Create a concrete polybeam" 4. "Create a concrete panel or wall" 5. "Create a concrete column" 6. "Create a concrete spiral beam" 7. "Create a concrete lofted slab" 8. "Concrete Detailing" 9. "Concrete components reference"		
	Articles should be so ranked so that using and downloading content from Warehouse is listed before creating your own content : "Getting started with [redacted] Warehouse", "Search for content in [redacted] Warehouse", "Using content from [redacted] Warehouse", "Prerequisites for using [redacted] Warehouse", "Download content from [redacted] Warehouse", "Insert [redacted] Warehouse content into a [redacted] model".		

Reason for wrong ranking	7	
Relevant content not ranked high enough: searched word occurs only once or few times, or not at all	2	2
"Insert a reference model" guide should be on the top. It doesn't mention word "ifc" very often but it is about inserting ifc (the word "reference model" we use in [redacted] means also ifc).		
"Hard-coded bending type identifiers in reinforcement shape recognition" should be ranked as 4th even if it mentions Rebar shape manager only once in the text.		
Irrelevant content ranked too high: even if the searched word occurs in text, the content does not tell about the searched topic	4	4
"Customize the Applications & components catalog" guide mentions words "components" and "custom" but guide is not about "custom components" .		
"Change drawing color" does not have anything to do with changing the background color. That guide should not be included.		
Many are not actually "release notes" but may mention the words; should not be included?		
These two are not about installation at all even if the word "install" occurs in the text: "INSTALL_ACTUAL", "INSTALL_PLAN".		
Search does not understand abbreviations correctly	1	1
"CC" has nothing to do with custom components, the abbreviation means here center of gravity (even if sometimes "CC" may have been used as abbreviation for "custom component"), "Reinforcement and neighbor reinforcement mesh mark elements" mentions abbreviation of CC but has nothing to do with custom components., "Reinforcement and neighbor reinforcement mark elements" mentions again the abbreviation of CC but has nothing to do with custom components.		

Appendix 5. Example page from the report

Example page from the report where the ranking of the existing search (screenshot on the left) was compared with subject matter experts' preferred ranking (written list on the right). The keyword searched in this example was "rebar" which means the same as reinforcement.



The screenshot shows four search results for the keyword "rebar". Each result includes a document icon, a title, a date and time, a user name, a star rating, a snippet of the article's content, and a URL. The results are as follows:

- Add reinforcement marks manually in drawings**
04.11.2020 18:17 by Tekla User Assistance ★★★★★
Add reinforcement marks manually in drawings ... Add reinforcement marks manually in drawings You can add marks manually to reinforcing bars and meshes in drawings. The reinforcement marks may already exist in a drawing if you have selected to create the marks at drawing creation. ...
https://support.com/2020/en/dra_add_reinforcement_marks
- Add reinforcement marks manually**
04.11.2020 18:17 by Tekla User Assistance ★★★★★
Add reinforcement marks manually ... Add reinforcement marks manually You can add marks manually to reinforcing bars and meshes in drawings. The reinforcement marks may already exist in a drawing if you have selected to create the marks at drawing creation. If there are ...
https://support.com/2020/en/dra_add_reinforcement_marks_manually
- Create a rebar set**
04.11.2020 18:33 by Tekla User Assistance ★★★★★
Create a rebar set ... Create a rebar set Rebar sets are reinforcing bars that you can modify by using direct modification and the rebar set guidelines, leg faces, and local modifiers. You can create rebar sets when you want to flexibly reinforce various ...
https://support.com/2020/en/rei_create_rebar_set
- Work with definitions in the rebar catalog**
04.11.2020 18:12 by Tekla User Assistance ★★★★★
Work with definitions in the rebar catalog ... Work with definitions in the rebar catalog You can add, copy, modify, and delete rebar definitions in the rebar catalog. To use the newly added or modified rebar definitions in the model, reopen the model. Add a new rebar definition ...
https://support.com/2020/en/cus_work_with_definitions_in_catalog

The ranking could be like the following:

1. "Create a rebar set" should be ranked the highest
2. "Group reinforcement"
3. "Create a reinforcing bar group"
4. "Create a curved reinforcing bar group"
5. "Create a reinforcement strand pattern"
6. "Create a circular reinforcing bar group"

Appendix 6. Screenshot of the interviewer's screen

Results: "XS_drawing"

Showing 1-10 of 144 results

2021 Not version-specific Clear filters

XS_DRAWING_CREATE_SNAPSHOT_ON_DRAWING_CREATION

XS_DRAWING_CREATE_SNAPSHOT_ON_DRAWING_CREATION Category: Drawing Properties
Set this advanced option to TRUE to create a snapshot of a drawing at the same time that you create the drawing. ...

2021 Product guide

XS_DRAWING_SHEET_POSITION_Y

You can set this in the following ways: XS_DRAWING_SHEET_POSITION_X=50 XS_DRAWING_SHEET_POSITION_Y=50 ...

2021 Product guide

XS_DRAW_REBAR_SELF_INTERSECTING_LEGS_WITH_OFFSET

XS_DRAW_REBAR_SELF_INTERSECTING_LEGS_WITH_OFFSET Category: Drawing Properties
When set to TRUE, this advanced option displays rebars in drawings with overlap in all representations. ...

2021 Product guide

XS_DRAW_BENDING_END_LINES_IN_UNFOLDING

XS_DRAW_BENDING_END_LINES_IN_UNFOLDING Category: Dimensioning: Unfolding
Set this advanced option to TRUE to draw bending end lines when creating unfolded single part drawing of a bent plate or a ...

2021 Product guide

XS_DRAWING_USE_WORKSHOP_FORM_FOR_DOUBLE_PARTS_IN_SINGLE_PART_DRAWINGS

XS_DRAWING_USE_WORKSHOP_FORM_FOR_DOUBLE_PARTS_IN_SINGLE_PART_DRAWINGS Category: Drawing Properties
Set this advanced option to TRUE to show haunch profiles always in workshop form as double parts ...

2021 Product guide

XS_DRAW_BENDING_END_LINE_DIMENSIONS_IN_

XS_drawing

Filters ▾

ACTIVE FILTERS
Product [redacted] Version 2021, Not version-speci

Click to add to query:

snapshot create assembly creation single sheet open part edit

trimble (200)

Nro	Title	Product	Version	Functionality	Content type	Env
1	Create drawings	[redacted]	[2021]	[Drawings, Reports, Templates]	Product guide	[]
2	Open drawings	[redacted]	[2021]	[Drawings]	Product guide	[]
3	Assembly drawings	[redacted]	[2021]	[Drawings]	Product guide	[]
4	Creating assembly drawings and single-part drawings	[redacted]	[Not version-specific]	[Steel components, Drawings]	Course	[No env spe
5	Edit drawings	[redacted]	[2021]	[Drawings]	Product guide	[]
6	Include single-part drawings in assembly drawings	[redacted]	[2021]	[Drawings, Setting Up]	Product guide	[]
7	Issuing drawings	[redacted]	[Not version-specific]	[Printing, Drawings]	Course	[De
8	Manage drawings	[redacted]	[2021]	[Drawings]	Product guide	[]
9	Drawings in [redacted]	[redacted]	[2021]	[Drawings]	Product guide	[]
10	Single-part drawings	[redacted]	[2021]	[Drawings]	Product guide	[]
11	First steps - Creating drawings	[redacted]	[Not version-specific]	[Drawing views, Drawings]	Course	[De
12	Reinforcement in drawings	[redacted]	[2021]	[Drawings]	Product	[]

Appendix 7. Thematic analysis of internal expert interviews in the evaluative phase

Main theme, Subtheme	Interviewees' comments	# comments	# interviewees (out of 4)
Ranking is not correct		20	
Beginner level article not high enough in ranking		13	4
	"What is Numbering and how to plan it" (were 40th in the ranking) is a concept level article , could be higher in the ranking, even right away on the top.		
	What is numbering and how to plan it" (40th) should be ranked first and "Number the model" (10.) should be second.		
	The "Number the model" (10th) could be a little higher up, it's a summary page with a lot of links.		
	These should be much higher in the rank: , "Number assemblies and cast units" (were 30th) and Tips for numbering (31st)		
	"Assign family numbers" (37th) could be at the same level in the ranking as "Control numbers" (7th)		
	This should be much higher in the rank: Plan your numbering series (35th).		
	The first results look good. Something is missing, though...assemblies and cast units could be higher in ranking.		
	Number one should be "Print drawings" (40th) and then maybe "Print a report" (53rd) as the second.		
	"Components" (34th) is related to custom components , although it is a top-level concept . That could be much higher, before other "custom" or "component" results. Also results ranked 35., 36., 38., 39., 40., and 45. are also about components". So here the "component" is the more dominant term than "custom". "Bind component objects to a plane" (43.) is about how to make a custom component, should be clearly ranked higher.		
	" Tips for templates " (30th) should be a little earlier in the list.		
	"Select the workplane" (61st) should have been included, it tells how to set the base point, pretty useful.		
	" Best practices in Tekla Model Sharing " (15th) should be much earlier.		
	"Manage reference models in [redacted] Connector" (11th) should be higher in the list, most used in [redacted] to import reference models.		
Advanced content should be ranked lower		7	2
	"Property files" (7th) should not be this high.		
	"Control numbers" (7th) could be ranked lower, that is not about basic numbering.		
	"Configuration files used in printing" (1st) is too specific to be right away on top. The average user do not need to adjust the files, it is more for the localization or administrator's matter.		
	"Printing settings and search order" (2nd) tells about settings, regular user do not need to adjust the settings. Should be lower in the ranking.		
	"Customize the property pane layout" (1st), don't start with this, the word "customize" refers to an already more advanced user.		
	" Administrator's release notes: Property pane updates" (3.), again the word "administrator" refers to an advanced user so this should not be ranked this high.		
	Maybe advanced options starting from rank 17. could be a little later; when you search with a general term you do not want to see details.		
Related content should be before those not related to searched topic		2	1
	"Share models and files" (33.) includes "[redacted]" and should be before the previous ones that are not relevant.		
	"XS_IGNORE_CUT_VALUE_IN_TEMPLATE [xs ignore cut value in template]" (33rd) relates to template editor, must precede those not related. "Template attribute files contentattributes.lst" (42nd) is quite closely related, so should be ranked before those not related. "Reports" (70th) is related to template editor, again should be ranked higher than those not related. "Tables in drawing layout" (71st) contains the search term many times, but still only in position 71?		
Content that tells about the new way should precede content that tells about the old way		1	1
	The old and new way seems to be mixed (3rd onward); articles with "(old printing)" in the title tells about the old way of printing. The new way of printing uses the Document Manager. The old stuff should be lower in the ranking. "Print to a single printer" (37th) might be about old printing, even if the title is missing the "(old printing)"?		
Search returns wrong content		17	
Content not related to searched topic		13	2
	"Example: Limit the number of outside dimensions" (43rd) is not about numbering , should not be included in the results.		
	"Change the pen numbers (line thickness) for colors" (51st) tells about something else entirely , should not be included in the results.		
	"Line thickness (pen number) in Color Table" (52nd) is not talking about numbering at all , should not be included in the results.		
	Same thing with "Example of a variable formula: Calculate the number of bolt rows" (53rd), should not be included in the results. Advanced option articles (from 54th onward) tell about numbering so those are ok.		
	"View object properties in Organizer" (16th) is not telling about the property pane. Should not be included here.		
	"Modify saved settings properties" (33rd) is not about property pane , no to be included in the results.		
	The rest are those where the word "custom" occurs but are not telling about "custom component" .		
	"Customize the dialog boxes of custom components by using a text editor" (4th) is not about template editor.		
	I do not search for information on what is a template, but the "template editor" .		
	"Create model templates" (23rd) and "Template attributes in filtering" (24th.) has nothing to with template editor. 26. - 29. are about something else , Organizer's property templates. "Clone using drawing templates in template library" (32nd) is about the drawing templates, not the same thing.		
	Base plates are not about this , remove those, those are connections used in steel. Seems to find all that contain word base". Stair base articles are not about base points. Next it finds all with word "point".		
	"Create your [redacted] Identity" (10.) is not about [redacted] Connect.		
	These are not about [redacted]: "Checklist of [redacted] deliverables needed in [redacted] licensing" (13th), "Connect [redacted] to the license server" (14th), "XS_GA_CONNECTING_SIDE_MARK_SYMBOL [xs ga connecting side mark symbol]" (17th), "Problems in [redacted] license server installation and connecting to the license server" (18th), and onward.		

Ranking is ok		27	
Ranking looks good		17	4
	"Number parts" (1.) don't come right away in TUA, you need to browse several pages. It is a basic command and the article works for many - good!		
	Quite bad results when you look at TUA - the looks much better.		
	Just fine ("on ihan jees").		
	Looks fine . It is in a right order: first what is ifc etc.		
	Looks pretty good ("ihän hyvältä näyttää"). In general, first what it is, then how to use it (like import a ready-made component), then only after that creation of new components. Now "Define custom components" (1st) is the first and "Custom Component settings" the second, both tell about creating new components. "Import and export custom components" (5th) should be before creating and editing.		
	Good start.		
	The first ones are ok.		
	The top results from 1. to 6. are ok.		
	Looks fine.		
	This is fine now.		
	Looks fine.		
	Many of the search results seems to tell about commands you can start from the property pane , so those are ok .		
	It's good to have "2020 administrator's release notes" (1st), after that the order doesn't matter.		
	"Drawing list" (1st) is ok. "XS_USE_OLD_DRAWING_LIST_DIALOG [xs use old drawing list dialog]" is ok too .		
	"How to use the side pane" (6th) is ok to be ranked high.		
	"Save and load object properties" (8th) is ok to be high in the ranking.		
	"Copy properties from another object" (10th); copying is a basic functionality so this is ok.		
Ranking is close to correct		10	4
	User is looking for "IFC insert" (4th) so that should be the number 1.		
	The first results look good. Something is missing, though... assemblies and cast units could be higher in ranking.		
	"View and modify model object properties by using the property pane" (2nd) would be good to be ranked as number one.		
	As well as "Create parts and modify part properties"(11th), could be even higher maybe.		
	The second could be "Edit tables in Template Editor" (1st) . 6. and 7. are pretty. The first ones are ok.		
	Results are fine, but the sequence could be changed. Rank basic to the top: how to create. Regular user's way of thinking. So basic since the search term is so basic. After creating and modifying the next would reporting and drawings.		
	"Add new bending shape rules manually in Rebar shape manager" (5th) should be the first. Really useful for the users. Then from the 1. onward: ok		
	The top 5 looks fine , then there is something else. Splitter properties (10th) could be after those 5 first ones.		
	Looks fine. "View properties" (3rd) could be ranked to the first. In general, first model view properties and then drawing view properties. "View and modify model object properties by using the property pane" (8th) could be among the top ranked.		
	Connector (9.) should be before articles 6., 7. and 8. that tell about Visualizer.		

Appendix 8. Thematic analysis of end user interviews in the evaluative phase

Main theme, Subtheme	Interviewees' comments	# comments	# interviewees (out of 7)	The comment affects	
				Beginners	Experts
Search difficulties		8	5	6	4
Existing search is difficult to use					
	B2 find using TUA search difficult , there are all those filters that you are not used to using (B2)			x	
	I did not initially find anything in TUA (E1)			x	
You do not know the right keywords					
	It is really hard at times when you don't know the name of things (B2)			x	
	You need to know the right "keywords" (E1, E4, E5)			x	x
You know the keywords but they are in wrong order					
	Although the search terms are correct, but their order is wrong , the search does not work (E1, B2).			x	x
	E1 uses Google when TUA does not work: if the order of words is wrong in TUA E1 uses Google instead (E1)				x
No results if you use many words or your own words					
	Zero results were found if you used many words in TUA (B2)			x	
	TUA does not understand phrases or multi-word search terms (E1)				x
Help needed to recall difficult things		3	2	0	3
	For an experienced or admin user, TUA would be better because it makes it easier to recall those things that are difficult to remember such as XS options. But for the basic user the Proto would be better because it gives a general understanding (E4)				x
	TUA found the article about a XS variable very well, it was ranked 1st. Proto did not return the XS variable article. (E1)				x
	Additional words suggested in the Proto or predictive text input like Google are good features for both a beginner user and expert user who knows the right keyword but doesn't remember it (E4).				x
Navigate to content via Google instead		7	6	3	4
	New users are not familiar with the TUA search but prefer to search on Google (E4)			x	
	Google did not find TUA content before but it does find it now (E5)				x
	Sometimes Google is better because it finds YouTube videos when TUA doesn't (E7)				x
	B6 doesn't always bother to ask everything from more experienced colleagues or user's mentor, user puts a Google search for "how to make something" after which user ends up on [redacted]'s pages . (B6)			x	
	Although the content was in TUA, TUA search didn't work properly . B3 wanted to make sure user was doing things the right way so user typed "[redacted] user assistance" in Google search field not to end up in a random YouTube video not created by [redacted]. Google returned the right TUA article right away on the top and was able to find what user needed . (B3)			x	
	E1 uses Google when TUA does not work : if the order of words is wrong in TUA E1 uses Google instead (E1)				x
	E4 looks first at TUA, then at the Discussion Forum, and last at Google (E4)				x
Add to query feature helps in search		6	4	6	4
	"Add to query" feature included in the Proto helps in search (B3).			x	
	The feature would be good because even if your working language is English the correct terms are not always remembered. The proposals would help forward. (B6)			x	
	E4 tries very often to find out what is wrong and in those cases suggestions like "troubleshooting" would help (the Proto suggested the word "troubleshooting"). Basic users are typically searching something because they are having a problem . (E4)			x	x
	The words the Proto's suggested point the user in the right direction (E5).			x	x
	Additional words suggested in the Proto or predictive text input like Google are good features for both a beginner user and expert user who knows the right keyword but doesn't remember it (E4).			x	x
	If the results contain articles from multiple concepts but the user is interested in only articles that contain info about only one of those concepts. The system should allow the user to filter away articles telling about the irrelevant concepts . (E5)			x	x
New search returns more user-friendly information -> New search returns more beginner-friendly knowledge		8	6	8	0
	TUA does not provide basic information , but the Proto shows better user-friendly material (E1)			x	
	The Proto is better since the search term was quite general while TUA went into detail (B2)			x	
	Proto gives "Create Drawings" as the third hit. B6 would use it right away as a newbie; basic knowledge is really needed . TUA did not return that article until the third page. (B6)			x	
	(B2 was looking for information on how the filtering logic works) TUA did not return anything that was typed in the keyword. Proto was better and opening the search results would probably help him to understand the thing (B2)			x	
	(B3 wanted instructions on how to create corbels) From TUA B3 was not able to find the modeling instructions: how to do corbels . "Modeling beam to beam web connections" course was only on the second page of TUA. B3 would not bother to go to the second page. Proto gives better modeling related topics that user could use such as "Modeling two-sided connection" and "Modeling beam to beam web connections". (B3)			x	
	The proto had better content, it showed more common things, which is a good thing . There were articles in the TUA results that the average user would hopefully never need (E5)			x	
	(E4 wanted to look for info on how to edit the steps.dat file. No basic information was found in TUA. Only 5 results were returned on TUA) If the matter had not been known before, the problem could not have been solved . Proto showed more results than TUA and the 2nd article "Custom steps" was what E4 was looking for . (E4)			x	
	For an experienced or admin user, TUA would be better because it makes it easier to recall those things that are difficult to remember such as XS options. But for the basic user the Proto would be better because it gives a general understanding (E4)			x	

Appendix 9. End users' comments for each tested keyword

The following table lists the keywords used and the testers' comments. For each keyword, the aim was to determine which of the search engines was better for the user. This was not always possible as users did not always comment on the results.

The last column contained a link to a screenshot stored in the target company's drive. The screenshots showed the test situation and the knowledge content returned by the two search tools: proof of concept called "proto" and the existing website search "TUA".

#	Tester	Keyword	Tester's comments	Which was better?	Link to image
1	E1	XS_drawing	<p>In TUA the 1. article is something the tester has used only a couple of times in 10 years. Didn't find anything the user might need. TUA does not provide basic information.</p> <p>A clear improvement, the proto shows better user-friendly material. Seems it does not take into account the beginning of XS_ at all, it retrieves with the word "drawing".</p>	Proto	XS_drawing
2	E1	<p>custon component</p> <p>custom component</p>	<p>Tested a multi-word search because TUA is really bad at it. Searched "custon components" with a small typo, on purpose.</p> <p>TUA seems to ignore the word "custon."</p> <p>In the prototype, the third article contains both words. The results improved when the word "custom", that was suggested by the proto, was added to the query.</p> <p>In a two-word search, TUA was reasonably good now, compared to the situation some years back. No major differences with the proto.</p>	No big differences	custon component
3	E1	part dimension plane table	<p>TUA found the article about XS variable very well (ranked 1st).</p> <p>Proto did not return the XS variable article.</p> <p>Tested adding the suggested "XS" term to the search but Proto did not</p>	TUA	<p>part dimension plane table</p> <p>part dimension plane table xs</p>

			return the XS variable article even then.		
4	E1	copy mirror	<p>The articles ranked 3rd and 4th were ok in TUA.</p> <p>The same articles were 1st and 2nd in the proto.</p>	No big differences	copy mirror
5	E1	export nc file	<p>TUA returned the article “NC files” last in the first page, other search results were not relevant.</p> <p>Proto ranked “NC files” as 1st. The article you would probably be looking for was the 2nd (not included in the first page in TUA’s results at all).</p> <p>The words suggested by Proto, like “dstv” in this case, might help.</p>	Proto	export nc file
6	B2	object filtering in drawings	<p>The user sought information on how the filtering logic works. TUA did not return anything that was typed in the keyword.</p> <p>Proto was better and opening the search results would probably help to understand the thing.</p>	Proto	object filtering in drawings
7	B2	modeling rebar	<p>It was good that Proto ranked 1st “Unable to create rebars” since the user typically is looking for help when something is not working and the article would be a direct answer to a problem. TUA ranked it as 3rd.</p> <p>Proto returns lessons (“Modeling rebar for rebar detailing” lessons 1-6), that’s good. Proto is better since the search term was quite general while TUA went into detail.</p>	Proto	modeling rebar
8	B2	creating general drawings	<p>User mentions that “Example: The article Clone a general arrangement drawings” is good because after creation it is often also necessary to copy or clone. The article was not found in the Proto.</p> <p>The user doesn’t comment which is better (but the results were actually quite similar).</p>	-	creating general drawings

9	B2	properties dialog box	<p>The user had used Google to find an answer to the question: how to change the default settings in the property pane so that all tick boxes are always on?</p> <p>Both TUA and Proto ranked 1st the right article "Properties dialog box: Clear all check boxes by default".</p> <p>More sensible things in Proto.</p>	Proto	properties dialog box
10	B3	precast corbel connection	<p>In TUA the 2nd is out of scope, but 1st is correct.</p> <p>The order in the Proto is better, it is more focusing on Corbel, the user feels that it's providing content that is more related to the corbel the user is interested in.</p>	Proto	precast corbel connection
11	B3	corbel connection modeling	<p>User wants instructions on how to create corbels.</p> <p>From TUA the user was not able to find the modeling part, how to do corbels. "Modeling beam to beam web connections" article was on the second page in TUA and if it was not on the first page the user would not bother to go to the second page.</p> <p>Proto gives better modeling related topics that the user could use (such as "Modeling bracing connections", "Modeling two-sided connections", "Model beam to column connections" and "Modeling beam to beam web connections").</p>	Proto	corbel connection modeling
12	B3	precast reinforcement detailing	<p>TUA's first 3 or 4 articles are ok.</p> <p>In the Proto 1st and 2nd are really good and enough for the user but the headings ("Reinforcement") are very vague. The 3rd "Details" is out of scope. 5th and 6th are not so related. Article "Modify reinforcement" (11th) should be on top.</p> <p>The best would be a combination of the two: general info from the Proto (the 1st and 2nd) and the more</p>	-	precast reinforcement detailing

			specific articles from TUA (the first 3 or 4 articles).		
13	B3	generating reinforcement drawings	<p>The user was not able to see the drawings part in the results in TUA. Only one article, "Example: hide reinforcing bar lines in drawings", mentioned the "drawings" but it was not about generating drawings.</p> <p>The 1st article "Reinforcement in drawings" returned by Proto is helpful. Other articles talk about drawings too but also about something else.</p> <p>After adding the suggested word "create" to the query, Proto also returned "Create drawings" (3rd) that would be good for new users, "Create views in drawings" would be helpful (11th), and the "Creating rebar drawings" (12th) that was exactly what the user was searching for.</p> <p>"Create" was the word that helped.</p>	Proto	<p>generating reinforcement drawings</p> <p>generating reinforcement drawings create</p>
14	E4	steps.dat	<p>User wanted to look for info on how to edit the steps.dat file.</p> <p>No basic information can be found in TUA. If the matter is not previously known the problem could not have been solved. Only 5 results.</p> <p>More results in Proto. The 2nd article "Custom step" was what the user was looking for.</p>	Proto	steps.dat
15	E4	objects.inp	<p>In objects.inp file the max length of an attribute is set to 19 characters. The user wants to find that info.</p> <p>TUA's 1st article "Properties of the objects.inp file" seems good.</p> <p>Proto returns the first 4 results in the same order as TUA.</p>	No big differences	objects.inp
16	E4	wall layout	TUA returns "Wall layout tools" article as 1st, that is what the user was looking for.	TUA	wall layout

			The same 1st article, followed by different content. Proto emphasizes the word “layout”, which causes drawings articles to be included. TUA was more accurate in this case.		
17	E4	model sharing settings	<p>The 1st result “[XXXXX] Model Sharing settings” in TUA is correct, the others also seem to be well related to the topic. A lot of XS options listed.</p> <p>The 1st hit in Proto is the same article as in TUA. For the basic user Proto would be better because it gives a general understanding. For an experienced or admin user, TUA would be better because it makes it easier to recall those things that are difficult to remember such as XS options.</p> <p>The word “troubleshooting” suggested by Proto would be really good.</p>	Proto <i>(for a basic user)</i>	model sharing settings
18	E5	Overlap overlap joint overlap connection cold rolled overlap collection	<p>The user wants to retrieve information about cold rolled overlap connections.</p> <p>TUA returns articles about overlapping numbering, which is probably the right result for the keyword used. The user asks how to tell the search to show content about overlap connections instead?</p> <p>Proto shows the cold rolled overlap articles on top. But the “Overlapping numbering series” may be now too low on the list (8th).</p> <p>In TUA the search term “overlap joint” returns “Overlapping numbering series” (4th) and the user asks why? The results mix overlapping in numbering, overlapping in rebars, and overlapping in connections.</p> <p>Did not test “overlap joint” in Proto but moved on.</p>	-	overlap overlap joint overlap connection

			<p>[The top three results were the same in both when the search term was “overlap connection”.]</p> <p>The user pondered about the missing cold rolled connections that were not included in the results.</p>		cold rolled overlap collection
19	E5	weight	<p>The user wonders why the very specific article WEIGHT_MAX is 1st in TUA. More general WEIGHT (2nd) should be on top.</p> <p>Proto clearly looks better. The results of Proto are what the user expected. Different from TUA results: “How does [XXXX] calculate weight” etc.</p>	Proto	weight
20	E5	clash check	<p>The results of TUA look like what the user would like to receive.</p> <p>Pretty much the same results in Proto. The XS options are ranked much lower.</p>	No big differences	clash check
21	E5	extend	<p>“Extend macros” are the 1st in both, that's good.</p>	No big differences	Extend
22	E5	template editor	<p>In TUA's results there are articles that an average user will hopefully never need (e.g. 3rd and 6th).</p> <p>Better content in the proto. Shows more common things which is a good thing.</p> <p>But “Introduction to the Template Editor” should be at the beginning, and then others after it. [TUA shows it at the end of the first page, not included in the Proto's search results at all.]</p> <p>Proto should suggest “layout” as an additional word for the search.</p>	Proto	template editor
23	E5	revit	<p>TUA shows "Export to Revit Geometry" (3rd), which means Warehouse help, which is great. The TUA side looks good.</p> <p>Proto shows the same also (2nd).</p>	No big differences	revit

24	B6	reinforce bars	<p>TUA gives hits that the user “could click”.</p> <p>Proto gives almost the same hits, a bit different order. For a newbie the both gives hits that the user would use.</p>	No big differences	reinforce bars
25	B6	how to make drawings	<p>TUA gives “ok” hits.</p> <p>Proto gives “Create drawings” as a 3rd hit. The user would use it right away as a newbie (really basic information is needed). TUA gives the same article on the 3rd page.</p>	Proto	how to make drawings
26	B6	how to add environment	<p>TUA doesn’t give any valid hits.</p> <p>The 3rd hit in Proto would be something the user would use.</p>	Proto	how to add environment
27	B6	environment	<p>“Ok” - the user doesn’t comment more</p>	-	environment
28	B6	environment, local	<p>The user wanted to test the commas between words as on Google.</p> <p>No feedback (tested only in TUA).</p> <p>At this point interviewer introduces “the quick buttons” of Proto: The user wants to add “setting” to search > Environment setting</p>	-	environment, local
29	B6	environment setting	<p>Proto: Now it gives good results.</p> <p>The user doesn’t comment on the hits on TUA and doesn’t comment on which is better.</p>	-	environment setting
30	B6	not square concrete	<p>The user didn’t remember the correct search word. However, the user would have opened the 3rd link in Proto.</p> <p>TUA didn’t give anything interesting.</p>	Proto	not square concrete
31	E7	custom commands	<p>User wants to look for info about custom commands related to ribbon editing.</p> <p>The “Customize the ribbon” article is 1st in TUA, and when you open that article, the included topic “Create a user-defined command with</p>	TUA	custom commands

			<p>Command editor” is what the user searched for (the user knew it because the user had searched it through Google before). User says that the TUA search works well.</p> <p>The user notes that the keywords probably work differently in TUA and Proto.</p> <p>After adding the word “ribbon” Proto’s 1st article was about ribbons commands but not about “custom”.</p>		<p>custom commands ribbon</p>
32	E7	ribbon xs_firm	<p>The user wants to find instructions on how to make a tab page in the ribbon via XS_FIRM. The user provides a link to old TS TUA to an article the user wants to see: “Distribute custom tabs using a firm or environment folder”.</p> <p>User points out the TUA’s 3rd result “Custom tab definition is not read from firm folder”. When the article is opened, the second link in “See also” takes you to the right article.</p> <p>In Proto, the 6th article is titled the same as the user wanted but it is not the same article as in the link the user provided. The article is new to the user. [Duplicate articles in TUA with the same title].</p> <p>Adding the word "project" to Proto's search - no help. Add the word "Customize" - still not.</p> <p>Words “ribbon xs_firm tab” in Proto returns the “Custom tab definition is not read from firm folder” as 4th.</p>	-	<p>ribbon xs_firm</p> <p>ribbon xs_firm project customize</p> <p>ribbon xs_firm tab</p>
33	E7	cambering	<p>The two top most results are the same in both.</p> <p>User thinks that the search does not find the articles from the old TUA (XXX.support.XXX.com). User wonders why Proto can't find "Cambering of steel beams" and that perhaps Proto requires the use of more words.</p>	-	<p>cambering</p>

34	E7	rebar set	<p>The 2nd in TUA "Create rebar set" is very good. [Also 2nd in the Proto]</p> <p>The user hopes to find videos and instructional materials, e.g. for rebar sets easily.</p>	-	rebar set
35	E7	on premises	<p>User looks for info on premises related to Model Sharing, not about on premises licensing.</p> <p>Added the word "sharing".</p> <p>Same article with the same name in both.</p> <p>The user hopes that the content of the article and style will remain the same, so that the user can easily navigate the articles that the user needs to return often.</p>	-	<p>on premises</p> <p>on premises sharing</p>

Appendix 10. The roadmap

